Annex III:
7th Call for Proposals (CFP07):
List and Full Description of Topics

Call Text
[R1]

- 08 November 2017 -

Revision History Table		
Version n°	**Issue Date**	**Reason for change**
R1	08/11/2017	Release for publication on the 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-2017-02@cleansky.eu*

Note that questions received up **until 15/01/2018, 17:00 (Brussels Time)** will be answered after analysis and published in Q&A when appropriate. In total, three publications of Q/As are foreseen: 15/11/2017, 15/12/2017 and 29/01/2018 (estimated dates).

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

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1. Call Rules

Before submitting any proposals to the topics launched in the Clean Sky 2 Call for Proposals, applicants shall refer to the applicable eligibility rules and conditions for participation as laid down in Chapter “3.3. Call management rules” of the Work Plan 2018-2019” [R1].

Topic specific conditions apply to the topic(s) related to the Technology Evaluator. For details, all applicants shall refer to the topic description(s).

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

SPD Area	No. of topics proposed per	Ind. topic Funding (M€)
IADP Large Passenger Aircraft	14	15.07
IADP Regional Aircraft	6	7.55
IADP Fast Rotorcraft	2	4.25
ITD Airframe	16	14.40
ITD Engines	15	16.30
ITD Systems	18	15.00
Small Air Transport (SAT) related topics*	[3]	[2.90]
ECO Design related topics**	[7]	[4.47]
Technology Evaluator	1	0.20
TOTAL	72	72.77

* SAT related topics are embedded in the concerned SPDs as follows:
AIR: 1 SAT topic, 0.90 M€,
SYS: 2 SAT topics, 2.00 M€

** Subject to ECO design funding upon positive evaluation against ECO High Level Objectives. ECO related topics are embedded in the concerned SPDs as follows:
LPA: 2 ECO topics, 1.40 M€
REG: 1 ECO topic, 0.57 M€
AIR: 4 ECO topics, 2.50 M€

3. Summary List of Topics

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP07-LPA-01-36	Innovative design for reliable and low weight power gearbox planet bearings	IA	0.75	GE Avio
JTI-CS2-2017-CfP07-LPA-01-37	Next Generation Low Pressure Turbine airfoils by ALM	IA	0.80	GE Avio
JTI-CS2-2017-CfP07-LPA-01-38	Advance Nacelle Aerodynamic Optimisation	RIA	2.20	Rolls-Royce
JTI-CS2-2017-CfP07-LPA-01-39	Skin Friction measurements on a real aircraft and Fiber-optics based pressure measurements for aircraft applications	IA	0.62	Airbus Operations GmbH
JTI-CS2-2017-CfP07-LPA-01-40	Novel mechanical drive disconnect for embedded Permanent Magnet machines	RIA	1.10	Rolls-Royce
JTI-CS2-2017-CfP07-LPA-01-41	Advanced manufacturing for MW range power dense electrical machines for aerospace applications	RIA	0.60	Rolls-Royce
JTI-CS2-2017-CfP07-LPA-01-42	Development of power electronic technologies for >1kV aerospace applications	IA	1.30	Rolls-Royce
JTI-CS2-2017-CfP07-LPA-01-43	Pulsating Heat Pipe (PHP) modelisation & characterisation	RIA	1.50	Liebherr
JTI-CS2-2017-CfP07-LPA-01-44	Quick Disconnect System	IA	0.60	Safran Electrical & Power
JTI-CS2-2017-CfP07-LPA-01-45	High Performance Generation Channel Integration	IA	0.80	Safran Electrical & Power
JTI-CS2-2017-CfP07-LPA-01-46	Intelligent Power Module	IA	0.60	Safran Electrical & Power
JTI-CS2-2017-CfP07-LPA-02-22	Development of a full size automated plant system for fuselage longitudinal and circumferential joints	IA	2.50	Fraunhofer
JTI-CS2-2017-CfP07-LPA-03-13	Design and development of smart sensors for detection of human cognitive states implementable in cockpit environment	IA	0.80	Honeywell International
JTI-CS2-2017-CfP07-LPA-03-14	Innovative validation methods and tools for FMS	IA	0.90	Thales Avionics
JTI-CS2-2017-CfP07-LPA [TOTAL]	**14 Topics**		**15.07**	
JTI-CS2-2017-CfP07-REG-01-11	Full scale innovative composite frames and shear ties for Regional Aircraft Fuselage barrel on-ground demonstrators.	IA	2.10	Leonardo Aircraft
JTI-CS2-2017-CfP07-REG-01-12	Full scale innovative composite doors, surrounds and sub-structure for Regional Aircraft Fuselage barrel on-ground demonstrators	IA	1.60	Leonardo Aircraft
JTI-CS2-2017-CfP07-REG-01-13	Full scale Innovative composite windows frames for Regional Aircraft Fuselage barrel on-ground demonstrators	IA	0.68	Leonardo Aircraft
JTI-CS2-2017-CfP07-REG-01-14	Full scale innovative composite pax and cargo floor grids for Regional Aircraft Fuselage barrel on-ground demonstrators	IA	1.20	Leonardo Aircraft
JTI-CS2-2017-CfP07-REG-01-15	Innovative Primary and Secondary Electrical Distribution Network for Regional A/C	RIA	1.40	Leonardo Aircraft
JTI-CS2-2017-CfP07-REG-02-04	Technological readiness at the operational level for additive manufacturing in primary structure and large size components	RIA	0.57	Airbus Defence & Space
JTI-CS2-2017-CfP07-REG [TOTAL]	**6 Topics**		**7.55**	

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP07-FRC-01-16	Full scale High speed aerodynamics characteristics of the Civil Tilt Rotor	RIA	3.50	Leonardo Helicopters
JTI-CS2-2017-CfP07-FRC-01-17	Innovative flotation methodologies (system) for tilt rotor	RIA	0.75	Leonardo Helicopters
JTI-CS2-2017-CfP07-FRC [TOTAL]	**2 Topics**		**4.25**	
JTI-CS2-2017-CfP07-AIR-01-30	Finalize and improve the manufacturing of the model of a laminar wing configuration bizjet (LSBJ)	IA	0.90	Dassault Aviation
JTI-CS2-2017-CfP07-AIR-01-31	Evaluation of the benefits of a laminar nacelle and a laminar HTTP installed on a bizjet configuration	RIA	1.50	Dassault Aviation
JTI-CS2-2017-CfP07-AIR-01-32	Prototype Tooling for manufacturing composite stiffened panel for a business jet lower wing	IA	0.60	Aernnova
JTI-CS2-2017-CfP07-AIR-01-33	Flexible RTM tool concept for composites with spring back adjustments capabilities	RIA	1.40	SAAB
JTI-CS2-2017-CfP07-AIR-01-34	Development of innovative aluminium filler wire based manufacturing of aeronautic components and structures	RIA	0.50	LORTEK
JTI-CS2-2017-CfP07-AIR-01-35	Development of an eco-friendly selective stripping for exterior surfaces of airframe structures	IA	0.60	Hellenic Aerospace Industry
JTI-CS2-2017-CfP07-AIR-01-36	Hybrid Aircraft Seating Manufacturing & Testing	IA	0.90	Fraunhofer
JTI-CS2-2017-CfP07-AIR-02-51	Light weight, certifiable airframe structures through combination with high performance materials	IA	0.50	Airbus Helicopters
JTI-CS2-2017-CfP07-AIR-02-52	Helicopter carbon composite engine deck	IA	0.50	Airbus Helicopters
JTI-CS2-2017-CfP07-AIR-02-53	Innovative & Flexible pilot plant Means for highly integrated AFP infusion wing box aiming at flying demonstrator manufacturing	IA	2.50	Airbus Defence & Space
JTI-CS2-2017-CfP07-AIR-02-54	Seals for FTB#2 Wing with Additive Manufacturing Technologies	IA	0.40	Airbus Defence & Space
JTI-CS2-2017-CfP07-AIR-02-55	Thermal conductive coating providing self-limitation of heating power at a selected temperature level	IA	0.60	Airbus
JTI-CS2-2017-CfP07-AIR-02-56	Advanced Integrated Testing Methods development	IA	1.20	Airbus
JTI-CS2-2017-CfP07-AIR-02-57	Tests and Modelling for reliability characterization and robustness of optoelectronic transceivers for optical SHM systems	RIA	0.90	Airbus
JTI-CS2-2017-CfP07-AIR-02-58	Optimization of hybrid joining (Refill Friction Stir Spot Welding + adhesive bond) for increasing mechanical properties and corrosion protection of the joints [SAT]	IA	0.90	PZL Mielec
JTI-CS2-2017-CfP07-AIR-02-59	Breakthrough design concept solutions and technologies for Regional Aircraft Cabin Interiors innovative configuration	RIA	0.50	Leonardo Aircraft
JTI-CS2-2017-CfP07-AIR [TOTAL]	**16 Topics**		**14.40**	
JTI-CS2-2017-CfP07-ENG-01-23	Improvement of high speed low pressure turbine performance through reduction of secondary effects	RIA	2.00	Safran
JTI-CS2-2017-CfP07-ENG-01-24	Crowned spline surface treatment and modelling	RIA	0.50	Safran
JTI-CS2-2017-CfP07-ENG-01-25	Gearbox bearing design & testing	RIA	1.00	Safran TS

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP07-ENG-01-26	Innovative acoustic fan frame liners technologies for UHBR	RIA	2.00	Safran AE
JTI-CS2-2017-CfP07-ENG-01-27	Composite process modelling and net-shape, complex geometry RTM tool design	RIA	0.70	GKN
JTI-CS2-2017-CfP07-ENG-01-28	Innovative HPC Flow Treatment Technologies: Design & Experimental Validation Using Advanced Measurement Techniques	RIA	0.80	GEDE
JTI-CS2-2017-CfP07-ENG-01-29	Characterization of the resistance of TiAl turbine blades to impact	RIA	0.55	Safran HE
JTI-CS2-2017-CfP07-ENG-01-30	Numerical and experimental study of high speed radial flow compressors	RIA	0.45	Safran HE
JTI-CS2-2017-CfP07-ENG-01-31	Unsteady pressure sensor for high pressure and hot environment	RIA	0.30	Safran HE
JTI-CS2-2017-CfP07-ENG-02-06	Experimental investigation of aerodynamic and heat transfer properties for a next generation turbine frame and nozzle	RIA	0.80	GKN
JTI-CS2-2017-CfP07-ENG-02-07	Aircraft design and noise assessment for a regional application	RIA	0.40	MTU
JTI-CS2-2017-CfP07-ENG-02-08	Optimization of TiAl CALPHAD databases of respective material systems	RIA	1.00	MTU
JTI-CS2-2017-CfP07-ENG-03-20	Emissions prediction for very large bypass ratio turbofans	RIA	1.80	Rolls-Royce
JTI-CS2-2017-CfP07-ENG-03-21	Novel Bearings	RIA	2.50	Rolls-Royce
JTI-CS2-2017-CfP07-ENG-03-22	Development and validation of a Powder HIP route for the manufacture of the UltraFan® Demonstrator IP Turbine casing from high temperature material allowing product enhancements at significantly lower costs and environmental footprint	IA	1.50	ITP
JTI-CS2-2017-CfP07-ENG [TOTAL]	**15 Topics**		**16.30**	
JTI-CS2-2017-CfP07-SYS-01-07	Development of a system for pilot eye gaze and gesture tracking in the cockpit environment	IA	0.90	TAV
JTI-CS2-2017-CfP07-SYS-01-08	Application of machine learning techniques to enable enhance aircraft performances database and facilitate mission optimization objectives	IA	0.60	TAV
JTI-CS2-2017-CfP07-SYS-01-09	Obstruction detection Sensor for Modular surveillance active Trajectory check improvement	IA	0.85	TAV
JTI-CS2-2017-CfP07-SYS-01-10	Development of 94 GHz (W-band) Radar Components	RIA	1.75	SAAB
JTI-CS2-2017-CfP07-SYS-02-36	Advanced Load Sensing technology for aerospace applications	IA	0.70	LLI
JTI-CS2-2017-CfP07-SYS-02-37	Development of a new backup electronics unit for Smart Inceptor	IA	0.90	SE&D
JTI-CS2-2017-CfP07-SYS-02-38	Ergonomic impact and new functions induced by Active Inceptor integration in cockpits	IA	0.60	SE&D
JTI-CS2-2017-CfP07-SYS-02-39	Development of a High Voltage Lithium Battery	RIA	0.50	DAV
JTI-CS2-2017-CfP07-SYS-02-40	Development of low insertion/extraction force electrical connecting device	IA	0.60	SE&P

Identification Code	Title	Type of Action	Value (Funding in M€)	Topic Leader
JTI-CS2-2017-CfP07-SYS-02-41	Development of methodology and tools based on advanced statistics applied to Electro Magnetic Compatibility analysis of cable harnesses in aeronautics	IA	0.70	SE&P
JTI-CS2-2017-CfP07-SYS-02-42	Development of low rating and high power HVDC optimized fuses	IA	0.50	ZEL
JTI-CS2-2017-CfP07-SYS-02-43	Design and Development of a high temperature HVDC busbar	IA	0.50	ZEL
JTI-CS2-2017-CfP07-SYS-02-44	Cabin air quality and passenger comfort	RIA	1.20	UTRC-I
JTI-CS2-2017-CfP07-SYS-02-45	Development of a Foreign Object Debris (FOD) protection device applied to an electrical ECS fresh air inlet.	IA	1.50	LTS
JTI-CS2-2017-CfP07-SYS-03-13	Electro-Mechanical Brake actuation for Small Aircraft [SAT]	IA	1.00	PAI
JTI-CS2-2017-CfP07-SYS-03-14	Development of Digital Integrated Multifunction Probe for Air Data Sensing [SAT]	IA	1.00	PAI
JTI-CS2-2017-CfP07-SYS-03-15	Super hydrophobic and erosion resistant coating for turbine scroll and downstream pipe	RIA	0.70	LTS
JTI-CS2-2017-CfP07-SYS-03-16	Aircraft mission modelling: ground and flight operations	IA	0.50	UTRC-I
JTI-CS2-2017-CfP07-SYS [TOTAL]	**18 Topics**		**15.00**	
JTI-CS2-2017-CfP07-TE2-01-06	TE Technology diffusion model	RIA	0.20	DLR
JTI-CS2-2017-CfP07-TE2 [TOTAL]	**1 Topic**		**0.20**	

4. Clean Sky 2 – Large Passenger Aircraft IAPD

I. <u>Innovative design for reliable and low weight power gearbox planet bearings</u>

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.1.3.4.1		
Indicative Funding Topic Value (in k€)	750		
Topic Leader	GE Avio	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[1]	Q4 2018

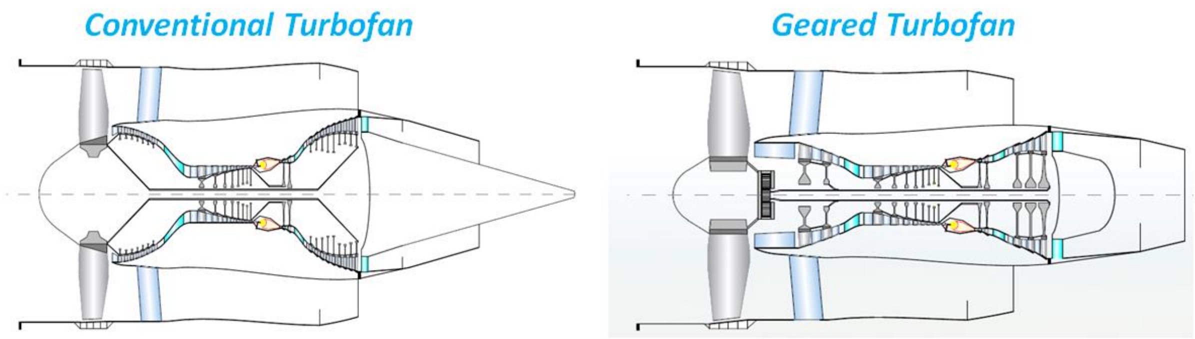
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-36	**Innovative design for reliable and low weight power gearbox planet bearings**
Short description	
The key objective of this topic is to provide innovative design criteria for designing power gearboxes planet bearings in terms of base material, geometry and heat treatment, including residual stress profile. Minimal crack(s) may appear and/or develop beneath the raceway of the roller (cracks so small that are impossible to detect via Health Monitoring techniques in the driveline). Considering the presence of these defects, guidelines and best practices on optimal enhancement of the strength of the component as well as on the maximization of its reliability in service, shall be developed, to be applied in the early stage of the design and allowing for a robust design optimization. The applicant(s) shall build a comprehensive methodology for component sizing and required compressive stress field (produced by the hardening), confirming the results via a crack growth numerical analyses and by base material / rotating component tests with induced defects.	

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

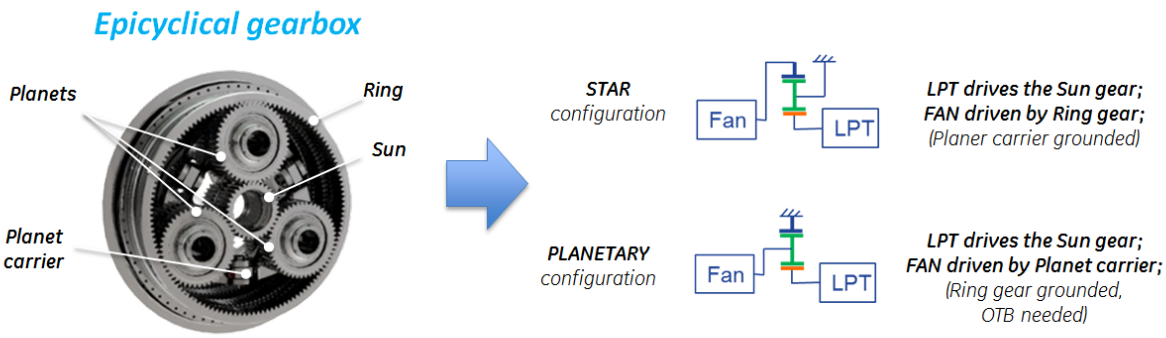
1. Background

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 engine performance of year 2000.

Ultra-High bypass ratio engines have been identified as key enablers for a significant reduction in fuel burn and emissions. Whether in an open rotor or in a ducted geared engine configuration, the Power GearBox (PGB) is one of the key enablers for decoupling the LPT from the Fan/Rotor blades, allowing for an improved propulsive and thermodynamic efficiency of the entire system.

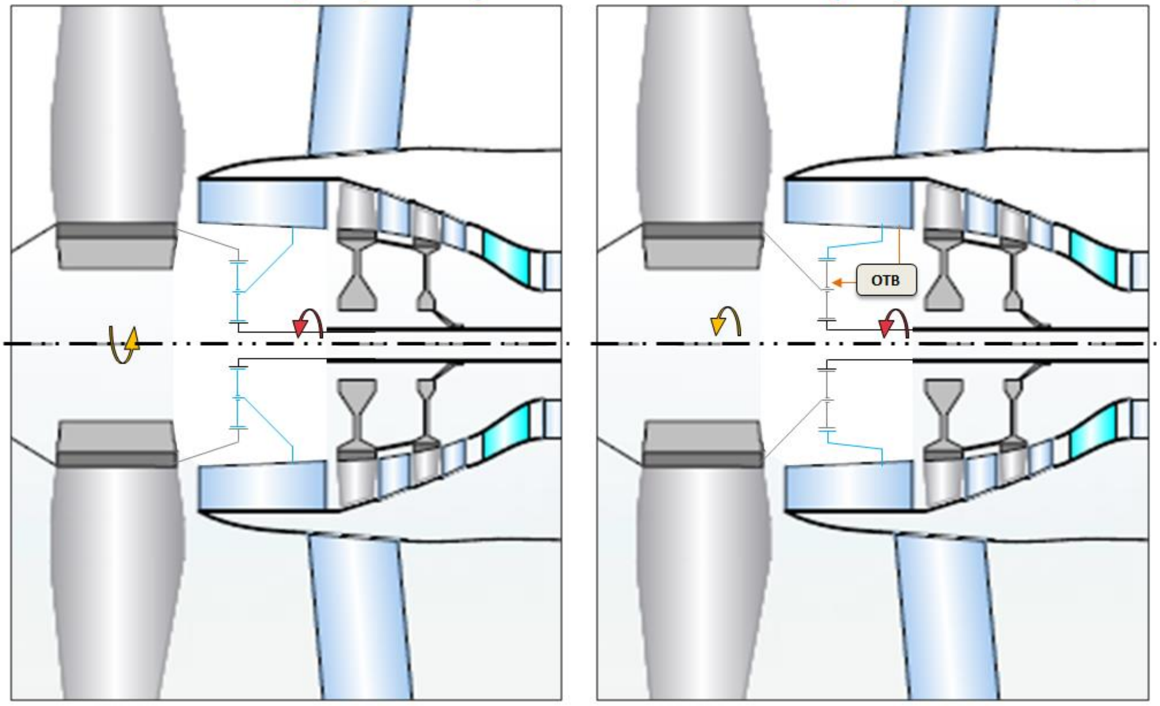


The epicyclical system is one of the most efficient mechanical design in order to increase the torque in through the power gearbox, which is desirable target. In particular, the epicyclical system is composed by three elements that rotate on the same rotational axis: an inner sun, the carrier - on which a variable number of planets is installed - and the ring. The sun meshes with the planets, and the planets mesh with the ring.



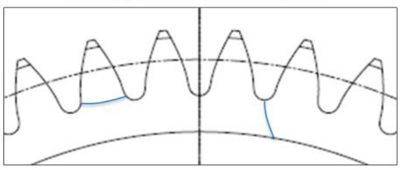
While the sun in general delivers the power in input, the output power may flow to either the carrier ("planetary" configuration), or the ring ("star" configuration). Both configurations have advantages and disadvantages. Keeping the tooth geometry fixed, the planetary configuration would deliver a higher reduction ratio, but the lubrication system of the planet bearings and the engaging meshes will have to rotate, making necessary the presence of an Oil Transfer Bearing (OTB). Moreover, the bearing will rotate on the planets that will have to withstand a centrifugal force field. The inertial motion of the bearing rollers may deliver to the system substantive forces, also to the planet rim. In a star configuration the inertial motion will be different and less straining, but nevertheless each roller passage will impose a cyclic stress on the rim material.

Geared Turbofan (IDS Star) Geared Turbofan (IDS Planetary)



The planet gear teeth will be subject to the periodic bidirectional meshing and fully reversed strain. Depending on the rim thickness (required to be as thin as possible to save weight) the strained area will encompass the whole fillet and root land. A failure mode may emerge as a result of a crack developing on the gear tooth. Due to geometry and severity of the defect, the crack may nucleate on the fillet or in the root, and propagate either to the inner tooth or to the rim. The former type of propagation would lead to the loss of the tooth and is less critical than the latter; moreover, due to common installation of magnetic particle detectors, the event may be discovered before a critical failure would occur. In the second case, instead, the crack on the rim would destroy the planet and eventually cause a failure of the whole power gearbox, potential loss of the aircraft and fatalities.

Gear failure modes - cracks



Crack through teeth Crack through Rim

Currently the preliminary design of the planet is mainly driven by legacy experience and is verified using time consuming, high-fidelity assessments in the detailed design phase, allowing only for minor design modifications and a relatively limited iterative process.

The objective of this topic is to improve the high level CTQs such as power density and reliability by defining innovative design criteria and methodologies to be eventually applied in the early stages of design, enabling a robust, topological optimization of the geometry and heat treatment procedure.

2. Scope of work

The topic proposes to perform a number of tasks using a phase and gate approach.

The following tasks are proposed to structure the project:

T1 Definition of design space

The applicant(s) will receive as an input from the topic manager a baseline design configuration, ie:

- Planet gear and bearing geometry (ie gear geometry, roller type and configuration)
- Planet loads, speed
- Application inlet and scavenge temperature
- Material, heat treatment, hardness and residual stress scenario
- Size of defect to be considered

The different inputs will be discussed (variation of the design parameters) and agreed between the applicant(s) and the topic manager prior starting the next phases.

T2 Preliminary damage tolerance analysis

The applicant(s) will perform a preliminary damage tolerance analysis for mapping the design space and assessing the various test article configurations.

The applicant(s) will perform a high fidelity analysis using state of the art in-house or commercial software and data available in literature or provided by the topic manager, or by its own reference information and eventually by additional specimen testing, on either (or both) core material or hardened material specimen on specific load conditions.

T3 Test articles design and manufacturing

With the support of the topic manager, the applicant(s) will design the test articles representative of planet baseline configuration from T1, in terms of crack nucleation and propagation behaviour.

The test articles, will be commonly approved between the topic manager and the applicant(s). they will then be procured or made available for testing by the applicant(s). After test, the results will be shared with the topic manager concerning the potential batches quality issues. The decision will commonly be made to decide whether tests articles pass or not the test criteria.

T4 Test rig design and manufacturing, test plan definition

The applicant(s) will use its own test facility to perform the test. He will present the means proposed to be used to check with the topic manager the capacities of suc a mean. The applicant(s) will explain whether the test means deserve any ugrade to exaustively cover the test plan and how to achieve this.

The test rig shall be able to perform rotating test, where centrifugal field may be superimposed on planet rim. Moreover the temperature effect shall be taken into account.

The test plan shall include the testing strategy, the instrumentation scheme, the pass and fail criteria.

The test plan will commonly be approved by the topic manager and the applicant(s) prior start of test and modifciations if any.

T5 Subscale Testing activity

During the subscale testing activity a number of viable subscale elements will be tested according to the test plan, in order to demonstrate the effects of variation of design elements, as point of crack initiation, residual stresses, crack propagation direction and path, etc.

Results shall be critically assessed considering the measurement errors, the variables involved and the number of performed tests through appropriate statistical methods

The applicant(s) and the topic manager will commonly analyse the test preparation to confirm whether tests can proceed or not.
The topic manager will be involved with the applicant(s) during the test phase.
After the termination of all the tests, the applicant(s), together with the topic manager, will analyse the results, taking into account potential outliers and/or non-typical results.

T6 Design criteria definition
Starting from the results coming from previous tasks, relevant quantitative criteria shall be enucleated even with additional calculations, in order to be able to induce a non-catastrophic fracture on the gear body, depending on the geometry, the crack defect position, heat treatment effects as hardness and residual stress distribution and depending on load and speed.

T7 Full scale test article design and manufacturing
A full scale planet bearing design will be completed by the applicant(s) supported by the topic manager to demonstrate the criteria defined in T6. The applicant(s) will design and manufacture a dedicated test article.
The applicant(s) and the topic manager will commonly analyse the test preparation to confirm whether tests can proceed or not
T8 Full scale testing
The full scale planet bearing will be tested through an appropriate test plan, commonly approved with the topic manager, for demonstrating the results derived in T6.
The final tests aims at demonstrating maturity level TRL5 with the designed planet bearings.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Baseline configuration	R	T0+3 months
D2	Preliminary study	R	T0+6 months
D3	T/A definition	R	T0+12 months
D4	Test rig design	R	T0+12 months
D5	Test plan definition	R	T0+12 months
D6	Subscale testing results	D	T0+23 months
D7	Design criteria report	R	T0+26 months
D8	Full scale T/A design	R	T0+32 months
D9	Full scale test results	D	T0+36 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Subscale T/A available	HW	T0+17 months
M2	Test rig ready	HW	T0+17 months
M3	Full scale T/A available	HW	T0+32 months

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

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

The above mentioned requirements will be finalized in details during the grant preparation phase.

Special Skills
The applicant(s) 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 a high readiness level to minimize program risks is an asset.
Proven experience in transient dynamic simulation of bearings.
The applicant(s) needs to demonstrate to be in the position to have access to test facilities suitable to meet the Topic goals.
Experience in aerospace R&T and R&D programs.
Special Skills:

- Experience in Supply Chain management or Production (for T/As procurement)
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution).

5. Abbreviations

CTQs	Critical to Quality
LPT	Low Pressure Turbine
OTB	Oil Transfer Bearing
PGB	Power GearBox
T/A	Test Article
IDS	Integral Drive System
PWT	Power Turbine

II. Next Generation Low Pressure Turbine Airfoils by ALM

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.1.3.4.1		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	GE Avio	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[2]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-37	**Next Generation Low Pressure Turbine Airfoils by ALM**
Short description	
The development of new materials joined with the extensive use of new Additive manufacturing technologies are fundamentals enablers to develop high technology components such as LPT blades that will be installed on the next generation engines, characterized by reduced weight, increased reliability and performance. The main objective of this call is to develop and assess alloys by Powder Bed Additive process to be applied on Next Generation Low Pressure Turbine airfoils production. The definition of the chemical composition along with the optimization of the Additive process and heat treatment are the key activities that will be performed in order to obtain the optimal mechanical properties and producibility.	

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

1. Background

The challenging environmental and operating goals for a sustainable and competitive aviation sector set by the ACARE Strategic Research and Innovation Agenda (SRIA) and Flightpath 2050 require radically new technologies for aircraft and engine with a particular focus for the ones that allow to reduce weight.

In this sense Avio Aero wants to focus its effort on the development of flow-path lightweight components for low pressure turbine. To reach this objective, the development of new materials joined with the extensive use of new Additive manufacturing technologies are fundamentals enablers to develop high technology components that will be installed on the next generation engines, characterized by reduced weight, increased reliability and performance.

Powder bed Additive Layer Manufacturing (ALM) techniques are processes consisting in depositing successive layers of powder and then fusing them to form objects based on 3D models. These technologies in concurrence with material suitable for high temperature applications allow to have more degrees of freedom during the airfoils design phase, adopting particular airfoil geometry that have significant impact in terms of weight, maintaining however the aerodynamic efficiency unchanged.

Additive Manufacturing processes are suitable for superalloy used in aircraft engines characterized by high mechanical strength, corrosion/oxidation resistance and high creep strength. The powder chemistries have to guarantee all these characteristics with the addition of manufacturability by means of Additive process.

In this scenario the development of the powder chemistry and process parameters are key elements in order to have both mechanical characteristics and manufacturability of the components by means of Additive techniques. Analytical models focused on the microstructure optimization of the components help in the definition of the powder chemistry and in the tuning of its related Additive manufacturing process. Powder characteristics can be customized based on the application and the required material properties.

2. Scope of work

The aim of this proposal is to develop new materials for LPT flow path using powder bed based Additive Layer Manufacturing techniques. The focus will be on Titanium Aluminide that has been proven to be produced by Electron Beam Melting as well as on Nickel alloys for higher temperature capability through laser beam melting.

The aim is to use both technologies to fabricate components and demonstrate the producibility in order to achieve a technology readiness level 3 (TRL3).

The applicant(s) will perform a number of tasks using a phase and gate approach as described within this section.

Task 1: Management

This task will make sure that a suitable framework agreed with the Topic Manager is in place throughout the entire duration of the project, allowing an effective management and execution of the action.

The activity will be managed with a Phase & Gate approach and management plan will be elaborated to describe this in edtails. The Topic Manager will paticipate in gate reviews during when common decision will be made with the applicant(s) to proceed with subsequent tasks in the light of the results achieved.

Task 2: Development of an enhanced Titanium Aluminide by Electron Beam Melting

This task will be focused on the development of a modified version of Ti 48Al-2Cr-2Nb, suitable for Electron Beam Melting process aimed to increase the mechanical performances in terms of creep and ductility without negatively impacting the fatigue properties.

Task 2.1: Chemistry optimization

After a preliminary screening of candidate compositions, the applicant(s) will provide the Topic Manager with a proposal of the 3 most promising compositions motivating the choices.
The selected compositions will be commonly approved between the topic manager and the applicant(s).

Task 2.2: Production of specimens and basic analysis

The applicant(s) will produce specimens using powder with the compositions identified in Task 2.1. Process parameters shall be defined to ensure material integrity and samples will be produced accordingly.
Heat treatment sensitivity study will be performed to evaluate the impact of heat treatment parameters on microstructure.
Chemical analysis will be performed to understand the effect of the melting process on lighter elements and correlation between microstructure and chemistry shall be evaluated.

Task 2.3: Mechanical test for selecting the final composition.

Selection of the final chemistry will be done through mechanical testing on specimens obtained with parameters defined in Task 2.2.

The tests tobe performed are:
- Tensile tests at room temperature and at high temperature up to 870°C;
- Stress rupture tests performed at high temperature up to 820°C;
- Low cycle fatigue tests performed at room temperature and at high temperature up to 760°;
- Fatigue crack growth tests

A detailed test plan shall be agreed between the Topic Manager and the applicant(s).

Thermal stability characterization will be performed as well to assess the effect of high temperature long term-exposure on microstructure and mechanical properties.

Task 2.4: Manufacturing and assessment of representative LPT blade(s)

The Topic Manager will provide the 3D model of a representative LPT blade that the applicant(s) will produce. Components quality will be evaluated by assessing the uniformity of the microstructure, chemistry, microporosity and mechanical properties through Destructive Tests. The Cut-Up scheme for the Destructive Tests will be provided by the Topic Manager.
The representative LPT blade will be produced with the composition selected in task 2.3. Additional representative LPT blades will also be produced with the alternative two compositions defined in task 2.1.

Task 2.5: Process simulation

The applicant(s) will develop a model tailored on Titanium Aluminide by Electron Beam Process to predict the properties of the materials in terms of final chemistry and microstructure.

Task 3: Development of Laser Beam Melting Ni-base Alloys for High Temperature applications.

This task will cover the development of two Nickel-base Alloys for High Temperature applications.

Task 3.1: Heat Treatment parameters set-up.

The Topic Manager will provide the initial set of process parameters for two Nickel-base Alloys for High Temperature applications. The applicant(s) will assess and define the optimal melting parameters in order to improve the quality of the final processed material.

For both alloys, heat treatment conditions will be defined in order to optimize component quality and performance. Microstructural and chemical analysis will be done on specimens to assess the effect of heat treatment on material.

Task 3.2: Feasibility material curve definition.

For both alloys, mechanical and thermal stability characterization will be performed on specimens obtained from representative coupons in the heat treated conditions as defined in task 3.1.

The tests to be performed are:

- Tensile tests at room temperature and at high temperature up to 980°C;
- Tatigue tests, LCF performed at room temperature and at high temperature up to 930°C and HFC tests done at room temperature;
- Stress rupture tests performed at high temperature up to 930°C;
- Fatigue crack growth tests.

A detailed test plan shall be agreed between the proposal and the applicant(s).

Thermal stability characterization will be performed to assess the effect of high temperature long term-exposure on microstructure and mechanical properties.

Specimens with as-built surfaces shall be produced and tested to verify the impact of surface roughness on fatigue resistence.

An assessment and statistical evaluation of typical process defect will be carried out together with the evaluation of the impact of such defects on mechanical properties.

Task 3.3: Manufacturing and assessment of representative LPT hollow blade

For both alloys, the Topic Manager will provide the 3D model of a representative LPT hollow blade that the applicant(s) will produce. Components quality will be evaluated by assessing the uniformity of the microstructure, chemistry, microporosity and mechanical properties through Destructive Tests. The Cut-Up scheme for the Destructive Tests will be provided by the Topic Manager.

Task 3.4: Surface finishing investigation

The applicant(s) will investigate different post processing options for improving the surface roughness and will perform trial to verify the effectiveness on geometry-representative coupons. The more promising methods will be tested for fatigue and compared against machined and as-built specimens.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Management Report	R	T0 + 24 months
D2	Chemistry optimization and HT set-up Report for enhanced TiAl by Electron Beam Melting	R	T0 + 6 Months
D3	Materials Characterization Report for enhanced TiAl by Electron Beam Melting	R	T0 + 15 months
D4	Process simulation Report	R	T0 + 16 months
D5	Assessment of the representative TiAl LPT blade(s)	R	T0 + 20 months
D6	Materials Characterization Report for Ni-base Alloys by Laser Beam Melting	R	T0 + 15 months
D7	Surface finishing Report for Ni-base Alloys by Laser Beam Melting	R	T0 + 20 months
D8	Assessment of the of the representative Ni-based LPT hollow blades	R	T0 + 24 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Ti-Al composition candidates selected	R	T0 + 6 months
M2	Mechanical properties available for enhanced TiAl by Electron Beam Melting	D	T0 +18 months
M2	Mechanical properties available for Ni-base Alloys by Laser Beam Melting	D	T0 + 15 months
M3	Representative TiAl LPT blade(s) available	HW	T0 + 20 months
M4	Representative Ni-based LPT hollow blades available	HW	T0 + 20 months

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

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

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

- Extensive and proven experience in design, development and validation of high technology aerospace materials (in particular with materials suitable for LPT Turbine) through Additive Manufacturing is mandatory.
- Proven experience on Titanium Aluminide is mandatory.
- Extensive experience in materials characterization for high temperature application in terms of chemical composition and mechanical properties.
- have access to the facilities required to meet the Topic goals (e.g. ALM machines).

Preferably, he will have access to Metallurgical Laboratory and Mechanical test facilities certified following the international certification standards (as required for aeronautical application, e.g. Nadcap certification).

- Experience in aerospace R&T and R&D programs is an asset.

5. Abbreviations

ALM	Additive Layer Manufacturing
HCF	High-Cycle Fatigue
HT	Heat Treatment
LCF	Low-Cycle Fatigue
LPT	Low Pressure Turbine
R&D	Research & Development
R&T	Research & Technology
TRL	Technology Readiness Level

III. Advance Nacelle Aerodynamic Optimisation

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.5		
Indicative Funding Topic Value (in k€)	2200		
Topic Leader	Rolls-Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[3]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-38	**Advance Nacelle Aerodynamic Optimisation**
Short description	
Design & develop innovative ' short ' and ' slimline ' nacelle fan cowls, optimised using the latest numerical analysis techniques to explore new areas of the design space, with the goal of maximising aerodynamic performance for the UltraFan® engine. Verify the optimisation by testing several designs, both at design point and ' off-design ' (Mn range 0.3 to 0.9), employing advanced aerodynamic measurement techniques to provide data from which the design methods can be validated.	

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

1. Background

Reducing fuel burn and CO2 emissions to meet the future EU ACARE and Flightpath 2050 goals is a major factor in the design of the UltraFan® next generation engines. Adoption of an UltraFan® low specific thrust engine cycle to maximise propulsive efficiency leads to an increase in engine fan diameter and a consequential increase in nacelle fan cowl (here on in referred to as nacelle) size & weight if conventional nacelle design rules are followed. The increase in nacelle drag will significantly diminish the fuel burn gains that can be realised from the more efficient engine cycle. Current standard nacelle design rules require the adoption of a length to diameter ratio for a single design point to ensure that significant shock wave drag is avoided at the cruise design Mach No. (Mn), and to prevent a significant rise in spillage drag as thrust and hence engine airflow is reduced through the cruise mission. Adoption of a novel philosophy of designing for the lowest integrated mission drag utilising smaller nacelles by allowing controlled levels of wave and spillage drag will enable the adoption of more compact nacelles. A further benefit of more compact UltraFan® nacelle designs will be the enhanced ability to efficiently install the nacelle closer coupled with the wing for low aircraft drag, further enhancing the targeted drag reduction. A more compact nacelle design closer coupled to the wing will also enable structural efficiency and weight saving opportunities.

Latest advances in automated multipoint, multi-objective numerical design optimisation, combined with latest Computational Fluid Dynamics (CFD) drag prediction techniques and advanced parametric geometry definition will need to be brought together to enable these novel short and slim nacelle fan cowls to be investigated. The outcome will be new design rules for mission optimised nacelles for the latest UltraFan® engines. Multipoint optimisation for an integrated mission will enable optimum nacelle pressure distribution to be identifed both to minimise profile and skin friction drag, and also control the supersonic regions on the nacelle forebody. Identifying novel optimum surface pressure distributions which can control the point where significant shock wave drag occurs will be a key enabler for short and slim nacelles of reduced size. Adopting a novel multipoint, lowest mission drag, design approach will require enhanced understanding of the non-linear drag behaviour of nacelles when shock wave and spillage drag occurs, to calibrate the CFD methods for these novel nacelle designs, and to verify the mission optimised short and slim nacelle philosophy. The enhanced understanding of short and slim UltraFan® nacelles and development of new verified design rules for 3D nacelles will enhance the performance gains for UltraFan® engines.

In addition to the cruise design point it will be important to consider the drag of a windmilling engine both under cruise diversion and end of runway take off conditions to ensure the new designs can meet key off-design requirements.

The aim of this programme is thus to apply the latest multipoint, multi-objective design optimisation techniques to enable new design opportunities to adopt short and slim nacelles for UltraFan® applications. Nacelle design should be developed for long range applications for Mach 0.85, and Mach 0.80 for medium range applications. It is envisaged that the nacelles will be 3D designs, and that the optimum designs from the multi-objective design space exploration will be down selected for verification wind tunnel testing to validate the new design space and mission drag approach. Installed CFD should be conducted to ensure that the projected drag benefits can still be realised in a representative installed configuration with the wing and pylon pressure field. CFD studies should also be condicted to identify the feasibility of simulating installed pressure field effects on the verification testing.

Testing of three to five nacelle geometries is anticipated utilising a proven wake momentum traverse technique. To ensure the drag opportunities are fully understood and to maximise the opportunities for CFD validation, enhancements in the wake momentum drag measurement resolution for nacelle performance is desired. In addition the application of novel measurement techniques to aid the understanding of non linear nacelle aerodynamic behaviour, to maximise CFD validation opportunities, (supersonic flow and spillage friction Cf), is significantly advantageous.

A programme to enable novel mission-optimised short and slim nacelles will provide:

- Validated aerodynamic design rules for short and slim nacelles.
- Verification of novel mission optimised drag approach, using novel multipoint multi-objective optimisation techniques.
- Evaluation of further drag improvements of installed short and slim nacelles relative to conventional designs.
- Transonic wind tunnel test to validate novel short and slim nacelle design space, with enhanced drag measurement resolution.
- Adoption of novel measurement techniques for nacelle flow evaluation to enhance understanding of flow physics for CFD validation.
- Evaluation of off design windmill behaviour.
- CFD study to evaluate the Installed drag benefits relative to conventional nacelles.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Multipoint design and Optimisation of short and slim nacelles	T0 + 12 months
2	Downselect of novel drag measurement enhancements and wing pressure field simuation feasibility	T0 + 12 months
3	Design and manufacture nacelle wind tunnel models, incorporating advanced instrumentation	T0 + 18 months
4	Conduct Transonic wind tunnel test to provide a validation database of novel short and slim design space	T0 +24 months
5	Installed Validation of CFD short and slim nacelle design methods, and generation of design rules	T0 +36 months

Task 1

- Application of latest multipont optimisation techniques, (CFD, geometry tools) to identify mission optimised short and slim nacelle designs for UltraFan® applications.
- Determine optimum nacelle configurations for novel short and slim design space for Mn 0.85 and Mn 0.80 cruise.

Task 2

- Study to downselect enhanced and novel measurement techniques for transonic nacelle aerodynamic flow measurement, to enhance understanding for CFD method verification.
- Study to determine feasibility of novel test features to perturb test conditions to represent installed pressure wing pressure field.

Task 3

- Design and manufacture wind tunnel models, incorporating advanced instrumentation to verify optimum short and slim nacelle designs.

Task 4

- Conduct Transonic wind tunnel test to provide a validation database of novel short and slim design space.

Task 5

- CFD study to confirm the performance of the advanced short and slim nacelle concepts in an installed cruise configuration.
- Validation of CFD drag prediction and design optimisation process against wind tunnel data.
- Produce design rules and guidelines for novel short and slim nacelles.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Work Plan for all tasks	Plan	T0+2 months
D2	Nacelle geometry definition for wind tunnel test.	CAD model + report	T0 + 12 months
D3	Wind tunnel nacelle novel measurement technique evaluation summary	Report	T0 + 12 months
D4	Wind tunnel model manufacture and rig measurement upgrade	Hardware	T0 + 18 months
D5	wind tunnel test and pre test CFD prediction	Data	T0 + 24 months
D6	Installed CFD short and slim nacelle benefits	Report	T0 + 24 months
D7	Post precessing of wind tunnel results	Report	T0 + 30 months
D8	Design rules for Short and Slim UltraFan® nacelles	Report	T0 + 36 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Work Plan agreed	Report	T0 + 2 months
M2	Short and Slim nacelle Design downselect	Review	T0 + 12 months
M3	Model and instrumentation definition for manufacture	Review	T0 + 14 months
M4	Wind tunnel test model manufacture complete	Hardware	T0 + 18 months
M5	Wind tunnel test complete	Data	T0 + 26 months
M6	Installed CFD evaulation complete	Report	T0 + 36 months

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

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

This package of work will require expertise in the application of multipoint, multi-objective design optimisation to underwing high bypass ratio turbofan nacelles, with the proven ability to rapidly generate aerodynamic quality parametric nacelle designs, and analyse them using CFD methods that are already validated against measured conventional nacelle configurations from the same facility to be utilised for the Advanced Nacelle test. To verify that the benefits of a short and slim nacelle can be maintained in a representative installed environment, proven ability to conduct installed nacelle CFD analysis benchmarked against industry standard test cases is required.

Wind tunnel test verification will require testing at transonic speeds, on models >300mm diameter, in a tunnel with working section > 2.4 m x 2.4m, in the Mn equals 0.3 to 0.9 range. It is anticipated that a proven wake momentum traverse approach will be utilised but enhancement of the near wall wake region will be required to enhance measurement fidelity. Expertise to enable novel measurement techniques for nacelles to enhance understanding of surface pressure distributions and near wall boundary layer characteristics. These could include Dynamic PSP {pressure sensitive paint} for surface pressures, PIV {particle image velicometry} or LDA {Laser Doppler Annemometry} to evaluate near wall boundary layers, and novel techniques to assess surface skin friction to enable enhanced CFD validation.

The applicant shall

- Have substantial technical knowledge in the domain of the proposed tasks.
- Proven expertise in underwing turbofan nacelle aerodynamic, advanced parametric geometry creation, multipoint multi-objective design optimisation and validated CFD analysis & drag extraction - benchmarked against turbofan nacelle test cases from the facility proposed for the Advanced nacelle test.
- Installed nacelle CFD experience, drag prediction benchmarked against industry standard research test case.
- Demonstrated expertise in project participation, international cooperation, project and quality management
- Proven achievement record showing knowledge is recognised in the scientific community
- Proven ablity to conduct industry standard transonic wind tunnel testing (>2.4 m x 2.4m working section) of turbofan nacelles of > 300 mm diameter, with applied incidence.
- Experience to develop and apply novel wind tunnel measurement techniques to enhance the understanding of nacelle drag behaviour.

5. Abbreviations

CFD	Computational Fluid Dynamics
Mn	Mach Number
CAD	Computer Aided Design
PSP	Pressure Sensitive Paint
Cf	Local skin friction coefficient
PIV	Particle Image Velocimetry
LDA	Laser Doppler Anemometry

IV. Skin Friction measurements on a real aircraft and fiber-optics based pressure measurements for aircraft applications

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.5.3		
Indicative Funding Topic Value (in k€)	620		
Topic Leader	Airbus Operations GmbH	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[4]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-39	**Skin Friction measurements on a real aircraft and fiber-optics based pressure measurements for aircraft applications**
Short description	
The great challenge to validate our understanding of how flow control works during flight testing is driven by the necessity to get a clear view on a very complex 3D flow field close to the very critical aircraft stall. State-of-the art techniques like flow-cons and pressure taps give a limited view in terms of time and space on the surface. In addition time-resolving flow-field information is required near to the wall of the wing surface. For this, pressure sensing fiber-optic sensors have shown considerable potential to fulfil this need. For skin friction measurements, hot film sensors seem to be a good approach. This CfP should develop, mature, pre-test, apply these sensors for the flight test demonstration and post-process the data required to show technical readiness of flow control.	

[4] 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 with 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 aircraft, the maximum local lift is significantly improved with strakes mounted on the inboard side of the engine nacelle. Yet, the aerodynamic effect of strakes is limited and for modern VHBR engines the problem of possible local flow separation persists, leaving further space for optimizing high-lift performance. With the upcoming introduction of highly efficient and more ecologic UHBR engines, slat-cut-outs will likely become larger and the problem will even become worse.
To remedy this drawback Active Flow Control (AFC) based on pulsed air blowing with/without net mass flux as well as steady blowing with net mass flux, could be applied at the engine-wing junction. A major part of the necessary technology development is conducted in the work package "Applied Technologies for Enhanced Aircraft Performance" of Large Passenger Aircraft (LPA) Platform. The global objective is to mature and flight test this technology in order to demonstrate its aerodynamic effectiveness and to validate our understanding of the associated physical mechanisms. This is a crucial prerequisite for further industrialization of the technology.
The great challenge to validate our understanding of how flow control works during flight testing is driven by the necessity to get a clear view on a very complex 3D flow field close to the very critical aircraft stall. In particular it is desired to understand the interaction of the AFC jets with the outer flow and the consequent impact of the flow manipulation on the wing surface. State-of-the art techniques like flow-cons and pressure tabs give a limited view in terms of time and space on the surface. The innovative in-flight PIV planned by the members provide mainly flow-field information perpendicular to the wing surface.
In addition time-resolving flow-field information is required near to the wall of the wing surface. For this pressure sensing fiber-optic sensors have shown considerable potential to fulfil this need. For skin friction measurements hot film sensors seem to be the best approach.
This knowledge would enable the members to transfer the gained experience during flight test both to other types of aircraft and to different areas of AFC application on the aircraft.
This CfP should develop, mature, pre-test and apply high resolution measurement technique for skin friction and surface pressure on a test aircraft, realize the measurement and post-process the data. The measurements will be done at the wing upper surface downstream the pylon/wing junction to demonstrate and quantify the effect of active flow control on the flow behavior in this area.

2. Scope of work

The skin friction measurement technique applied on the aircraft shall be robust to cope with environmental conditions, like rain and changing air temperatures. The used technique shall indicate the value and direction of the skin friction, giving a clear indication about regions of attached and detached flow respectively. The request for high a time resolution of the measured values of skin friction is derived from the highly unsteady nature of the flow in this area with local separation.

In addition to skin friction measurements, a series of pressure measurements is required in the area downstream the AFC location. The unsteady pressure measurements are mandatory due to the complex and unsteady nature of the flow with local separation. These unsteady pressure measurements should complement the skin friction measurements in the same area without influencing each other which calls for small-scale sensors with reduced or non-existent electro-magnetic interference. Further requirements include the robustness and low sensitivity of the devices w.r.t. environmental aspects such as changing air temperature or rain. Pressure sensing fiber-optic sensors have shown considerable potential to fulfill the requirements.

A suitable sensitivity, resolution and range of measured values and time resolution shall be ensured for both measurement techniques. The time resolution of both measuring techniques shall be as such that the unsteady behavior of the flow in the regime close the wing stall will be captured. Therefore the measuring technique for skin friction shall enable a sampling rate of at least 1 kHz whereas the surface pressure measurement shall enable a sampling rate of at least 10 kHz.

The installed sensors and wiring on the wing surface shall not disturb the flow to be measured in such a way, that the flow behavior is considerable biased or changed due to the installed sensors. The height of sensors of both techniques above the aerodynamic surface shall not exceed 2.5mm. An installation of the sensors and wiring should be possible without major mechanical processing of the aircraft wing.

Tasks		
Ref. No.	**Title - Description**	**Due Date**
T1	Capturing of refined requirements for the skin friction and surface pressure measurement technique for real aircraft	M2
T2	Develop and mature the high resolution skin friction and surface pressure measurement technique	M8
T3	Proof of the concept using pre-testing of the techniques in a wind tunnel	M10
T4	Installation of the measurement techniques on the aircraft	M12
T5	Realization of the measurement during the flight test	M18
T6	Data post-processing and analysis of the results	M24

Task 1: Capturing of the requirements for the skin friction and surface pressure measurement technique for real aircraft

More details will be given w.r.t. the positions of the sensors, installation details on the aircraft, flight and ambient conditions and storage of the recorded data.

Flight tests are conducted at Ma of 0.35 at altitudes in the range of 6000ft to 20000ft.

Task 2: Develop and mature the high resolution skin friction and surface pressure measurement technique

The measuring techniques are matured to meet the specific requirements for flight testing. Special emphasis shall be given to the installation of the sensors and the cable routing on the surface of the aircraft, to the accuracy and robustness of the techniques, to the potential interference between the two techniques and to the data acquisition and storage.

Task 3: Proof of the concept using pre-testing of the technique in a wind tunnel
Task 3 will comprise a pre-testing of the techniques, proving the required accuracy, sensitivity and robustness of the sensors. A calibration of the sensors w.r.t. the absolute measured values and, in case of skin friction, also w.r.t. the flow direction shall be conducted. Any potential interference between the two different techniques during operation needs to be assessed during pre-testing.

The facilities of the LSWT, Bremen, may be used to pre-test the sensors. Detailed definitions for the pre-testing procedure will be given during execution of the project.

Task 4: Installation of the measurement technique on the real aircraft
An approximate region for the positioning of the sensors is given at **Fig 1.** However the exact positions of the sensors will be communicated during the execution of the project. There shall be a number of 20-25 sensors for each of the measurement techniques.

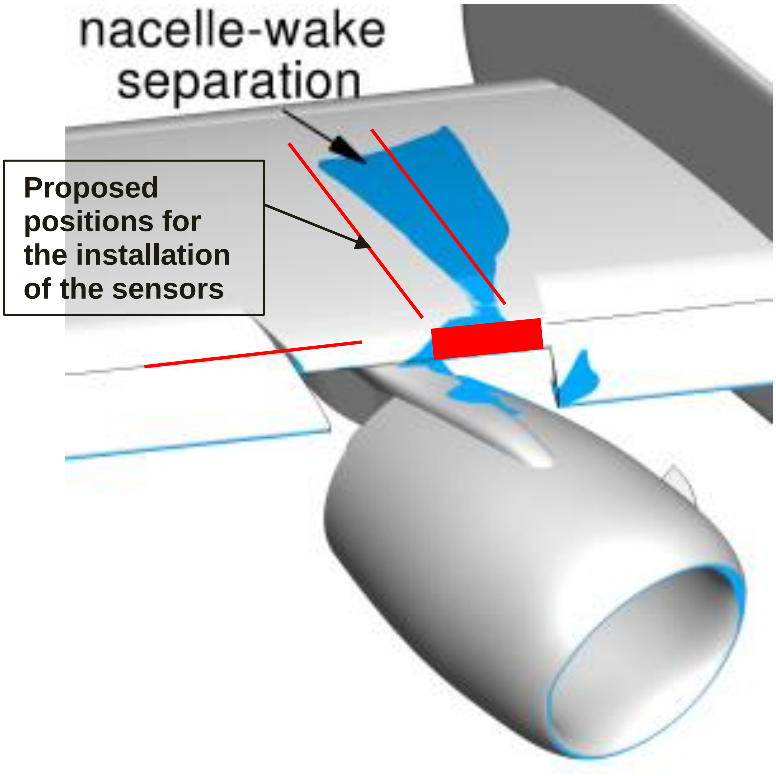


Figure 1: Sketch of the area for sensor installation

Acquisition and storage of the measured data on the aircraft will be done by the applicant. It shall be assured, that time synchronization of the pots-processed data from both techniques is possible.
The time needed for the installation of the sensors and the wiring on the aircraft shall not exceed 4 weeks. The installed measuring technique shall be removable and the dismantling of the sensors and wiring shall not result in damage on the aircraft skin.

Task 5: Realization of the measurement during the flight test

During flight test the applicant shall assure the correct and robust working of the installed technique, the data acquisition and storage of recorded data.

In addition the applicant shall be able to replace damaged or not properly working sensors during the flight test phase.

Having in mind the very complex flow at this region, it is expected to change the position of a certain number of sensors or to provide additional sensor position on the wing.

The applicant shall provide a certain number of spare sensors and equipment to be able to execute the flight test in the planned time.

Task 6: Data post-processing and analysis of the results

After completion of the flight test, the measured data shall be post-processed and provided to the members. A final report shall be delivered, exhibiting time resolved and time averaged results. The report shall give also information about the accuracy of the data (error band) and possible biases of the data due to changing environmental conditions during the flight test campaign.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D1	Delivery of the hardware for pre-testing	Hardware	M8
D2	Report of the pre-testing campaign	Report	M10
D3	Delivery of the hardware for flight testing	Hardware	M11
D4	Analysis report of the flight testing	Report	M24

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

Milestones (when appropriate)			
Ref. No.	Title - Description	Type*	Due Date
M1	Refined requirements agreed with members and captured		M2
M2	Pre-testing of the measurement technique finished and outcome reviewed with members		M10
M3	Installation of the measurement techniques on the aircraft		M12
M4	Flight test finished		M18

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

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

The applicant shall have profound knowledge in developing and maturing of skin friction and surface pressure measuring techniques, which offers a high time and space resolution, robustness against changing flight conditions and adequate accuracy. In addition, the applicant must give proof of profound knowledge and experience in using skin friction and surface pressure measuring techniques applied to aircraft or other aerodynamic surfaces exposed to ambient conditions. The applicant shall be able to customize their hardware to satisfy requirements and match DAQ interfaces with topic manager requirements. It should be possible to the applicant to quickly react to new requirements for sensors and data acquisition hardware. Furthermore, the applicant must be agile to account for potential complications during flight testing, e.g. damage to sensors or DAQ hardware.

5. Abbreviations

AFC	Active Flow Control
BPR	Bypass Ratio
FPR	Fan Pressure Ratio
UHBR	Ultra-high Bypass Ratio
VHBR	Very high Bypass Ratio
DAQ	Data Acquisition
LSWT	Low Speed Wind Tunnel

V. Novel mechanical drive disconnect for embedded Permanent Magnet machines

Type of action (RIA or IA)	RIA		
Programme Area [SPD]	LPA		
(CS2 JTP 2015) WP Ref.	WP 1.6.1		
Indicative Funding Topic Value (in k€)	1100		
Topic Leader	Rolls Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[5]	Q2 2018

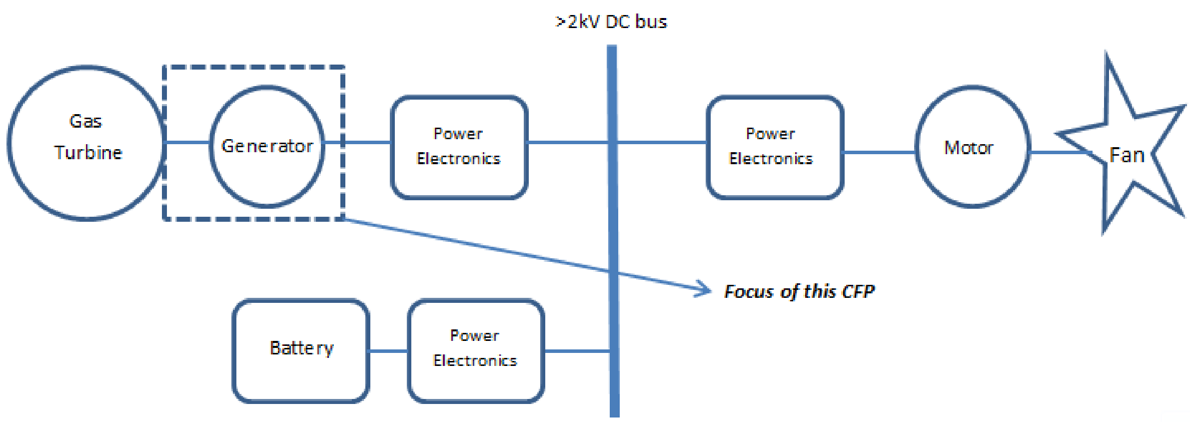
Topic Identification code	Topic Title
JTI-CS2-2017-CfP07-LPA-01-40	**Novel mechanical drive disconnect for embedded Permanent Magnet machines**
Short description	
Development of novel mechanical drive disconnects solution for an electrical machine. The solution will focus on rapid response to faults within harsh environments. This proposal will be aimed at their development and integration into new technologies that will be developed and demonstrated in WP1.6 of LPA IADP.	

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

1. Background

With regard to meeting the Flightpath 2050 targets, the optimisation of gas turbine engines and aircraft in isolation may not yield the required levels of improvement and more integrated designs will subsequently be required. The most optimum solutions are likely to benefit from distributed propulsion concepts that will not only increase propulsive efficiencies, but will also improve an aircraft's aerodynamic characteristics by providing propulsive force when and where required. The key enabler for distributed propulsion is the hybrid electrical power transmission, which will efficiently distribute the power throughout the propulsion system.

In order to open up this new design space, a number of challenges have to be first understood and then overcome. The requirement of high power densities and efficiency in electrical machines for aerospace application(s) can be challenging with the safety and certification constraints. Permanent Magnet (PM) machines can cater to both requirements, however, there is a need to have a mechanical disconnect to manage faults from cascading to the system.



The project will focus on designing and developing a novel disconnect solution for an embedded generator, closely working with the Topic Manager on exploring the feasibility of a filed Rolls-Royce ' mechanical disconnect ' Patent, and realising it in hardware to TRL3/4. The proprietary mechanical disconnect is a fail-safe solution that is specifically aimed at embedded electrical machines within the core of gas turbines. The proprietary mechanical disconnect is an integral part of an electrical machine, and is different to conventional, standalone, disconnect solutions such as a clutch or active shear neck. Upon activation, the proprietary mechanical disconnect will in effect "dis-assemble" part of an electrical machine and disconnect the mechanical input (generating mode) or mechanical output (motoring mode) from an electrical machine. The Work Break-down Structure (WBS) will be split into three Work Packages (WP's) as below ;

WP1 Build on an existing disconnect concept – build and protoype to TRL 4
WP2 Build a stator with instrumented pre-determined faults eg turn to turn faults
WP3 Build and demonstrate a machine incorporating the concepts in WP1 and WP2

This strategic theme falls under the umbrella of Clean Sky 2 Platform 1 work package (WP) 1.6 – Demonstration of radical aircraft configurations within Large Passenger Aircraft

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1.1	Design of a rotor incorporating a novel disconnect concept.	T0 + 6
Task 1.2	Build the rotor designed	T0 + 10
Task 1.3	Test the rotor disconnect concept	T0 + 12
Task 2.1	Design the stator with pre-determined faults	T0 + 5
Task 2.2	Build the stator incorporating the instrumentation required for testing	T0 + 10
Task 2.3	Test stator	T0 + 12
Task 3.1	Assemble the electrical machine, incorporating controls from Topic Manager	T0 + 15
Task 3.2	Test and demonstrate disconnect concept as per requirements	T0 + 18

High level prototype requirements for build and test :
120kVA , 18000rpm PM machine
less than 0.25s activation time for disconnection

Task 1.1 : Design of a rotor incorporating a novel disconnect concept.
Involves designing the rotor of the electrical machine incorporating the existing disconnect concept and working closely with the Topic Manager. This task would require knowledge of rotor design as well as machine integration, given that the disconnect concept has not been prototyped yet.

Task 1.2 : Build the rotor designed
This task would involve the manufacture and build of the rotor designed in task 1.1. At least two prototypes will be required for proving the method of manufacture.

Task 1.3 : Test the rotor disconnect concept
Testing the rotor to prove the function of the disconnect solution, up to partial power at the applicants facilty.

Task 2.1 : Design the stator with pre-determined faults
Involves designing a stator for the final machine test that will include some pre-determined faults as agreed with the Topic Manager. There will be a requirement to incorporate more than one fault for the purpose of testing.

Task 2.2 : Build the stator incorporating the instrumentation required for testing
This task will involve the manufacture and the build of the stator with all the instrumentation that will be required to monitor and implement faults in the machines. It will include some controls and will require working closely with the Topic Manager.

Task 2.3 : Test stator
Testing the stator functionalilty at the applicants facility.

Task 3.1 : Assemble the machine incorporating controls from the Topic Manager
This task entails building the electrical machine, including assembly of the rotor and stator from the previous tasks. The controls will be developed closely with the Topic Manager, and will be implemented in the machine as agreed.

Task 3.2: Test and demonstrate disconnect concept as per requirements
Full testing and demonstration of the electrical machine with the disconnect concept at the rated power at the applicants facility. Various faults would be tested for safety, and the prototype is to satisfy all of the requirements set by the Topic Manager – the High Level requirements having been defined above.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Test report – rotor disconnect concept	R, HW	T0 + 12
D2.1	Manufactured stator with pre-determined faults	HW	T0 + 10
D3.1	Testing of concept at full power	R, HW, D	T0 + 18

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Design of rotor with concept disconnect completed	D	T0 + 6
M1.2	Manufactured rotor with disconnect	HW	T0 + 10
M2.1	Design of stator complete with incorporated faults	D	T0 + 5
M2.2	Testing of stator completed	R	T0 + 12
M3.1	Full prototype assembled and ready to test	HW	T0 + 15

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

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

- Skill 1 : PM electrical machine design and development knowledge requried
- Skill 2 : Understanding of electrical integration and testing capabilities

5. Abbreviations

PM	Permanent Magnet
WBS	Work Break-down Structure
WP	Work Package

VI. Advanced manufacturing for MW range power dense electrical machines for aerospace applications

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.6.1		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Rolls Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[6]	Q2 2018

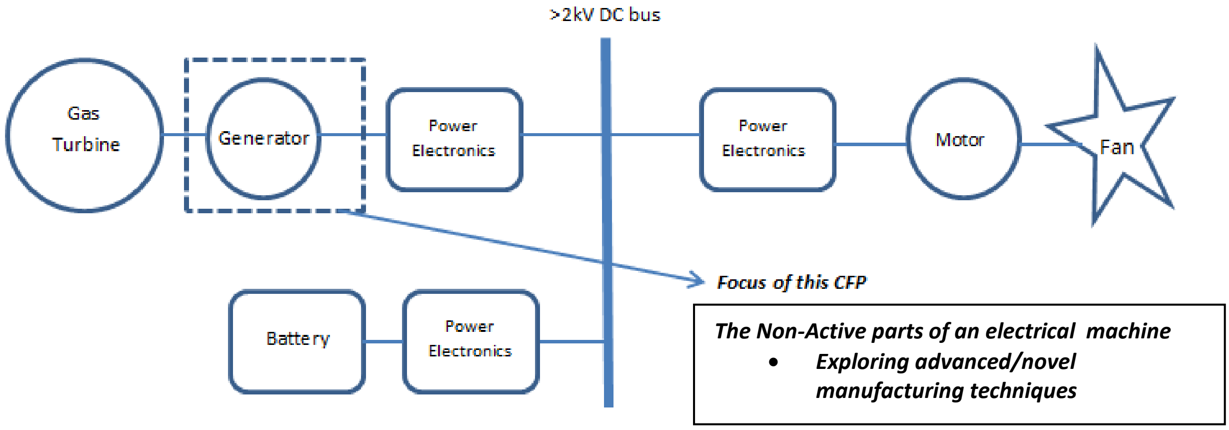
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-41	**Advanced manufacturing for MW range power dense electrical machines for aerospace applications**
Short description	
Application of advanced manufacturing techniques for MW range power dense electrical machines. Focusing on but not limited to casings, coils and rotors. This topic will be aimed at their development and integration into new designs that will be developed and demonstrated in WP1.6 of LPA IADP.	

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

1. Background

With regard to meeting the Flightpath 2050 targets, the optimisation of gas turbine engines and aircraft in isolation may not yield the required levels of improvement and more integrated designs will subsequently be required. The most optimum solutions are likely to benefit from distributed propulsion concepts that will not only increase propulsive efficiencies, but will also improve an aircraft's aerodynamic characteristics by providing propulsive force when and where required. The key enabler for distributed propulsion is the hybrid electrical power transmission, which will efficiently distribute the power throughout the propulsion system.

In order to open up this new design space, a number of challenges have to be first understood and then overcome. The requirement of high power densities and efficiency in electrical machines for aerospace application can be challenging with the safety and certification constraints. Typically, the non-active part of electrical machines contribute to 30 – 40% of the total weight. Weight Reduction of this part can significantly improve power densities.



The Topic will focus on designing and developing ultra-lightweight non-active components of an electrical machine, closely working with the Topic Manager upto TRL3/4. The focus will be on casings and shafts initially. The Work Break-down Structure (WBS) will be split into two Work Packages (WP's) as below ;

WP1 Design and development of lightweight non-active parts.
WP2 Testing of the lightweight solutions.

This strategic theme falls under the umbrella of Clean Sky 2 Platform 1 work package (WP) 1.6 – Demonstration of radical aircraft configurations within Large Passenger Aircraft.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1.1	Understanding of existing manufacturing methods for non-active parts of an electrical machine.	T0 + 3
Task 1.2	Design of non-active component(s) to requirements set by Topic Manager	T0 + 9
Task 1.3	Build prototype components	T0 + 14
Task 2.1	Mechanical Integrity Testing of prototype(s)	T0 + 16
Task 2.2	Electro-Magnetic Compatibility (EMC) compliance of component	T0 + 18
Task 2.3	Integration of the non-active component(s) into an existing electrical machine defined/provided by Topic Manager	T0 + 24

High level requirements for build and test :
>1MW power rating, >10,000rpm speed rating.
Non-active power density of >25kW/kg.

Task 1.1 : Understanding of existing manufacturing methods for non-active parts of an electrical machine.
Review and understand all existing manufacturing methods for non-active parts of an electrical machine. This will be required to decide the way forward for the component development at later stages.

Task 1.2 : Design of non-active component(s) to requirements set by Topic Manager
This task will involve the design of the non-active part (eg. Casing) of the electrical machine for the high level requirements set by the Topic Manager. The design should provision for advanced manufacturing methods to be used in building the component, and should be closely developed with the Topic Manager – as the final integration will involve testing of the prototype in an electrical machine defined/provided by the Topic Manager.

Task 1.3 : Build prototype components
This will involve the development of the actual non-active component to be tested. More than two prototypes maybe required to be built.

Task 2.1 : Mechanical Integrity testing of prototype
The prototype needs to be tested for its mechanical integrity and performance. The test plan and test definition to be discussed and agreed with the Topic Manager.

Task 2.2 : Electro-Magnetic Compatibility (EMC) compliance of component
The developed prototype will need to be tested for EMC compliance as specified by the Topic Manager.

Task 2.3 : Integration of the non-active component(s) into an existing electrical machine defined/provided by the Topic Manager
This task will involve the integration of the component(s) developed during the project into an electrical machine working closely with the Topic Manager. The component has to be fully integrated into an existing electrical machine and tested to the requirements set by the Topic Manager – the High Level requirements

having been defined above.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Manufacture prototype non-active component(s)	R, HW	T0 +14
D2.1	Testing report of component developed	R	T0 + 18

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Data on existing manufacturing methods	D	T0 +3
M1.2	Design of non-active component(s) finalised	D	T0 + 9
M2.1	Mechanical Integrity Test Data	D	T0 + 16
M2.2	Prototype fully assembled into an electrical machine - ready to test	HW	T0 + 22

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

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

- Skill 1 : Advanced design and manufacturing capability for electrical machine components
- Skill 2 : Understanding of electrical machine integration.

5. Abbreviations

WBS	Work Break-down Structure
WP	Work Package
EMC	Electro-Magnetic Compatibility

VII. Development of power electronic technologies for >1kV aerospace applications

Type of action (RIA or IA)	IA		
Programme Area [SPD]	LPA		
(CS2 JTP 2015) WP Ref.	WP 1.6.1		
Indicative Funding Topic Value (in k€)	1300		
Topic Leader	Rolls Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[7]	Q2 2018

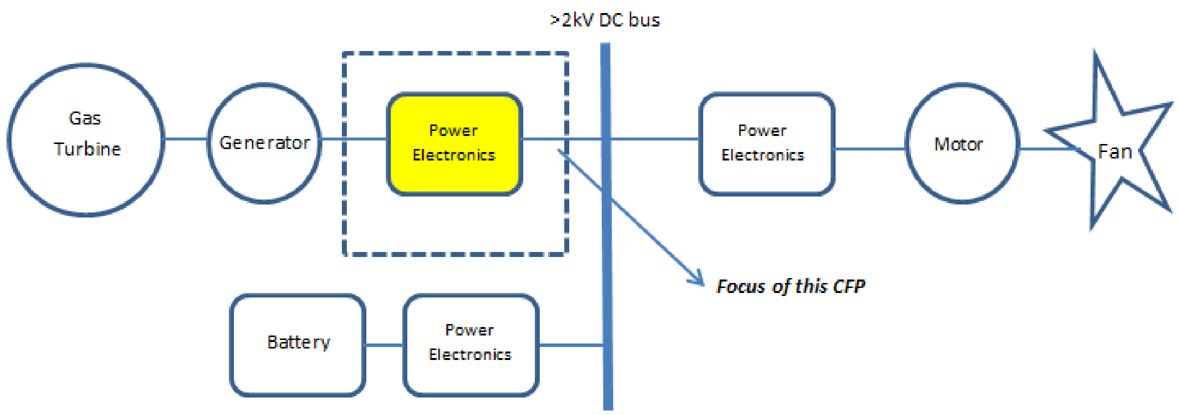
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-42	**Development of power electronic technologies for >1kV aerospace applications**
Short description	
Development of power electronic technologies for >1kV rated aerospace hybrid electrical applications. Focusing on but not limited to high voltage insulation design for high power dense converter, matched thermal management for power electronics, packaging of passive components and High Voltage High Current Interconnects. This Topic will be aimed at their development and integration into new designs that will be developed and demonstrated in WP1.6 of LPA IADP.	

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

1. Background

With regard to meeting the Flightpath 2050 targets, the optimisation of gas turbine engines and aircraft in isolation may not yield the required levels of improvement and more integrated designs will subsequently be required. The most optimum solutions are likely to benefit from distributed propulsion concepts that will not only increase propulsive efficiencies, but will also improve an aircraft's aerodynamic characteristics by providing propulsive force when and where required. The key enabler for distributed propulsion is the hybrid electrical power transmission, which will efficiently distribute the power throughout the propulsion system.

In order to open up this new design space, a number of challenges have to be first understood and then overcome.



Aerospace power electronics require high power density and higher efficiency performance. Technologies contributing to this would be required to operate at medium voltage (>2KV) and higher switching frequencies (>10KHz), whilst operating at high altitudes (>30000 ft). The project is split into three Work Packages (WP's) as below ;

WP1 : Active/passive Technologies, including high speed machine drives as defined by the Topic Manager.
WP2 : Interconnect technology for medium voltage, high current application.
WP3 : Packaging for high power medium voltage converters for aerospace applications.

This strategic theme falls under the umbrella of Clean Sky 2 Platform 1 work package (WP) 1.6 – Demonstration of radical aircraft configurations within Large Passenger Aircraft.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1.1	Identification and development of components (passive and active) for selected topologies as defined by Topic Manager	T0 + 8
T1.2	Modelling of components/concepts	T0 + 10
T1.3	Testing of components	T0 + 16
T2.1	Design of interconnects and cables for medium voltage drives	T0 + 6
T2.2	Prototype of interconnect designs	T0 + 12
T2.3	Testing of interconnect technologies	T0 + 14
T3.1	Identification of lightweight packaging technologies including materials.	T0 + 5
T3.2	Development and testing of a prototype converter at representative environments.	T0 + 24

Requirements: 300KW, > 10 KHz switching frequency, > 2KV DC voltage rating, up to TRL 6 development.

Work Package 1

To identify and develop advanced passive and active components for Aersopace Medium Voltage (MV) drive applications. These will include concept study, modelling, prototyping and experimental testing of key components of a power converter that are suitable to operate with higher voltage/current, higher switching frequency, higher temperature and lighter weight in a laboratory environment.

Task 1.1:

To identify and develop potential technologies/concepts for passive/active components suitable for key requirements detailed above by the Topic Manager, for aerospace Medium Voltage (MV) applications.

Task 1.2:

To carry out essential modelling of proposed technologies/concepts, as well as the design and build of prototype component(s).

Task 1.3:

To carry out experimental testing based on the prototype component(s) to validate the key design specifications in a laboratory environment and to complete a technical test report of the test results.

Work Package 2

To identify and develop suitable interconnect technologies for Aerospace MV power systems, and to demonstrate the technology in a laboratory environment. These will include the concept development, prototype build and experimental validation of interconnect technologies which meet the requirements for MV power distribution in a harsh environment at high altitude.

Task 2.1
To identify and design prototype interconnect and cabling technologies for MV power distribution of advanced aircraft power systems.

Task 2.2
To build prototype interconnect components and to develop a relevant test rig for proof of concept.

Task 2.3
To carry out experimental testing of developed prototype interconnect components in a laboratory environment, and to complete a test report on the key experimental results.

Work Package 3
To identify lightweight packaging methods and materials for high power medium voltage converters for aerospace applications. These will also include technologies such as 3D packaging etc. which can be realised at the power level requirements set by the Topic Manager, as defined/detailed above. This WP also includes the development of a full converter as specified by the Topic Manager to demonstrate the technologies developed within the project.

Task 3.1
To identify packaging technologies that enable lightweight converters to improve power density. These can be techniques and/or materials used for packaging the converter.

Task 3.2
To build and test a full converter as specified by the Topic Manager, at a full rated power level in representative environments for aerospace at the applicants facility.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1.1	Identification and development of components (passive and active) for selected topologies as defined by Topic Manager	T0 + 8
T1.2	Modelling of components/concepts	T0 + 10
T1.3	Testing of components	T0 + 16
T2.1	Design of interconnects and cables for medium voltage drives	T0 + 6
T2.2	Prototype of interconnect designs	T0 + 12
T2.3	Testing of interconnect technologies	T0 + 14
T3.1	Identification of lightweight packaging technologies including materials.	T0 + 5
T3.2	Development and testing of a prototype converter at representative environments.	T0 + 24

Requirements: 300KW, > 10 KHz switching frequency, > 2KV DC voltage rating, up to TRL 6 development.

Work Package 1

To identify and develop advanced passive and active components for Aersopace Medium Voltage (MV) drive applications. These will include concept study, modelling, prototyping and experimental testing of key components of a power converter that are suitable to operate with higher voltage/current, higher switching frequency, higher temperature and lighter weight in a laboratory environment.

Task 1.1:

To identify and develop potential technologies/concepts for passive/active components suitable for key requirements detailed above by the Topic Manager, for aerospace Medium Voltage (MV) applications.

Task 1.2:

To carry out essential modelling of proposed technologies/concepts, as well as the design and build of prototype component(s).

Task 1.3:

To carry out experimental testing based on the prototype component(s) to validate the key design specifications in a laboratory environment and to complete a technical test report of the test results.

Work Package 2

To identify and develop suitable interconnect technologies for Aerospace MV power systems, and to demonstrate the technology in a laboratory environment. These will include the concept development, prototype build and experimental validation of interconnect technologies which meet the requirements for MV power distribution in a harsh environment at high altitude.

Task 2.1

To identify and design prototype interconnect and cabling technologies for MV power distribution of advanced aircraft power systems.

Task 2.2

To build prototype interconnect components and to develop a relevant test rig for proof of concept.

Task 2.3

To carry out experimental testing of developed prototype interconnect components in a laboratory environment, and to complete a test report on the key experimental results.

Work Package 3

To identify lightweight packaging methods and materials for high power medium voltage converters for aerospace applications. These will also include technologies such as 3D packaging etc. which can be realised at the power level requirements set by the Topic Manager, as defined/detailed above. This WP also includes the development of a full converter as specified by the Topic Manager to demonstrate the technologies developed within the project.

Task 3.1

To identify packaging technologies that enable lightweight converters to improve power density. These can be techniques and/or materials used for packaging the converter.

Task 3.2

To build and test a full converter as specified by the Topic Manager, at a full rated power level in representative environments for aerospace at the applicants facility.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Report on modelling and testing of the components considered	D, R	T0 + 16
D2.1	Interconnect technologies, hardware & prototype testing report	HW, R	T0 + 14
D3.1	Report on lightweight packaging technologies.	R	T0 + 5
D3.2	Converter hardware and testing report	R, HW	T0 + 24

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Review of identified technologies	D	T0 + 8
M2.1	Requirements capture document	R	T0 + 2
M2.2	Review of prototype design	D	T0 + 6
M3.1	Mid-point review of converter design	D	T0 + 10

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

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

- Skill 1 : Power Electronics design and development knowledge requried
- Skill 2 : Understanding of electrical integration and testing capabilities
- Skill 3 : Medium Voltage capabilities

5. Abbreviations

WP	Work Package
MV	Medium Voltage
KV	Kilo volts

VIII. Pulsating Heat Pipe (PHP) modelisation & characterisation

Type of action (RIA or IA)	RIA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.6.2		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[8]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-43	**Pulsating Heat Pipe (PHP) modelisation & characterisation**
Short description	
The Pulsating Heat Pipe (PHP) is a promising solution for controlling extremely high heat fluxes (>200 W/cm2). The objective of this topic is to: - Develop a data base retrieved from tests results allowing to build a PHP mathematical macro model thanks to an interpolation method (kriging, neurons and so on); - Develop a numerical predictive model to design multi-bubble and multi-source PHP. The software shall allow obtaining complementary information on the global behavior of the PHP and impact of various perturbations.	

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

1. Background

Thermal management is a key enabler of hybrid propulsion and needs the introduction of innovative cooling technologies with enhanced performances and improved integration capabilities. Pulsating Heat Pipe (PHP) is a promising solution to enable thermal management improvement for such applications.

Drawing on experimental prototype results, PHP is subject to academic studies in particular to well understand its behaviour in order to create numerical modeling.
This cooling system is a major current concern as evidenced by the last International Heat Pipe Conference which took place the last year in Korea. Indeed several sessions were dedicated to the theme ”Pulsating Heat Pipes, Oscillating Heat Pipes” with 20 presentations [1][2][3][4].

The aims of this project are:

- to develop a PHP predesign tool including for instance:
  - multi source heat loss,
  - the PHP geometry,
  - the fluid properties,
  - transient calculations,
  - FMU/FMI format (allowing a link to Dymola for instance),
  - Dry out phenomena,
  - and so on.
- to lead tests campaign using as much as necessary PHP prototypes in order to:
  - calibrate the previous PHP predesign tool,
  - develop a PHP data base allowing to build thanks to a neuronal method a mathematical macro model of the PHP. To that purpose, an adaptative test bench shall be developped in order to characterize the PHP prototypes according to a design of experiment. This latter shall be built in taking into account the whole PHP parameters.

Both numerical and experimental studies shall be dealt with in concert.

[1] David Dufraisse, Vincent Ayel, Yves Bertin, Cyril Romestant, “Performances and Limits of a Multi-Source Pulsating Heat Pipe Tested Under High Heat Flux Density”, 18th International Heat Pipe Cconference, 2016

[2]Haoren Deng, Xiao Sun, Dongyang Han, Shunhao Wang, Bo Jiao, J.M. Pfotenhauer, Zihua Gan, “Experimental Study on a Hydrogen Pulsating Heat Pipe with Different Adiabatic Lengths” , 18th International Heat Pipe Cconference, 2016

[3] Laura Fourgeaud, Vadim Nikolayev, Eric Ercolani, Jérôme Duplat, Philippe Gully, “In Situ Investigation of Liquid Films in PHP”, 18th International Heat Pipe Cconference, 2016

[4] Rémi Bertossi, Balkrishna Mehta, Cyril Romestant, Yves Bertin, Sameer Kandhekar, ” Motion of Liquid Plugs between Vapor Bubbles in Capillary Tubes: A Comparison between Fluids”, 18th International Heat Pipe Cconference, 2016

2. Scope of work

	Tasks	Start	End
1	**PHP predesign tool development**		
1.1	Bibliography of recent modelling and innovations in PHP fields	T0	T0+6
1.2	Development of a prediction model of the PHP and architecture trade-off	T0	T0+48
1.3	Designing and manufacturing the PHP demonstrators used for the validation of the PHP predesign tool	T0	T0+36
1.4	Validation tests to calibrate the PHP predesign tool	T0+18	T0+48
2	**PHP mathematical macro-model**		
2.1	Adaptable tests bench development - design and manufacturing	T0	T0+18
2.2	Designing and manufacturing the PHP demonstrators	T0	T0+18
2.3	Tests campaign according to the DoE	T0+18	T0+36
2.4	Development of the mathematical macro model	T0+18	T0+48

Task 1.1: Bibliography on numerical aspects
Pulsating Heat Pipes are nowadays well known for the performance in thermal management because of the advantageous combination they can offer: great heat transfer capacity for a very low cost of manufacturing. But its thermo-fluidic behavior is not simple and many aspects of the internal heat and mass transfers remain unknown. Several numerical studies are developed over the world in order to clarify this aspect.
Bibliography of task 1.1 should focus on recent achievements on modelling aiming at representing the global behavior of the heat pipe. A detailed scientific background is expected concerning both single bubble and multi-bubble PHP bibliography. This study should finally be focused on predictive model advantages and drawbacks and therefore depict what could be possible and impossible concerning a dedicated numerical approach on this project.
A research regarding the PHP patents should complete this bibliography.

Task 1.2: PHP modelling
The topic manager is willing to integrate such a heat transfer device to cool some of its equipment exposed to severe thermal and vibrating environments. For such critical systems, the topic manager needs simulation tools to help product designers to perform the right choice and therefore manufacture products with an interesting reliability.
A description of the topic manager constraints shall be delivered to the applicant in order to help bordering the interfaces and thermal domain of the pulsating heat pipe. The model developed in this task shall be easy to implement so as to fulfill the following rules:

- Numerical interfaces of the model shall be compatible with FMU/FMI norms for a further integration in a MODELICA system model;
- A parametric model allowing the topic manager to perform integration trade-offs : geometrical, thermal and environmental parameters;
- A switchable modelling time dependence from transient to steady state depending on the final use.

The applicant shall develop a simulation tool with a user interface to predict the PHP global parameters from its geometry and material properties. The simulation shall account for the interaction of multiple vapor bubbles inside the PHP including the effect of the liquid films of variable length inside the bubbles. The simulation shall be capable to predict the PHP functioning limits, in particular its dry out.

Task 1.3: Validation demonstrators
In parallel to numerical developments, in order to update and validate the numerical predesign tool, the aplicant shall design and manufacture as much PHP demonstrators as necessary.

Task 1.4: Validation tests campaigns
The demonstrators shall answer to criterions defined on previous task.

Task 2.1: Adaptable tests bench development - design and manufacturing
Regarding the tests campaign, in order to create the PHP data base, the applicant shall design and develop an adaptable tests bench. This bench shall be interfaced with the whole PHP demonstrators developed in the following task 2.2.
The validity range of the PHP relevant parameters shall fit with the manager topic specification.

Task 2.2: Heat pipe manufacturing and integration
The applicant shall design and develop as many PHP demonstrators as necessary to perform a comprehensive study (cf. task 2.3) highlighting its global performance depending on its relevant parameters.

Task 2.3: Experimental study
The applicant shall build a Design of Experiment and follow it to characterize the thermal behavior of the heat pipe for the whole PHP relevant parameters. Tests campaign shall cover the entire validity ranges of each parameters based on the topic manager specification.

Task 2.4: Mathematical macro model
The applicant shall develop thanks to the experimental results retrieved from the task 2.3 a mathematical model describing the right thermal behaviour of a PHP in the framework of the topic manager specification.

3. Major Deliverables and Milestones and schedule (estimate)

Deliverables			
Ref. No.	**Title - Description**	**Type***	**Due Date**
D1.1	Bibliography report	R	T0+6
D1.2	Model user manual and numerical model	R+M	T0+48
D1.3	PHP demonstrator design description report	R+D	T0+36
D1.4	Test results report and model calibration report	R	T0+48
D2.1	Tests bench description and operational acceptance testing report	R	T0+18
D2.2	Manufacturing and Integration demonstrator report	R+D	T0+18
D2.3	Experimental description and validation report	R	T0+36
D2.4	Macro-model description and validation report	R+M	T0+48

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

4. Special skills, capabilities

- Skills
  - PHP manufacturing
  - Thermodynamics applied to PHP
    - Modelling interaction of multiple vapor bubbles
    - Liquid film behaviour
    - PHP functionning limits such as the dry out
  - Numerical skills for two phase flows
  - Experimental skills for two phase systems
- Capabilities
  - Machining facilities for PHP manufacturing
  - PHP integration such as brazing
  - Experimental facilities for two-phase fluid filling
  - Experimental facilities for prototype testing
- Achievements
  - Mono bubble modelling
  - Multiple bubbles modelling
  - Scientific dissemination about PHP modelling (papers, thesis and so on)

5. Abbreviations

PHP	Pulsating Heat Pipe
DOE	Design Of Experiment

IX. Quick Disconnect System

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.1.10		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	SAFRAN ELECTRICAL & POWER	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[9]	Q2 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-LPA-01-44	**Quick Disconnect System**
Short description	
This topic will develop and demonstrate a novel highly robust and reliable fault detection and mechanical isolation system to mitigate the risks of potentially highly dissipative failure modes associated with the high-performance electrical power generator technologies required for future energy-optimised aircraft. Future optimised electrical power systems with actively controlled power sharing between electrical sources will use high-speed, highly efficient electrical generators. The wide operating speed range of these generators and the technologies used to maximise their power density, as well as the greater criticality of the electrical power system, increase the severity of potential failure modes.	

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

1. Background

This topic will develop and demonstrate a novel highly robust and reliable fault detection and mechanical isolation system to mitigate the risks of potentially highly dissipative failure modes associated with the high-performance electrical power generator technologies required for future energy-optimised aircraft.

The ACARE Strategic Research and Innovation Agenda Flightpath 2050 goals for Challenge 3 (Protecting the environment and the energy supply) require system and multi-system optimisation, using combinations of effects on different areas of design and benefits of individual equipment technologies to yield larger step changes in energy efficiency.

The electrical power system is under significant scrutiny due to the increasing amount of electrical power used by increasingly More Electric Aircraft, culminating in future hybrid electric and all electric propulsion architectures, and because of the effects of its components on other aspects of aircraft design and performance. With these increasing power conversion requirements, it is necessary to consider enhanced electrical power generation technologies.

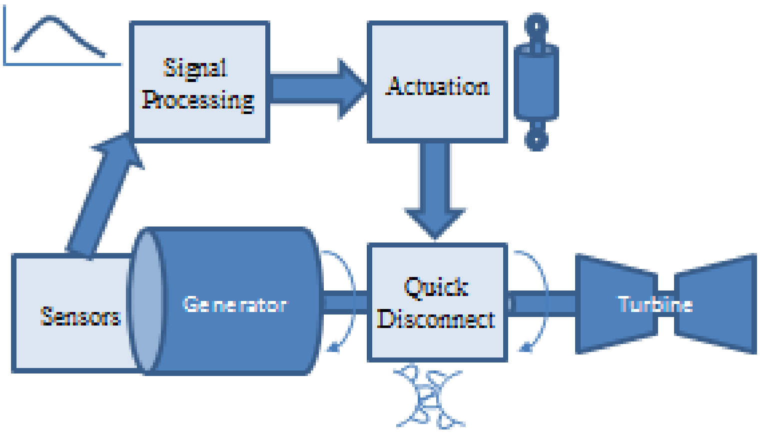
The introduction of Variable Frequency Generator technology has permitted simplification of the mechanical drive train, offering greater power capability than traditional constant frequency generator technologies, and it has facilitated the electrification of the main engine start function, integrating it with the electrical generation channel. The current evolution of electrical power distribution away from alternating current additionally offers the possibility of increased rotational speed of the generators and consequently increased power density.

A further challenge to the electrical power generation system comes from the limitations on the maximum permissible quantity of power off-take from the high-pressure turbine of the new generations of increasingly efficiency turbofan engines. To overcome this, solutions are being developed to enable power off-take from the low-pressure turbine which is less susceptible to mechanical shaft power variation and offers a reduced impact on engine efficiency, but has a significantly wider speed range (greater than 5:1 ratio between maximum and minimum speed) than the high-pressure turbine (typically 2:1 ratio between maximum and minimum speed), or to draw power from the Auxiliary Power Unit. Such solutions open the possibility of further benefits through active power sharing between power sources.

The drive for increased efficiency, power density and wider operating speed range, with the rotor stored kinetic energy ever increasing, necessitate a departure from traditional rotor mechanical design and are requiring consideration of alternative and simpler machine technology such as permanent magnet synchronous.

In view of the increased criticality of the electrical system, the increasing amount of mechanical stored energy, the very significant amount of mechanical power available from the turbine and the potential new electrical failure modes of the generators, an effective and reliable means of mechanical isolation of the generator from the turbine is required so as to assure control of the possible generator failure modes which could be more widely damaging to the surrounding systems and equipment.

This Work Package focusses upon the Quick Disconnect-based mechanical isolation system depicted below, the elements of the system being the Sensors, Signal Processing, Actuation and Quick Disconnect.



The work will require analysis of system requirements and reliability to support architecture definition, in-depth study of materials and coupling devices to be used in the Quick Disconnect, evaluation of sensing techniques and signal processing for fault identification and design of the actuation means. The requirements will include the definition of interfaces with the off-the-shelf generator(s) so as to permit representative operation of the Quick Disconnect device.

The primary focus will be mechanical faults resulting in loss of integrity of bearings or structure, and therefore in poorly constrained axial or radial movement of the rotating components. Future extension of the sensor suite to detect electrical and other failures specific to particular types of machine may be considered time allowing, but these are not intended to be specifically studied in this activity as the mechanical failure conditions are seen as technically more challenging and are more broadly applicable. The activity will not aim to demonstrate the behaviour of a complete generator with imposed faults but the performance of the developed hardware will be tested with an off-the-shelf generator under harsh conditions (vibration, misalignment) as part of the related Integration work package.

Initial validation will be through dynamic behavioural analysis and physical testing of the Quick Disconnect in isolation under laboratory conditions, emulating the turbine and generator using appropriate drive motor and load respectively. The testing will require specialised capabilities in order to permit assessment of the effects of multiple disturbances simultaneously, for example mechanical load combined with vibration and temperature. Further, in order to assess robustness, the effects of manufacturing tolerances and wear conditions shall be evaluated. The test equipment will be capable of emulating and characterising the effects of mechanical failures resulting in relaxation of axial and/or radial constraints surrounding the disconnect device (not as complete generator) under harsh environment conditions.

A second validation phase will occur through the related "High Performance Integration Channel' topic, whereby a Disconnect System shall be provided for integration with one or more off-the-shelf electrical generator(s). This will permit the operation of the disconnect system to be tested with representative equipment under normal and emulated failure conditions.

Preliminary studies of the applications indicate the following approximate specification points:

- Continuous mechanical drive requirement: 60kW
- Short-term overload: 120kW

- Operating speed range: 5000-35000 rpm

Demonstration of scalability of the Quick Disconnect to an order of magnitude larger mechanical drive requirement will be necessary.

Disconnect capability will be demonstrated over 5000 - 35000 rpm speed range at up to the generator shaft shear neck rupture torque under harsh conditions (considering vibration, misalignment, temperature). It is anticipated that the contributors will be able to utilise, and as necessary adapt, existing test capabilities already reasonably aligned with the performance objectives. Should it be determined that demonstration testing is physically limited by the scale of the investment required, the scalability up to the required levels will be substantiated by analysis.

The Work Package contributors will include experts in the field of mechanical engineering and will validate their designs against the severe operating requirements of the application. Validation will be performed both through test of the Quick Disconnect itself under combined environmental effects and non-ideal configurations, and as part of the integrated system illustrated above.

The particular challenges surround the required robustness and reliability in the harsh environment, combined with the stringent requirements for size and weight.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1.1	Initial Requirements Capture and preliminary architecture definition – through discussion with stakeholders	T0+3
T1.2	Shaft coupling and actuator concept definition – perform initial mechanical analyses to enable the selection of an initial concept, with consideration of properties of available materials	T0+12
T1.3	Supply chain identification and industrialisation assessment	T0+15
T1.4	Disconnect system definition, including sensors and signal processing, and reliability-based analysis	T0+12
T1.5	Modelling and simulation of detailed behaviour with external and non-ideal effects	T0+24
T1.6	Shaft coupling and actuation detail definition – perform detailed mechanical analyses and design definition to enable hardware procurement	T0+24
T1.7	Disconnect System procurement / manufacture	T0+28
T1.8	Performance testing and validation	T0+34
T1.8	Integration support and test	T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1.1	Preliminary Requirements Specification	R	T0+3
D1.2	Shaft Coupling Topology and Materials Trade Study Report	R	T0+12
D1.3	Disconnect System architecture definition	R	T0+12
D1.5	Initial Simulation & Analysis Report	R	T0+15
D1.6	Final Simulation & Analysis Report	R	T0+24
D1.8	Two Disconnect System ship sets for integration	HW	T0+28
D1.9	Test and Validation Report	D	T0+34
D1.10	Final Report	D	T0+36

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1.4	Quick Disconnect Concept Design Review	R	T0+15
D1.7	Quick Disconnect Detailed Design Review	R	T0+24

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

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

- Materials knowledge and analysis capability, particularly of metals
- Mechanical engineering expert
- System requirements capture and analysis
- Reliability-based system architecture analysis
- Understanding of sensing techniques, signal processing and control
- Existing test capabilities aligned with the performance objectives.
- Dynamic behavioural analysis, including external and environmental effects
- Mechanical / Material Failure analysis
- Procurement or manufacturing of precision mechanical assemblies
- Multi-parameter “real life” testing (laboratory conditions and interfacing with Integration CfP)

University partners could be well-suited.

5. Abbreviations

AC	Alternating Current
DC	Direct Current

X. High Performance Generation Channel Integration

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.1.10		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	SAFRAN ELECTRICAL & POWER	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[10]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-45	**High Performance Generation Channel Integration**
Short description	
This topic will integrate and demonstrate, in the context of a developed supervisory control architecture, a high-performance high-voltage direct current electrical power generation system with a dependable mechanical isolation system for the protection against highly dissipative failure modes. These technologies are fundamental to optimized highly power dense and efficient power systems, using for example Permanent Magnet Generators, and permitting sharing between electrical sources to meet the needs of future more electric aircraft systems. The demonstration will utilise a high-performance test rig permitting combinations of external effects to be applied as well as emulation of faults and degradation of hardware.	

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

1. Background

This topic will develop and implement a supervisory control architecture which will be used to control a high-performance high-voltage direct current electrical power generation system. This will be used to demonstrate the system-level performance of Intelligent Power Modules and a Quick Disconnect developed under 2 other specific topics, but primarily will have the objective of demonstrating the attainability of certain targets for dynamic controllability of the electrical power with a view to utilising this controllability to optimise future systems.

The ACARE Strategic Research and Innovation Agenda Flightpath 2050 goals for Challenge 3 (Protecting the environment and the energy supply) require system and multi-system optimisation, using combinations of effects on different areas of design and benefits of individual equipment technologies to yield larger step changes in energy efficiency.

The electrical power system is under significant scrutiny due to the increasing amount of electrical power used by increasingly More Electric Aircraft, culminating in future hybrid electric and all electric propulsion architectures, and because of the effects of its components on other aspects of aircraft design and performance. With these increasing power conversion requirements, it is necessary to consider enhanced electrical power generation technologies.

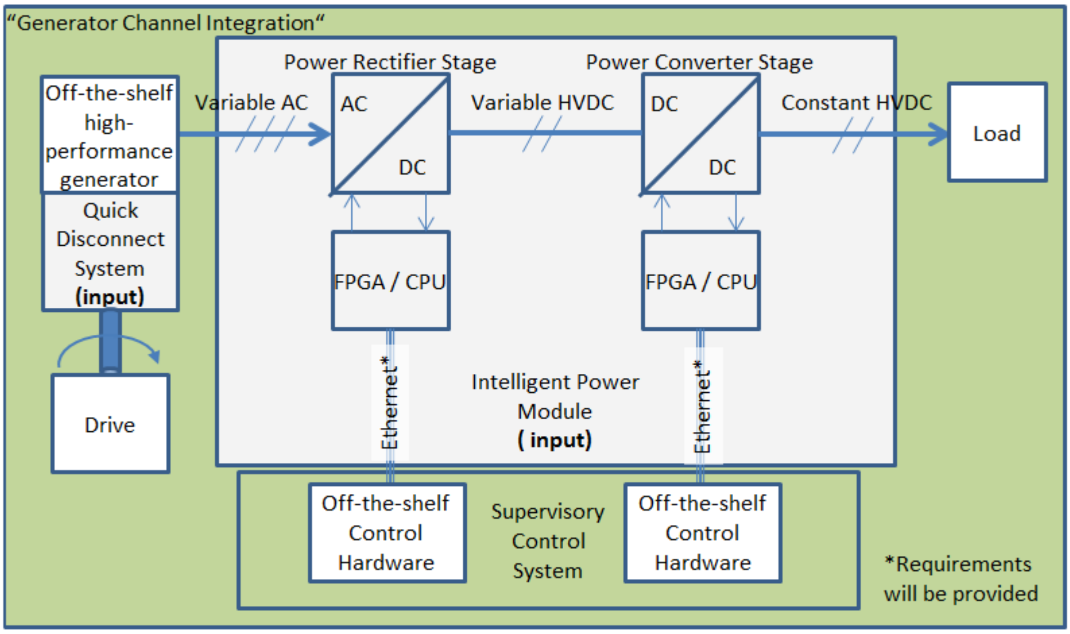
The introduction of Variable Frequency Generator technology has permitted simplification of the mechanical drive train, offering greater power capability than traditional constant frequency generator technologies, and it has facilitated the electrification of the main engine start function, integrating it with the electrical generation channel. The current evolution of electrical power distribution away from alternating current additionally offers the possibility of increased rotational speed of the generators and consequently increased power density.

A further challenge to the electrical power generation system comes from the limitations on the maximum permissible quantity of power off-take from the high-pressure turbine of the new generations of increasingly efficiency turbofan engines. To overcome this, solutions are being developed to enable power off-take from the low-pressure turbine which is less susceptible to mechanical shaft power variation and offers a reduced impact on engine efficiency, but has a significantly wider speed range (greater than 5:1 ratio between maximum and minimum speed) than the high-pressure turbine (typically 2:1 ratio between maximum and minimum speed), or to draw power from the Auxiliary Power Unit. Such solutions open the possibility of further benefits through active power sharing between power sources.

The drive for increased efficiency, power density and wider operating speed range, with the rotor stored kinetic energy ever increasing, necessitate a departure from traditional rotor mechanical design and are requiring consideration of alternative and simpler machine technology such as permanent magnet synchronous.

It is envisaged that with the advent of High-Voltage DC networks power sharing will also be made possible, with the load on individual power sources being controlled to optimise the overall operating point and efficiency of the aircraft under each operating condition. To achieve this a high degree of control of the electrical power needs to be achieved, whilst ensuring minimum impact on the size and weight of the systems.

Through this topic the integrated system illustrated below will be developed, and in particular the supervisory control algorithms and the test bench itself to enable the simultaneous application of different disturbances to the system. The supervisory control system and test bench will bring together the power electronic conversion, quick disconnect and other existing technologies associated with the system. The diagram illustrates the interactions between the different items being developed through this and the 2 other associated topics considered as an input for this topic.



The work will require analysis of system requirements to support control system and test bench architecture definitions, development of control algorithms, validation of the algorithms through simulation and then test. The test bench design will need to consider the interfaces with the existing off-the-shelf equipment and the items to be received from the Integrated Power Module and Quick Disconnect System topics (the applicant(s) can have a look on the 2 others topics description to get additional information). The test bench will be conceived so as to be capable of combining environmental effects and also emulating degradation of the products under test. The applicant(s) will also perform in-depth analysis of the test results, in order to validate the overall performance goals, with. the dynamic controllability of the overall power generation system.

Preliminary studies of the applications indicate the following approximate specification points:

- Mechanical drive requirement: 60kW
- Short-term mechanical drive overload: 120kW
- Generator speed of rotation: 5000-35000rpm
- Continuous electrical load requirement: 45kW
- Short-term electrcial overload: 90kW
- Maximum heat rejection to Conditioned liquid cooling during continuous operation: 10kW

The Work Package contributors will have demonstrated capability in the field of machines and drives integration and testing, including the disciplines of test rig design, data acquisition, test rig commissioning, test rig integration for high-performance electrical generation systems, test planning and test management.

The objective will be to validate the performance of bespoke components individually as required, and as a system, against the severe operating requirements of the application.

Particular challenges surround the very high robustness and reliability of the test equipment, capable of a harsh environment, required in order to adequately validate the equipment under test, which is itself designed for high robustness and reliability. The test set up shall be designed not to exceed the limits for the electromagnetic environment defined for the equipment under test and shall as a minimum be immune to the limits of electromagnetic emissions permitted for the equipment under test. The requirement to demonstrate robustness and reliability of the quick disconnect will require simultaneous application of environmental effects, such as vibration and temperature during performance testing, and the ability to impose non-ideal installation constraints on the equipment under test. Data acquisition will need to be capable of capturing the anticipated rapid rate of change of system and equipment parameters during the testing.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T3.1	Initial Requirements Capture – define requirements and interfaces through discussion with stakeholders	T0+3
T3.2	Component selection – perform initial assessments to enable baseline selection of test rig and data acquisition system components to meet the main performance requirements.	T0+4
T3.3	Test rig architecture & functional definition	T0+7
T3.4	Test rig and data acquisition equipment specification	T0+12
T3.5	High-level test plan definition	T0+12
T3.6	Test rig commissioning planning	T0+12
T3.7	Test rig and data acquisition equipment procurement	T0+24
T3.8	Test rig commissioning	T0+27
T3.9	Quick Disconnect test procedure definition	T0+27
T3.10	Quick Disconnect test	T0+33
T3.11	Generator Channel test procedure definition	T0+33
T3.12	Generator Channel test	T0+44

3. Major deliverables/ Milestones and schedule

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D3.1	Preliminary Requirements Specification	R	T0+3
D3.3	High-level test plan	R	T0+12
D3.5	Quick Disconnect test procedure	R	T0+27
D3.7	Generator Channel test procedure	R	T0+33
D3.9	Generator Channel Test report	R	T0+44
D3.10	Final report	R	T0+48

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D3.2	Test Rig Preliminary Design Review	D	T0+7
D3.4	Test Rig Design Review	D	T0+12
D3.6	Quick Disconnect Test Readiness Review	D	T0+27
D3.8	Generator Channel Test Readiness Review	D	T0+33

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

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

The availability of elements of reusable test equipment and rigs would be a significant advantage as this would enable a wider scope for novel aspects of testing and novel capabilities to be developed.
The ability to extend the test to include a second, traditional, generator in parallel with the above would also be an advantage as it would permit validation of paralleling performance.

- Facilities with suitable capacity for the nature of this project, requiring vibration and environmental testing of high-performance machines
- Strong capabilities in validation and verification of high-performance machine performance
- Capabilities in environmental testing
- Test rig design capability
- Test equipment specification and commissioning capability
- Links with, or internal, capacity in test rig procurement and commissioning

5. Abbreviations

AC	Alternating Current
FPGA	Field Programmable Gate Array
CPU	Central Processing Unit
DC	Direct Current
FPGA	Field Programmable Gate Array
HVDC	High Voltage DC
IPM	Intelligent Power Module
PWM	Pulse Width Modulation

XI. Intelligent Power Module

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 1.1.10		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	SAFRAN ELECTRICAL & POWER	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[11]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-01-46	**Intelligent Power Module**
Short description	
This topic is for the development and demonstration of a highly robust and reliable Intelligent Power Module for integration into machines applications for arduous applications. Future optimized power systems permitting sharing between electrical sources will use high-performance electrical machines requiring conditioning of their output power using power electronics, such as Permanent magnet machines which permit maximum power density. The hardware required for power conditioning will need to be extremely light, small and robust, and the objective is to achieve these requirements through use of high-efficiency wide bandgap components and through integration with the electrical power generator in its harsh environment.	

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

1. Background

This topic will develop and demonstrate highly a robust and reliable high-performance Intelligent Power Module. Future optimized power systems permitting sharing between electrical sources will use high-performance electrical machines requiring conditioning of their output power using power electronics, such as Permanent magnet machines which permit maximum power density. The acceptability of the hardware required for power conditioning, centered around high-performance power modules, will depend on it being light, small and robust. This topic will develop the fundamental building block required to achieve these requirements through use of high-efficiency wide bandgap components and through integration with the electrical power generator in its harsh environment.

The ACARE Strategic Research and Innovation Agenda Flightpath 2050 goals for Challenge 3 (Protecting the environment and the energy supply) require system and multi-system optimisation, using combinations of effects on different areas of design and benefits of individual equipment technologies to yield larger step changes in energy efficiency.

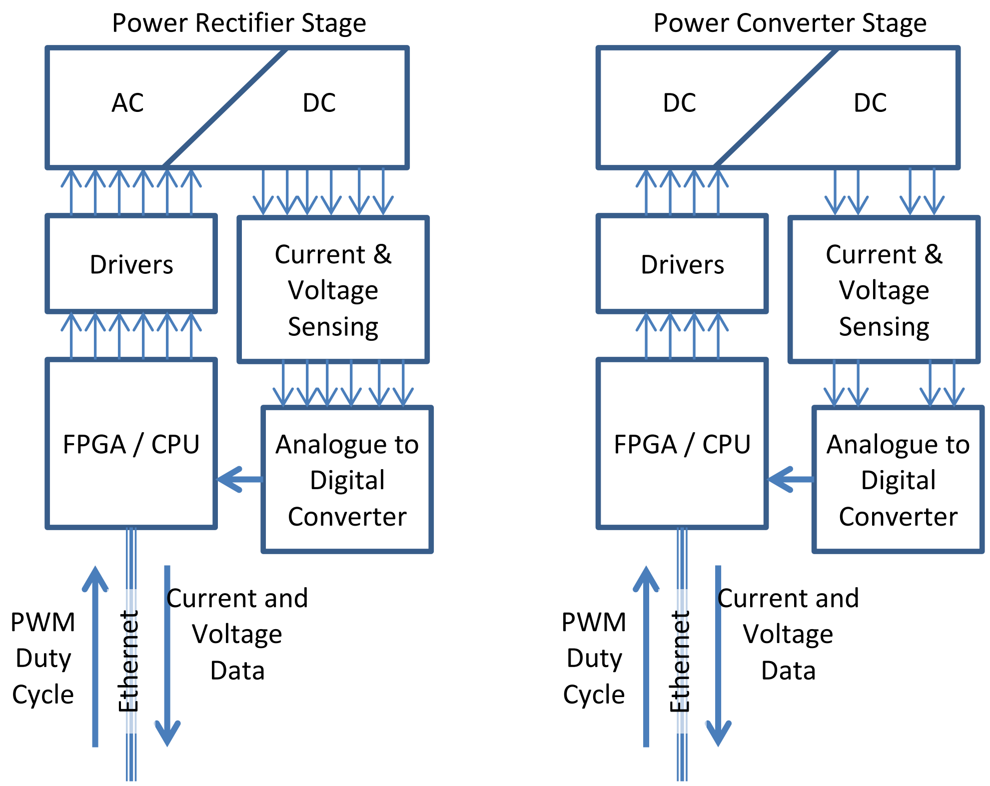
The electrical power system is under significant scrutiny due to the increasing amount of electrical power used by increasingly More Electric Aircraft, culminating in future hybrid electric and all electric propulsion architectures, and because of the effects of its components on other aspects of aircraft design and performance. With these increasing power conversion requirements, it is necessary to consider enhanced electrical power generation technologies.

The introduction of Variable Frequency Generator technology has permitted simplification of the mechanical drive train, offering greater power capability than traditional constant frequency generator technologies, and it has facilitated the electrification of the main engine start function, integrating it with the electrical generation channel. The current evolution of electrical power distribution away from alternating current additionally offers the possibility of increased rotational speed of the generators and consequently increased power density.

A further challenge to the electrical power generation system comes from the limitations on the maximum permissible quantity of power off-take from the high-pressure turbine of the new generations of increasingly efficiency turbofan engines. To overcome this, solutions are being developed to enable power off-take from the low-pressure turbine which is less susceptible to mechanical shaft power variation and offers a reduced impact on engine efficiency, but has a significantly wider speed range (greater than 5:1 ratio between maximum and minimum speed) than the high-pressure turbine (typically 2:1 ratio between maximum and minimum speed), or to draw power from the Auxiliary Power Unit. Such solutions open the possibility of further benefits through active power sharing between power sources.

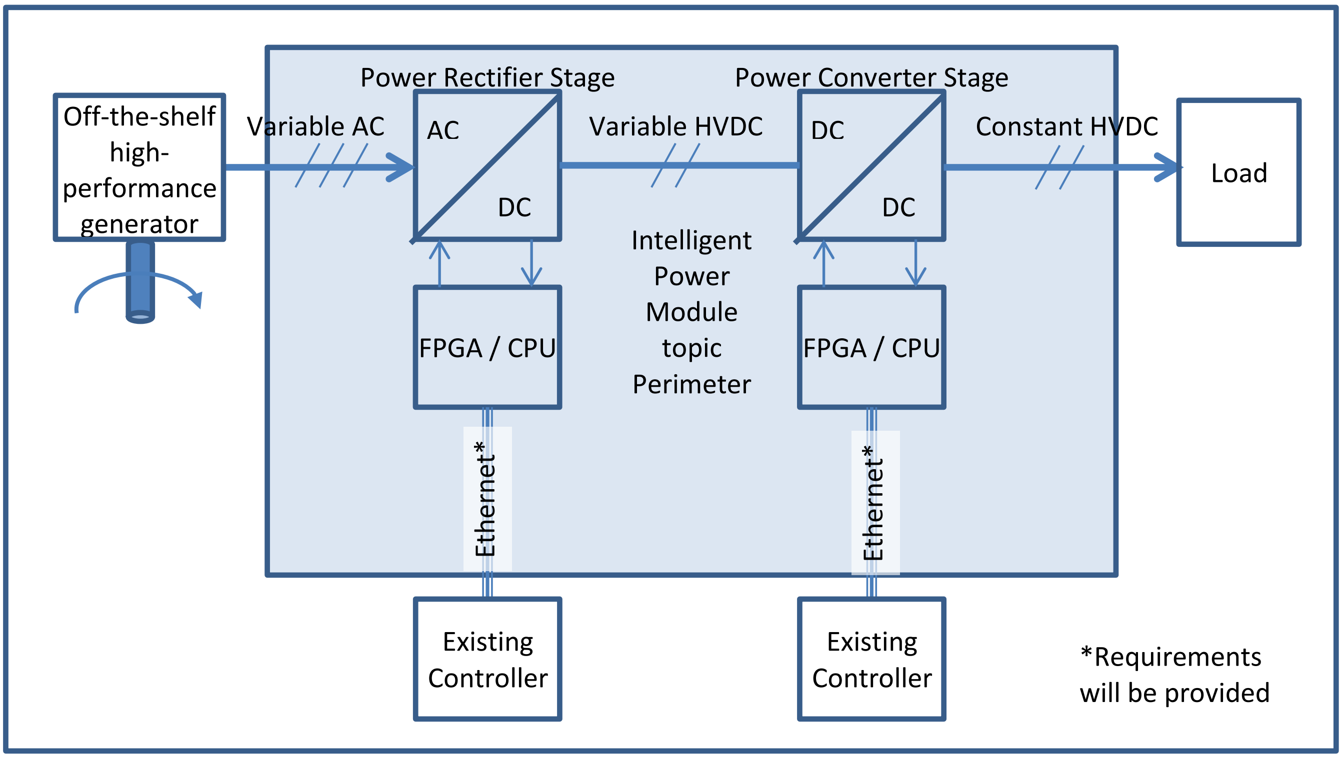
To achieve the above objectives, a high degree of control of the electrical power needs to be achieved, whilst ensuring minimum impact on the size and weight of the systems, and this drives the requirements for the Intelligent Power Modules (IPM) to be developed through this CfP.

Two configurations of IPM will be developed through the topic, defined in the diagrams below. The first enables conversion from alternating current (variable voltage, variable frequency) to direct current. The second enables conversion from direct current at one, possibly variable, voltage to direct current at another, constant, voltage. The diagram shows the main functional blocks, not all of the physical components. The modules' intelligence is associated with the FPGA or CPU, which is used to interpret the drive commands coming from the Ethernet connection and, via high bandwidth control and protection functions, to control the operation of the individual Power Electronic switches so as to ensure reliable behaviour in accordance with the commands received. Due to their similarity it may be possible for a number of the functional blocks to be reused.



The particular performance challenges to be demonstrated surround the required robustness and reliability in the harsh environment, being integrated with the electrical machine, combined with the stringent requirements for size, weight, efficiency and compatibility with aeronautical performance standards.

The IPMs will be validated by analysis and laboratory test, followed by which two IPMs will be integrated with one or more existing generators and will be tested through the "High performance Generation Channel Integration" topic to validate their performance in the system context. The diagram below illustrates the envisaged interfaces for the topic as are relevant to the IPMs.



Preliminary studies of the applications indicate the following approximate specification points:

- Continuous electrical load requirement: 45kW
- Short-term overload: 90kW
- Power input frequency 200-1500Hz
- Target Power Converter efficiency at maximum continuous load: >95%

The Work Package contributors will be experts in the field of power electronic converter analysis and design, including the disciplines of power electronics, microelectronics, digital control, mechanical and thermal engineering, and in the selection of components and specification and/or manufacture of power modules for high reliability applications. The objective will be to validate designs against the severe operating requirements of the application.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T2.1	Initial Requirements Capture – define requirements and interfaces through discussion with stakeholders	T0+1
T2.2	Component selection – perform initial performance analyses to enable baseline selection of power components to meet the main performance requirements.	T0+3
T2.3	Module architecture definition	T0+6
T2.4	Functional modelling and failure mode analysis	T0+9
T2.5	Module Functional definition	T0+9
T2.6	Supply chain identification and industrialisation assessment	T0+12
T2.7	Module Preliminary Design and performance prediction	T0+15
T2.8	Functional mock-up testing	T0+13
T2.9	Module Detailed Design	T0+20
T2.10	Module manufacture	T0+26
T2.11	Module electrical and thermal performance characterisation and environmental test	T0+30
T2.12	Integration support	T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D2.1	Preliminary Requirements Specification	R	T0+3
D2.2	Module Architecture Report	R	T0+6
D2.3	Industrialisation Assessment Report	R	T0+12
D2.6	Test report	R	T0+32
D2.7	Two Intelligent Power Module shipsets for integration	HW	T0+30
D2.8	Final report	R	T0+36

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D2.4	Preliminary Design Review	D	T0+15
D2.5	Detailed Design and Manufacturing Review	D	T0+20

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

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

- Specialist in Power Electronics and Electronics
- Multi-physics analysis capability
- Links with, or internal, industrial capacity in power electronics
- Wide bandgap semiconductor experience
- Test capability to support detailed behavioural characterisation of power components and their failures, including electrical, electromagnetic, thermal and combined effects.
- Control of power device switching characteristics
- Filter design

5. Abbreviations

AC	Alternating Current
FPGA	Field Programmable Gate Array
CPU	Central Processing Unit
DC	Direct Current
FPGA	Field Programmable Gate Array
HVDC	High Voltage DC
IPM	Intelligent Power Module
PWM	Pulse Width Modulation

XII. Development of a full size automated plant system for fuselage longitudinal and circumferential joints

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 2.4.4		
Indicative Funding Topic Value (in k€)	2500		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[12]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-02-22	**Development of a full size automated plant system for fuselage longitudinal and circumferential joints**
Short description	
The joining process of the longitudinal and circumferential seam for two pre-integrated, full-size thermoplastic fuselage shells shall be performed by an automated plant system. Within this project, an automated solution has to be developed, taking into account a double-sided and limited accessibility for full fuselage sections.	

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

1. Background

Internationally growing flight and passenger numbers have led to a joint order backlog of Airbus and Boeingapproximately 12,500 aircrafts. With today's production rates the delivery of all aircrafts would take 8.5 years. The resulting endeavor for higher productivity requires more flexible manufacturing solutions. Based on today's newest robotic solutions – suitable for changing and limited work environments – automation becomes more attractive for aerospace industry. The assembly of major components as well as aircraft sections, which dominate the lead time in today's pulse line based production has always been a challenging process. Reducing manufacturing time and costs and parallelizing multiple assembly steps is one of the key drivers for the factory of the future.
Thermoplastic carbon fiber resin materials for major components (like fuselage shells) show great opportunities to redefine the manufacturing order, avoid or reduce riveting, and significantly decrease the lead time. Joining of fuselage shells made of aluminum or carbon fiber reinforced plastics with thermoset resin, mostly requires drilling and fastening. Resulting chips or dust prevent the pre-installation of cabin systems and components due to the required cleaning process after joining. With thermoplastic carbon fiber resin materials joining by welding becomes dustless.
The multifunctional fuselage demonstrator developed in LPA WP2.1 will have two cylindrical, thermoplastic half shells that shall be manufactured by Platform 2 core partners and joined to one single-aisle fuselage section. This enables a re-arrangement of the assembly process chain, since pre-installation would now be possible (performing the pre-installation is not part of this topic). The major advantage in this scenario is the pre-installation on the open fuselage half-shells, so structural or cabin components no longer have to fit through the entrance doors of the fuselage. Furthermore, large pre-assembled modules could be prepared in parallel to the manufacturing of the fuselage shells and lifted, positioned and fastened into the open fuselage. However, the longitudinal and circumferential joint of pre-installed fuselage shells becomes even more challenging. Within this project, an automated solution has to be developed taking into account a double-sided accessibility and in terms of space and weight limited accessibility for full fuselage sections.

Major Objective

The major objectives of the multifunctional fuselage demonstrator are illustrated in Figure 1. The overall system reference is based on the A321 ACF with respective dimensions. For conceptual design the automation system is supposed to assemble parts with a longitudinal length of up to 25m, albeit the demonstrator in this project will have a length of 8m. The conceptual design of the shells as well as the fuselage demonstrator is still in progress. All required information will be provided within the start phase of this project.

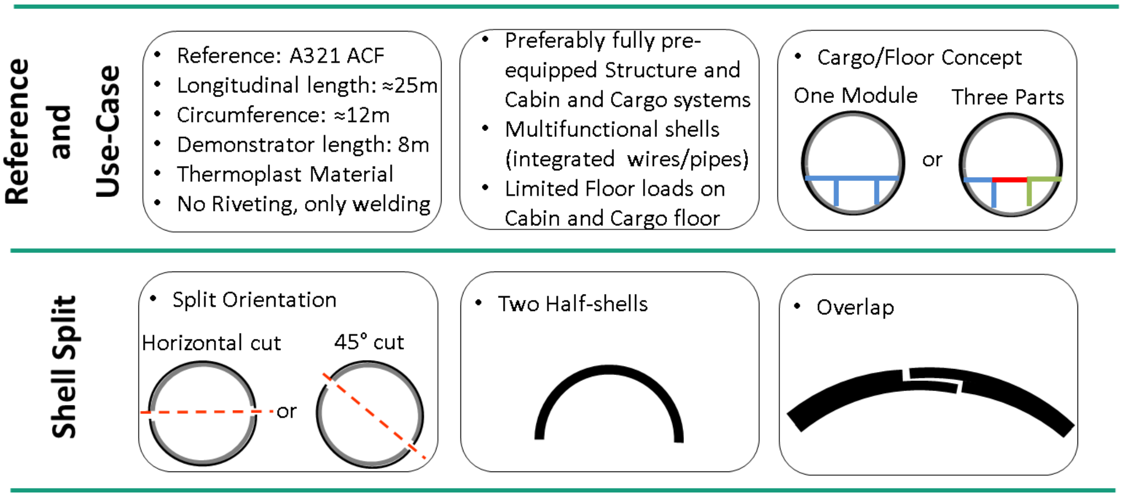


Figure 1: Major Objective

The maximum distributed normal force that can be applied to the floor panel inside the fuselage for cabin and cargo is F = 750 N/in². The normal force for rolling load is 40kg per roll with a contact area of approx. 200mm². Because of one-sided loads/ wrong handling the A/C Manufacturer suggest using a safety factor of min. 50%.

To realize the assembly process of a thermoplastic fuselage, tolerances become a major topic. The positioning and orientation of the fuselage shells as well as resulting deformations caused by the welding process need to stay within the tolerances. Comparable accuracies can be oriented to the state of the art process of longitudinal joint. Here, the position error in each direction should be within 0.5mm (in some exceptions up to 1mm). Even if the final requirement is currently not available for the thermoplastic joining process, the same positioning accuracy can be assumed. Furthermore, in the state of the art, process gaps between both shells are filled with sealant material. While riveting the sealing gap between the shells have to be reduced to a minimal gap size. For the thermoplastic welding process it would be necessary to fulfill an all-over contact between the joining areas.

The final thermoplastic welding technology – developed by the core partners – will be choosen at the beginning of this project. However, it can be assumed that a pre-load on the joint surface from both sides of approx. 1000N (independent of the welding technology) for a welding seam of 20mm width is required by the automation system. Furthermore, the core technology for the welding end-effector will have an own weigth of minimum 100kg. This does not includes further required peripherie, like media and power supply or adapters.

Figure 2: State of the art of half-shell longitudinal joining

Environmental requirements and limitations

For the development of the demonstrator various partners are involved. The Workshare of these partners is illustrated in Figure 2. Three core partners will design, develop and produce the shells and the welding technology. Supported by the Topic Manager, the applicant will develop an automated plant system for the longitudinal and circumferential joints. The process and device for positioning and shape adjustment of the shells will be provided by the Topic Manager. The final multifunctional fuselage demonstrator will be provided to the A/C Manufacturer. As such, accession to the LPA Platform 2 consortium agreement will be proposed to the selected applicant(s).

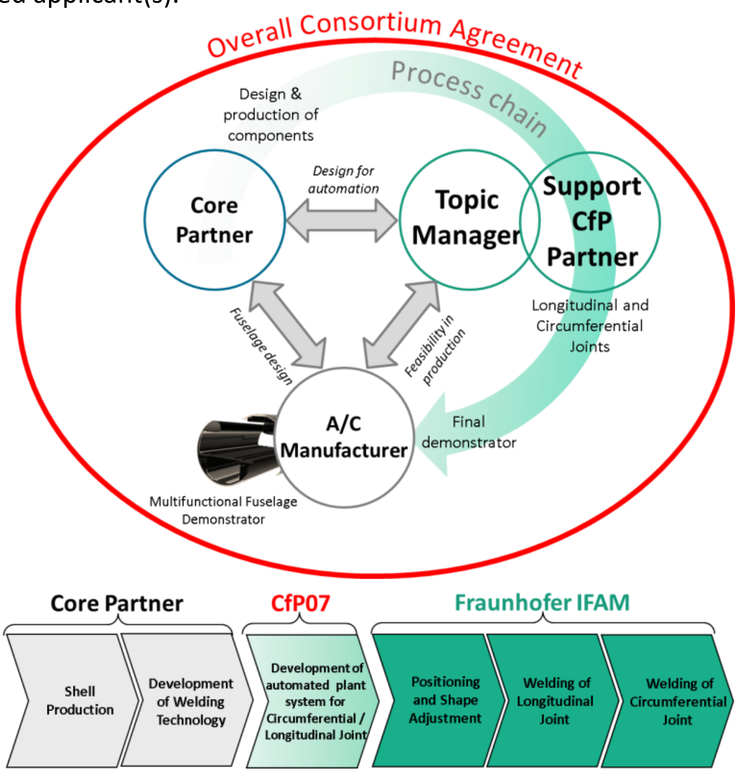
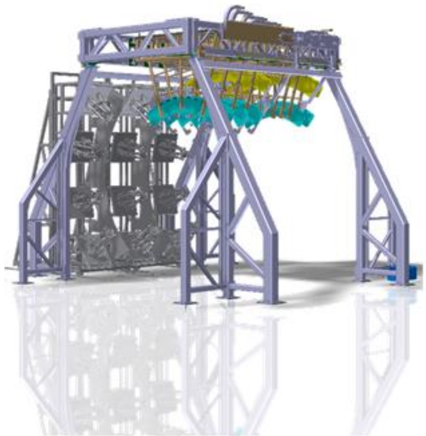
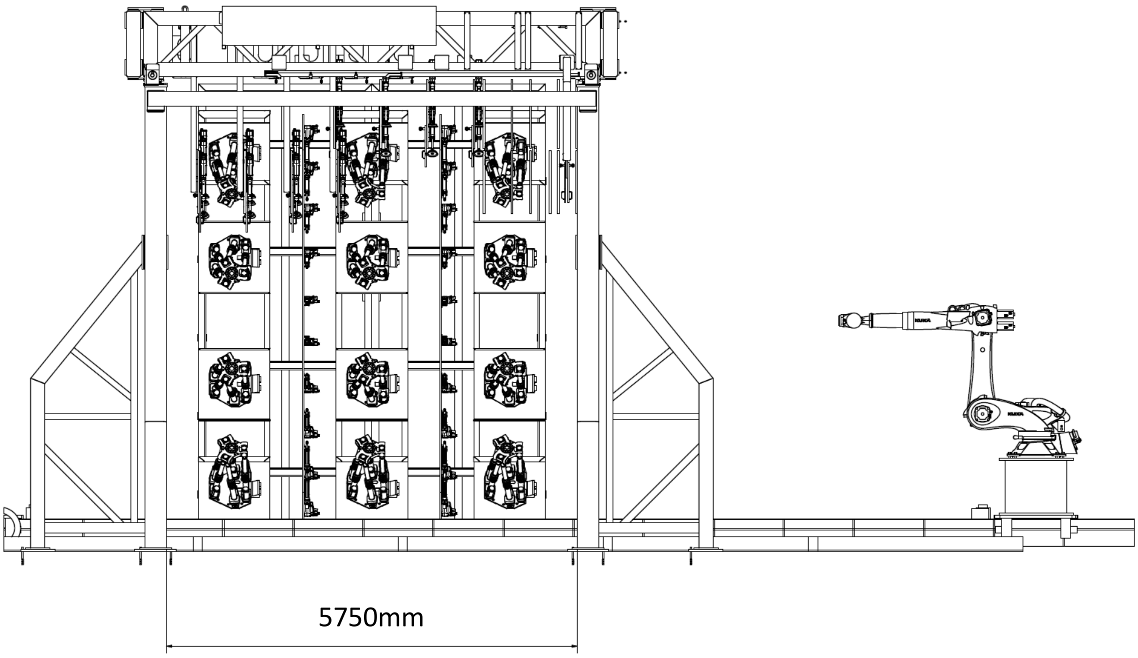


Figure 2: Work-Share in Consortium and Processchain

In Figure 3 the dimensions of the available assembly plant system at the Topic Manager facilities are illustrated. The automated part manipulation enables precise and stress-free holding of almost every part within 2m to 8m in length and up to 6m height. The assembly plant system is currently able to hold a 180° shell of a single aisle airplane. This is made possible by a flexible arrangement of currently 10 co-operating hexapods, 24 linear units and modular rack elements. Vacuum grippers with force and torque 6D sensors gently adjust the pose and shape of the part, as required by the tolerance management in the assembly process. Even complex joining motions can be implemented with co-operating hexapods. The guidance and monitoring of these fast and iterative adjustment processes is done by an optical measuring device. All necessary information regarding the existing plant system will be given at the beginning of the project by the topic manager.

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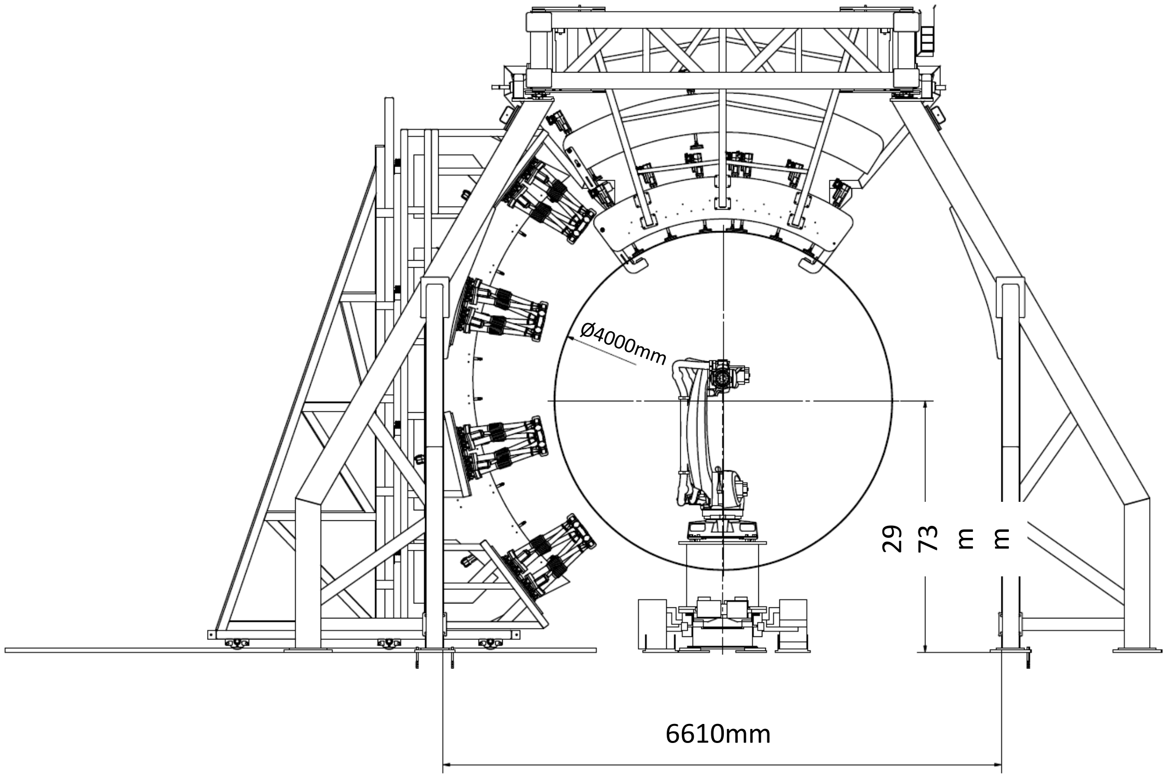


Figure 3: Dimensions of available assembly plant system at Topic Manager facilities

The Topic Manager will be responsible for the modifications of this assembly plant system for holding a whole 360° fuselage. These modifications will depend on the concept and development of the automated plant system for longitudinal and circumferential joint in this CfP. A vision of possible concepts can be seen in Figure 4. For the demonstration of joining, the fuselage shells will be equipped with adapter parts at both joints. This will enable multiple trials as the adapters can be replaced after a complete joint and the process can be repeated and optimized.

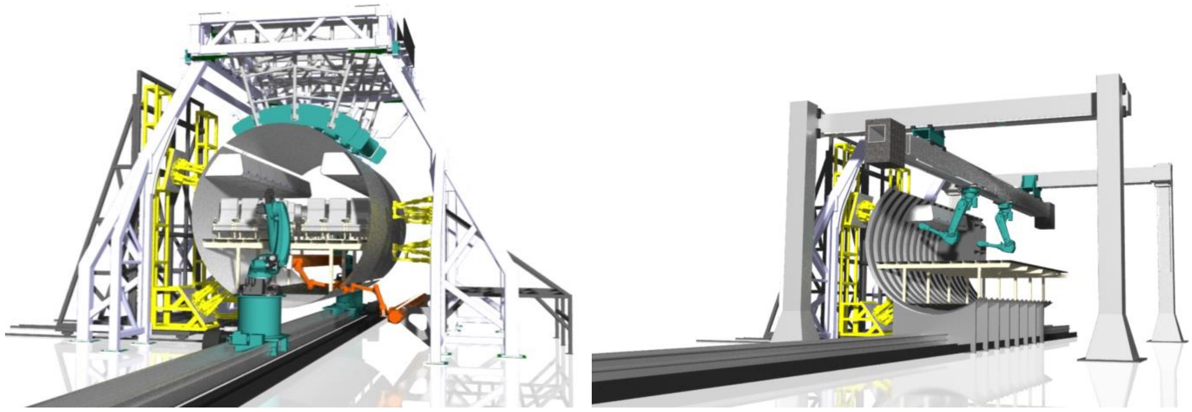


Figure 4: Vision | Longitudinal joint (left) and assembly on open fuselage (right)

2. Scope of work

The main scope of this project is the conceptual design, the elaboration and the realization of a full scale test setup for automated assembly and joining processes of a multifunctional fuselage demonstrator. The test setup has to be integrated into the existing plant system of the Topic Manager. The applicant is expected to design and elaborate manufacturing concepts for the following 3 use cases:

1. **Longitudinal Joint of two thermoplastic fuselage half shells**
2. **Circumferential Joint of thermoplastic fuselage sections**
3. **Assembly of structural and/or cabin components on an open fuselage half shell**

For the design, the elaboration as well as the manufacturing and set up phase the existing hardware of the topic manager (see Chapter 1 "Environmental requirements and limitations") has to be taken into account. The expected set up of an automated plant system as well as the first tests, the optimization and the final validation will take place at shop floor of the topic manager and will be limited to the first and the second use case. The joining technology – thermoplastic welding process – will be developed by a CleanSky 2 LPA core partner. The core technology will be made available by the core partner. The applicant will have to integrate this technology in form of an end-effector to the automation concepts and the plant system set up. The topic manager will support the applicant with information concerning the fuselage demonstrator design and existing hardware. Work packages and tasks to be executed are listed as shown in the table below:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	Design and selection of manufacturing concepts for full size automated plant systems regarding 3 use cases: *Longitudinal Joint*, *Circumferential Joint* and *Assembly on open Fuselage* ▪ Definition and collection of requirements for all 3 use cases ▪ Elaboration of specification sheet ▪ Analysis of automation potentials for all 3 use cases ▪ Development of concepts for all 3 use cases ▪ Assessment of results together with the topic manager, the A/C manufacturer and the core partners ▪ Selection of final concept together with the topic manager, the A/C manufacturer and the core partners	t_0 +6
WP 2	Elaboration and design of selected concept(s) for all 3 use cases, taking the existing plant design of the topic manager into account ▪ CAD design of plant system ▪ Development of plant control ▪ Integration of existing controller at topic managers facility ▪ Simulation of manufacturing process for all 3 use cases ▪ Integration and modification of thermoplastic welding technology	t_0 +12

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 3	Manufacturing and set up of full size automated plant systems for demonstration of the use cases thermoplastic welding of *Longitudinal Joint* and *Circumferential Joint* ▪ Ordering and manufacturing of sub-components ▪ Pre-integration of sub-modules and first tests at the partners facility ▪ Integration of automated plant at topic managers facility	t_0 +18
WP 4	Start-up of automated plant system, first tests, optimizations and process development of joining technology in collaboration with the topic manager ▪ Start-up of system components ▪ Programming and optimization of automated units ▪ Development of full scale automated welding process of *Longitudinal Joint* and *Circumferential Joint* using adapter elements between fuselage shells	t_0 +24
WP 5	Final tests of joining processes on full scale multifunctional fuselage demonstrator ▪ Final tests of joining processes ▪ Preparation for final joint processes of multifunctional fuselage demonstrator ▪ Final demonstration of industrialized automated joining processes ▪ Validation and documentation of results	t_0 +30
WP 6	Demonstration and tests of robustness as well as reproducibility of joining processes with the validated automated plant system ▪ Supporting for the topic managers activities ▪ Multiple joining tests and analysis of disturbance behavior ▪ Investigations on joining accuracy and reproducibility ▪ Process variations ▪ Analysis and simplified tests for further use-cases and applications	t_0 +36

3. Major deliverables/ Milestones and schedule (estimate)

Milestones			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Design and selection of manufacturing concepts completed	Report	t_0 +6
M2	Elaboration and design of selected concept(s) completed	Report, CAD data	t_0 +12
M3	Set up of automated plant system completed	All hardware components ready for start-up	t_0 +18
M4	Start-up phase and process development completed	Tested automation system with full functionality	t_0 +24
M5*	Final tests completed and process evaluated	Report	t_0 +30
M6	Robustness and reproducibility evaluated	Demonstration	t_0 +36

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Preliminary concepts	Report/Presentation	t_0 +3
D 1.2	Final evaluated and selected concepts	Report	t_0 +6
D 2.1	Preliminary design	Presentation & CAD data	t_0 +9
D 2.2	Final elaborated design	Report & CAD data	t_0 +12
D 3	Automated plant system	All automation components like tools, end-effectors and programs	t_0 +18
D 4	Tested functionality of plant system and optimized joining process	Demonstration	t_0 +24
D 5*	Final evaluation of joining processes in full scale	Report & Demonstration	t_0 +30

**This is a critical deliverable and milestone in terms of interactions with the overall consortium as well as the time schedule of the multifunctional fuselage demonstrator. For this reason, the validation of the full scale joining process is scheduled due to the date t_0 +30 and not to the end of the project.*

	Year 1				Year 2				Year 3			
Activity *months → t_0*	+3	+6	+9	+12	+15	+18	+21	+24	+27	+30	+33	+36
Design and selection of manufacturing concepts for full size automated plant systems regarding 3 use cases: Longitudinal Joint, Circumferential Joint and Assembly on open Fuselage	D	M D										
Elaboration and design of selected concept(s) for all 3 use cases, taking the existing plant design of the topic manager into account			D	M D								
Manufacturing and set up of full size automated plant systems for demonstration of the use cases: Thermoplastic welding of Longitudinal Joint and Circumferential Joint						M D						
Start-up of automated plant system, first tests, optimizations and process development of joining technology in collaboration with the topic manager								M D				
Final tests of joining processes on full scale multifunctional fuselage demonstrator										M D		
Demonstration and tests of robustness of joining processes with the validated automated plant system												M

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

The Applicant shall be a worldwide operating and leading expert in the development, realization and supply of automation systems possessing additionally the skills and capacities necessary for the implementation of an innovative project within the aerospace industry. Furthermore, the applicant must have extensive experience in the realization of automation systems for large aerospace components. In the following, further special skills are listed:

- Capabilities in development, realization and supply of flexible automation solutions
- Capabilities in development, realization and supply of flexible jigs, end-effectors and automation equipment
- Knowledge in automation of bonding processes for primary structures in aerospace industry
- Capabilities in sensor guided automation processes for joining
- Knowledge in handling of large CFRP elements
- Capabilities in development, realization and supply of software for communication between versatile and mobile systems for automated assembly lines
- Knowledge in simulation and virtual commissioning of automated systems
- Proven expertise in the set-up of automation plants for large aircraft components
- Established supplier for the aircraft industry

XIII. Design and development of smart sensors for detection of human cognitive states implementable in cockpit environment

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 3.1.4.9		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	Honeywell International	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[13]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-03-13	**Design and development of smart sensors for detection of human cognitive states implementable in cockpit environment**
Short description	
The applicant(s) will be responsible for research, design and development of advanced sensing hardware that reduces intrusiveness and improves performance with respect to state of the art. The novel sensors will be prepared for installation in a Business Jet/Large Passenger Aircraft cockpit in compliance to regulations.	

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

1. Background

In the Platform 3 of Large Passenger AircraftIADP, an activity related to Pilot State Monitoring in Business Jet cockpit aims at developing a prototype of a system that will initially detect drowsiness/sleep and in a second step enable real time monitoring of pilot workload during operations in an aircraft cockpit.
Integrating Pilot State Monitoring technology in a Business Jet cockpit improves fatigue risk management by detecting drowsy crew member, thus contributing to a safer flight.

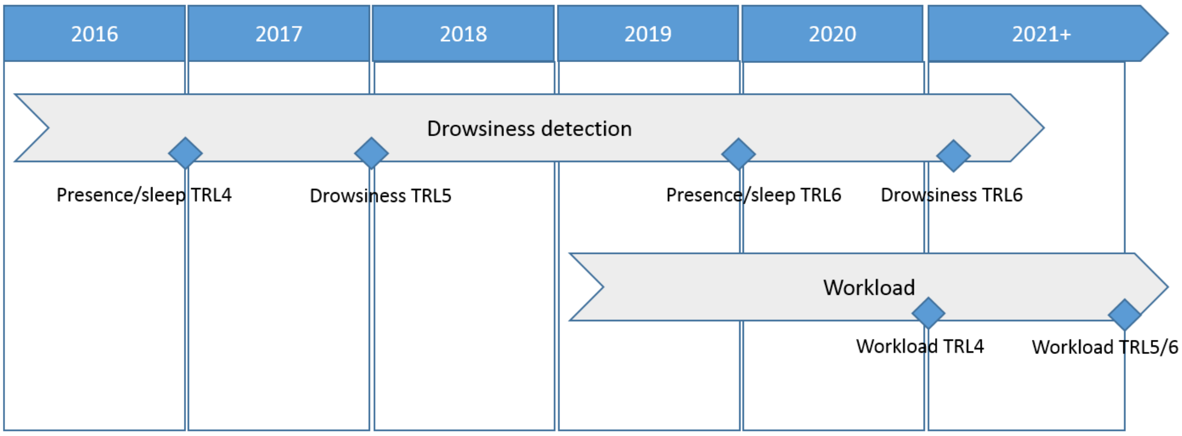
In commercial aviation, fatigue has been classified by NTSB as a "most wanted risk" and by NBAA as a "key hazard" since excessive fatigue, and sometimes two sleepy crew members, contributes indirectly or directly to 70% accidentology.

Key contributors to fatigue are long haul flights and deprived sleep (typically less than 5 hours). Long Range Business Jet crew members can be significantly impacted by those conditions.
FTL regulations being in place for Business Jets today, a 3rd crew member would have to be present for long haul flights without any Pilot State Monitoring technology in the cockpit.

Pilot State Monitoring in Business Jet cockpit will allow for flights without a 3rd crew member at no additional risk compared to today's standard, providing that a drowsiness detection system can prevent the sole crew from falling asleep when the other crew member is sleeping. In this respect, Pilot State Monitoring technology contributes to the competitiveness of European Business Jet thanks to the design of an optimized cabin layout.

In the Platform 3 of Large Passenger AircraftIADP, the topic leader started developing a prototype based on COTS sensors which is acquiring biological and behavioral data that are interpreted in machine learning module with respect to sleep/drowsiness & presence. The sensors are placed in a cockpit simulator regardless of installation restrictions within a real aircraft cockpit.
A pool of sensors that provide data for fusion and interpretation regarding the state of the pilot was initially selected based on their applicability in sleep/drowsiness & presence detection as well as on experience in other industries such as automotive.
It is intentended to keep maturing this prototype with the integration of a new generation of sensors specifically developed for long-term state inference in aircraft cockpit. Those sensors should be the outcome of this topic and are intended to detect sleep/drowsiness and presence. They should take into account the requirements of their integration into a cockpit, and particularly be non-intrusive with a high acceptance factor by the crew.

The maturation of the different bricks of the technology is scheduled as follows:



2. Scope of work

The applicant shall design and develop advanced sensing hardware for the purpose of Pilot State Monitoring in a Business Jet cockpit. The sensing hardware will respect data transfer interfaces defined by the topic leader before the start of the project and will be integrated by the topic leader into a prototype in accordance with integration guidelines provided by the applicant.

It is expected to depart from existing sensors already developped for different applications in other industries (e.g. automotive, biomedical) and the project will drive their adaptation and maturation to meet the requirements of the aerospace industry.

The applicant will be able to propose at least two different sensing technologies to meet the objectives of the project.
To date, because of for their high acceptance in the cockpit and their potentiality in terms of biodata measurement, the preferred technologies are:

- vision sensors that can be integrated in the dashboard (e.g remote eyetracker, 3D cameras, etc…)
- sensors that can be integrated into a pilot seat (e.g. pressure sensors, electrocardiogram, etc…)

Nevertheless, the applicant(s) have the flexibility to propose other innovative technologies that he foresees fit for purpose.

There are three main technical challenges that the applicant will have to address with the novel sensor designs in order to provide robust and reliable detection of biosignals or physiological markers

- The ability of the human operator to perform his tasks must not be limited. In particular, pilots frequently move while seating to operate controls in the cockpit. Unlike in automotive, the frontal view of head is not conserved for most of the time as pilots monitor several displays in the cockpit.
- The environmental conditions change frequently and may alternate between extreme values in short time. Specifically, the effect of varying lighting conditions, vibrations and inertial forces must be considered.
- The cockpit environment provides limited resources in terms of placement, space and power supply.

In order to successfully solve the challenges, the applicant will review his current sensor solution and design improvements to the sensor hardware to meet detailed requirements provided by the topic leader. As part of the work, it is expected that certain level of signal pre-processing will be performed inside the sensor.

The applicant will create software API to allow for data transfer from the sensor to the analytics prototype under development. The API will be defined in cooperation between topic leader and applicant(s) and will allow for exchange of signal data in close to real time conditions. The signal data consider a respective biosignal as well as associate quality descriptors – noise ratio, signal validity etc.

The performance of the novel sensors will allow to detect via the analytics prototype the human psychological states of incapacitation, sleep and drowsiness, and in the longer term also a states of stress and workload.

The existing analytics protype being based on state-of-the-art COTS sensors, the technologies developped in this topic should have the following features:

- SmartEye cameras for facial features (head roll and yaw, eye opening dimension and optionally derived metrics such as PERCLOS)
- Empatica wrist band for heart rate and electro-dermal activity
- Binary 3x3 pressure sensor array for movement and posture detection

Unlike the state-of-the-art COTS sensors, the new generation sensors will acquire bio-signals without any direct skin contact with the pilot and pilots will interact minimally with the sensors in terms of personal adjustments or calibration. An exception could be accepted for sensors newly integrated to devices that are already in contact with the pilot such as goggles, headsets, etc...

Also non-intrusive sensors shall not obstruct behavior of the pilot in the cockpit nor obstruct the view of the pilot to any control or display in the cockpit or out of the window. Finally, they shall not create nuisance nor distractrion to the pilots.

The topic leader will validate the solution in the cockpit of Falcon 7X bussines jet aircraft and as part of the requirements in the beginning of the project, the topic leader will provide specification of cockpit geometry and resource limits for space and power supply. The applicant will assure the compliance of sensors to this specfication and will assist the topic leader in integration of the sensors in the cockpit and with the analytics prototype.

The outcome of this project will be a prototype of a system based on a sensor suite, integrated in a representative environment of a Business Jet aircraft cockpit for validations at TRL 6.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
Task 1	**Specification of new sensors for aircraft cockpit** **Description:** Based on the topic leader high level requirements and cockpit geometry provided at the start of the project, the applicant shall specify target CTQs of each sensor that the applicant will mature. The CTQs must consider all key elements enabling a route to exploitation. The specification shall contain feasibility study explaining how the CTQs will be met. **Result:** Report	Q1 2019
Task 2	**Application of sensor data for assessment of human operator state** **Description:** The applicant shall develop a software interface (API) that allows for real-time assessment of markers for human operator state. The task covers spatial/temporal resolution of signal, algorithms for signal pre-processing on sensor hardware to reduce data traffic and means of data transfer from the sensor to the prototype of Pilot state monitoring system. **Result:** SW API for data acquisition from a sensor with API documentation	Q3 2019
Task 3	**Design and development of sensors** **Description:** The applicant shall design and develop sensor hardware to meet specified CTQs. The sensors shall meet CTQs in laboratory environment at applicant's facility **Result:** sensor HW and laboratory test report	Q3 2020
Task 4	**Validation of sensors in relevant environment** **Description:** The applicant shall contribute to setting up a validation in relevant environment, e.g. aircraft simulator. The applicant shall support the integration of his sensors into the Topic Leader's environment. Potential integration into aircraft for flight testing if any is not under the responsibility of the applicant. **Result:** instruction documents and physical assistance	Q4 2020
Task 5	**Deployment of sensors in relevant environment** **Description:**The applicant shall provide a thorough documentation for the final integration of his sensors in a real cockpit. The documentation shall cover required resources, necessary wiring, spatial restrictions and feasibility of compliance to regulations. **Result:** Installation documentation	Q2 2021

3. Schedule for Major Deliverables/Milestones (Estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1	Sensor specification and regulation compliance	R	Q2 2019
D2	Algorithms for signal refinement and interpretation	R	Q3 2020
D3	Improved sensors and cockpit integration	HW	Q1 2021
D4	Validation report	R	Q2 2021

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

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

- Design and manufacturing of sensors for one or more of mentioned biological signals. The efficient design of the sensor requires basic understanding of physiology related to the biosignal that the sensor should detect.
- Digital signal processing and methods for improving signal quality for detection of low amplitude signals in noisy environment.
- Ergonomics for designing solution that does not affect the activity and comfort of pilots especially in long term monitoring.
- Design and manufacturing for aviation or other transportation industry with unstable environment, spatial constraints.
- Understanding of regulations in aviation on applicable materials and methods for signal acquisition.

5. Abbreviations

API	Application Programming Interface
COTS	Commercial Off The Shelf
CTQ	Critical To Quality
ECG	Electrocardiogram
fNIR	Functional Near-InfraRed spectroscopy
FTL	Flight Time Limitation
NBAA	National Business Aviation Association
NTSB	National Transportation Safety Board
TRL	Technology Readiness Level

XIV. Innovative validation methods and tools for FMS

Type of action (RIA or IA)	IA		
Programme Area	LPA		
Joint Technical Programme (JTP) Ref.	WP 3.5		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Thales Avionics	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[14]	Q2 2018

Topic Identification code	**Topic Title**
JTI-CS2-2017-CfP07-LPA-03-14	**Innovative validation methods and tools for FMS**
Short description	
The objective is to avoid late detection of inadequate design and accelerate maturity growth of new functions within FMS product by increasing drastically the FMS operational exposure, by securizing the whole data chain from originator to embedded FMS product, and by extracting value from larger amount of simulated trajectory data with big data mining techniques.	

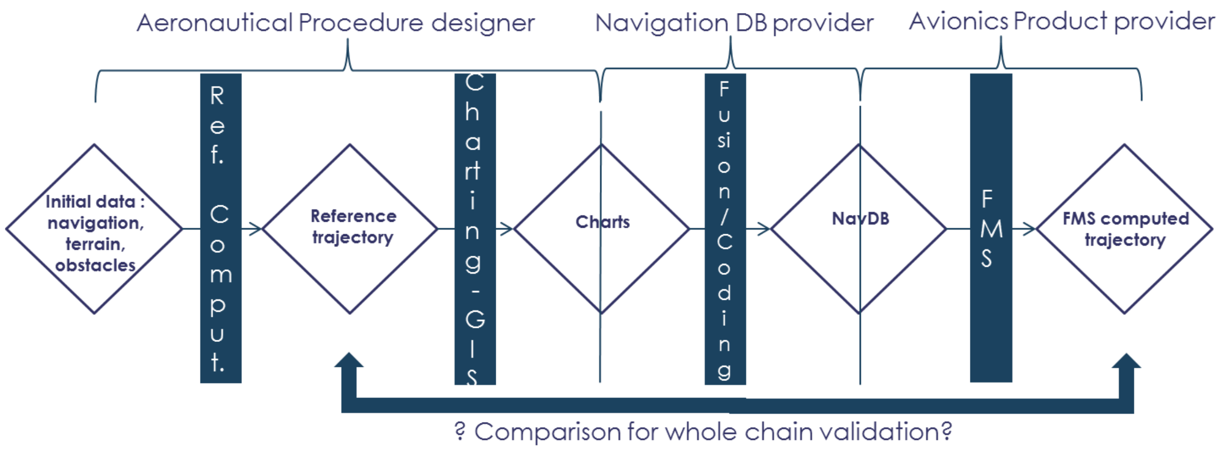
[14] The start date corresponds to actual start date with all legal documents in place.

1. Background

The Flight Management System (FMS) avionic product uses lots of data and specifically a navigation Data Base containing, among other data, coded departure and approach procedures for taking off or landing at airports.

The corresponding end-to-end data chain include three consecutive steps :

- Design of the aeronautical procedures described in charts
- Coding of these procedures into a navigation data base
- Generation on board within avionics by the FMS of the corresponding reference trajectory to be flown for a specific mission



Today, the above steps are considered independently.

An end-to-end validation of these steps, although such an approach has never been performed, would be highly beneficial. Indeed it would :

- improve flight safety by securing the whole data chain from originator to embedded FMS product, when flying high precision trajectories such as RNP AR and/or RNAV visual procedures,
- offer extended demonstration means to aviation authorities to accelerate validation of new procedures.

The Flight Management System is also a very complex avionic product by itself : indeed it is a very open system, meaning multiple interactions from the crew are permitted to initialize the mission, perform flight plan revision during its execution (around 160 ways of altering it !), and tune parameters. This high combinatorics explains why, even if certified, problems on usage are still reported by airlines during commercial operations.

In order to validate new Cleansky functions to avoid late detection of inadequate design, and to achieve a maturity objective at end of CleanSky II compatible with insertion of these functions into a civil transport disruptive cockpit platform, increasing drastically the FMS operational exposure is then a must have .

From this perspective, it is necessary to be able to cope with a number of simulations at least an order of magnitude (a few tens of millions of trajectories) larger than what is classically done during validation and verification steps.

It will require also to significantly improve FMS tests analysis by extracting value from very large amount of trajectory data with big data analysis and data mining techniques. The performance objective here is to decrease the analysis duration from 2 weeks to one day : this will offer a new horizon for the maturity and robustness of new capabilities.

2. Scope of work

The final objectives are to:

i. Quantify and qualify offsets between the theoretical trajectories and computed trajectories by FMS for departure and approach procedures. Issue recommendations upon design and sizing for procedures, and coding rules, and comfort FMS computation hypotheses,

ii. Enhance FMS system tests in term of level of exposure through acquisition of methods and means for large scale dynamic exposure,

iii. Enhance FMS validation and verification tests analysis to accelerate design maturity through acquisition of data analytics methods and means, to be applied to the very large simulation tests sets obtained.

i) With regards to approach procedures, combined validation of procedure design/coding on one side, and trajectory computation by FMS on the other, is required to validate more easily and speedily new chart production, and in case of anomaly to isolate and allocate defects sources either to procedures definition or to FMS computations.

The concrete expected activity is to define and implement comparison means between a ground computed reference theoretical trajectory underlying procedure definition and an FMS generated one.

Hence expected work encompasses the following items :

- Specification of comparison algorithms upon distance measures between the two trajectories and threshold criteria
- Development and validation of comparison tool

ii) Intensive validation within a representative operational environment is required to acquire FMS design maturity for new CleanSky functions.

The objective is here to define and prototype a virtual crew module for FMS IVV means aimed at emulating pilots actions, thus allowing large scale dynamic testing.

Expected work is aimed at increasing the representativity of the tested set of crew interactions. It includes :

- Definition and prototyping of means allowing to :
  - Generate and insert synthetic perfect pilot actions scripts through simulation facility or FMS man-machine interface
  - Generate and insert synthetic pilot unexpected/imperfect actions scripts through same items (late pilot actions for instance)
  - Insert post flight analyzed or recorded pilot actions script for replay on simulation facility

iii) Intensive testing required to perform new CleanSky functions operational validation implies a significant reinforcement of FMS validation and verification through the analysis of a very high volume of computed trajectory data as test results (a few tens of millions of trajectories) . To cope with that a change of paradigm for tests analysis is sought after by introducing classification prior to detailed "abnormal"cases analysis

Expected tooling for that is a set of data analytics tools.

Expected work encompasses:

- Definition and implementation of methods and means to store and archive trajectories computed by FMS in a data warehouse
- Structured trade-off of data mining methods and tools (statistics oriented : 'R', Statistica, … ; classification oriented : WEKA, Orange, Python library) for :
  - Trajectory anomaly / outlier detection
  - Unstructured classification of FMS produced trajectories : correlation analyses and clustering
- Provision of a customized tooled up set including the selected functional bricks and MMI facilities allowing :
  - Data storing, data preprocessing (local features extraction, global trajectory characterization aids), data clustering

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	Technical resources and problem definition	T1 + 5 months
WP2	Innovative FMS validation methods and tools design	T1 + 10 months
WP3	Innovative FMS validation methods and tools development	T1 + 16 months
WP4	Innovative FMS validation methods and tools validation	T1 + 21 months
WP5	Support and evolution	T1 + 24 months

This work could benefit from:

- the collaboration with approach procedures providers,
- the experience of Advanced Research Institutes with a strong background on data analytics,
- an industrial experience with regards to aeronautical navigation products.

WP1 : Technical resources and problem definition

The objectives of this work package are to:

- describe technical resources :
    - characteristics of FMS generated trajectories obtained by simulation
    - input data for combined analysis of procedure reference trajectory and FMS generated one,
    - status on applicable methods to FMS generated trajectories classification, both from a local view and from a global one
- define technical problem :
    - actions to be modelled, use cases & functional scope spanning for a virtual crew module
    - core parameters and criteria for procedure reference trajectory and FMS generated one comparison
    - FMS trajectories data warehouse organization and sizing, tooled up suite architecture
- define technical requirements for :
    - comparison of procedure reference trajectory and FMS generated one,
    - virtual crew module and replay of test scenario (capabilities and interfaces) ,
    - data analytics studio including data warehouse for simulated trajectories, processing components for outlier detection and trajectories classification and user MMI.

WP2 : Innovative FMS validation methods and tools design

After the specifications, the methods and tools design process should convert them into solutions.

Consequently, the objectives of this work package are to:

- define and describe solutions for trajectory comparison (external interfaces, internal parameters, relations between external interfaces and internal parameters),
- define and describe solutions for virtual crew model (external interfaces, replay capability),
- select and describe solutions for trajectories data warehouse and data analytics studio (external interfaces, replay capability),

* give a first description of validation tests according to technical requirements defined in WP1 for the three items (combined procedure/FMS validation comparison tool, virtual crew model, data analytics studio)
* define and describe a preliminary validation plan (scenarii, criteria) for the above three items

WP3 : Innovative FMS validation methods and tools development

The objectives of this work package are to:

* develop comparison tool for combined procedure/FMS validation according to the design established in WP2,
* develop virtual crew model according to the design established in WP2,
* develop trajectory data warehouse, data analytics building blocks and user MMI ; perform unit testing and integration of these components

WP4 : Innovative FMS validation methods and tools testing

The objectives of this work package are to:

* define detailed validation test plan for the three items (combined procedure/FMS validation comparison tool , virtual crew model, data analytics studio)and description of testing chains,
* develop testing means,
* apply validation test plan and analyse results.

WP5 : Support and evolution

The objective of this work package is to provide a support for possible problem fixes or evolutions.
This WP shall guarantee the maintenance of the developed components until the end of the project by providing fixes of the last unsolved anomalies and the delivery of the final version.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Technical Resources and Problem Definition Document (V1)		T1 + 2 months
D1.2	Technical Requirement Document (V1)		T1 + 4 months
D2.1	Comparison tool Description Document (V1)		T1 + 8 months
D2.2	Virtual crew and replay capability model Description Document (V1)		T1 + 8 months
D2.3	Data analytics Description Document (V1)		T1 + 9 months
D2.4	Validation Test Plan (V0)		T1 + 9 months
D3.1	Comparison tool Package Delivery (V1)		T1 + 14 months
D3.2	Virtual crew and replay capability model Package Delivery (V1)		T1 + 14 months

Deliverables			
Ref. No.	*Title – Description*	*Type*	*Due Date*
D3.3	Data Analytics Package Delivery (V1)		T1 + 15 months
D4.1	Validation Test Plan (V1)		T1 + 17 months
D4.2	Validation Test Report Delivery (V1)		T1 + 20 months
D5.1	Tools Packages Delivery (V2)		T1 + 23 months
D5.2	Update of previous documents if required(V2)		T1 + 23 months

Milestones (when appropriate)			
Ref. No.	*Title – Description*	*Type*	*Due Date*
M1	Prototypes Development Readiness Review		T1 + 10 months
M2	V1 Results Review		T1 + 21 months
M3	Final Acceptance		T1 + 24 months

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

Skill 1: Approach procedure charts design

Whatever the solution for , the partners shall demonstrate that they have in depth knowledge of how approach procedures charts are derived from an initial data set. With respect to input data, this includes capture, storage, analysis, data curation, data use, visualization, querying, updating.

Skill 2: Data Analytics technologies

This topic implies a strong request for innovation on trajectory data analysing processes including outlier detection and classification functions design (beyond use of classical methods). The partners shall demonstrate that they have the knowhow and the background in data analytics domain. They could benefit from experience of advanced research institutes.

5. Abbreviations

FMS	Flight Management System
IVV	Integration, Validation and Verification
RNP AR	Required Navigation Performance Authorization Required

5. Clean Sky 2 – Regional Aircraft IADP

I. Full scale innovative composite frames and shear ties for Regional Aircraft Fuselage barrel on-ground demonstrators

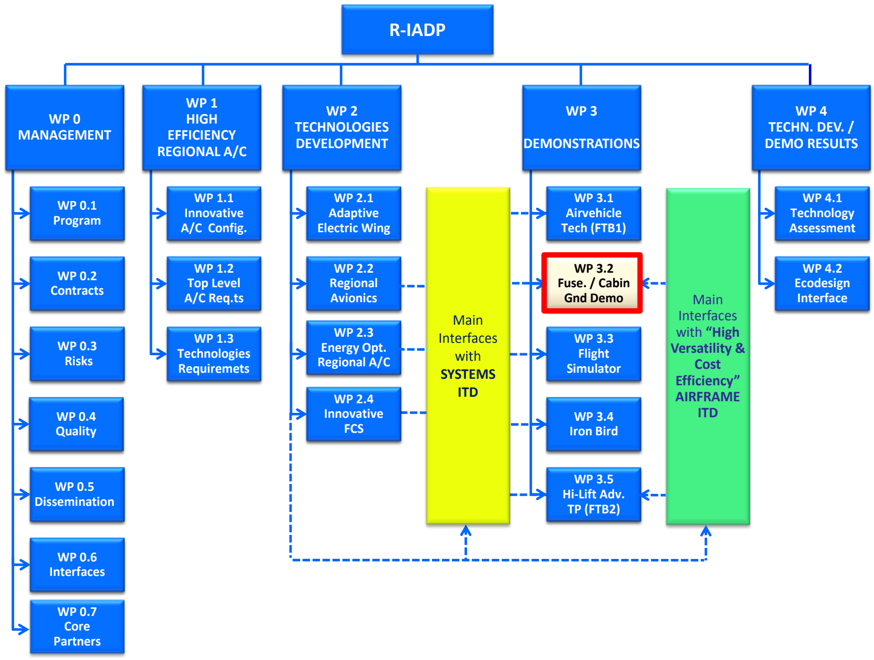
Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 3.2		
Indicative Funding Topic Value (in k€)	2100		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	16	**Indicative Start Date**[15]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-REG-01-11	**Full scale innovative composite frames and shear ties for Regional Aircraft Fuselage barrel on-ground demonstrators**
Short description	
Validation at full size level of CFRP frame and shear tie manufacturing process (Thermoplastic / Infusion) and fabrication of 2 shipsets for Regional Aircraft Fuselage barrel on-ground demonstrators. Moreover an industrial and cost evaluation based on a pre-defined production business case is requested.	

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

1. Background

Activities to be performed according to the present Topic description are included in a wider context of work in the framework of the Regional Aircraft IADP of Clean Sky 2. In particular, the Work Package 3.2 “Fuselage/Cabin Integrated Ground Demonstrator” represents the field where activities requested to the Applicant shall be performed. The relevant Work Breakdown Structure is shown below putting in evidence the WP 3.2:



More in detail, the activities will cover the definition, design, manufacturing, assembling and on-ground testing phases for full-scale structural Fuselage and passenger Cabin demonstrators representative of a Regional Aircraft.

Innovative low cost and low weight technologies shall be intagrated into the Fuselage structural demonstrator with the objective to obtain: structural weight reduction, manufacturing recurring cost reduction, maintenance improvement and implementation of new eco-compatible materials and processes.

Innovation based on an human-centered-design approach and on board systems shall be intagrated into the passenger Cabin demonstrator with the objective to obtain: improvement of cabin comfort and wellbeing, cabin interiors weight reduction, cabin interiors manufacturing recurring cost reduction, implementation of new eco-compatible materials and processes.

2. Scope of work

Actually thermoset composite materials are currently used in a wide range of applications in the aerospace industry in order to reduce weight and to optimise corrosion resistance and directional performances compared to metallic solutions.

Nevertheless, today reference for fuselage frames/shear ties is metallic technology because composite standard manufacturing processes are not convenient due to higher recurring costs.

For this reason, in order to take full benefit of the composite properties for a future regional Turbo Prop aircraft development, the focus needs to be on manufacturing time reduction through innovative concepts and technologies such as liquid resin infusion and thermoplastics processes.

Researches carried out in recent years and still nowadays on-going are proving the technical feasibility of liquid infusion and thermoplastic material based processes to manufacture structural aeronautical components, but they need to be up-scaled at industrial level, upon checking the technical, economic and environmental impact in real productive conditions.

The scope of the present Topic is therefore the fabrication of regional aircraft composite fuselage frames (typical frames and "door surround" frames), shear ties and related splices, using advanced and innovative industrial manufacturing processes that allow a significant reduction of part weight (with a consequent reduction of operating costs for airlines) with at least same overall production costs, compared to traditional metallic solutions.

To achieve this objective, the main activities requested to the selected Applicant are divided and described in the tasks listed in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Process set up and validation at full size level	M0+8
2	Parts fabrication for on-ground fuselage demonstrators	M0+16
3	Industrial cost evaluation	M0+16

a) **Task 1: Process set up and validation at full size level**

In the present task the selected Applicant, on the basis of material and technology identified by Topic Manager and to be detailed at KOM, is requested to identify the best choices regarding process details, driven by manufacturing costs reduction and high volume industrial applicability.

The Applicant will then fabricate a full scale part for each of the representative families, verifying the compliance with drawing requirements through destructive and non destructive characterization, in order to validate and freeze process steps and parameters for final demonstrators.

The following fabrication processes and materials shall be preliminary considered for all Frames:

- RTM process with the selected materials coming from COFRARE 2.0 Call for Proposal (RTM 6 resin system and Dry NCF Preforms with carbon fibers);

The following fabrication processes and materials shall be preliminary considered for Shear Ties and Splices:

- Thermoforming process with thermoplastic material PPS/carbon T300J 5HS;

The final manufacturing technologies (material and process) for each part family will be confirmed and detailed by Topic Manager during the KOM.

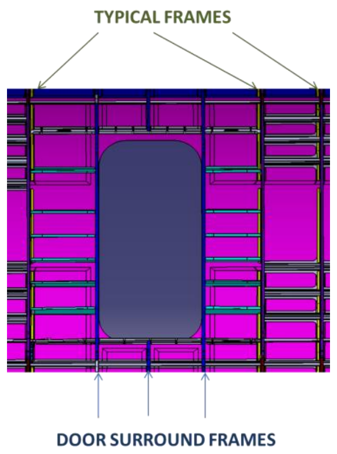
In details the following activities shall be performed by the selected Applicant:

- Selection of the most economical process details for high volume production.
- Purchasing of all materials needed for parts fabrication (deliverable and auxiliary).
- Design and construction of necessary tools for full scale manufacturing trials.
- Availability of necessary facilities/equipments.
- Process parameters set up.
- Manufacture of representative full scale items (1 for frame and 1 for shear tie) to be selected, in accordance with Topic Manager, among part families described in Task 2.
- Manufacture of NDI standard on the basis of information that will be provided by Topic Manager.
- Visual analysis, dimensional check and ultrasonic inspection of each full scale manufacturing trial.
- Destructive characterization (micrographic and chemical-physical) of each full scale manufacturing trial to check/quantify possible internal defects, such as porosity, delamination, inclusion, wrinkles, resin richness, resin content, fiber volume, etc.
- "Producibility Report" issue to verify parts producibility in accordance with drawing requirements using the selected innovative process.
- "Manufacturing Process Control Document" issue, describing all process parameters and manufacturing steps to be used for final Demonstrators.

b) **Task 2: Parts fabrication for on-ground fuselage demonstrators**

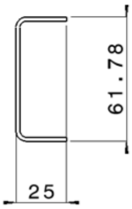
Topic Manager Company is responsible for design and sizing of the parts object of the present Call, while the selected Applicant is responsible for manufacturing of Frames, Shear Ties and Splices to be assembled (at Topic Manager facility) on N°2 on-ground composite fuselage demonstrators (one for structural test and one for comfort analysis).

Each fuselage frame is composed by 3 sectors (crown, side, keel) joined by means of 3 frame splices. Each sector has a C-section shape and a curvature radius of about 1700 mm.

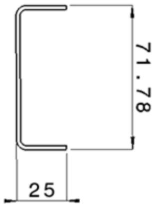


For typical frames, the crown sector has a constant height, while side and keel sections have height variation in zones where the floor beams are connected to the frames.

Preliminary dimensions/thicknesses for typical frames are shown in the pics below:

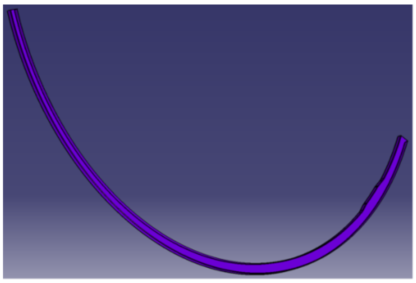


Constant Height Section

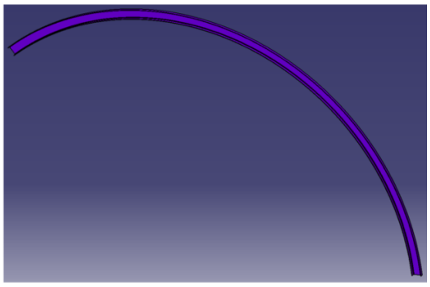


Height in Floor Connection Section

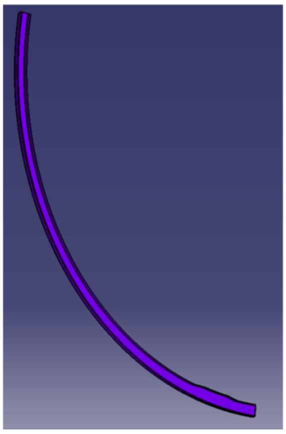
Thickness Crown section: 3,2 mm
Thickness Side section: 2,4 mm
Thickness Keel section: 4.6 mm



Keel Sector
4144mm arc lenght

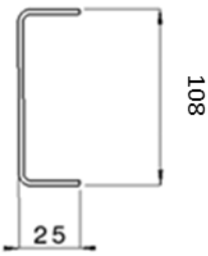


Crown Sector
3673mm arc lenght



Side Sector
2753mm arc lenght

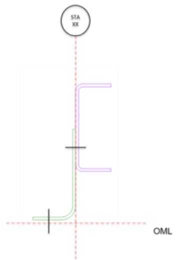
Preliminary dimensions/thicknesses for “door surround” frames are shown in the pics below:



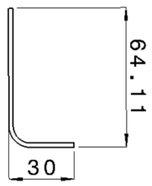
Thickness Door Surround
section: 4.6 mm

Height of Door Frames

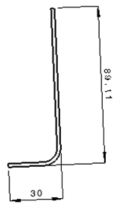
Each frame is connected to the fuselage skin by means of shear ties as per the following sketch:



Each shear tie has L-section shape and preliminary dimensions/thicknesses are shown in pics below:



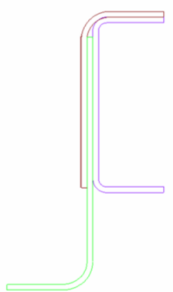
Thickness Crown sector: 2.4 mm
Thickness Keel sector: 4.6 mm

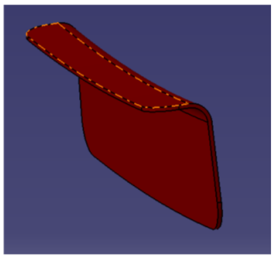


Thickness: 4.6 mm

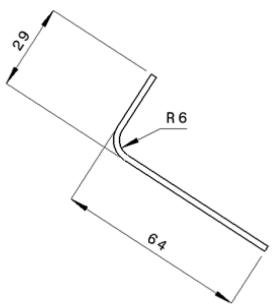
Due to the variability of stringer bays, shear ties aren't of the same length (approximately between 150 and 700 mm), but they can be collected in families of the same geometry. At the present day 3 families of shear ties are foreseen. Also joggles in the flange to be connected with the skin can be introduced.

The three sectors of each single frame are joined by means of splices.





Each splice has a L-section shape and preliminary dimensions are shown in picture below:



Thickness Crown sector: 3.2 mm
Thickness Keel sector: 4.6 mm

The preliminary total number of frames, shear ties and splices are provided in the following table:

Items	Quantity for each Demonstrator
Frame Sectors	42
Frame Splices	42
Shear Ties	~380

The preliminary condition of supply of the parts are the following:

- All parts should be trimmed in accordance with drawings
- The typical frames should be drilled (key and coordination holes)
- The door and splices frames should be drilled (coordination and pilot holes)
- The shear ties should be drilled (pilot holes) for first Demonstrator (first and second shipments) while they should be blank (no hole) for second Demonstrator (third and fourth shipments).
- Edge sealing and surface treatments in accordance with drawings.
- it is requested to the selected Applicant to perform n°2 shipments for each Demonstrator, for a total number of 4 shipments. At KOM will be provided the list of the parts for each shipment.

At KOM, the Topic Manager will provide to the selected Applicant the information about:

- Detailed CATIA models
- Final condition of supply

In details the following activities shall be performed by the selected Applicant:

- Purchasing of all needed materials (deliverable and auxiliary) for the fabrication of parts for two final Demonstrators.
- Design and manufacture of tool chains for requested parts.
- Manufacture of items for fuselage demonstrators with selected innovative process.
- Quality Plan issue to be agreed with Topic Manager.
- Visual analysis, dimensional check and ultrasonic inspection for each part.
- Issue of quality Report containing the results of non destructive characterization and weight measurements of each part.
- Shipment of the parts to Topic Manager (Pomigliano d'Arco-Naples Plant)

c) **<u>Task 3: Industrial cost evaluation</u>**

This Task is addressed to evaluate the technical and economical impact deriving from the introduction of the selected innovative technology to allow the Topic Manager to compare it with existing baseline technologies (cost / performance evaluation).

The final cost evaluation analysis shall be performed by selected Applicant who will be responsible for the following activities:

- industrial assessment of non-recurring and recurring manufacturing costs based on the business case to be provided by the Topic Manager at KOM, with particular reference to automated solutions for high volume production.

- detailed report issue, containing:
    - quantities and costs of auxiliary / deliverable materials
    - manufacturing process flow with details about touch labor
    - needed tools and related costs
    - typologies and characteristics of the necessary equipments and facilities

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Detailed schedule	R	M0+1
D1.2	Process selection	R	M0+2
D1.3	Tool design and fabrication	D/HW	M0+6
D1.4	Full scale manufacturing trial fabrication and characterization	HW/R	M0+8
D1.5	Manufacturing/assembly process description	R	M0+8
D2.1	Tool chain fabrication for items manufacturing	HW	M0+12
D2.2	Manufacturing and quality plans preparation	R	M0+8
D2.3	Items fabrication for 1st demonstrator	HW	M0+12
D2.4	Items fabrication for 2nd demonstrator	HW	M0+16
D3.1	Industrial cost evaluation	R	M0+16

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Full scale manufacturing trial fabrication and characterization report	R	M0+8
M2.1	Tool chain availability for parts manufacturing	HW	M0+12
M2.2	1st shipment for 1st demonstrator delivery	HW	M0+10
M2.3	2nd shipment for 1st demonstrator delivery	HW	M0+12
M2.4	1st shipment for 2nd demonstrator delivery	HW	M0+14
M2.5	2nd shipment for 2nd demonstrator delivery	HW	M0+16
M3	Industrial cost evaluation report	R	M0+16

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

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

- Skill 1: Proven competence in design and stress analysis for aeronautical tools manufacturing.
- Skill 2: Proven experience on aeronautical composites manufacturing innovative processes.
- Skill 3: Proven experience on non-destructive inspections. Evidence of ultrasonic NDI qualification shall be provided.
- Skill 4: Proven experience in cost estimation at industrial level for aeronautical full scale composite structures.

5. Abbreviations

CFRP	Carbon Fiber Reinforced Plastics
KOM	Kick Off Meeting
NCF	Non Crimp Fabric
NDI	Not Destructive Inspection
PPS	Polyphenylene Sulphide
RTM	Resin Transfer Moulding

II. Full scale innovative composite doors, surrounds and sub-structure for Regional Aircraft Fuselage barrel on-ground demonstrators

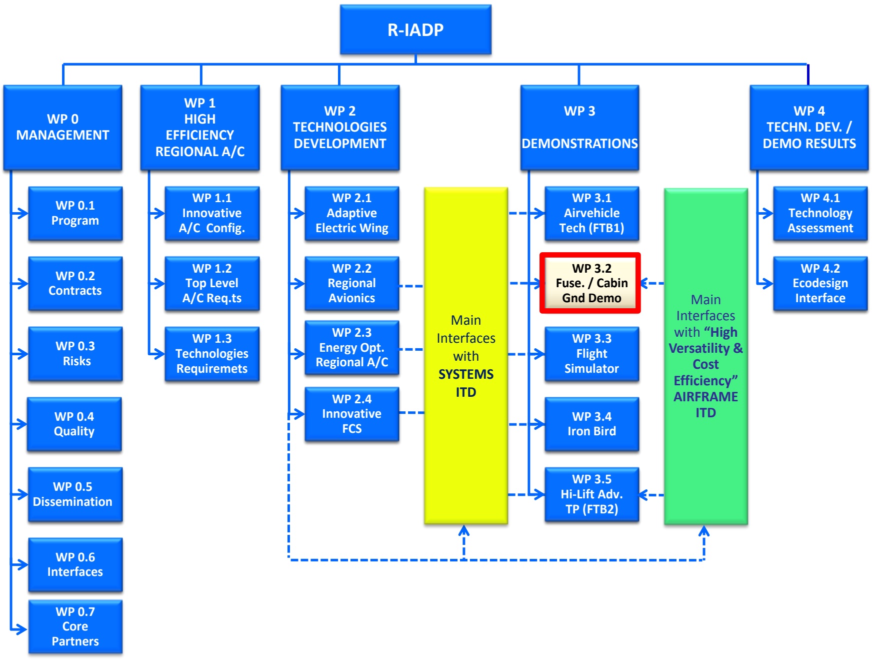
Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 3.2		
Indicative Funding Topic Value (in k€)	1600		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	16	**Indicative Start Date**[16]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-REG-01-12	**Full scale innovative composite doors, surrounds and sub-structure for Regional Aircraft Fuselage barrel on-ground demonstrators**
Short description	
Validation at full size level of major CFRP door components manufacturing process and fabrication of 2 full shipsets of pax and service doors, surrounds and sub-structures for Regional Aircraft Fuselage barrel on-ground demonstrators with the implementation of innovative solutions for components integration. Moreover an industrial and cost evaluation based on a pre-defined production business case is requested.	

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

1. Background

Activities to be performed according to the present Topic description are included in a wider context of work in the framework of the Regional Aircraft IADP of Clean Sky 2. In particular, the Work Package 3.2 “Fuselage/Cabin Integrated Ground Demonstrator” represents the field where activities requested to the Applicant shall be performed. The relevant Work Breakdown Structure is shown below putting in evidence the WP 3.2:



More in detail, the activities will cover the definition, design, manufacturing, assembling and on-ground testing phases for full-scale structural Fuselage and passenger Cabin demonstrators representative of a Regional Aircraft.

Innovative low cost and low weight technologies shall be intagrated into the Fuselage structural demonstrator with the objective to obtain: structural weight reduction, manufacturing recurring cost reduction, maintenance improvement and implementation of new eco-compatible materials and processes.

Innovation based on an human-centered-design approach and on board systems shall be intagrated into the passenger Cabin demonstrator with the objective to obtain: improvement of cabin comfort and wellbeing, cabin interiors weight reduction, cabin interiors manufacturing recurring cost reduction, implementation of new eco-compatible materials and processes.

2. Scope of work

The scope of the present topic is the development and validation of advanced fabrication and assembly processes of doors and their surrounds for regional aircraft composite fuselage which allow a significant reduction of the overall production costs and flows.

Frequently metallic solution is in fact preferable, especially on regional aircraft, given its consolidated fabrication/assembly processes and consequent lower recurring costs.

Therefore innovative processes shall be selected and tested in order to make the composite solution as the better one, within the overall cost balance, for a new regional aircraft.

The activities to be performed are divided in the tasks listed in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Process set up and validation at full size level	M0+8
2	Parts fabrication for on-ground fuselage demonstrators	M0+15
3	Parts assembly	M0+16
4	Industrial cost evaluation	M0+16

a) Task 1: Process set up and validation at full size level

In the present task the selected Applicant, on the basis of material and technology identified by Topic Manager and to be communicated/confirmed at KOM, is requested to identify the best choices regarding process details, driven by manufacturing costs reduction and high volume industrial applicability.

The Applicant will then fabricate a full scale part for each of the representative families, verifying the compliance with drawing requirements through destructive and non destructive characterization, in order to validate and freeze process steps and parameters for final demonstrators.

The following fabrication processes and materials shall be preliminarily considered:

- Thermoforming process with thermoplastic material (PPS matrix and T300 carbon fibers) for doors primary structures.
- Welding technique for thermoplastic beams integration with door skins.
- Thermoset material (977-2 resin system and IMS carbon fibers) for doors surrounds
- Metal machining for fittings installed on doors and door surrounds.

For assembly following processes/materials might be considered as valuable opportunities for innovation and cost reduction:

- One side installation bolt.
- One shot drilling.
- One Up Assembly for composite-composite stack-up.

The final manufacturing technologies (material, process and assembly) will be confirmed and detailed by Topic Manager (TM) during the Kick-Off Meeting (KOM).

The Applicant shall be responsible for:

- Selection of the most economical process/assembly details for high volume production.
- Purchase of all materials needed for parts fabrication (deliverable and auxiliary) and assembly.
- Tool design and fabrication.
- Selection and purchase of the needed equipments.
- Process development and set-up for parts manufacturing, welding and assembly.
- Manufacture of NDI standard on the basis of information that will be provided by Topic Manager.
- Fabrication of a representative full scale item for each family (1 item for doors stiffeners and 1

item for surrounds) and a simplified subcomponent of welded door structure. The item choice will be communicated by TM during KOM.

- Structural testing on welded coupons for verification of mechanical properties. The test matrix and minimum requirements will be communicated by TM during KOM.
- Visual analysis, dimensional check and ultrasonic inspection of each full scale manufacturing trial.
- Simplified Mock-up door assy for innovative assembly technologies validation.
- Destructive characterization (micrography and chemycal-physical analysis) of each manufacturing trial (to check/quantify possible internal defects, such as porosity, delamination, inclusion, wrinkles, resin richness, resin content, fiber volume, etc.)
- “Producibility Report” issue to verify parts producibility in accordance with drawing requirements using the selected innovative processes.
- “Manufacturing Process Control Document” issue, describing all process parameters and manufacturing/assembly steps to be used for final Demonstrators.

b) Task 2: Parts fabrication for on-ground fuselage demonstrators

Topic Manager Company is responsible for design and sizing of the parts object of the present Call, while the selected Applicant is responsible for manufacturing of Doors Assy and doors surrounds to be assembled (at Topic Manager facility) on N.2 on-ground composite fuselage demonstrators (one for structural test and one for comfort analysis).

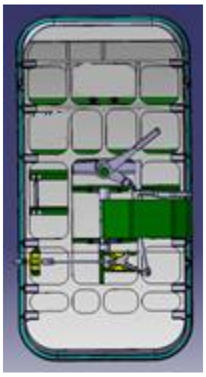


Fig.1 Outbd View

Fig.2 Inbd View

Fig.3 Door Internal structure

In Fig.1-2-3 an overview of the typical plug-tipe door is shown.

The doors overall dimensions are as follows:

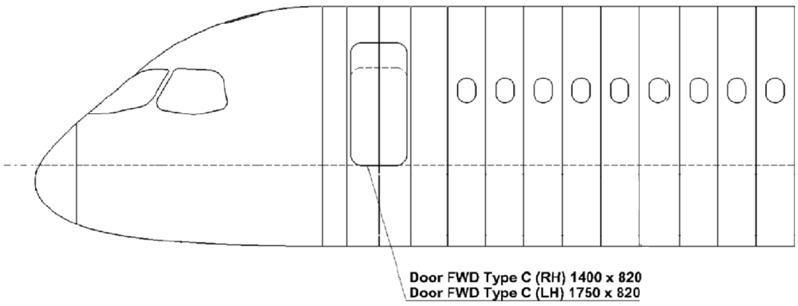


Fig.4 Doors Dimensions

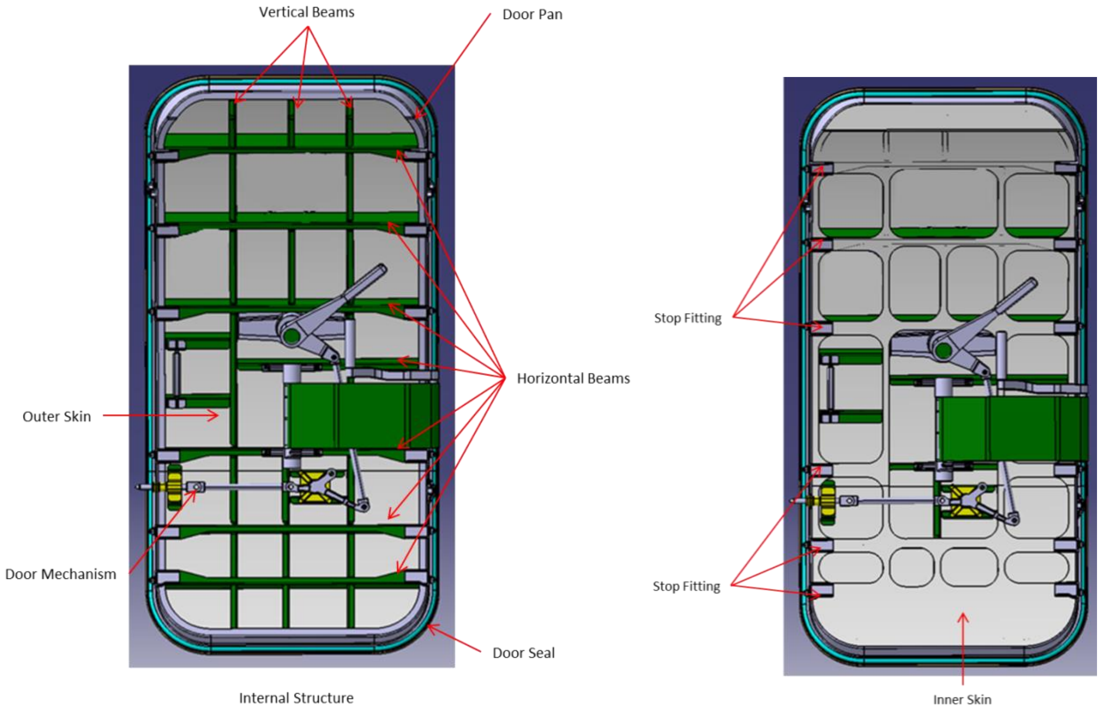


Fig. 5 Door Structure

Elements of both doors are shown in figures 5.

The preliminary conditions of supply of the parts are the following:

- All parts shall be trimmed in accordance to drawings.
- Edge sealing and surfaces treatments in accordance to drawings.

Final part drawings and specific condition of supply will be provided by the TM during the KOM.

Typical door surround structure is illustrated in Fig.6. The applicant shall supply all the longitudinal elements of the door surround (intercostals, upper and lower sills), seal, seal depressor and all the fittings (stop fittings, guides, shoot bolts housings).

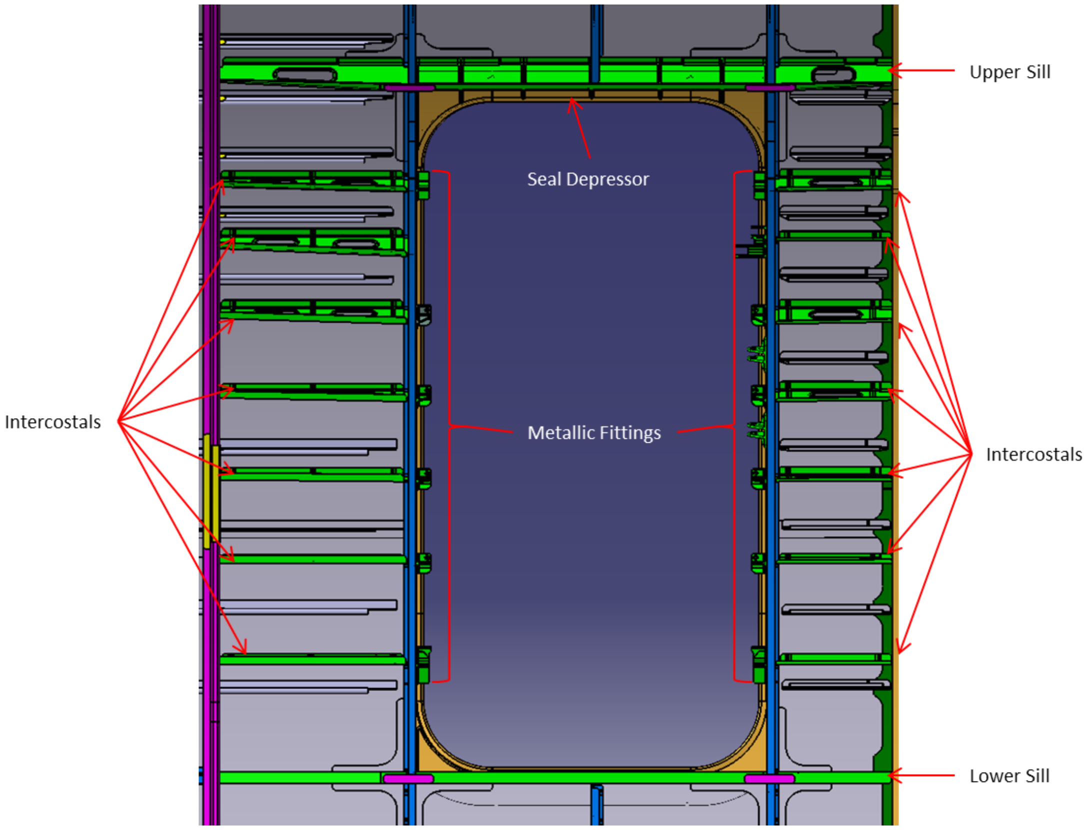


Fig.6 Door Surround

The applicant shall be responsible for:

- Purchase of all materials needed for part fabrication (deliverable and auxiliary).
- Tool chain design and fabrication.
- Metal parts purchasing/machining.
- Fabrication and NDT inspection of all items for the demonstrators.
- Quality Plan issue to be agreed with Topic Manager.
- Issue of quality Report containing the results of non destructive characterization and weight measurements of each part.
- Shipping of all items of door surround to the TM's facility (Pomigliano d'Arco – Napoli Plant). N.1 shipment for each demonstrator is requested to the Applicant for a total number of N.2 shipments. A detailed list of the parts for each shipment will be provided by the TM during the KOM.

c) **Task 3: Parts assembly**

Both demonstrators (Structural demonstrator and cabin demonstrator) will be equipped with a complete set of doors (pax and service). So the following items will be needed:

- N.1 Pax Door Assy for each demonstrator.
- N.1 Service Door Assy for each demonstrator.

The precise number of parts and fasteners will be defined by the TM once completed the final assembly drawings.

Final assembly drawing and specific condition of supply will be provided by the TM during the KOM.

The applicant shall be responsible for:

- Purchase of all needed materials and miscellaneous parts, including fasteners and semi-automatic tools for installation.
- Design and fabrication of assembly jigs.
- Assembly of all items for the fuselage barrel demonstrators.
- Quality Plan issue to be agreed with Topic Manager.
- Quality report of all items including weigth measurements.
- Shipping of all door assies to the TM's facility (Pomigliano d'Arco – Naples plant). N°1 shipment for each demonstrator is requested to the Applicant for a total number of N.2 shipments.

d) Task 4: Industrial cost evaluation

This Task is addressed to evaluate the technical and economical impact deriving from the introduction of the selected innovative technology to allow the Topic Manager to compare it with existing baseline technologies (cost / performance evaluation).

Industrial business case conditions will be provided by the TM during the KOM.

The applicant shall be responsible for:

- Evaluation of industrial recurring and not recurring costs, including fabrication and assembly, based on the above business case. Particular attention shall be given to innovative automated solutions for high volume production.
- Detailed descriptive report containing:
    - quantity and associated costs of deliverable/auxiliary and standard materials;
    - fabrication and assembly phases with relevant cost of labour;
    - types and main characteristics of needed equipments and facilities;
    - list of tools/jigs and related costs.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Detailed schedule	R	M0+1
D1.2	Process selection	R	M0+2
D1.3	Tool design and fabrication	D/HW	M0+6
D1.4	Full scale manufacturing trial fabrication and characterization	HW/R	M0+8
D1.5	Manufacturing/assembly process description	R	M0+8

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D2.1	Tool chain fabrication for items manufacturing	HW	M0+9
D2.2	Manufacturing and quality plans preparation	R	M0+8
D2.3	Items fabrication for 1st demonstrator	HW	M0+12
D2.4	Items fabrication for 2nd demonstrator	HW	M0+15
D3.1	Assembly jig fabrication	HW	M0+12
D3.2	Doors assembly for 1st demonstrator	HW	M0+13
D3.3	Doors assembly for 2nd demonstrator	HW	M0+16
D4.1	Industrial cost evaluation	R	M0+16

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Full scale manufacturing trial fabrication and characterization report	R	M0+8
M2.1	Tool chain availability for parts manufacturing	HW	M0+9
M2.2	1st surround shipset for 1st demonstrator delivery	HW	M0+12
M2.3	2nd surround shipset for 2nd demonstrator delivery	HW	M0+15
M3.1	1st door assies shipset for 1st demonstrator delivery	HW	M0+13
M3.2	2nd door assies shipset for 2nd demonstrator delivery	HW	M0+16
M4	Industrial cost evaluation report	R	M0+16

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

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

- Proven competence in management of complex research projects and manufacturing technologies, including quality and risk assessment capabilities demonstrated in international research projects and/or industrial environment.
- Proven competence in tool design for aeronautical composite part fabrication.
- Proven experience and competencies in the requested technologies for fabrication and assembly of aeronautical composite substructures for aeronautical programs. This competence shall include a strong knowledge of materials and processes, quality, tooling, part programs for NC machines.
- Proven experience in NDT inspections. Evidence of ultrasonic NDT qualification shall be provided.
- Proven experience in experimental testing (micrographic and chemical-physical analysis) at coupon levels. Evidence of laboratories qualification shall be provided.
- Proven experience in cost estimation at industrial level for aeronautical composite components.

5. Abbreviations

CFRP	Carbon Fiber Reinforced Polymer
IMS	Intermediate Modulus Strength
KOM	Kick-Off Meeting
NC	Numerical Control
NDI	Non-Destructive Inspection
NDT	Non-Destructive Technique
PPS	Polyphenylene Sulphide
TM	Topic Manager

III. Full scale Innovative composite windows frames for Regional Aircraft Fuselage barrel on-ground demonstrators

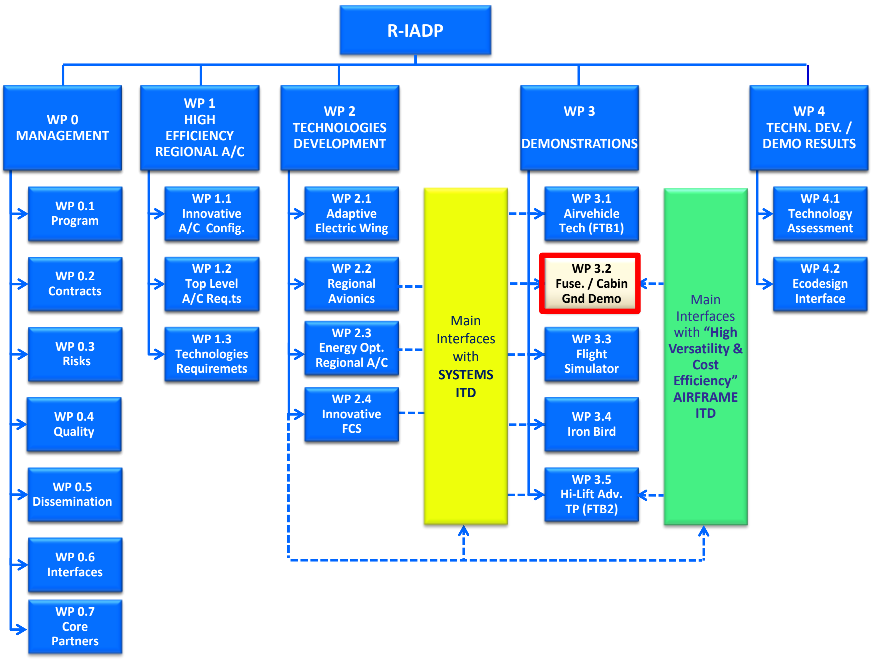
Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 3.2		
Indicative Funding Topic Value (in k€)	680		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	16	**Indicative Start Date**[17]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-REG-01-13	**Full scale Innovative composite windows frames for Regional Aircraft Fuselage barrel on-ground demonstrators**
Short description	
Validation at full size level of CFRP windows frame manufacturing process (Thermoplastic) and fabrication of 2 shipsets for Regional Aircraft Fuselage barrel on-ground demonstrators. Moreover an industrial and cost evaluation based on a pre-defined production business case is requested including hypotheses of high volume automated solutions.	

[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 3.2 “Fuselage/Cabin Integrated Ground Demonstrator” represents the field where activities requested to the Applicant shall be performed. The relevant Work Breakdown Structure is shown below putting in evidence the WP 3.2:



More in detail, the activities will cover the definition, design, manufacturing, assembling and on-ground testing phases for full-scale structural Fuselage and passenger Cabin demonstrators representative of a Regional Aircraft.

Innovative low cost and low weight technologies shall be integrated into the Fuselage structural demonstrator with the objective to obtain: structural weight reduction, manufacturing recurring cost reduction, maintenance improvement and implementation of new eco-compatible materials and processes.

Innovation based on an human-centered-design approach and on board systems shall be integrated into the passenger Cabin demonstrator with the objective to obtain: improvement of cabin comfort and wellbeing, cabin interiors weight reduction, cabin interiors manufacturing recurring cost reduction, implementation of new eco-compatible materials and processes.

2. Scope of work

The scope of the present topic is the development and validation of an advanced fabrication process of composite window frame for regional aircraft composite fuselage manufacturing which allows a significant reduction of the overall production costs and flows.

Frequently metallic solution is in fact preferable, especially on regional aircraft, given its consolidated fabrication processes and consequent lower recurring costs.

Therefore innovative processes shall be selected and tested in order to make the composite solution as the better one, within the overall cost balance, for a new regional aircraft.

The activities to be performed are divided in the tasks listed in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Process set up and validation at full size level	M0+8
2	Parts fabrication for on-ground fuselage demonstrators	M0+15
3	Parts assembly	M0+16
4	Industrial cost evaluation	M0+16

a) Task 1: Process set up and validation at full size level

In the present task the selected Applicant, on the basis of material and technology identified by Topic Manager (TM) to be detailed/confirmed at Kick-Off Meeting (KOM), is requested to identify the best choices regarding process details, driven by manufacturing costs reduction and high volume industrial applicability.

The Applicant will then fabricate a full scale part, verifying the compliance with drawing requirements through destructive and non-destructive characterization, in order to validate and freeze process steps and parameters for final demonstrators.

The following fabrication processes and materials shall be preliminarily considered:

- Thermoforming with thermoplastic material PPS/carbon T300J 5HS;
- Compound moulding with thermoplastic chopped UD fiber.

The final window frame manufacturing technology (material and process) will be communicated by TM during the KOM.

The Applicant shall be responsible for:

- Identification of the lowest-cost solution.
- Purchase of all materials needed for parts fabrication (deliverable and auxiliary).
- Tool design and fabrication.
- Selection and supply of the needed equipment.
- Process development and set-up.
- Fabrication and non-destructive inspections (visual analysis, dimensional check and ultrasonic inspection) of the first full scale item.
- Quality plan issue to be agreed with TM.
- Manufacture of NDI standard on the basis of information that will be provided by Topic Manager.
- Visual analysis, dimensional check and ultrasonic inspection of full scale manufacturing trial.
- Destructive characterization (micrographic and chemical-physical analysis) of first full scale manufacturing trial to check/quantify possible internal defects, such as porosity, delamination,

inclusion, wrinkles, resin richness, etc.

- Producibility evaluation report to verify parts producibility in accordance with drawing requirements using the selected innovative process.
- Manufacturing process control document (MPCD) preparation, describing all process parameters and manufacturing steps to be used for final demonstrators.

b) Task 2: Parts fabrication for on-ground fuselage demonstrators

Composite window frames will be fabricated for two regional aircraft fuselage barrel on-ground demonstrators. N.12 window frames will be fabricated for each barrel demonstrator (N.24 window frames in total) and shipped to the TM's facility after assembly. Fig.1 shows the preliminary omega frame section. The frame assy shall cover a skin cut-out of 300 mm x 400 mm.

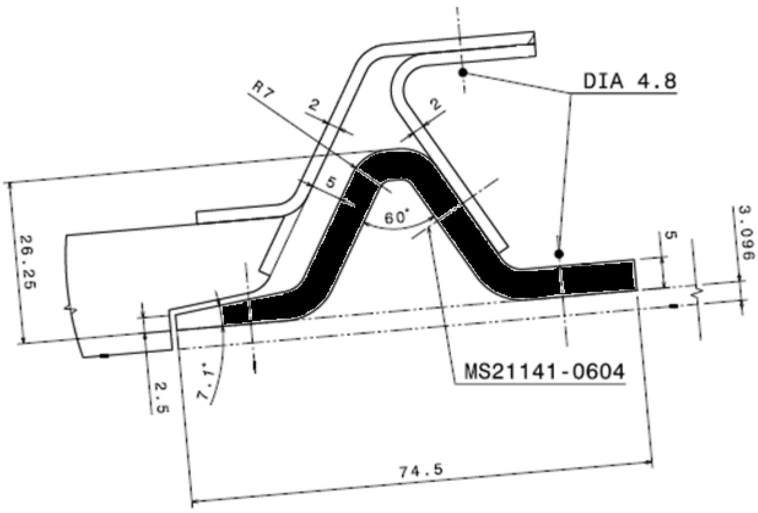


Fig.1. Window frame section (measurements in mm).

The preliminary condition of supply of the window frames before assy foresees:

- for the first demonstrator, the execution of a certain number of coordination holes (see fig.2 on the left), ø = 3,175 mm $^{[+ 0,0762 \text{ mm}, 0]}$. The precise location and number of holes will be defined in part drawing.
- For the second demonstrator, the execution of N.2 coordination holes (see fig.2 on the right), ø = 3,175 mm $^{[+ 0,0762 \text{ mm}, 0]}$. The precise location and number of holes will be defined in part drawing.
- Window frame trimming according to part drawing.
- Surface finishing and sealing to be defined in part drawing.

Fig.2. Coordination holes for window frame.

Final part drawing and specific supply conditions will be provided by the TM during the KOM.

The Applicant shall be responsible for:

- Purchase of all materials needed for parts fabrication (deliverable and auxiliary).
- Tool chain design and fabrication.
- Fabrication and non-destructive inspection of all items for the barrel demonstrators.
- Quality plan issue to be agreed with TM.
- Quality report of all items including weight measurements.

c) <u>Task 3: Parts assembly</u>

A first barrel ("structural demonstrator") will include a simplified window frames system (only frame and dummy glass type A and B, see fig.3 and fig.4) for structural test. So the following items will be needed:

- N.12 window frames (fabricated and inspected in task 2);
- N.8 metallic dummy glass panels type A;
- N.4 metallic dummy glass panels type B;
- N.4 metallic plugs;
- N.4 O-ring seals.
- fasteners (number to be defined).

Finally fig.5 shows fastener types for skin-glass-frame and glass-plug assembly.

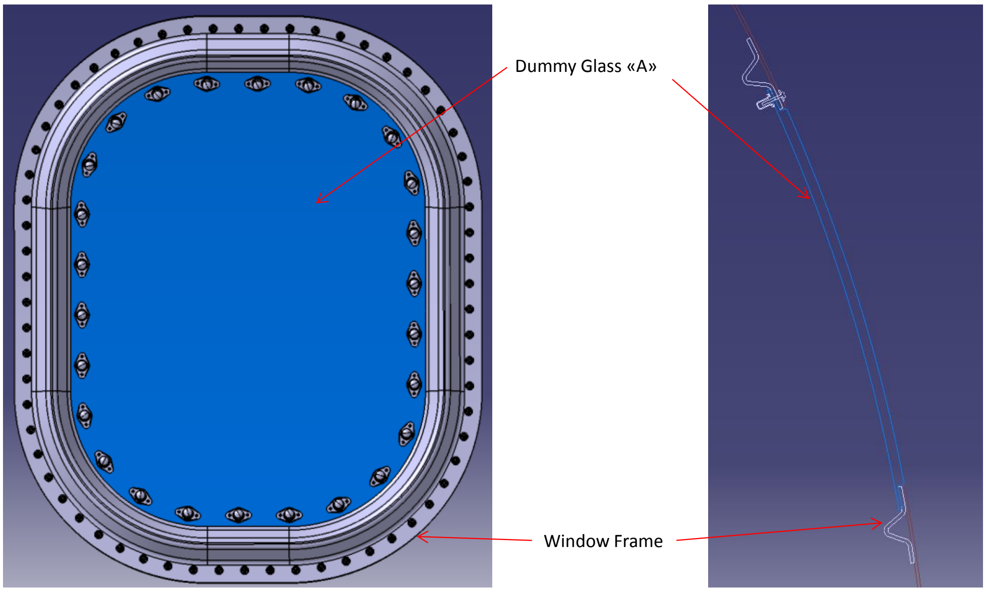


Fig.3. Simplified window frame assy with dummy glass A for structural demonstrator.

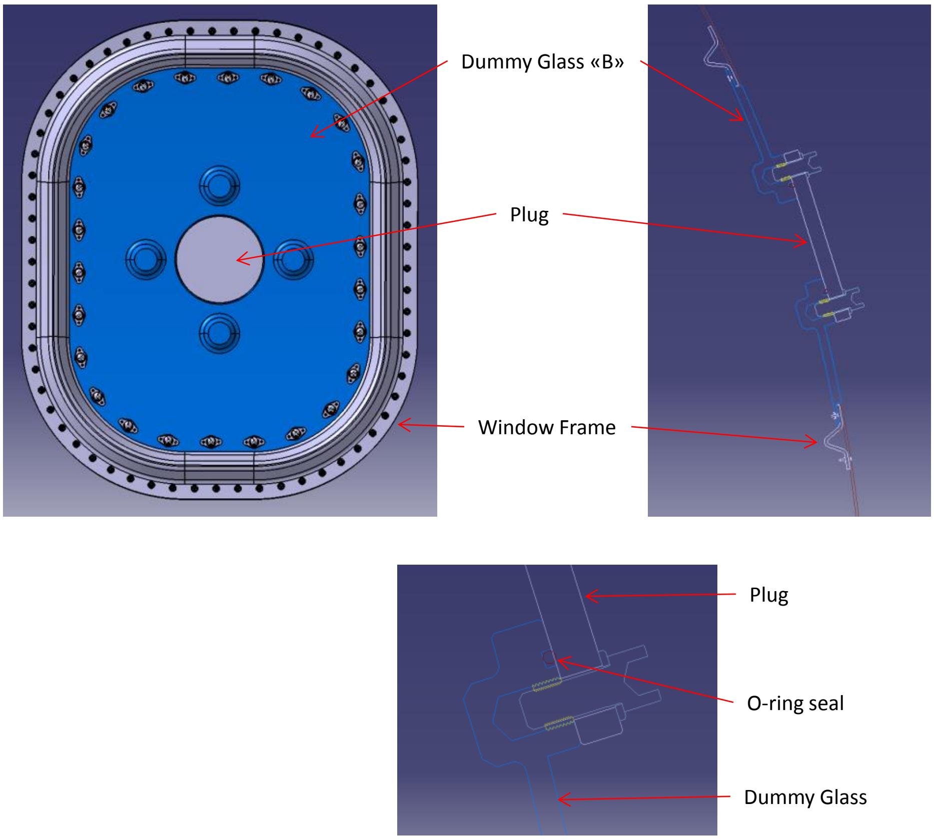


Fig.4. Simplified window frame assy with dummy glass B for structural demonstrator.

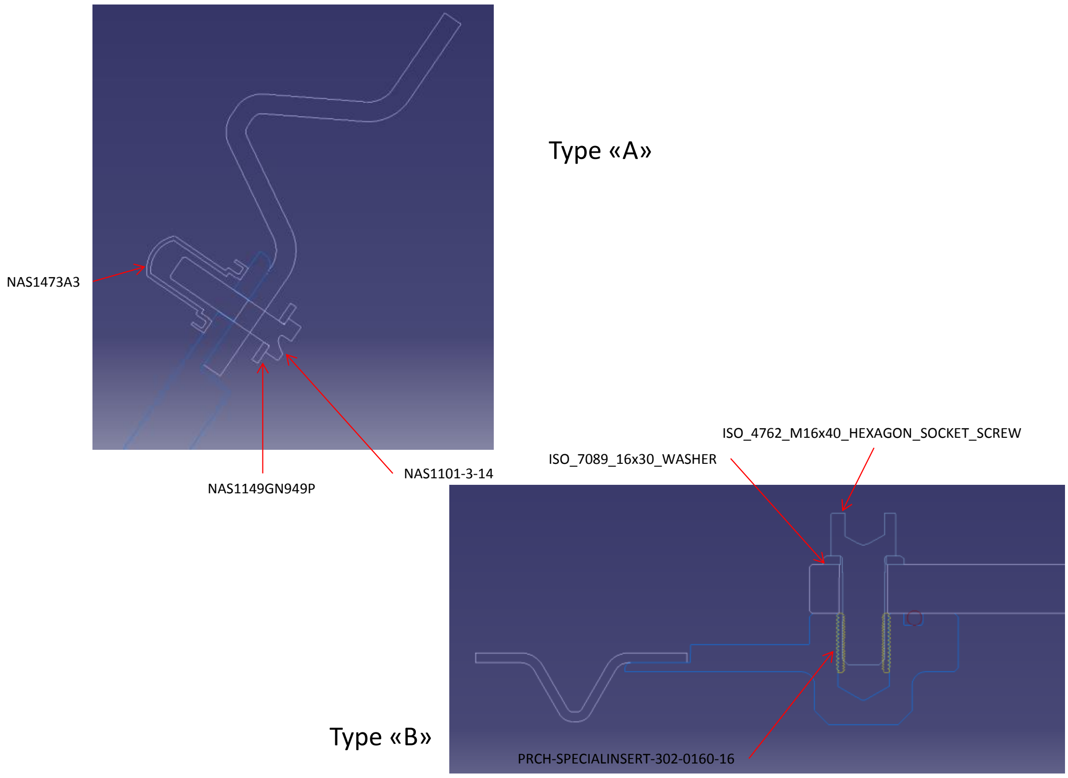


Fig.5. Fasteners for window frame assembly.

The second barrel demonstrator ("cabin demonstrator") will be equipped with a complete window frames system (frame, double-glass panel, glass seal and retainers) for comfort assessment (see fig.6). So the following items will be needed:

- N.12 window frames (fabricated and inspected in task 2);
- N.24 glass panels (N.2, internal and external, for each window);
- glass seal;
- N.72 retainers;
- fasteners.

The precise number of retainers and fasteners will be defined once completed the final assembly drawings.

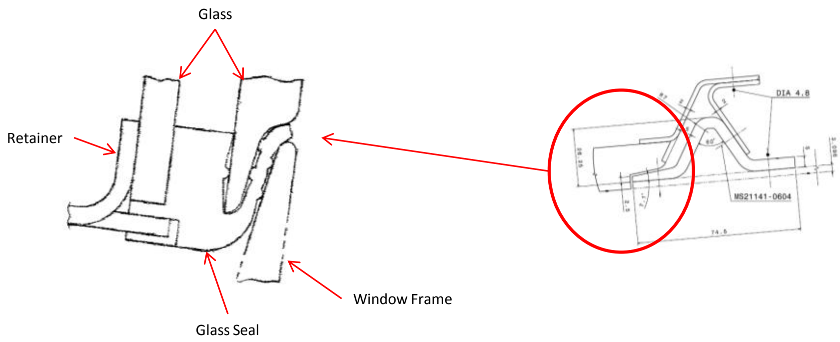


Fig.6. Window frame assy for cabin demonstrator.

The preliminary condition of supply of window frames assy foresees:

- Surface finishing and sealing to be defined in part drawing.
- N.2 shipments for each demonstrator are requested to the Applicant for a total number of N.4 shipments (see milestones 3.1 through 3.4 in the table below). A detailed list of the parts for each shipment will be provided by the TM during the KOM.

Final part and assembly drawing and specific supply conditions will be provided by the TM during the KOM.

The Applicant shall be responsible for:

- Purchase of all needed materials and miscellaneous parts, including fasteners and semi-automatic tools for installation.
- Design and fabrication of assembly jigs.
- Visual analysis, dimensional check and NDT for each part to be assembled.
- Assembly of all items for the fuselage barrel demonstrators.
- Quality plan issue to be agreed with TM.
- Quality report of all items including weight measurements.
- Shipment of all assembled items to the TM's facility.

d) Task 4: Industrial cost evaluation

Industrial business case conditions will be provided by the TM during the KOM.

The Applicant shall be responsible for:

- Evaluation of industrial recurring and not recurring costs, including fabrication and assembly, based on the above business case. Particular attention shall be given to innovative automated solutions for high volume production.
- Detailed descriptive report containing:
    - o quantity and associated costs of deliverable/auxiliary and standard materials;
    - o fabrication and assembly phases with relevant cost of labor;
    - o types and main characteristics of needed equipments and facilities;
    - o list of tools/jigs and related costs.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Detailed schedule	R	M0+1
D1.2	Process selection	R	M0+2
D1.3	Tool design and fabrication	D/HW	M0+6

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.4	Full scale manufacturing trial fabrication and characterization	HW/R	M0+8
D1.5	Manufacturing process description	R	M0+8
D2.1	Tool chain fabrication for items manufacturing	HW	M0+12
D2.2	Manufacturing and quality plans preparation	R	M0+8
D2.3	Items fabrication for 1st demonstrator	HW	M0+12
D2.4	Items fabrication for 2nd demonstrator	HW	M0+15
D3.1	Assembly jig fabrication	HW	M0+12
D3.2	Items assembly for 1st demonstrator	HW	M0+13
D3.3	Items assembly for 2nd demonstrator	HW	M0+16
D4.1	Industrial cost evaluation	R	M0+16

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Full scale manufacturing trial fabrication and characterization report	R	M0+8
M2.1	Tool chain availability for parts manufacturing	HW	M0+12
M3.1	1st shipment for 1st demonstrator delivery	HW	M0+10
M3.2	2nd shipment for 1st demonstrator delivery	HW	M0+13
M3.3	1st shipment for 2nd demonstrator delivery	HW	M0+14
M3.4	2nd shipment for 2nd demonstrator delivery	HW	M0+16
M4	Industrial cost evaluation report	R	M0+16

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

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

- Proven competence in management of complex research projects and manufacturing technologies, including quality and risk assessment capabilities demonstrated in international research projects and/or industrial environment.
- Proven competence in tool design for aeronautical composite part fabrication by a documented experience in participating in actual programs.
- Proven experience in fabrication and assembly of aeronautical thermoplastic material based substructures, for actual programs. This competence shall include a strong knowledge of materials and processes, quality, tooling, part programs for NC machines.

- Proven experience in non-destructive inspections. Evidence of ultrasonic NDI qualification shall be provided.
- Proven experience in experimental testing (micrographic and chemical-physical analysis) at coupon levels. Evidence of laboratories qualification shall be provided.
- Proven experience in cost estimation at industrial level for aeronautical composite components.

5. Abbreviations

CFRP	Carbon Fiber Reinforced Polymer
KOM	Kick-Off Meeting
MPCD	Manufacturing Process Control Document
NC	Numerical Control
NDI	Non-Destructive Inspection
NDT	Non-Destructive Technique
PPS	Polyphenylene Sulphide
TM	Topic Manager

IV. Full scale innovative composite pax and cargo floor grids for Regional Aircraft Fuselage barrel on-ground demonstrators

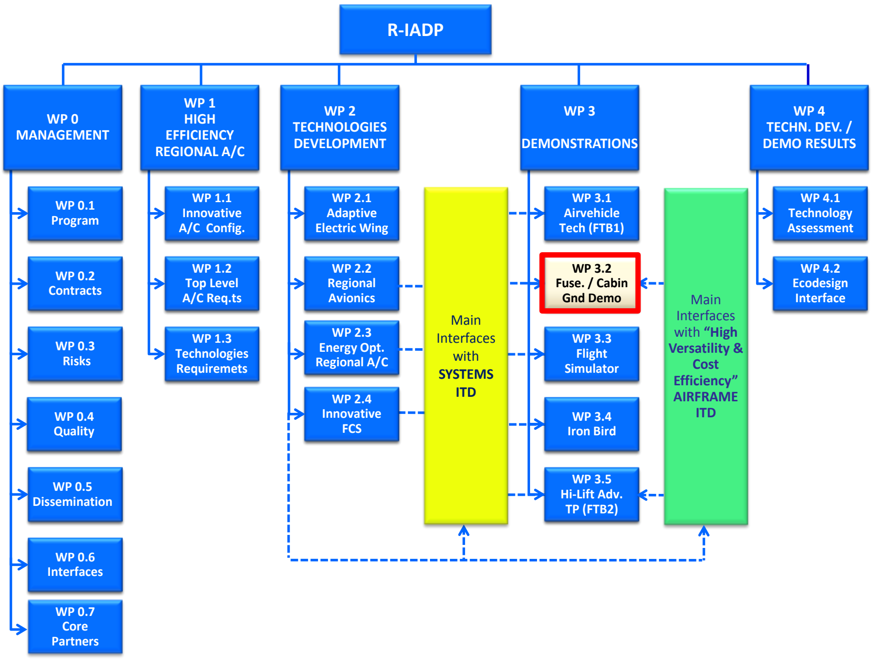
Type of action (RIA or IA)	IA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 3.2		
Indicative Funding Topic Value (in k€)	1200		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	16	**Indicative Start Date**[18]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-REG-01-14	**Full scale innovative composite pax and cargo floor grids for Regional Aircraft Fuselage barrel on-ground demonstrators**
Short description	
Validation at full size level of major CFRP floor grid components manufacturing process and fabrication of 2 full shipsets of pax and cargo floor grids for Regional Aircraft Fuselage barrel on-ground demonstrators with the implementation of innovative solutions for components integration and high volume automated solutions. Moreover an industrial and cost evaluation based on a pre-defined production business case is requested.	

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

1. Background

Activities to be performed according to the present Topic description are included in a wider context of work in the framework of the Regional Aircraft IADP of Clean Sky 2. In particular, the Work Package 3.2 “Fuselage/Cabin Integrated Ground Demonstrator” represents the field where activities requested to the Applicant shall be performed. The relevant Work Breakdown Structure is shown below putting in evidence the WP 3.2:



More in detail, the activities will cover the definition, design, manufacturing, assembling and on-ground testing phases for full-scale structural Fuselage and passenger Cabin demonstrators representative of a Regional Aircraft.

Innovative low cost and low weight technologies shall be integrated into the Fuselage structural demonstrator with the objective to obtain: structural weight reduction, manufacturing recurring cost reduction, maintenance improvement and implementation of new eco-compatible materials and processes.

Innovation based on a human-centred-design approach and on board systems shall be integrated into the passenger Cabin demonstrator with the objective to obtain: improvement of cabin comfort and wellbeing, cabin interiors weight reduction, cabin interiors manufacturing recurring cost reduction, implementation of new eco-compatible materials and processes.

2. Scope of work

The state of the art for fuselage floor grids configuration (pax and cargo) for Regional Aircrafts is a metallic configuration, due to higher recurring cost of traditional composite solutions. So, in order to gain a competitive configuration in terms of weight saving compared to metal and recurring cost reduction compared to traditional composite, the Applicant has to provide the manufacturing of all single parts and the assembly of floor grids, using innovative solutions for high volume automated production and components integration.

The activities of the present call are divided in four tasks, listed in the following table.

In the next paragraphs there are detailed descriptions of each tasks.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Process set up and validation at full size level	M0 + 8
2	Parts fabrication for on-ground fuselage demonstrators	M0 + 16
3	Parts assembly	M0 + 18
4	Industrial cost evaluation	M0 + 18

a) Task 1: Process set up and validation at full size level

In this task, the Applicant, on the basis of the preliminary technologies/materials here indicated by the Topic Manager and to be detailed /confirmed at KOM, has to select the best process solutions on the basis of weight saving, recurring cost reduction and high volume industrial applicability.

The Applicant will then fabricate a full scale part for each of the major composite element (floor beam and stanchion), verifying the compliance with drawing requirements through destructive and non-destructive characterization, in order to validate and freeze process steps and parameters for final demonstrators.

The following fabrication processes and materials shall be preliminary considered for major composite pax floor elements:

- “compression moulding” using PPS thermoplastic matrix and T300J 5HS carbon fiber for floor beams and false rail (if it is not metallic). A continuous process is preferred for recurring cost saving.
- “wrap forming” process for stanchion and crash link with thermoplastic (PPS matrix with T300 carbon fiber) or prepreg thermoset material

The metallic elements of the pax floor shall be manufactured according to the description in paragraph 2.2.

The following fabrication processes and materials shall be preliminary considered for major composite cargo floor elements:

- thermoforming process using PPS Thermoplastic matrix with T300J 5HS carbon fiber

For assembly following processes/materials might be considered as valuable opportunities for innovation and cost reduction:

- One shot drilling
- One Up Assembly for composite-composite stack-up.

In details the following activities shall be performed by the Applicant:

- Selection of the most economical process details
- Purchasing of all materials (included auxiliary materials)
- Design and construction of tools for the full scale manufacturing trials
- Make the necessary facilities/equipment available

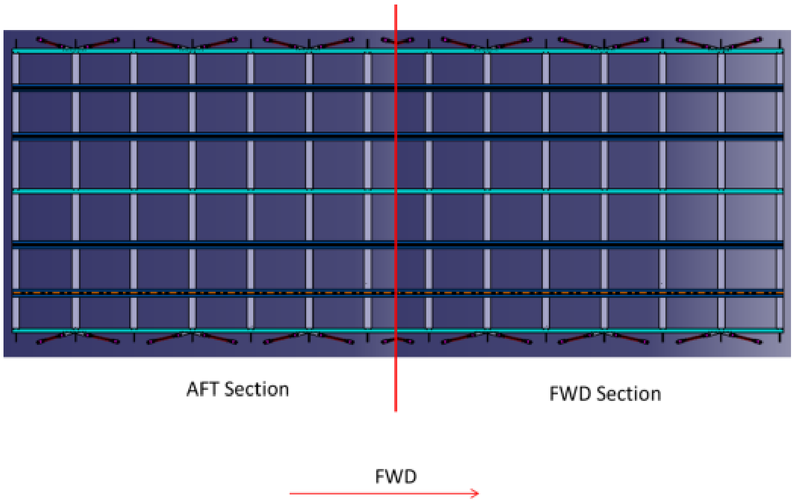
- Process parameters set up for parts' manufacturing and assembly
- Manufacture of representative full scale items (one floor beam and one stanchion) to be selected, in accordance with Topic Manager, among part families described in Task 2
- Manufacture of NDI standards on the basis of information that will be provided by Topic Manager.
- Visual analysis, dimensional check and ultrasonic inspection of each full scale manufacturing trial
- Destructive characterization (micrographic and chemical-physical) of each full scale manufacturing trial to check/quantify possible internal defects, such as porosity, delamination, inclusion, wrinkles, resin richness, resin content, fiber volume, etc.
- Release of the "Producibility Report" to verify parts producibility in accordance with drawing requirements using the selected innovative process
- Release of the "Manufacturing instruction" , describing all process parameters and manufacturing/assembly steps to be used for final Demonstrators

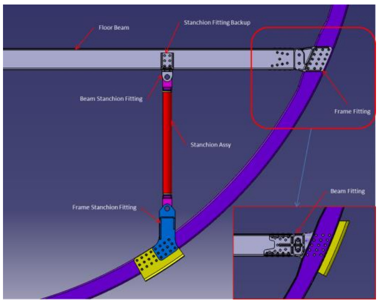
b) Task 2: Parts fabrication for on-ground fuselage demonstrators

Topic Manager is responsible for design and sizing of the parts object of the present Call, while the selected Applicant is responsible for manufacturing and assembly of pax and cargo floor grids to be assembled (at Topic Manager facility) on N°2 on-ground composite fuselage demonstrators (one for structural test and one for comfort analysis).

Passenger FLOOR grid

Passenger Floor Grid is divided in two sections: Forward and Afterward Section. Forward section covers 7 frame stations and aft section covers other 7 frame stations, as in the following pictures.

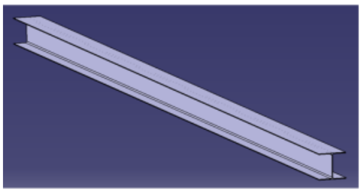


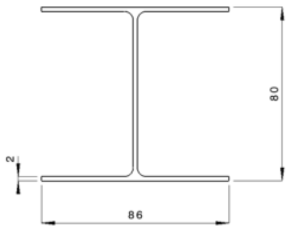


Each floor station is composed by: 1 floor beam, 2 frame fittings, 2 beam fittings, 2 stanchions, 2 beam stanchion fittings, 2 frame stanchion fittings, 4 stanchion fittings backup and all hardware needed to connect stanchion to both fittings and hardware to connect frame fittings to beam fittings; in addition for each section there are 4 seat tracks and 3 false rails.

Also metallic seat tracks and false rails splices to join together fwd and aft sections have to be considered.

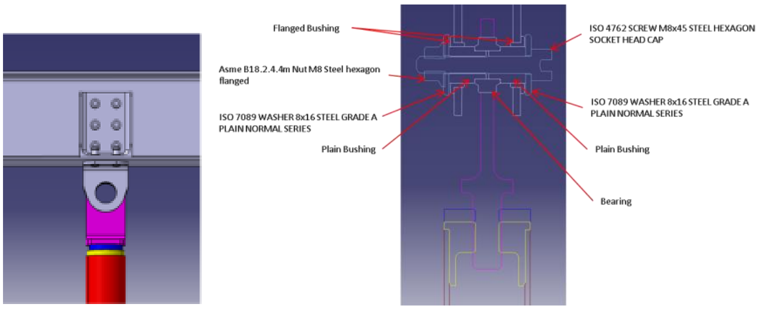
Each floor beam has a double-T section and preliminary dimensions are shown in pics below.





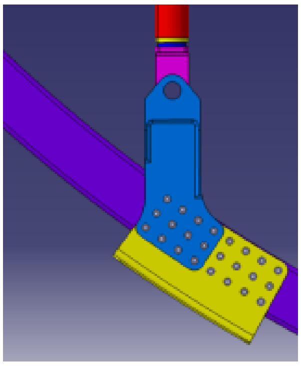
Frame Fitting and Beam Fitting are machined parts that connect the floor beam to the frame. Each fitting has housing for 2 pins.

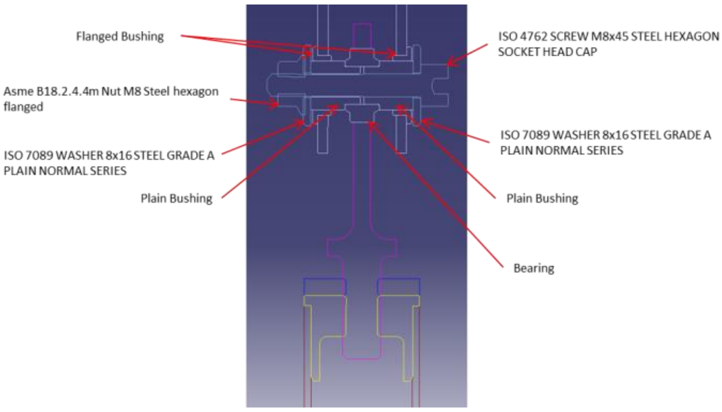
Stanchion Fitting and Stanchion Fitting Backup are machined parts



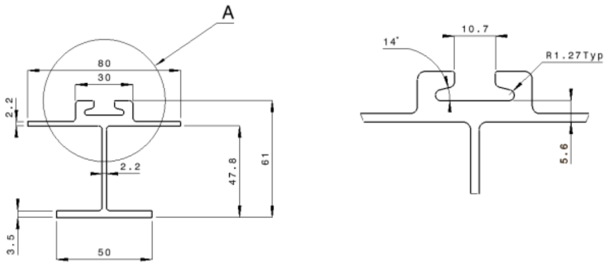
Each Stanchion Assy is composed by a fixed rod and 2 end rods in order to guarantee the adjustability of the total length at assembly level.

Each Frame Stanchion fitting is a machined part used to connect the stanchion to the frame.

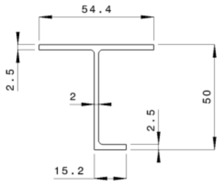




Each seat track is an metallic extruded section. Preliminary dimensions are shown in pic below



Each false rail is a thermoplastic section. Preliminary dimensions are shown in pic below



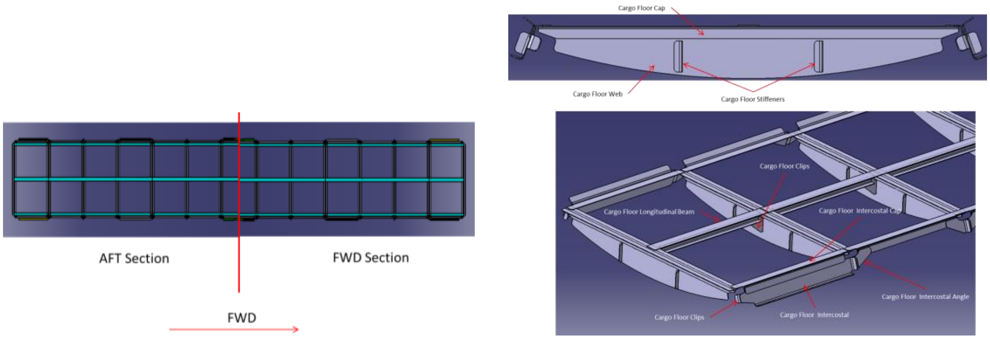
Each Crash Link is composed by a fixed rod and 2 end rods in order to guarantee the adjustability of the total length at assembly level. Crash Links are connected to the floor structure and to the skin-stringer by means of machined fittings.

Pax floor panels are flat sandwich structure. Dimensions and number of panel will be detailed at KOM. The following table summarize the amount of parts for one of the two demonstrators.

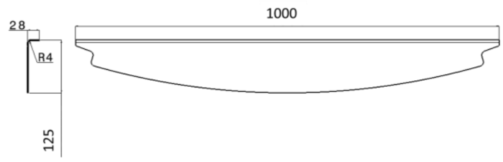
Items	Quantity for each demonstrator
Floor Beams	14
Stanchion assy	28
Beam Stanchion Fitting	28
Frame Stanchion Fitting	28
Stanchion Fitting Backup	56
Frame Fitting	28
Beam Fitting	28
Crash Links	24
Crash Links Fittings	72
Seat Tracks	8
Seat Track/False Rail Splices	7
False Rails	6
Pax panels	TBD

CARGO FLOOR

Cargo Floor Grid is divided in two sections: Forward and Afterward Section. Forward section covers 7 frame stations and aft section covers other 7 frame stations as shown in the following pictures.

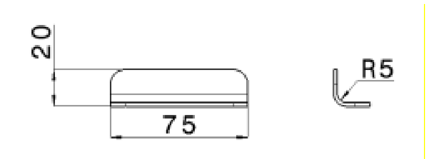


Each Cargo Floor Web has an L-Shape and preliminary dimensions are shown in pic below

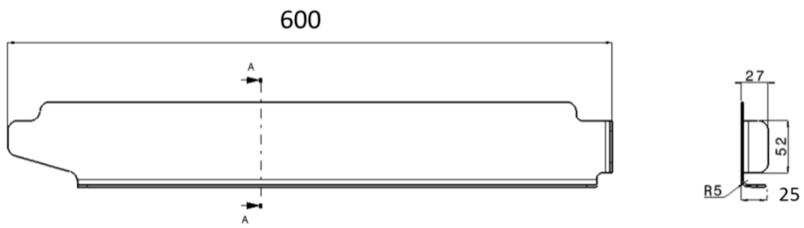


Each Cargo Floor Cap has an L-Shape and preliminary dimensions are shown in pic below

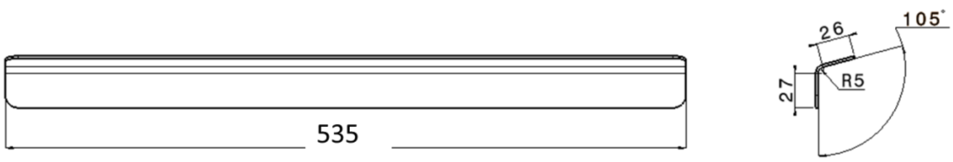
Each Cargo Floor Stiffener has an L-Shape and preliminary dimensions are shown in pic below



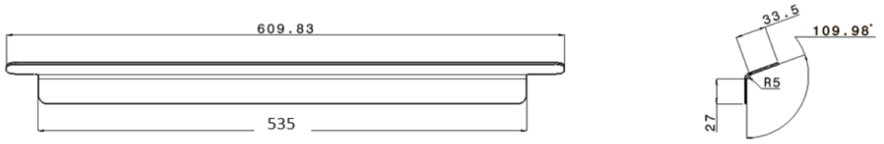
Each Cargo Floor Intercostal has an L-Shape and preliminary dimensions are shown in pic below



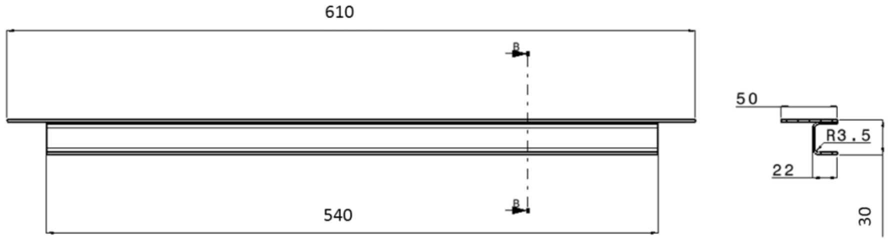
Each Cargo Floor Intercostal Cap has an L-Shape and preliminary dimensions are shown in pic below



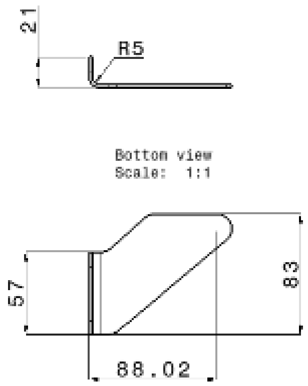
Each Cargo Floor Intercostal Angle has an L-Shape and preliminary dimensions are shown in pic below



Each Cargo Floor Longitudinal Beam has an J-Shape and preliminary dimensions are shown in pic below



Each Cargo Floor Clip has an L-Shape and preliminary dimensions are shown in pic below



The following table summarize the amount of parts for one of the two demonstrators.

Items	Quantity for each demonstrator
Cargo Floor Web	14
Cargo Floor Cap	14
Cargo Floor Stiffener	28
Cargo Floor Intercostal	10
Cargo Floor Intercostal Cap	10
Cargo Floor Intercostal Angle	10
Cargo Floor Clips	52
Cargo Floor Longitudinal Beam	13

The preliminary condition of supply of the single parts are the following:

- All parts have to be trimmed and drilled according with the drawing
- All frame stanchion fittings shall be delivered separately with the holes drilled according to the drawings
- All frame fittings shall be delivered separately with the holes drilled according to the drawings
- All cargo parts have to be delivered separately

At KOM, the Topic Manager Company will provide to the selected Applicant the information about:

- Detailed CATIA models for single parts

- Final condition of supply of single parts

In details the following activities shall be performed by the selected Applicant:

- Purchasing of all materials (included auxiliary materials for the fabrication of composite parts for the two final Demonstrators)
- Metal parts purchasing/machining
- Design and manufacture of tool chains for requested shipsets
- Manufacture of items for fuselage demonstrators
- Visual analysis, dimensional check and NDT for each part
- Release "Quality plan" to be agreed with Topic Manager
- Release of the "Quality Report", containing the results of NDT and the compliance with drawing requirements and weight measurements for each single part
  - Shipping pax and cargo lose patrs to TM's facility. It is requested to the selected Applicant to perform n.2 shipments for each Demonstrator, for a total number of 4 shipments. At KOM will be provided the list of the parts for each shipment.

Task 3: Parts assembly

N.1 complete pax floor grid assy (a part from what required to be delivered as lose part) for each demonstrator.

The preliminary condition of supply of the assembled grids are the following:

- Edge sealing and surface treatment according to drawing.
- it is requested to the selected Applicant to perform n°2 shipments for each Demonstrator, for a total number of 4 shipments. At KOM will be provided the list of the parts for each shipment.

At KOM, the Topic Manager Company will provide to the selected Applicant the information about:

- Detailed CATIA models for assy
- Final condition of assembly

In details the following activities shall be performed by the selected Applicant:

- Purchasing of standards, tools, equipment, miscellaneous/metallic components
- Design and building of assembly jig
- Assembly of all parts of pax and cargo floor grid for both demonstrators
- Release of the "Quality Report", containing the results of NDT and the compliance with drawing requirements and weight measurements for assembled grids.
- Shipment of pax floor grids to Topic Manager Company (Pomigliano d'Arco, Naples, Italy)

c) Task 4: Industrial cost evaluation

This Task is addressed to evaluate the technical and economic impact deriving from the introduction of the selected innovative technology to allow the Topic Manager to compare it with existing baseline technologies (cost / performance evaluation).

The final cost evaluation analysis shall be performed by selected Applicant who will be responsible for the following activities:

- industrial assessment of non-recurring and recurring manufacturing and assembly costs based on the business case to be provided by the Topic Manager at KOM, with particular reference to automated solutions for high volume production.
- detailed report issue, containing:
- quantities and costs of auxiliary / deliverable and standard materials
- manufacturing and assembly process flow with details about touch labour
- types and main characteristics of needed equipments and facilities
- needed tools, equipment, jig and related costs

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Detailed schedule	R	M0+1
D1.2	Process selection	R	M0+2
D1.3	Tool design and fabrication	D/HW	M0+6
D1.4	Full scale manufacturing trials fabrication and characterization	HW/R	M0+8
D1.5	Manufacturing/assembly process description	R	M0+8
D2.1	Tool chain fabrication for demonstrators single parts manufacturing	HW	M0+10
D2.2	Manufacturing and quality plans preparation	R	M0+8
D2.3	Items fabrication for 1st demonstrator	HW	M0+12
D2.4	Items fabrication for 2nd demonstrator	HW	M0+16
D3.1	Assembly jig fabrication	HW	M0+10
D3.2	Items assembly for 1st demonstrator	HW	M0+14
D3.3	Items assembly for 2nd demonstrator	HW	M0+18
D4.1	Industrial cost evaluation	R	M0+18

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Full scale manufacturing trial fabrication and characterization report	R	M0+8
M2.1	Tool chain availability for parts manufacturing	HW	M0+10
M3.1	1st shipset for 1st demonstrator delivery	HW	M0+12
M3.2	2nd shipset for 1st demonstrator delivery	HW	M0+14
M3.3	1st shipset for 2nd demonstrator delivery	HW	M0+16
M3.4	2nd shipset for 2nd demonstrator delivery	HW	M0+18
M4	Industrial cost evaluation report	R	M0+18

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

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

- Proven competence in design and stress analysis for aeronautical tools manufacturing.
- Proven experience in NDT inspections. Evidence of ultrasonic NDT qualification shall be provided.
- Proven experience in cost estimation at industrial level for aeronautical full scale composite structures.
- Proven competence in management of complex research projects and manufacturing technologies, including quality and risk assessment capabilities demonstrated in international research projects and/or industrial environment.
- Proven experience and competencies in the requested technologies for fabrication and assembly of aeronautical composite substructures for actual aeronautical programs. This competence shall include a strong knowledge of materials and processes, quality, tooling, part programs for NC machines.
- Proven experience in experimental testing (micrographic and chemical-physical analysis) at coupon levels. Evidence of laboratories qualification shall be provided.

5. Abbreviations

CFRP	**Carbon Fiber Reinforced Plastics**
KOM	**Kick Off Meeting**
NC	**Numerical Control**
NDI	**Non-destructive Inspection**
NDT	**Non-destructive Techniques**
Pax	**Passengers**
PPS	**Polyphenylene Sulphide**
TM	**Topic Manager**

V. Innovative Primary and Secondary Electrical Distribution Network for Regional A/C

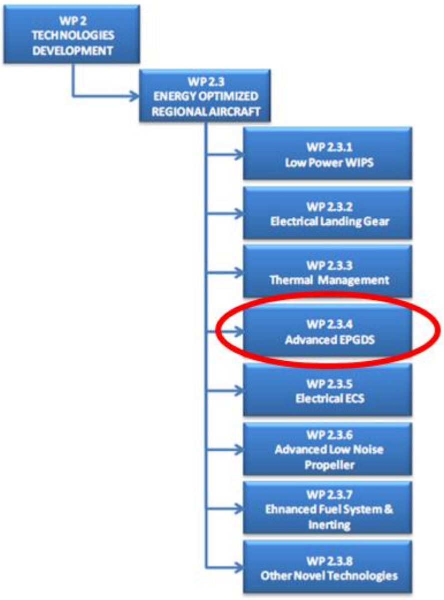
Type of action (RIA or IA)	RIA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 2.3.4 - 3.4		
Indicative Funding Topic Value (in k€)	1400		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	26	**Indicative Start Date**[19]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-REG-01-15	**Innovative Primary and Secondary Electrical Distribution Network for Regional A/C**
Short description	
Design, development, manufacturing, validation and integration of an innovative solid-state based electrical power distribution network system for future Regional A/C, also equipped with enhanced electrical energy management functionalities.	

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

1. Background

The Clean-Sky 2 IADP for Regional aircraft (REG IADP) has the scope to integrate and validate, at a further level of complexity than currently pursued in Clean-Sky (up to aircraft level), advanced technologies for Regional aircraft so as to drastically de-risk their integration on future products, improving the outlook on EU industrial leadership in this sector.
The activity of this topic is a part of the REG WP 2.3.4 “Advanced Electrical Power Generation and Distribution System”.



Indeed, the Regional power-plant, either new or the existing one, will interface to an Advanced Electrical Power Generation and Distribution System (EPGDS) installed on board in order to perform a full scale demonstration of the All-Electric technologies applied to Regional aircraft. This effort may comprise - depending on cost and availability of suitable complete systems or components - the adoption and implementation of enabling technologies in the areas of:

- Electrical Power Generation and Conversion System (EPGCS);
- Electrical Power Distribution System (EPDS) with Enhanced Electrical Energy Management,

Some of them already assessed in the frame of previous Clean-Sky, but requiring a big further integration step for their application on the next generation Regional aircraft.
All-Electric solutions are addressed because they potentially improve operative efficiency of on board systems and simplify maintenance and ownership costs so critical for Regional aircraft. In turn, they contribute to reduce fuel consumption and emissions because electrical systems are more energy efficient and use less polluting materials than traditional solutions.

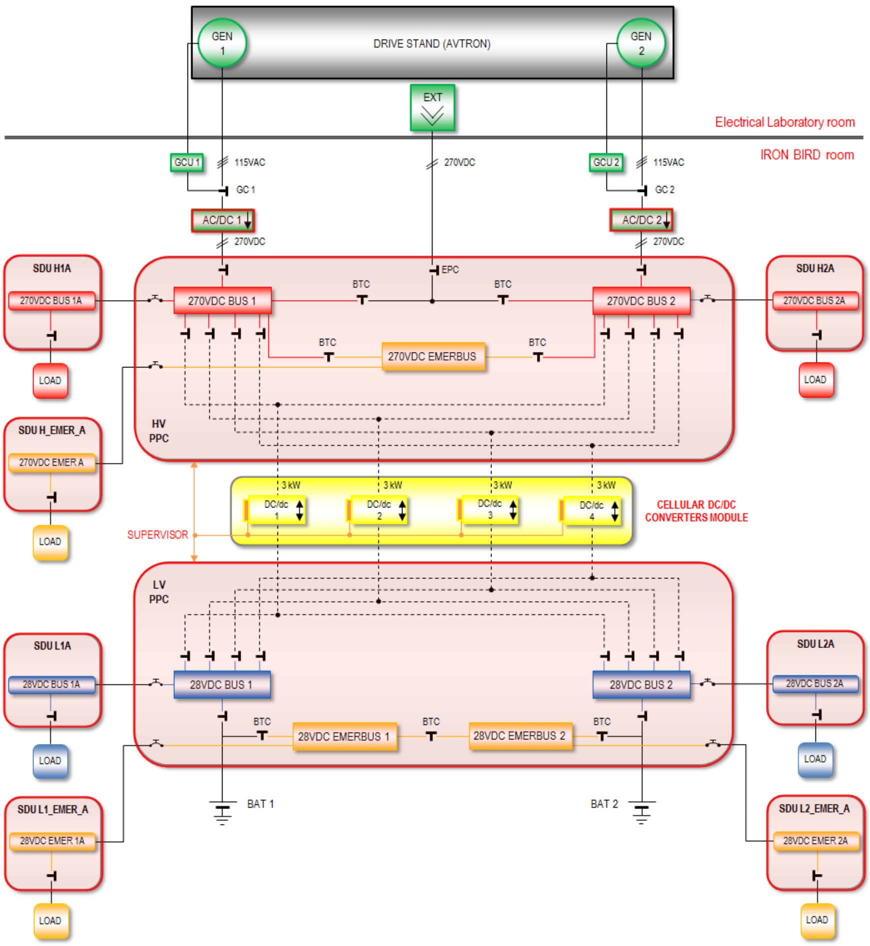
The main objective of the WP 2.3.4 is to design and develop an innovative strategy for an highly decentralized, modular and flexible smart grid based EPDS network. In addition, the EPDS will be equipped with the Enhanced Electrical Energy Management (E^2-EM) functionalities in order to further reduce or even delete the overload capabilities of main generators and thus saving weight for electrical machines integration. The above will allow to perform on ground demonstrations of the key elements of innovative EPDS in order to demonstrate that relevant solutions correctly perform in a relevant Regional A/C operative environment (REG IADP Iron Bird Demonstrator).

2. Scope of work

The scope of this Topic is to design, develop, manufacture, validate and integrate an innovative solid-state based electrical power distribution network for future Regional A/C, including the following subsystems:

- two "centralized" Primary Power Centres (PPC) (including HV and LV primary bus bars, primary contactors and I/O interfaces);
- at least four "decentralized" Secondary Distribution Units (SDU) (including HV and LV secondary bus bars, secondary contactors and I/O interfaces), one of them embedding innovative "energy management" capabilities;
- two AC/DC converters (rectifiers) to convert 115V ACWF to 270V DC (from two real 40 kVA electrical generators to primary distribution network),

according to the following sketch (for reference only). The parts highlighted in red are the components required by this Topic (the remaining parts are already available at Topic Manager premises or will be provide by other CfP Projects).



Iron Bird Architecture for Innovative Primary and Secondary Electrical Distribution Network

The 270V and 28V DC PPC's could be also part of the same equipment. In any case, the PPC's shall interface with the DC/DC cellular bidirectional converters equipment (yellow box).

All the contactors and circuit breakers included in the primary and secondary distribution boxes shall be based on solid-state technology (e.g. SSPC).

The PPC's shall both automatically and manually manage the opening/closure of Bus Tie Contactors (BTC's) and External Power Contactor (EPC) depending on the different simulated test scenarios (e.g. supply from external power, failure of one generator, short circuit on a bus bar, etc.). The contactors between HV and LV PPC's shall be able to be controlled by the Supervisor of the DC/DC converters module. Each contactor shall be able to provide a feedback on its status (open/closed/failed).

Each secondary distribution unit (SDU) can include both HV and LV secondary bus bars, as well as the control logics for powering the loads, depending on the number and type of loads to be supplied. Each SDU shall provide electrical power to a group of real or simulated aircraft loads, according to the following list:

Landing Gear SDU:

- 1 Nose Landing Gear EMA (max power ~1 kW TBC);
- 1 Main Left Landing Gear EMA (max power ~4.5 kW TBC);
- 1 Main Right Landing Gear EMA (simulated) (max power ~4.5 kW TBC);

Flight Control System SDU:

- 2 Winglet EMA's (max power ~0.5 kW TBC each);
- 1 Wingtip EMA (max power ~0.5 kW TBC);
- 2 Aileron EMA's (max power ~1 kW TBC each);

Energy Storage and Regeneration System SDU:

- 1 EMA-type motor load simulating an FCS Rudder EMA (including a DC/DC bi-directional converter equipped with local supercapacitor-based energy storage elements for smart control of regenerative loads) (max power ~5 kW TBC);

Simulated Loads SDU:

- 3 Programmable DC Load Banks (max power 25 kW each).

In addition, this SDU shall embed specific hardware in order to implement some Enhanced Electrical Energy Management functionalities. The E^2-EM concept extends the Electrical Energy Management logics as already implemented and validated in Clean-Sky, where "voltage choppers" (i.e. monodirectional DC/DC buck converters, based on SSPC's + filtering stage) were designed, manufactured and tested. In particular, this SDU shall embed at least three converters able to allow their integration into the global E^2-EM logics. Innovative control, modulation and supervision techniques able to obtain the voltage chopping effect are required. The possibility of an automatic or semi-automatic code generation for the relevant firmware is an asset, as well as the introduction of digital communication protocols (CAN, ARINC, EtherCAT or TBD) for real-time monitoring.

In this respect, the overall system (primary and secondary electrical distribution network) shall interface with the Centralized Smart Supervisory control for Enhanced Electrical Energy Management strategy, as it has been launched by another REG CfP Project.

The overall system (primary and secondary electrical distribution network) shall be integrated into the REG Iron Bird ground demonstrator and therefore it shall interface with the overall demonstrator infrastructure, mainly composed of the following subsystems:

- Electrical Power Generation System (Drive Stand + 115V ACWF Electrical Alternators);
- Engineering Test Station;
- Central Control Unit and Interface Unit;
- Data Acquisition System;

- Health Management System Module (TBC)
- Other FCS Equipment (Flight Control Computers, Cabin Dummy, Flight Mechanics Simulation Computer) (TBC);
- Others (Rack, Panels, Sockets, Signal Cables, Labels, Etc.).

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.

All the equipment referred to in this CfP will be located in a laboratory room for validation and functional tests (target TRL 5). As a consequence, the environmental requirements shall be limited to a compatibility of the equipment with the laboratory environmental conditions.

However, in order to ease the process to reach a TRL 6 gate after the completion of the Project, the whole system shall be designed to the minimum weight that assures all required performances and shall be as compact as possible (higher power density wrt state-of-the-art solution).

The electrical power generation system of the Iron Bird test rig will provide 270V DC input power, whose normal and abnormal characteristics in steady-state and transient conditions 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 within 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 system shall comply with European standards related to electrical power 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.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
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 + 3M
Task 2	Preliminary Design: To validate the equipment requirements and check that equipment preliminary design is consistent with these requirements: architecture concept according to performance, energy management and safety requirements, sizing, interfaces definition, substantiation of design choices.	T0 + 9M
Task 3	Critical Design: To realize the detailed design (mechanical, electrical, thermal, etc.), realize detailed CAD drawings, finalize safety analysis, validate the energy management control and supervision strategy, prior to launch equipment manufacturing.	T0 + 12M
Task 4	Manufacturing: To manufacture all the equipment (primary and secondary distribution boxes), following the CDR documentation.	T0 + 16M
Task 5	Testing and validation: To perform the final tests for validating the system functionalities and performances, including dedicated energy management tests.	T0 + 20M

Task 6	Delivery and Support: To deliver and integrate the system onto the Iron Bird demonstrator at Topic Manager premises and provide full support during the testing phase.	T0 + 26M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Analysis phase: Requirements matrix and support documentation.	R	T0 + 3M
D2	PDR: Preliminary Design Review and associated deliverables.	R	T0 + 9M
D3	CDR: Critical Design Review and associated deliverables.	R	T0 + 12M
D4	Installation and Commissioning: Delivery of the complete system with its associated documentation (preliminary DDP), installation and commissioning on site.	HW	T0 + 20M
D5	Final Validation Tests and DDP: Validation tests report and final results (final DDP).	R/D	T0 +22M
D6	Optimization and Support: Support the rig operations to correct potential faults during this probation period.	R	T0 + 26M

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Preliminary Design Review	R	T0 + 9M
M2	Critical Design Review	R	T0 + 12M
M3	System Delivery	HW	T0 + 20M

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

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

- Expertise in electrical system design (power generation, power conversion, power distribution network, power consumers),
- Knowledge of Industrial/Aeronautical field constraints and procedures,
- Experience in system simulation methods and modeling,
- Recognized experience in advanced control system techniques,
- Background in control and supervision of complex systems.
- Experience in laboratory or industrial test benches design, manufacturing and installation.

5. Abbreviations

ACWF	Alternate Current Wild Frequency
CDR	Critical Design Review
DDP	Declaration of Design and Performance
E^2-EM	Enhanced Electrical Energy Management
EMA	Electro-Mechanical Actuator
EPDS	Electrical Power Distribution System
EPGCS	Electrical Power Generation and Conversion System
FCS	Flight Control System
HV	High Voltage
IB	Iron Bird
ICD	Interface Control Document
I/O	Input/Output
LV	Low Voltage
PDR	Preliminary Design Review
PPC	Primary Power Centre
SDU	Secondary Distribution Unit
SSPC	Solid-State Power Controller
TBC	To Be Confirmed
TBD	To Be Defined

VI. Technological readiness at the operational level for additive manufacturing in primary structure and large size components

Type of action (RIA or IA)	RIA		
Programme Area	REG		
Joint Technical Programme (JTP) Ref.	WP 3.5		
Indicative Funding Topic Value (in k€)	570		
Topic Leader	AIRBUS Defence & Space	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[20]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CFP07-REG-02-04	**Technological readiness at the operational level for additive manufacturing in primary structure and large size components**
Short description	
Design, analysis, manufacture and test of structural elements with high curvature applicable to Regional Aircraft configuration of leading edges. The technologies applied will cover: composite structures with long fibre reinforcement in thermoplastic resins, additive manufactured short fibre reinforcements and hybrid metal – composites techniques with rivet-free unions.	

[20] 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 manufacturing technologies of highly integrated aerostructures. In the last years, high growth of additive methods, composite welding, jigless component integration and hybrid joints between composite and metal components has occurred. This topic will deal with these technologies up to full scale demonstration to Regional Aircraft leading edge configurations.

High curvature composite parts have been typically manufactured either manually or automated with AFP (Automatic Fibre Placement) in thermoset resins materials. Other ones, like thermoplastic resins, with high performance properties at impact, are not fully developed due to manufacturing difficulties that need additional research.

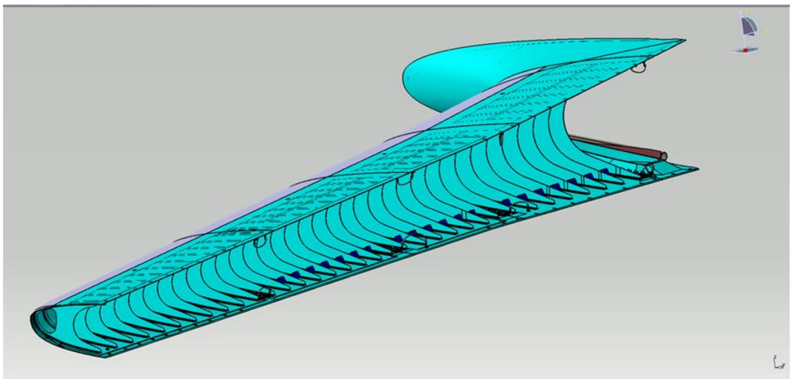


Figure: Leading edge of lifting surface with skins and ribs in composite

The new concepts of leading edges include a great number of shape ribs, each having a different geometry as the aerodynamic shape changes along the span. Such great number of different components lead to high Non Recurrent Costs –NRC- in terms of a large amount of tooling; being difficult to amortize during production phase. New short fibre reinforced thermoplastic 3D structures can be applied to these complex shape parts; creating great savings in tooling required. On the other hand, topological optimization that additive manufacturing (AM) may offer is very attractive for designers because allows new lightened ribs with reticulated structure.

The materials proposed in this topic are the family of PAEK (Polyaryletherketone, which englobes polymers like PEEK & PEKK), providing both the mechanical & impact strength needed for several A/C parts. This type of materials provides new ways of integration and joints as, for example, automated induction welding. With thermoplastic welding technologies, the functionality of the structure is even increased by eliminating the need of rivets.

Hybrid (metal-composite) unions by adhesive means are another way of weight & cost saving that can be applied to these type of components. The goal is to have a hybrid bond that can withstand impact loads for these kind of part requirements.

In addition, the work intends to address an AM component assembly procedure that does not require the industrialization of specific and expensive tools. This methodology introduces the structural joints in the assemblies without tools (jigless), which adds value to the ambit of the call.

2. Scope of work

The scope of the work is to progress in manufacturing technologies applicable to full size aeronautical structures with focus on:

- Composite structures with long fibre reinforcement in thermoplastic resins in "out of autoclave" processes, applicable for instance to skins
- Additive Manufactured short fibre reinforcements pieces in thermoplastic resin, applicable for instance to ribs
- Investigation on simplified industrial means with reduced cycle steps keeping aeronautical requirements like aerodynamic tolerances in wet surfaces
- Investigation in hybrid metal – composites techniques with rivet-free unions, applicable to nose metal protection in leading edges
- Investigation in integration techniques of pieces in different technologies like induction welding between skins and ribs

The demonstration of the technology lines will be done in a full scale lifting surface structure -wing or tail leading edge-. The demonstrator will be representative of Regional Aircraft with airworthy requirements. The aim is the integration in the Regional FTB#2 in-flight demonstrator, when passing the Fly/No-Fly decision gate with the corresponding documentation of design, manufacturing, processes and structural justification to accomplish a Permit to Fly.

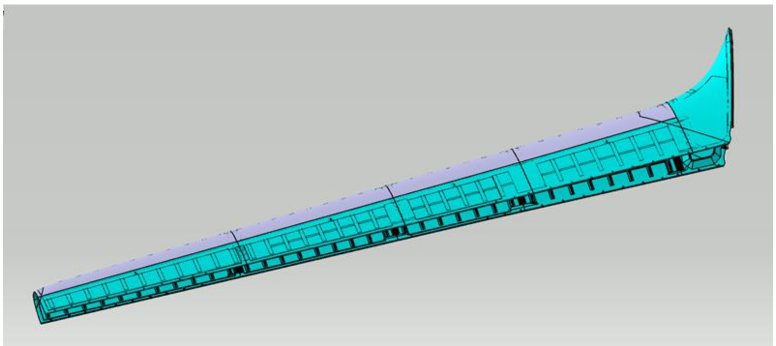


Figure: Typical example of leading edge of lifting surface with skins and ribs topology

The topic purpose is the manufacturing of aeronautical structures, as a wing or stabilizer leading edges, by using layer manufacturing means for high-end, aerospace grade thermoplastic materials with continuous fibre and AM short fibre reinforcement. Regarding processing, the aim is to go one step ahead from current process requiring both complex industrial means plus several cycle steps, achieving composite structures with long fibre reinforcement at lower tooling & industrial means with surface quality suitable for aerodynamic surfaces.
For this purpose, the skins should be manufactured by means of continuous fibre reinforced thermoplastic with 3D AM thermoplastic short fibre reinforced shape ribs. Those ribs will be welded by induction welding means to the skins, forming a rivet-less assembly of all composite components.

A second way of research included in the topic is the manufacture of hybrid aero-structures with particular focus on the hybrid join metal – thermoplastic composite without rivets. This forthcoming approach requires the validation of the surface preparation for bonding and the bonding itself with the goal of a rivet free union for lightweight and post-assembly free process.

It is a common goal for the considered technologies a qualification of parts based on a process qualification. The final target is the exploitation in Regional FTB#2 demonstrator depending of the feasibility conditions.

The tasks of the topic will be grouped following the corresponding technology lines:

Tasks		
Ref. No.	Title - Description	Due Date
T1	Process development for long-fibre reinforced thermoplastic manufacturing, achieving autoclave quality grade parts	T0 + 18
T2	Process development for short-fibre reinforced thermoplastic additive manufacturing	T0 + 18
T3	Inductive welding development for carbon fibre reinforced thermoplastic composites	T0 + 12
T4	Development of hybrid structures joints, methodology study for thermoplastic – metal surface preparation & bonding parameters	T0 + 12
T5	Testing campaign of thermoplastic welding for mechanical validation	T0 + 24
T6	Testing campaign of hybrid joints for mechanical validation	T0 + 24
T7	Manufacture of representative size demonstrator for concept validation	T0 + 36

- The Applicant will have the responsibility of the fabrication of the demonstrators involving the structural tests. Furthermore will do the scale up industrial level and set up of the process and the equipment in collaboration with the Topic Manager in order to prepare the complete manufacture of the full scale demonstrator.
- The Topic Manager will provide the adequate information and technical requirements for design and manufacturing of the demonstrator.
- In case of the implementation for in-flight demonstration, the Applicant will support the Topic Manager with all the documentation to obtain the Permit to Fly.

3. Major Deliverables / Milestones and schedule

The deliverables and milestones are in accordance with the general work plan of the REGIONAL Aircraft FTB2 demonstrator as shown below.

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D1	Process & quality achievements for long & short fibre reinforced AM components	R	T0 + 18
D2	Bonding quality & process achievements	R	T0 + 12
D3	Test campaign results for thermoplastic welding	R, D	T0 + 24
D4	Test campaign results for hybrid unions	R, D	T0 + 24
D5	Demonstrator	HW	T0 + 36

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

Milestones (when appropriate)			
Ref. No.	Title - Description	Type*	Due Date
M1	Manufacturing process selection for long fibre reinforced thermoplastic	R	T0 + 3
M2	Manufacturing process selection for short fibre reinforced thermoplastic	R	T0 + 3
M3	Topology optimisation for shape ribs	D	T0 + 6
M4	Inductive welding process definition	R	T0 + 6
M5	Hybrid joints process definition	R	T0 + 6
M6	First flat panels manufacturing for long fibre process validation	HW	T0 + 6

Milestones (when appropriate)			
Ref. No.	Title - Description	Type*	Due Date
M7	Manufacturing quality assurance of long fibre flat panels	R	T0 + 18
M8	Samples manufacturing of short fibre reinforced polymers	HW	T0 + 6
M9	Manufacturing quality assurance of short fibre flat panels	R	T0 + 18
M10	Test campaign requirements provided by Airbus	D	T0 + 12
M11	Process repeatability for thermoplastic welding	D	T0 + 12
M12	Process repeatability for hybrid joints	D	T0 + 12
M13	Test campaign beginning	D	T0 + 12
M14	Demonstrator PDR	R	T0 + 12
M15	Decision gate: fly/no-fly	D	T0 + 18
M16	Demonstrator CDR	R	T0 + 20
M17	Demonstrator manufacturing trials begin	D	T0 + 24

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

The Applicant will work in close cooperation with the Topic Manager who will provide the adequate information and technical requirements. 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 topic 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)

- **R&T Management**
  - Management of complex R&T and industrial projects for aeronautical composite & metallic components by automated manufacturing processes.
  - High experience on international R&T projects
- **R&T Methodology**
  - Fast track trial and error methodology
  - Experience on simulations to reduce R&T lead time.
- **Design and Data Management**
  - High competence for managing aeronautical 3D design software, structural analysis for composite materials lay up design and lay up simulation.
  - Strong Structural FEM competences.
  - Experienced on topology optimisation.
- **Materials & Processes**
  - High experience on Thermoplastic AFP and 3D AM.
  - Experience on thermoplastic raw materials internal development.
  - Experience on fast Non Destructive Inspections.
  - Cost efficient and energy saving innovative integrated manufacturing systems.
  - Experience on material physico-chemical analysis.
- **Manufacturing**
  - In-situ consolidation means for both 2D and 3D lay-ups with carbon fibre reinforced composites with short & long fibre.
  - Experience on thermoplastic inductive welding.
  - Experience on hybrid unions development.
  - Previous experience on aerospace manufacturing processes.
- **Industrial Means Innovation**
  - Design, development, manufacturing and integration of carbon fibre reinforced thermoplastic components by 2D and 3D additive manufacturing.
  - Monitoring and recording of manufacturing processes parameters.

Innovative and online approaches for project development

5. Abbreviations

A/C	Aircraft
AFP	Automatic Fibre Placement
AM	Additive Manufacturing
CAD/CAM	Computer-Aided Design/Manufacturing
CDR	Critical Design Review
DMU	Digital Mock-Up
FDM	Fused Deposition Modeling
FEM	Finit Element Model
ICD	Interface Control Documents
NDA	No Disclosure Agreement
SoA	State of the Art
TRR	Test Readiness Review
WP	Work Package

6. Clean Sky 2 – Fast Rotorcraft IADP

I. Full scale High speed aerodynamics characteristics of the Civil Tilt Rotor

Type of action (RIA or IA)	RIA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP1		
Indicative Funding Topic Value (in k€)	3500		
Topic Leader	Leonardo Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[21]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-FRC-01-16	**Full scale High speed aerodynamics characteristics of the Civil Tilt Rotor**
Short description	
The Topic is aimed to characterize at high speed the fundamental aerodynamic aspects of the new tilt rotor configuration. The task shall be accomplished through a key support of an experimental wind tunnel test investigation. The activity will be accomplished by design, manufacturing and testing up to Mach 0.6 the basic configuration model including variants (in power off conditions). The main aerodynamic data set to feed Flight Mechanics simulation tools at full scale will be provided at the end of the activity with the support, if needed, by CFD.	

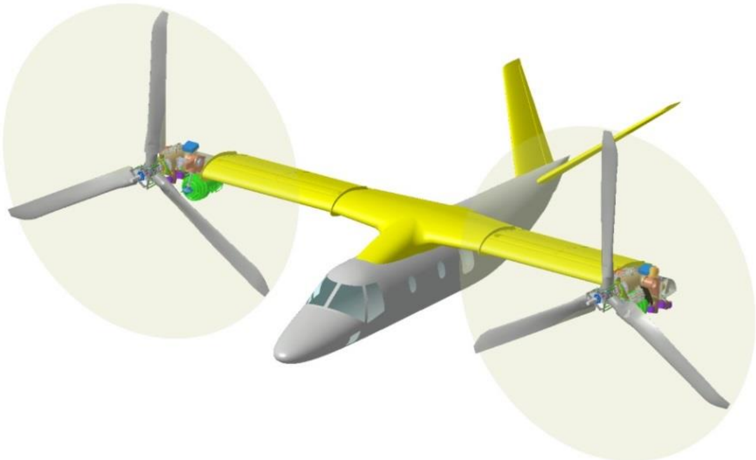
[21] The start date corresponds to actual start date with all legal documents in place.

1. Background

The overall objective of this Topic is to support, by experimental confirmation, the aerodynamic configuration definition of the novel tilt rotor NGCTR TD demonstrator. In order to guarantee the correct fulfillment of the design solution a dedicated wind tunnel test campaign at high speed is required to support the configuration definition, with the aim to verify and confirm the key architectural choices of the configurations. The activity shall culminate with the release of the high speed data set at full scale conditions, even by a CFD support for the extension (or confirmation) of the wind tunnel data at full Reynolds number if not achieved during the test campaign.

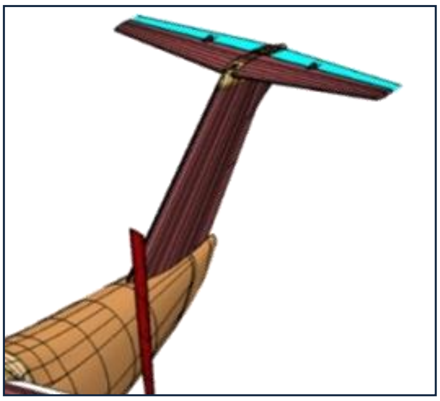
The figure below shows the configuration of the NGCTR TD. The existing bare fuselage of the current flying TiltRotor will host a new wing and a new empennage configuration.

The main aim of this topic is to experimentally evaluate the aerodynamic characteristic at high speed of this set-up and to confirm the choice of the empennage V-Tail scheme with respect to the classical T-Tail.

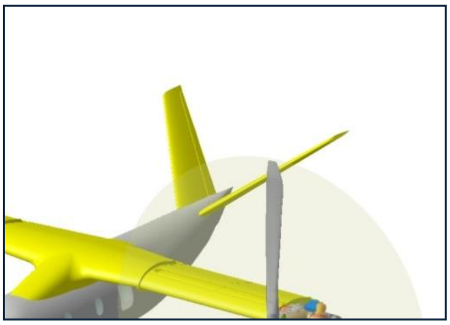


The main difference between the configurations to be analysed and tested in this Topic is then the empennage geometry: two options will be studied in this Topic:

1. The classical T-Tail empennage, as installed on the current tilt rotor:



2. A new advanced V-Tail empennage, specifically studied for NGCTR and to be installed on NGCTR-TD:



All the other components (the so called tail-off configuration) are in common to both empennages, i.e the wing remains the same.

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

- *Model design and manufacturing*
- *Model wind tunnel tests*
- *Data analysis and reports*

2. Scope of work

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

- **Task 1**: Management and project coordination
- **Task 2**: Design of the unpowered model components
- **Task 3**: Manufacturing of the unpowered model components
- **Task 4**: Wind tunnel tests of the un-powered model
- **Task 5**: Wind tunnel data analysis and reporting

Task 2: Design of the unpowered model components

The model shall include (but it's not limited to) the following main components:

- Internal frame for model support and wind tunnel main balance attachment
- Left & right wings with movable flaperons (remotely controlled). Hinge flaperon moments shall be measured as well.
- Secondary wing balance and dedicated attachment to the model mainframe: to correlate wing forces and moments, as accurately measured by balances, with the static pressure data integration. This step is helpful to evaluate the full scale behaviour by a sound experimental data base for CFD. Moreover, the application of transition strip on wing will be supported. In addition, being the wing design totally new, these data will support and confirm the air loads data set for structural substantiation and high speed.
- Tail Empennages (Basic T-Tail & Alternate V-Tail) with movable surfaces (remotely controlled)
- Empennage secondary balance and dedicated attachment to the model mainframe: to identify the individual aerodynamic loads of each empennage in order to confirm the released loads for structural substantiation at the fuselage/tail boom attachment bulkhead. Moreover, as far as the

aerodynamic test campaign, the installations of transition strips as for the wing will benefits of both pressures and integral loads measurements. It's suggested to design a model able to maintain the same balance installation for both empennage configurations
- Left & right engine nacelles detachable and movable (remotely controlled)
- Left engine nacelle instrumented with a dedicated components balance
- Left & right spinners (not rotating)

The following pressure measurements are required:

- Wing static pressure taps (160 locations, one wing only)
- Fuselage static pressure taps (120 locations)
- Empennage static pressure taps (90 locations)
- Dynamic press. Sensors on Empennage (20 transducers)
- Dynamic press. sensors on wing (18 transducers on one wing)

The model shall be designed to sustain a test matrix bounded by a Pitch attitude ranges from -20 to +30 deg, and a Yaw attitudes range from -30 up to +30 deg, both with a maximum free stream Mach number of not less than 0.6.

For a first assessment of the task, the full scale TD wing span (distance between the two rotor center lines) is 12m, the full scale NGCTR TD length (nose to tail end) is 14m, the full scale NGCTR TD wing chord is 1.85 m.

The model shall host a wing balance, a nacelle balance, an empennage balance, an overall main balance: all these balances will be supplied the Applicant.

Inputs from Topic Leader:

- Wind tunnel model specification – T0
- CAD model in CATIA V5 format - T0

Outputs from the Applicant (T0 +12):

- 2D drawings (printed and Catia format)
- 3D drawings (Catia format)
- Detailed design and stress report
- Structural substantiation report
- Material properties and characteristics

Task 3: Manufacturing of the unpowered model components

This task deals with the manufacturing and the instrumentation (pressure transducers and balances, surface movable control system) of the wind tunnel model.

Outputs from the Applicant:

- Model manufacturing (T0 + 24)

Task 4: Wind tunnel tests of the unpowered model

This task includes:

1. Provision of a Wind Tunnel able to guarantee the allocation of the model attitudes as needed and a

tunnel speed not less than Mach 0.6.

2. Definition of the test matrix in agreement with the ITD. Being not available at this stage the full text matrix to be accomplished, the Applicant shall consider the following 3 set of data points:
    a. First set: tail-off configuration to establish the basic aerodynamic characteristics in terms of static stability (30 polars in total)
    b. Second set: empennage 1-on configuration: 200 polars in total
    c. Third set: empennage 2-on configuration: 200 polars in total
3. Measurements of model main aerodynamic steady loads using the appropriate balances as required in Task 1 and the associated pressures in order to fulfil the data analysis as required in Task 4 and to support the extension to full scale.
4. Any other tests useful for transition strips location on wings, empennage and fuselage.
5. Any additional tests to evaluate the interference wind tunnel effects are not included in the previous a,b, c sets: those, if needed, shall be added by the applicant according to its own wind tunnel needs.

Inputs from Topic Leader:

- Support in the test matrix definition

Outputs from the Applicant:

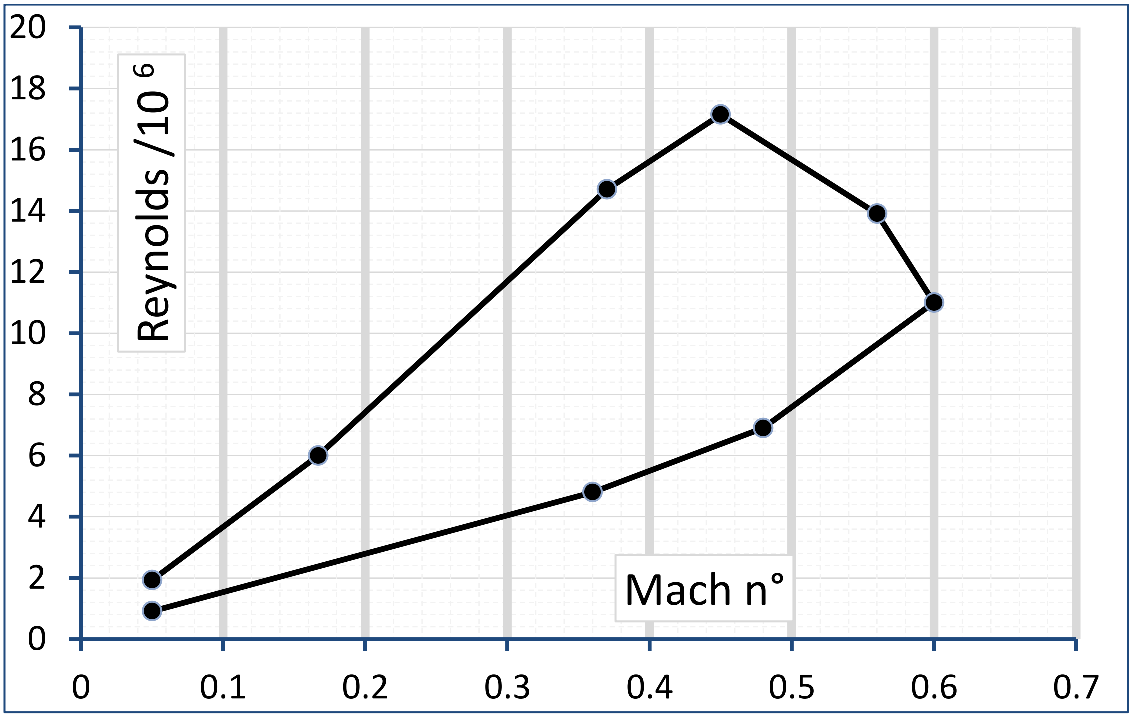
- Test Matrix Report – T0 + 3 M
- Raw data of the tunnel tests – T0 + 24 M

Task 5: Wind tunnel data analysis

This task includes:

1. Delivery of the force and moments data reports, in a condensed and readable format to be agreed with ITD. The reports (as many as necessary) shall include:
    a. the wind tunnel raw data as acquired by all balances,
    b. the correction criteria used for post-processing such as tunnel wall and support interferences (if any), buoyancy corrections and other effects as peculiar of the applicant wind tunnel
    c. the final post-processed aerodynamic integral data of the overall configuration and of the individual components as measured by balances
2. the comparison results between the two tested empennage configurations in terms of pure static aerodynamic variation vs. aircraft attitudes (pitch and yaw) including the static stability curves (longitudinal and lateral)Delivery of the surface pressure (static and dynamic) report, in a condensed and readable format to be agreed with ITD
3. Analysis of the aerodynamic characteristics of the configurations at high speeds at full scale conditions (Full Mach and Full Reynolds). If a Reynolds number similarity is not guaranteed in the wind tunnel plant, a support from CFD shall be envisaged in this task, and the Proposal plan shall be structured accordingly. The Applicant should consider the following Mach-Reynolds envelope at full

scale (based Reynolds based on the Wing chord).



Inputs from Topic Leader:

- Condensed and readable format and conventions T0 + 12M

Outputs from the Applicant:

- Wind tunnel entry – T0 + 23 M
- Wind tunnel force, moments and pressure report – T0 + 30 M
- Full scale aerodynamic characteristics – T0 + 36M

Tasks		
Ref. No.	Title - Description	Due Date
T1	Management and project coordination	T0 + 36
T2	Design of the unpowered model components	T0 + 12
T3	Manufacturing of the unpowered model components	T0 + 24
T4	Wind tunnel tests of the unpowered model	T0 +26
T5	Wind tunnel data analysis	T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date (in Month)
D1	Preliminary Design Report (preliminary CATIA 3D)	R	T0 + 6
D2	Final Design and Analysis Report - Comprehensive Documentation Package (CATIA 3D, 2D manuf. dwgs)	R	T0 + 12
D3	Model delivery	D	T0 + 20
D4	Wind tunnel test matrix	R	T0 + 3

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

Milestones (when appropriate)			
Ref. No.	Title - Description	Type*	Due Date (in Month)
M1	Tiltrotor Model PDR (Go ahead with detailed design)	RM	T0 + 6
M2	Tiltrotor Model CDR (Go ahead with manufacturing)	RM	T0 + 12
M3	Tiltrotor Model Test Readiness Review	RM	T0 + 23
M4	Tiltrotor Model Wind Tunnel Entry	RM	T0 + 23

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

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 Topic, in particular:

- High Speed wind tunnel model design, instrumentation and manufacturing
- Management and conduction of high speed wind tunnel tests
- Proof capability in managing data acquisiton and post-processing of highly instrumented wind tunnel models
- Proof experience in managing the aerodynamics of a Tilt Rotor
- Numerical CFD capability in management the high speed aircraft conditions
- Management of Projects at International level

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

5. Abbreviations

NGCTR	Next Generation Civil Tilt Rotor
NGCTR TD	Technology Demonstrator
CFD	Computational Fluid Dynamics
PDR	Preliminary Design Review
CDR	Critical Design Review

II. Innovative flotation methodologies (system) for tilt rotor

Type of action (RIA or IA)	RIA		
Programme Area (ref. to SPD)	FRC		
Joint Technical Programme (JTP) Ref.	WP1		
Indicative Funding Topic Value (in k€)	750		
Topic Leader	Leonardo Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in months)	36	**Indicative Start Date**[22]	Q3 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-FRC-01-17	**Innovative flotation methodologies (system) for tilt rotor**
Short description	
Development of Innovative low weight floatation methodologies (system) for tilt rotor, including multibody model of ditching, validated by comparison with results of model testing, to allow seaworthiness verification by analysis and not by test.	

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

1. Background

In the framework of Clean Sky 2 FRC IADP, the present Call requires Partner(s) (company or consortium) to develop Innovative low weight flotation methodologies (system) for tilt rotor.

2. Scope of work

The main objectives of this Call are:

- the development of a validated floatation model, and
- the determination of the best architecture for an unconventional floatation system

As first step of the design the Partner(s) shall develop a multibody model able to simulate the ditching of a tilt rotor. The model shall be validated by comparison with results of tests performed in a naval tank, using a scale model of the tilt rotor.

The second step is the evaluation (by means of the validated model) of different floatation methodologies and systems, in particular looking for unconventional systems having a weight and cost lower than the usual floatation systems.

The third step is the manufacturing of the first prototype of the best configuration identified by the second step.

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

The design and development of the system shall follow the standard procedures for aeronautic software.

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0 + mm]
T01	Kick Off Meeting(1)	T0
T02	Development of the multibody model	T0 + 06
T03	Model testing	T0 + 12
T04	Validation of the model	T0 + 18
T05	Floatation system comparative analysis	T0 + 24
T06	Design of flotation system components	T0 + 30
T07	Manufacturing of the first flotation system prototype	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 LH 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	Multibody model	CFD FILE	T0 + 06
D02	Multibody ditching analysis	DOCUMENT	T0 + 06
D03	Model Tests Procedure	DOCUMENT	T0 + 09
D04	Model Tests Result	DOCUMENT	T0 + 12
D05	Comparative analysis of model results and experimental results	DOCUMENT	T0 + 18
D06	Floatation system comparative analysis	DOCUMENT	T0 + 24
D07	Flotation system design description	DOCUMENT	T0 + 30
D08	Flotation system components drawing	DOCUMENT	T0 + 30
D09	Flotation system prototype	DOCUMENT	T0 + 36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0 + mm]
M01	Kick-off meeting	Design review	T0
M02	Multibody model presentation	Design review & model availability	T0 + 06
M03	Closure of Experimental campaign	Document and design review	T0 + 18
M04	Comparative analysis report	Document and review	T0 + 24
M05	Design review	Design Review	T0 + 30
M06	Flotation system prototype	Parts availability	T0 + 36

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

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

- Compliance to SAE AS9100.
- Familiarity with, or at least knowledge, of aeronautic rules, certification processes and quality requirements.
- Capability to design, validate, manufacture airborne equipment
- Experience in research, development and manufacturing in the following technology fields:
    - Multibody simulation
    - Floatation system

- Experimental test capabilities (nice to have)

- Shape, component design and structural analysis using CATIA v5 and NASTRAN.
- Capability to optimize the HW and SW design, to model mathematically/numerically complex mechatronic systems with suitable simulation tools and to analyze both simulation and experimental results to ensure that the various required performance goals are met.
- Capability to repair "in-shop" equipment due to manufacturing deviations.

Detailed Quality Assurance Requirements for Supplier will be provided to the selected Partner(s) following the signature of dedicated NDA or equivalent commitment.
The Partner shall guarantee consumable availability and technical support even following achievement of all milestones.

5. Glossary

NDA	Non disclosure agreement
HW	Hardware
SW	Software
DOA	Design Organization Approval
PPT	Power Point Presentation
DOCUMENT:	Document issued
REPORT:	Document or ppt presentation

7. Clean Sky 2 – Airframe ITD

I. Finalize and improve the manufacturing and the instrumentation of the model of a laminar wing configuration business jet (LSBJ)

Type of action (RIA or IA)	IA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP V5) Ref.	WP A-2.2		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Dassault Aviation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	12	**Indicative Start Date**[23]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-01-30	**Finalize and improve the manufacturing and the instrumentation of the model of a laminar wing configuration business jet (LSBJ)**
Short description	
The purpose of the topic is to finalize and improve the manufacturing of the LSBJ half-model started in the EULOSAM project in the frame of CS1 SFWA ITD. The final objective is to perform WTT (but it is out of the perimeter of the CfP) in order to identify the behaviour of a laminar wing at high Re number and low speed conditions. The expected innovation and improvement are new processes to manufacture flaps, aileron and HTP, a motorization to move the HTP and the implementation of transducers inside the leading edge with plug and play systems.	

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

1. Background

Laminarity is one of the most important technological routes toward a more efficient aircraft, as it can provide a significant improvement on drag & aircraft aerodynamic efficiency. Major demonstrations of natural laminarity for a partially modified wing will be performed in Clean Sky. This demonstration will validate the concept.
The topic is devoted to the manufacturing of a large scale half-model for testing in a pressurized low speed wind tunnel. The fuselage (with nacelles and Vertical Tail Plane) and the wing main box will be provided by the Topic Manager. In order to integrate an additional touch of innovation concerning the manufacturing processes and instrumentation, it is allowed to modify the fuselage and/or the wing-box as far as the modifications won't modify the existing pieces of the existing model. These modifications shall be considered as part of this CfP.
Most of the model design and a part of the manufacturing were completed under a previous CS1 SFWA ITD CfP project. Some adaptation of the design to the final geometry may nevertheless be necessary within this topic in particular to implement new concepts for improving the efficiency of the WTT.

2. Scope of work

List of the tasks

The tasks to be carried in this project are:

Tasks		
Ref. No.	Title - Description	Due Date
T1	Preliminary design of the improvement of the model	T0+2
T2	Detailed design of the improvement of the model	T0+4
T3	Manufacturing of the remaining parts of the model	T0+9
T4	Instrumentation of the model	T0+11
T5	Inspection (geometry and instrumentation) of the model	T0+11.5
T6	Manufacturing of the needed storage boxes and shipment of the complete model	T0+12

The wing will be an innovative low sweep high aspect-ratio design with an airfoil designed to be laminar in cruise conditions (M=0.75 – 43kft). Innovative high-lift systems are outputs of related CS1 SFWA studies and shall include:

- Krueger slats
- Conventional single slotted flap
- Innovative Flaps devices

Wing modularity also includes:

- A removable leading edge for different leading edge concepts/shapes
- Spoilers and airbrakes
- Ailerons

The parts already existing are:

- Fuselage

- Wing Main box
- One set of clean leading edge
- Interface plate between the wing and the balance of the wind tunnel

The parts to design and manufacture within this topic are therefore:
- Instrumentation of the manufactured wing main box and clean leading edge
- All the trailing edge parts
- Body fairing between the root of the wing and the fuselage
- Conventional trailing edge : inboard and outboard flap and one aileron instrumented
- Leading edges derivatives (7 parts)
- Slats (overall span) instrumented
- Smart flaps (inboard and outboard) instrumented
- Landing gear
- VTP and HTP with mechanism for the trim

General Size of the model
The model is a left-hand-side half-wing with high aspect ratio (around 11) and low sweep (20°).
At model scale, the half-wing will be roughly 2.25 m in span for an area of ≈ 1 m2.
At model scale, the HTP will be 0.8 m in span for an area of 0.26 m2.
The generic Falcon fuselage (with nacelles and VTP) and the wing main box will be provided by the Topic Manager and adapted if needed to the new instrumentation by the applicant.

Figure 1: Provided generic Falcon fuselage with nacelles with a generic Falcon Wing

Fuselage description
In the current FALCON model from which the fuselage will be provided for the current topic, the wing is directly attached to the balance via an interface plate. The same setting will be used for this model. The new interface plate is already manufactured. The body faring that aims to fit the new wing with the existing fuselage is already designed and has to be manufactured.

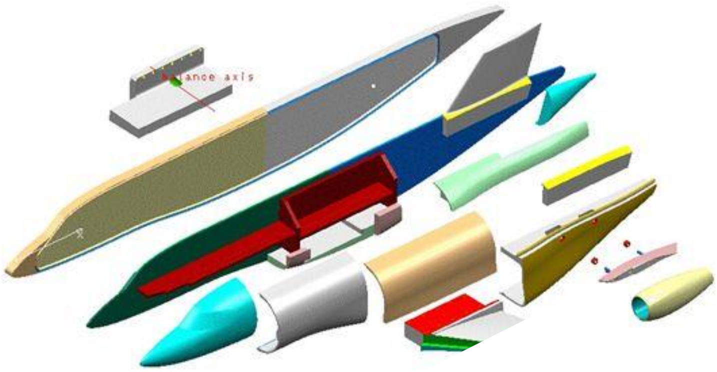
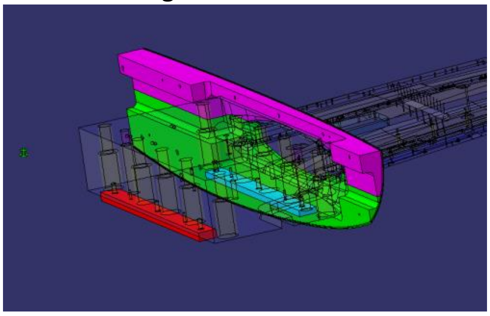


Figure 2: Cutaway of the fuselage

Wing description
The parts of the wing to be manufactured are:

- Leading edge derivatives. For the 4 different parts in span, 3 different (partially in span) LE shapes, named: CL, CM, CC, have to be manufactured to complete the clean leading edge already manufactured. So 7 different leading edge parts with a chord extension of around 25% are therefore required. Each LE part is divided in upper and lower parts.
- Body fairing to fit the fuselage with the wing



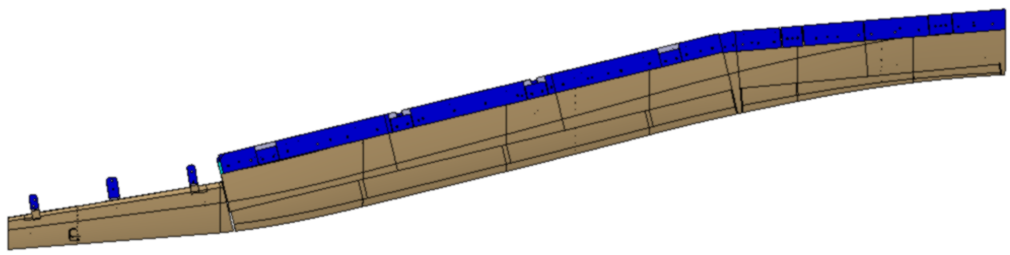
- A modular trailing edge architecture capable of 2 different trailing edge concepts
    - Conventional single slotted flaps
        - Clean configuration: the flaps are at 0° deflection
        - Take-off configuration including a +-5° modification deflection system. The brackets shall permit a slight capacity of overlap and gap settings (roughly a X and Z setting capacity)
        - Landing configuration including a +-5° modification deflection system. The brackets shall permit a slight capacity of overlap and gap settings (roughly a X and Z setting capacity)

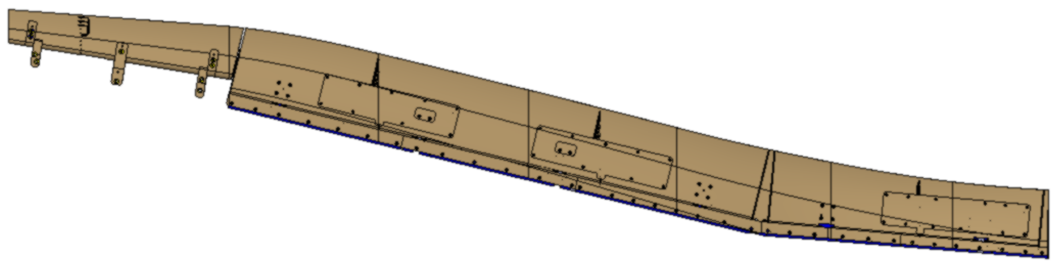
    - Innovative Flap devices:
        - Clean configuration: the flaps are at 0° of deflection
        - Take-off configuration: at a given extension, a bracket that enables a camber setting from -30°° to 20°. The brackets shall also permit a slight capacity of overlap and gap settings (roughly a X and Z setting capacity)
        - Landing configuration: at a given extension, a bracket that enables a camber setting from -30°° to 40°. The brackets shall also permit a slight capacity of overlap and gap settings (roughly a X and Z setting capacity)

In terms of moving parts, one shall therefore consider:

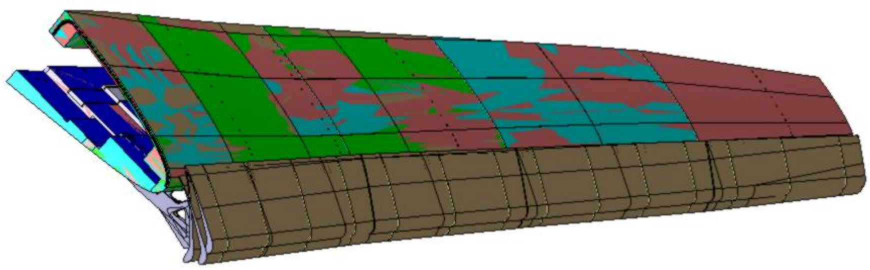
- 2 different outer flaps (1 conventional flap + 1 "smart flap") and 2 different inner flap (1 conventional flap + 1 "smart flap")
- 2 sets of flap roof (one for the "Smart Flaps" and one for the two others)
    - For the conventional flap roof, 4 spoilers/airbrakes have to be considered with 4 deflections each (including 0°)
    - For the "Smart Flap" roof, it is asked to manufacture one set of flap roof at 0° (already designed).

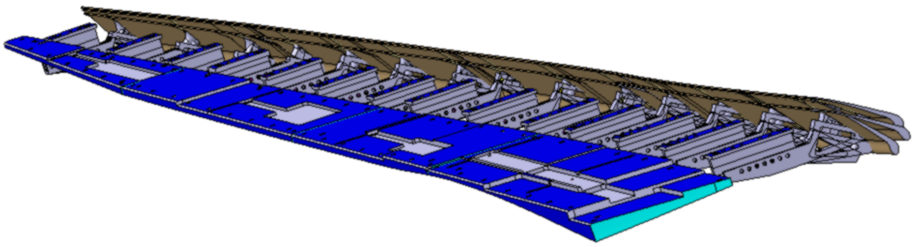
- An aileron



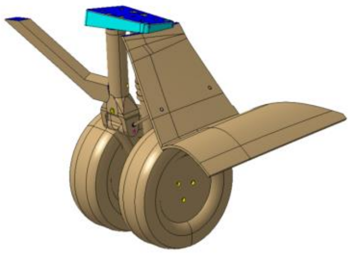


- A set of Kruger slats with slight capacity of gap and overlap settings. The Kruger slat will be dedicated to only one set of leading-edge. This specific set of leading edge shall therefore also present a removable lower panel to mimic the open cavity when the slat is deployed. That is why each LE part is divided in upper and lower part. The Krueger slat will be divided in 4 parts in span and for each part, 3 different set of brackets will be manufacture to enable different slat deflection.





- A simplified main landing gear with doors will be manufacture and integrate into the wing in a generic cavity. The cavity can be closed with a dedicated and manufactured part at the lower side of the wing for clean and take-off configurations.



Wing Instrumentation

The wing will be equipped with 4 lines of around 80-100 pressure probes each. In a given line, there will be some pressure taps in

- Wing-box
- Leading-edge
- Flap (pressure needed for all deflections)
- Aileron

To achieve quick-change capacity during the test, one shall therefore consider quick connectors for the taps to be installed in the moving parts.

4 strain gauges will be installed on the upper part of the wing

Rough parts for flaps and aileron will be manufactured with SLM process in order to integrate pressure taps routes. The supplier will be able to design new parts and define design rules necessary for machining process. Moreover, it will be able to provide stress test for justifying mechanical strength. Leading Edge parts will be redesigned for replacing pressures taps by transducers. Those will be integrated with plug and play interface.

HTP description

The HTP will be a simple one-part all movable part. That means no movable elevator is asked within this topic. It is asked to manufacture a new HTP with a new attachment that allows fitting with the existing trim system. The trim system is already provided with the VTP.

In order to optimise machining time and cost, rough parts for HTP will be manufactured with sand casting. Mould core will be realised with additive manufacturing adapted to sand casting. The supplier will be able to design this part and define design rules associated. Moreover, it will be able to provide stress test for justifying mechanical strength.

In order to develop supplier design skills, the supplier will design a complete system to motorise the HTP trim, with the control program associated and compatible with WTT interfaces. This system won't be integrated to the model but used in a workbench for proof test.

HTP angular displacement : [- 14° ; + 3°]
Angular accuracy : < 0.03° and < 0.08° with aerodynamic force
HTP trim switch time : < 1min

Model loads

Expected loads on the wing model are: (X Chord-Wise ; Y Span-Wise; Z Normal)

- Fx = 4000 N
- Fy = -10000 N
- Fz = 50000 N
- Mx = -4000 Nm
- My = -10000 Nm
- Mz = 5200 Nm

The expected normal loads on moving parts are:

- Inner flap: 800 N
- Outer Flap : 1800 N
- Slats (loads for the full span) : 3200 N

Expected loads on the HTP model are:

- Fx = -3400 N
- Mx = -900 Nm
- My = -350 Nm (at 40% chord)

One can increase these values by 20% to take into account the dynamic loads at stall.

The stress report is available and is an output of a previous project. The material is already defined for each parts of the model. The applicant must take notice that some critical parts (only brackets) have to be manufactured in Maraging steel with all provisioning issues that this constraint implies.

Shape tolerances

The applicant shall respect the following given tolerances:

Shape tolerance		+- 0.1	mm
Root airfoil angle setting		+- 0.1	°
Local twist (root airfoil reference)		+- 0.075	°
Moving surfaces deflection (flap, slat, aileron)		+- 0.1	°
Flap overlap & gap setting		+- 0.15	mm
Slat overlap & gap setting		+- 0.1	mm
Leading-edge roughness including slats & flaps (x/c > 0.25)		Ra<0.2	µm
Other parts Roughness		Ra<0.4	µm
Slat & Leading-Edge Waviness (x/C < 0.25)		< 0.5	%
Pressure taps diameter		0.4	mm

The applicant shall also adjust the different parts to avoid any backward or forward facing step at the skin of the model. One shall specially pay attention to the leading-edge/ wing-box adjustment where some sealing is needed to avoid upper/lower wing contamination.

Control of the model

The applicant shall include a control review of the model. A detailed document will be provided by the Topic Manager to complete the following instruction, in order to specify the inspection requirements according to the final geometry of the model. The specification will concern single part as well as the overall model inspection (size, dihedral, twist of the wing, …).

Planning of the topic

The topic is devoted to improve the existing design and the manufacturing of the remaining parts of a low speed half model. One former topic for the design and another for the manufacturing of this given model have produced the main inputs to finalise the model. The CAD-File of the model and drawings are available in CATIA V5 R18 readable format. The Topic Manager will be responsible for all the CAD files and will provide them directly to the applicant. The outputs of former studies are therefore:

- CAD file of the model to be manufactured with its structural design including:
    - Instrumentation integration
    - Type of raw material to use in given parts (steel, aluminium, …)
    - Fasteners
    - …
- Justification of the model design in regards of the loads foreseen during the WTT
- Control reports of the parts already manufactured

All the modification needed to improve the efficiency of the WTT will be justified (stress report) by the applicant.

The complete model shall be transferred in the wind tunnel facility in the needed storage boxes. These boxes are also part of the topic.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	PDR for the improvement concepts	Meetings + Report	T0+2
D2	CDR for the improvement concepts	Meetings + Report	T0+4
D3	Update of the model CAD including all the modifications	Data	T0+5
D3	Inspection report	Report	T0+11,5
D4	Buy-off	Meeting + Report	T0+11,5
D5	Delivery of the model	Hardware + Report	T0+12

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

In addition to those deliverable, the applicant will be asked to get the Topic Manager informed of manufacturing progress or issues. Weekly reports by mail or telephone, with pictures of parts in manufacturing and updated planning, will be appreciated.

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	PDR	Meeting	T0+2
M2	CDR	Meeting	T0+4
M3	Intermediate Review of the manufacturing	Meeting	T0+7
M4	Buy-off	Meeting	T0+11,5

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

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

- The applicant shall have experience in designing and manufacturing Wind Tunnel Models for the aeronautical industry.
- The applicant shall comply with Topic Manager procedures concerning WT model design and manufacturing. This will be provided in the model requirement document to be issued at the beginning of the project.
- The applicant shall have confidential agreement(s) with all partners participating in the Low Speed Platform to which this topic is related. To be managed by the Topic Manager.
- The applicant shall have proficiency in using Dassault System CATIA R18 Software.

5. Abbreviations

WTT	Wind Tunnel Test
WT	Wind Tunnel
LE	Leading Edge
HTP	Horizontal Tail Plan
VTP	Vertical Tail Plan

II. Evaluation of the benefits of innovative concepts of laminar nacelle and HTP installed on a business jet configuration

Type of action (RIA or IA)	RIA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP A-2.2		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Dassault Aviation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	9	**Indicative Start Date**[24]	Q4 2018

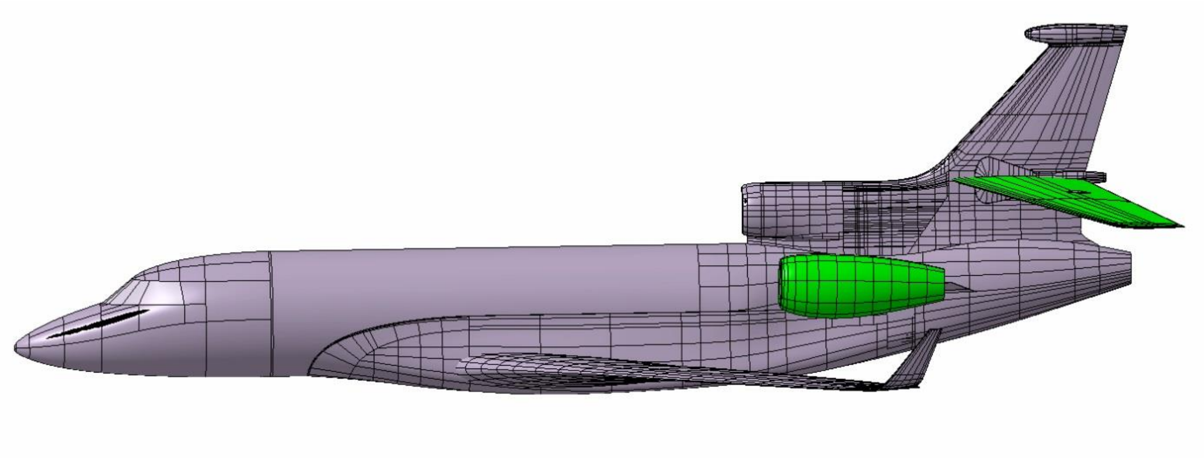
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-01-31	**Evaluation of the benefits of innovative concepts of laminar nacelle and HTP installed on a business jet configuration**
Short description	
The purpose of the topic is to design and manufacture the specific model pieces to adapt the laminar parts of an existing full model as well as to perform the WTT tests dedicated to the evaluation of their laminar benefits in cruise conditions (High Reynolds number and high speed) including innovative visualisation means to identify the laminar extension.	

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

1. Background

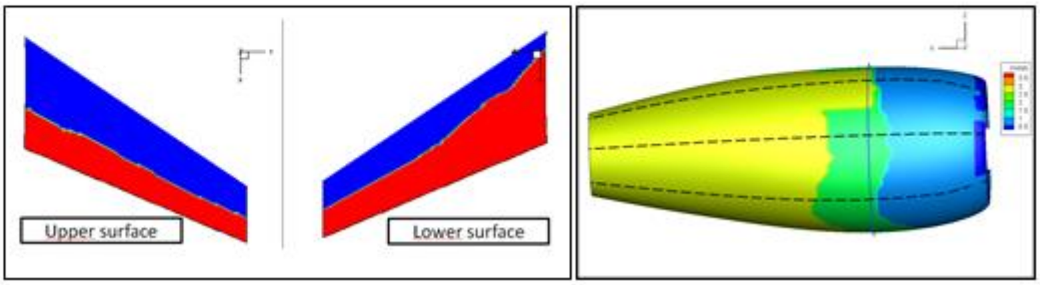
Laminarity is one of the most important technological routes toward a significant improvement on drag & aircraft aerodynamic efficiency. This demonstration is linked with AIRFRAME WP A-2.2 and LPA PF1 WP-1.4.6 activities and will validate the drag benefits and check the handling qualities of such innovative aircraft in cruise conditions.

On this new aircraft concept the additional laminar parts are highlighted in green below:



These green parts have to be manufactured in this project. In addition, the laminar drag benefits as well as the extension of the laminarity will be identified through wind tunnel tests in cruise conditions.

The extension of the laminarity expected with regards to a business jet application is illustrated in blue colour below (aerodynamic computation):



At the end, it is expected to obtain a reduction of the overall aircraft drag from 2% to 3%.

2. Scope of work

Model Design

The Topic Manager will provide to the Applicant the full set of the existing model CAD and the geometry of the specific laminar shapes. The Applicant shall design the new laminar parts without modification of the existing parts of the model. By this way the new and the old configurations shall be fully interchangeable.
The existing model is fully representative of a classical and turbulent business jet and was designed to be compatible with interchangeable nacelles and HTP. The span of the existing full model is around 1.5 m with a mean aerodynamic chord of around 0.25 m.
In case the applicant has to modify the existing model all the modifications have to be done taking into account that the previous configuration can be tested again.
The stress report for these new parts will be justified through e.g. FEM computations by the Applicant to the WT. For this task the Topic Manager will provide the most critical aerodynamic loads and the tests conditions. All these data will be similar to the data used for the existing model.

Model Manufacturing

The Applicant shall manufacture all the specific model parts needed from a full model already available to perform the tests.

Testing

The Applicant shall perform wind tunnel tests and will measure all the information needed to be compared to the reference configuration results available. These tests will be representative of flight conditions in term of Reynolds number (around 15 Million) for transonic Mach number up to 0.95. Pure Reynolds number, Mach number and aeroelastic effects have to be tested during the wind tunnel test campaign.

Three configurations are requested:

- Reference configuration with turbulent nacelle and HTP at only one reference trim position (0°)
- Reference configuration with turbulent nacelle and laminar HTP including 3 different settings of the HTP (trim). The existing model will include a remotely motorized HTP.
- Reference configuration with laminar nacelle and laminar HTP at only one reference trim position (0°)

The Applicant shall suggest innovative visualisation means in order to identify the transition location of the laminar flow on at least one side of the model on nacelle and HTP. These data will be then analysed by the Topic Manager to compare CFD prediction and WTT data obtained within this topic.
These tests have to be fully independent to the reference ones. It means that the model modifications if needed have to be done taking into account that the initial model have to re-usable.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Design the laminar specific parts (nacelles and HTP) of the model	T0+3
T2	Manufacturing and adjustment of the laminar specific parts of the model	T0+6
T3	Perform WTT	T0+8
T4	Write the test report	T0+9

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Specific Laminar Model parts	HW	T0+6
D2	Test results	D	T0+8.5
D3	Test report	R	T0+9

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	PDR	Meeting + Report	T0+1
M2	CDR	Meeting + Report	T0+3
M3	Entry in the tests section	Meeting	T0+8
M4	Tests results	Data + Report	T0+9
M1	PDR	Meeting + Report	T0+1

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

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

- The applicant shall have a large experience in designing and manufacturing model parts for aerodynamic wind tunnel tests in cryogenic condition.
- The applicant shall have a large experience in testing at flight Reynolds conditions
- The applicant shall be proficient in using Dassault Systèmes CATIA V5 r20 software (Design modules in particular).

5. Abbreviations

WTT	Wind Tunnel Test
HTP	Horizontal Tail Plan
FEM	Finite Element Method

III. Prototype Tooling for manufacturing composite stiffened panel for a business jet lower wing

Type of action (RIA or IA)	IA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP A-3.1		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Aernnova	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	14	**Indicative Start Date**[25]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-01-32	**Prototype Tooling for manufacturing composite stiffened panel for a business jet lower wing**
Short description	
The aim of this Call for Proposal is to develop, design, manufacture and deliver to the Topic Manager facilities, all the prototype subcomponent manufacturing tooling needed to manufacture the stiffeners and panel of lower wing (including all auxiliary tools). The development of this tooling should be innovative in order to implement the best performances in the following fields: Composite Materials, Low Cost, 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.	

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

1. Background

Within WP3.1 Airframe ITD, Dassault Aviation is developing a composite solution for business Jet lower wing panel (LWP), based on typical architecture of existing Falcons. A general view of the Finite Element Model of the wing and the associated fuselage part is provided hereafter.

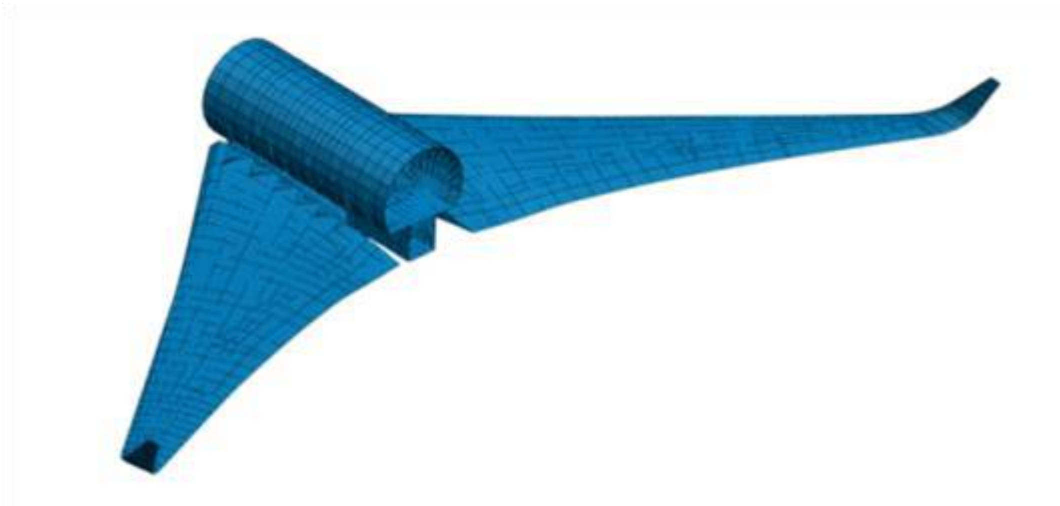


Figure 3. Business jet wing panel

The principles of the composite solution are studied on a full Lower Wing Panel. Expected size of the Lower panel to be manufactured by the Topic Manager (TM) is 5m span wise by 2 / 1.2m chord wise (TBC). A typical number of stringers would be around 16. See figure 2.

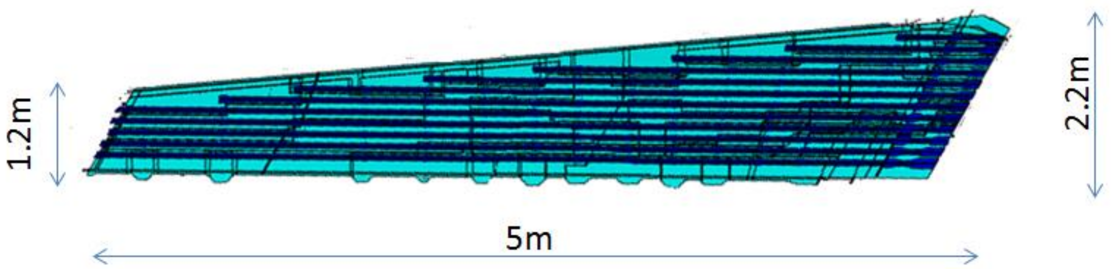


Figure 2. Expected size of Lower Panel

The Partner that will be selected for this Call will be responsible to develop, design, manufacture and deliver to the TM the tooling set for the manufacture of the stringers and the panel, including auxiliary tools to ensure the correct position of the stringer on the panel, in accordance with the materials, manufacturing processes and technical specifications selected or developed by the TM.

2. Scope of work

the general dimension on the figure 3.

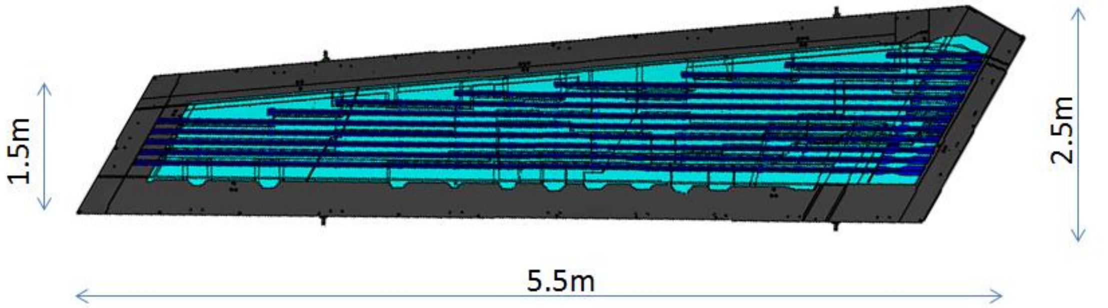


Figure 3. Expected size of Lower panel tool

The final requirements, including the manufacturing process of each parts, and features needed for the Prototype Manufacturing tooling will be provided to the Partner by Topic Manager at the beginning of the project.

The innovative character of the manufacturing tooling developed in this CfP will be reflected in the materials employed, the interaction between the expansion coefficient and thermal conductivity of the different materials. In order to reduce costs the possibility of using the stringer tools modules during the forming process of the preform shall also be studied.

The materials selected will be optimized to reduce the thermal inertia and to improve their thermal conductivity. Their manufacturability will also be studied in order to ease the modification of the mould due to new requirements identified during the specimen manufacturing (e.g. surface finish improvement or spring back modification).

For the manufacture of skin panel curing tool, composite material must be selected. Tool will include some external elements to ensure the correct position of the stringer.

The Partner shall:

- Propose the most suitable and innovative tooling design for the chosen technology to be applied for each Single Part, including mould, press or hot-forming, drill, trim, etc. to produce a part according to the drawing set.
- Define and Manufacture Prototype Tooling for Stringers and Panel that will assure the full functionality of each Single Part and, if needed, modify their designs in order to improve Single Part functionality.
- Define and Manufacture Prototype Tooling that will assure the demanded quality of each part in accordance with the Technical Specifications.
- Generate a tooling documentation in agreement with the Topic Manager specification. This documentation will include, at least, geometrical definition and geometrical control (if needed) of the tooling in line with the requirements laid down by the Topic manager. Work with geometrical verification means e.g. laser tracker.
- Delivery of the Prototype Tooling set 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 demonstrator.

• Identify and report at least the following information: RC, weight (if applicable), materials, manufacturing procedures, LCA data, etc. always establishing the study versus the current solutions applied in industry.

It will be appreciated and desirable if the defined Prototype Tooling can simplify the single part manufacturing process when compared with current tooling systems. In addition, the implementation, in the Prototype Tooling Design, of innovative and low cost concepts in terms of Materials and Design processes will be appreciated.

Tasks		
Ref. No.	Title - Description	Due Date
Task 1	Tool design approach (Development of every tooling needed to manufacture stiffeners and panel and manufacturing trials)	T0 + 6 months
Task 2	Detailed design of every tooling applying tools compensation generated by TM	T0 + 9 months
Task 3	Manufacture of the tooling	T0 + 11 months
Task 4	Validation of the tooling as agreed with the TM (dimensional, porosity, etc.)	T0 + 11 months
Task 5	Delivery of the manufacturing tooling to the TM facilities	T0 + 12 months
Task 6	Support and tooling set-up	T0 + 14 months

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Trade-offs report: - *Design trade-offs based on TM proposed concepts. Manufacturing approaches for any proposed solution.* *Materials, RC, Weight, etc.*	*Report*	To+9
D2	Delivery of tools to TM facilities in Illescas: - Prototype Tooling ready to produce parts. - Auxiliary tooling needed for forming, positioning, etc. - Quality inspection reports-CoC - Tooling Manufacturing Report Prototype Tooling Maintenance and Working or Manufacturing Orders.	*Toolings* *Report* *Drawings* *Hardware*	To+12
D3	Final report: Conclusions and lesson learned	*Report*	To+14

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

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

- Experience in design and manufacturing of manufacturing tooling for structures in conventional composite materials and innovative metallic components (M).
- Design and analysis tools of the aeronautical industry: i.e. CATIA v5 r21 (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)
- Advanced Non Destructive Inspection (NDI) and tooling inspection like (A):
    - Dimensional and shaping inspections
    - Morphology studies of materials-if needed.
    - Ultrasonic inspection capabilities.
    - Contactless dimensional inspection systems.
- Simulation and Analysis of Tolerances and PKC/AKC/MKC (Product, and Manufacturing Key Characteristics). (A)

(M) – Mandatory; (A) – Appreciated

5. Abbreviations

TM	Topic Manager
CfP	Call for Proposal
RC	Recuring Cost

IV. Flexible RTM tool concept for composites with spring back adjustments capabilities

Type of action (RIA or IA)	RIA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	WP A-3.1		
Indicative Funding Topic Value (in k€)	1400		
Topic Leader	Saab	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[26]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-AIR-01-33	**Flexible RTM tool concept for composites with spring back adjustments capabilities**
Short description	
The objective of the work is to develop the next generation RTM Tooling that can be adjusted due to spring back effects. The tooling shall be capable of handling all aspects of the RTM process, i.e. temperature, pressure and different matrix systems.	

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

1. Background

This topic is part of Airframe High Performance and Energy Efficiency (Activity Line A). The topic is one of the key research activities which will ultimately result in the demonstration of an innovative integrated composite wing structure. This topic is part of Work Package A-3.1: Multidisciplinary wing for high and low speed.

Control surface structures are an essential part of a wing. One control surface which will be an area for research/development in AIR ITD is a highly integrated composite flaperon for a large passenger aircraft.

Composite structures for the aerospace industry are traditionally made of prepreg (pre-impregnated carbon fiber) cured at high temperature (120°C – 180°C) and under pressure in an autoclave. Depending on the product and the production rates, several parts are cured in one autoclave cycle. In order to achieve this, each specific autoclave load needs to be qualified. All of the above makes it difficult to produce parts in a lean system, i.e. single-unit manufacturing and reduces the level of flexibility. Composite processes are not only using prepregs. There are several other processes on the market but few of them are used for structural parts within the aerospace industry. In recent years, RTM (Resin Transfer Moulding) has emerged as one of the most potential processes for producing composite parts. This process can be divided into several similar processes (SQRTM, vacuum infusion, vacuum injection etc.). The basic idea however of all these processes is to use a closed mould and to inject the resin. Depending on which process is selected the tooling has different specifications.

All composite parts are subject to spring back effects. These effects differ dependent on the geometry of the part, the lay-up sequence of the composite material and the manufacturing process. It is common within the industry that the composite mould tools needs to be adjusted based on the spring back effects, especially when the geometry is complex. This is a costly and time consuming operation and in difficult cases it might need to be performed more than once. Software analysis tools are available on the market and are used with different results but they are currently not mature enough to handle the different lay-up effects when complex composite parts are produced, e.g. using traditional hand lay-up techniques.

Within a RTM tool there has to be several functions to handle the flow of resin, the flow of air and the temperature cycle for curing the part. Increased complexity within the mould tool will make any adjustment due to spring back effects more difficult to perform. In order to reduce recurring manufacturing costs and to be able to cope with increased production rates a new more innovative way of designing RTM tools needs to be developed. Furthermore the design of the tooling should have automation in focus, i.e. the production cell should be able to carry out task like cleaning and preparing the tooling, placing the fabric, resin injection, curing and demoulding.

2. Scope of work

Technical activities will be organised under the following structure. The structure of non-technical activities like management is left to the applicant.

Work Packages		
Ref. No.	***Title - Description***	***Due Date***
WP 1	Tool concept	T0 +6
WP 2	Testing and manufacturing	T0 +22
WP 3	Automation	T0 +24

WP 1. Tool concept

This is the first phase of the development work and the phase ends once the conceptual design is finalized. It is important that the chosen concept is suitable for production tooling which often requires a short lead time, i.e. the concept selected shall decrease the current lead time for composite mould tools. It is also important to consider different ways of heating/curing the composite parts with the aim of achieving a shorter lead time, induction heating is one example of this.

In order to be able to adjust the tool due to spring back effects it is possible for example to have removable inserts in the tooling. If inserts are chosen as a suitable tool for spring back compensation then it is important that these inserts are capable of handling the resin and the curing cycles.

Selected concept shall also have automation in focus in order to ensure a cost effective production and it shall be able to handle production rates up to 200 pcs per month.

WP 2. Testing and manufacturing

During this phase test samples to be used for stress test are being produced in a smaller (lab-sized) tool using the technique developed in the concept phase. This is also the phase where the design is verified on a small scale and a test tools is manufactured. The nature of the tests and the detail of the tooling shall be agreed with the topic manager but the test shall aim at verifying that the selected concept is able to produce parts that are defect free and meet the requirements equal to today prepreg quality.

The phase ends with the production of the final tool. This tool shall be used in the production of the test demonstrator within WP A-3.1. Size of the tooling will be approx. 2.5x0.8x0.5 meters and it shall be able to handle metallic inserts if such are included in the design of the demonstrator. Complete demonstration of the production cell shall be performed including the selected level of automation.

WP 3. Automation

In this phase the different demands for automation of the different activities surrounding the tooling are also evaluated. This will be:

- Level of automation for the injection process
    - This step shall handle activities such as attaching the injector, mixing the resin, extracting air etc.
- Level of automation for the placement of fibers

- This step shall handle activities such as plies, both single and bundles, keeping controlling fibre angles, placing surface films etc.

- Level of automation for cleaning and release treatment of the tool surfaces
    - This step shall handle the activities such as removal of resin, cleaning of surface, applying release agents, checking for damages, etc.

It is important that the automation steps selected are able to be verified in the demonstration listed in WP2.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D 1.1	Tool concept	R	T0 +6
D 2.1	Test tool manufactured	HW	T0 +9
D 2.2	Test sample produced	HW	T0 +11
D 2.3	PDR	R	T0 +14
D 2.4	CDR	R	T0 +16
D 2.5	Final tool	HW	T0 +20
D 2.6	Verification report	R	T0 +22
D 3.1	Concept of automation	R	T0 +12
D 3.2	Test and verification of automation	R	T0 +24

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Tool concept approved	R	T0 +6
M2	PDR	R	T0 +14
M3	CDR	R	T0 +16
M4	Automation demonstration	R	T0 +24

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

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

Special expected skills are:

- Proven experience in composite manufacturing for the aerospace industry
- Proven experience in tool design
- Proven experience in tool manufacturing
- Proven experience in RTM process of CFRP-parts
- Proven experience of automation.
- Solid knowledge in design of automated handling systems.
- Proven experience of manufacturing of composite parts for the aerospace industry.
- Knowledge in material selection for composites.

- Knowledge in the FPQ process
- Experience in technological research and development for innovative products and processes
- Experience of working with airframe designers, tooling design and joint design.
- Experience of working with suppliers of composite material.
- Experience of working with suppliers of composite mould tools.
- Proven experience in collaborating with aeronautical companies Research and Technology programs.

The applicant(s) are required to have access to the following capabilities:

- CATIA CAD software, V5 R24 or later, for design compatibility with topic manager
- Automation capabilities for material and tool handling
- Suitable simulation software for automation
- Suitable manufacture and machining facilities for tool production
- Suitable prototype workshop
- Composite curing facilities
- Laboratory facilities for mechanical testing, residual stress measurements and NDI

5. Abbreviations

RTM	Resin Transfer Moulding
CFRP	Carbon Fibre Reinforced Plastic
FPQ	First Part Qualification
NDI	Non Destructive Testing

V. Development of innovative aluminium filler wire based manufacturing of aeronautic components and structures

Type of action (RIA or IA)	RIA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP A-3.4		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	LORTEK	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[27]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-AIR-01-34	**Development of innovative aluminium filler wire based manufacturing of aeronautic components and structures**
Short description	
The activities in this topic will be directed to the development of a new aluminium filler wire, which will be applied to the manufacturing of aeronautic parts by Additive Manufacturing and Laser Beam Welding (by Topic Manager).	

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

1. **Background**

This topic is part of AIRFRAME ITD, Activity Line A (High Performance and Energy Efficiency), TS A-3 (High Speed Airframe) and WP A-3.4 (Eco-Design for Airframe). Figure 4 shows the WBS of Activity Line A of the AIRFRAME ITD and the relation of the present topic on it.

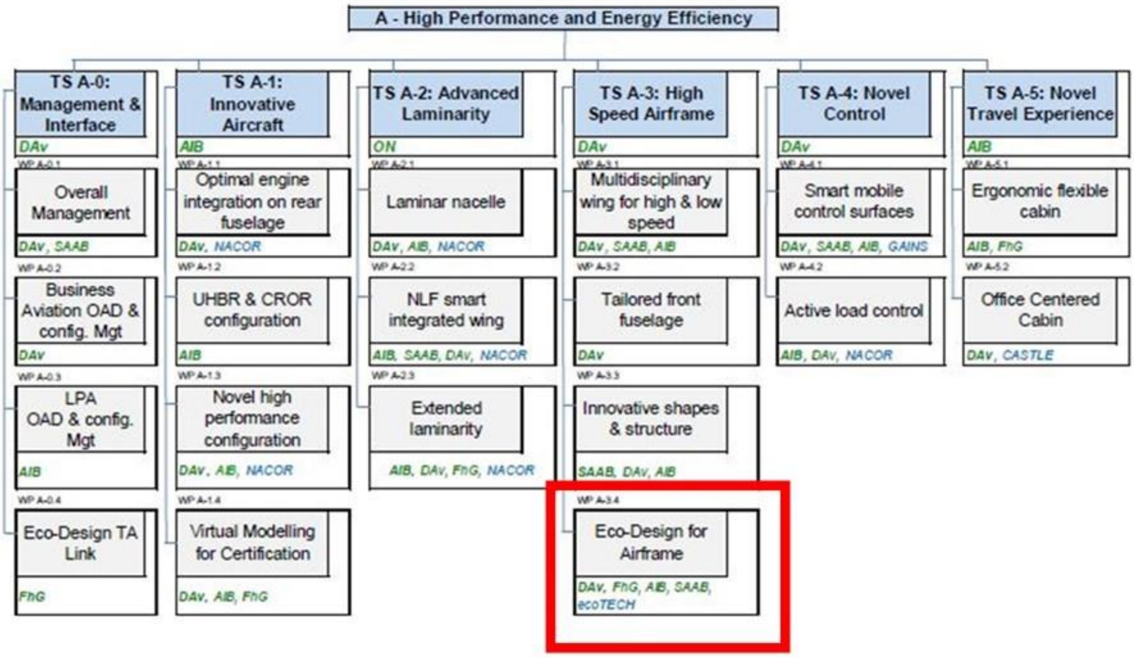


Figure 4: WBS of Activity Line A of AIRFRAME ITD

Within WP A-3.4 the Topic Manager will develop metallic structures using advanced manufacturing technologies such as Laser Beam Welding and Additive Manufacturing. These structures will be manufactured based on newly developed Al-Li alloys (AA2198, AA2060, AA2099, AA2196, etc.) and are expected to offer environmental benefits such as reduced structural weight, improved corrosion resistance as well as improved recyclability.

Some of the issues when implementing Laser Beam Welding and Additive Manufacturing processes using commercially available filler wires (AA4047, AA2319…) are the achievement of high strength of the joints/components as well as difficulties in recycling operations. The majority of available filler wire materials present relatively low strength properties compared to aeronautic grade aluminium alloys. In addition to that, the weld formation using filler materials of different chemical compositions than the base aluminium alloys results in difficulties in recycling operations (alloy separation, re-melting operations…).

In the scope of this topic, the development of a new filler wire with good weldability, corrosion resistance and comparable strength properties as the current aluminium alloys used for aeronautic parts (newly developed Al-Li alloys …) is expected. The chemical composition of the wire to be developed is expected to be compatible with the novel aluminium-lithium alloys in order to increase the potential for recycling of welded components. This new aluminium filler wire will be implemented in Additive Manufacturing processes using wire format as material to be deposited, as well as in Laser Beam Welding processes (as a parallel activity by the Topic Manager). The implementation of the new wire for Additive Manufacturing of aeronautic components is expected to produce benefits such as material savings, low buy to fly ratios, low cost of feedstocks, high deposition rates and productivity, etc.

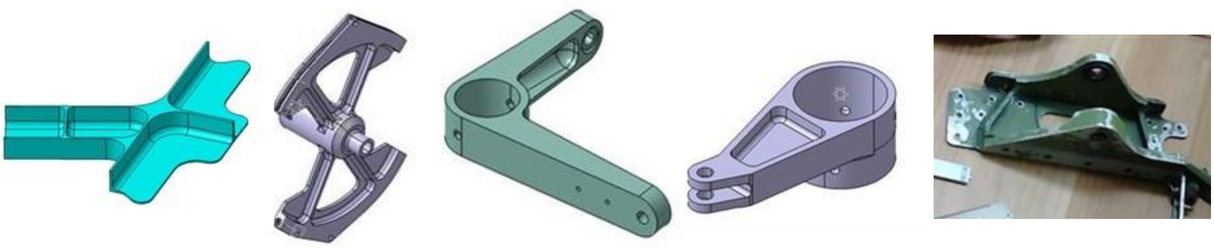
2. Scope of work

The scope of this Topic comprises the development of a new aluminium filler wire and its implementation for Additive Manufacturing of aeronautic components. The implementation of the developed filler wire in Laser Beam Welding processes will be carried out as a parallel activity in collaboration with the Topic Manager.

The expected main characteristics of the new aluminium filler wire will be:

- Good weldability
- High strength and mechanical performance, similar to aerospace grade aluminium alloys
- Low density
- Good corrosion resistance
- Similar chemical composition as newly developed Al-Li alloys in order to improve the potential for recycling welded structures

In the scope of the work to be performed within this Topic, the new aluminium filler wire will be implemented in Additive Manufacturing processes as material to be deposited. A process development phase followed by a demonstrator manufacturing phase will be carried out. The type of the demonstrator to be developed will be defined by the Topic Manager. Some indicative examples are given below after.



As a parallel activity carried out by the Topic Manager, the new aluminium filler wire will be implemented in Laser Beam Welding processes. Thus, aeronautic structures and demonstrators will be manufactured by Laser Beam Welding skin, stiffener or frame components based on newly developed Al-Li alloys. The selection of base materials to be used in this activity includes Al-Li alloys such as AA2198, AA2060, AA2099, AA2196 or other similar alloys. Therefore, the new aluminium filler wire to be developed is expected to have similar mechanical strength, corrosion resistance and chemical composition (in order to increase the potential for recycling).

The indicative tasks or work packages proposed in order to achieve the objectives of this Topic are shown in the following table:

Work packages		
Ref. No.	***Title – Description***	***Due Date***
WP1	Definition of suitable new aluminium alloys for wire manufacturing	T0+6 months
WP2	Development of wire material based on new aluminium alloys	T0+20 months
WP3	Wire deposition based Additive Manufacturing process development	T0+30 months
WP4	Material property characterization and heat treatment cycle optimization	T0+30 months
WP5	Demonstrator manufacturing by wire deposition based Additive Manufacturing	T0+36 months
WP6	Management	T0+36 months

WP 1: Definition of suitable new aluminium alloys for wire manufacturing

Typical filler wires for welding aluminium alloys are based on Al-Mg, Al-Si or Al-Cu alloys that present some problems such as relatively low strength or significantly different local chemical compositions when they are applied to the manufacturing of aeronautic structures. These issues are limiting factors for the implementation of manufacturing processes such as Laser Beam Welding or Additive Manufacturing that make use of aluminium wire as filler material.

The introduction of newly developed Al-Li alloys present new opportunities for aeronautic structure manufacturing due to their high strength, low density, good corrosion resistance or enhanced weldability.

In this work package, a selection of suitable aluminium alloys for wire production and its implementation in Laser Beam Welding and Additive Manufacturing processes will be performed. The main requirements for the new aluminium filler wire are:

- Suitable for wire production
- Comparable mechanical properties as aeronautic grade aluminium alloys
- Improved weldability
- Corrosion resistance
- Similar chemical composition as newly developed Al-Li alloys (AA2198, AA2060, AA2099, AA2196 or other similar alloys)

With the contribution of wire producers, chemical compositions of aluminium alloys that meet the requirements and are suitable for wire production will be selected. Beyond the high strength and weldability requirements, it is very important to consider corrosion and recycling issues. Therefore, wire materials based on aluminium alloys showing similar compositions as reference newly developed Al-Li alloys are preferred. Other material solutions such as metal matrix composites or aluminium alloys with embedded ceramic particles shall be avoided unless innovative procedures for recycling and corrosion protection of (welded) components are proposed.

WP 2: Development of wire material based on new aluminium alloys

In this work package, new aluminium filler wire materials will be produced, taking aluminium alloy compositions and materials selected in WP1 as starting point. The main characteristics of the wire to be produced (diameter, quantity, surface condition…) will be defined in agreement with the Topic

Manager.

Upon wire production, the producer is expected to supply the new aluminium filler wire for the implementation in Additive Manufacturing and Laser Beam Welding processes. Thus, the new wire materials will be delivered to:

- Wire deposition based Additive Manufacturing process development (WP3 and WP5)
- Laser Beam Welding process development (Topic Manager's activity)

It is expected that 2-3 wire material developments will be realized. The wire material production and delivery will be made in a progressive manner so that initial production and delivery for implementation in Additive Manufacturing and Laser Beam Welding will be followed by an optimized and final production and delivery. During this whole process constant interactions between wire producers and Additive Manufacturing and Laser Beam Welding (Topic Manager) leaders shall be carried out.

WP3: Wire deposition based Additive Manufacturing process development

In this work package, an Additive Manufacturing process development will be performed taking the new aluminium filler wires developed in WP2 as material to be deposited. A wire deposition based Additive Manufacturing technology will be selected and developed (EBAM, LMD, WAAM…).

The Additive Manufacturing process development will include (but will be not limited to):

- Initial deposition tests – process parameter optimization (source power, scan velocity, deposition rate, scan strategy…)
- Basic metallurgical analysis for microstructure evaluation
- Test plan for advanced characterization of specimens manufactured by Additive Manufacturing (to be performed in WP4)
- Manufacturing of specimens for advanced characterization (in WP4). These specimens shall be manufactured by different process parameters in order to evaluate the results and select the most suitable ones.
- Relevant process data collection necessary to perform the LCA (Life Cycle Assessment) analysis (in cooperation with the Topic Manager).

WP4: Material property characterization and heat treatment cycle optimization

In this work package, a material property characterization of specimens manufactured in WP3 will be carried out.

In order to improve the mechanical performances and corrosion resistance of the parts produced by Additive Manufacturing, a heat treatment cycle optimization shall be performed. Thus, several heat treatment cycles shall be performed and the properties of materials upon completion of different thermal cycles shall be characterized.

A characterization test campaign shall be planned and carried out in order to select the best conditions for the manufacturing of parts by Additive Manufacturing with subsequent heat treatment. The characterization of the specimens will include:

- Metallographic analysis
- Static tests
- Fatigue tests

- Corrosion
- Chemical

Upon completion of the characterization test campaign, the best conditions for part manufacturing by Additive Manufacturing and subsequent heat treatment will be defined.

Relevant process data collection necessary to perform the LCA (Life Cycle Assessment) analysis will be carried out in cooperation with the Topic Manager.

WP5: Demonstrator manufacturing by wire deposition based Additive Manufacturing

In this work package, a demonstrator part will be produced by Additive Manufacturing using the new aluminium filler wire developed in WP2 as material to be deposited and the manufacturing conditions defined in WP3 and WP4 (including heat treatment).

The Topic Managers will provide the 3D model of the demonstrator part. Considered candidate parts are:

- Floor fitting
- Support lugs for hydraulic actuators
- Pin supports
- Pulleys for wire-ropes
- Wing ribs or spars

It has to be noted that only one of the above candidate parts will be selected.

The development of the demonstrator will include:

- Shape optimization for optimum functionality (application/specification), manufacturability (Additive Manufacturing process parameters) and weight optimization
- Manufacturing of 2 identical demonstrator parts including the necessary machining and/or other finishing operations:
    - 1 part for destructive testing
    - 1 part for NDI, dimensional control and exhibition
- Evaluation of cost, weight and LCA analysis of the demonstrator parts and comparison with equivalent conventional part

In order to verify the demonstrator parts in terms of structural integrity and strength the following tests will be performed:

- Component-like specimen testing
- Micrographic examination
- NDI
- Dimensional control

WP6: Management

Reporting, communication, dissemination and other management activities will be conducted during the whole duration of the project.

Extensive communication activities and interactions between the wire producer and Additive Manufacturing and Laser Beam Welding (Topic Manager) leaders are expected, especially during the wire materials definition and development phases (WP1 and WP2).

3. Major deliverables/milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1.1	Suitable new aluminium alloys for wire manufacturing	R	T0+4
D2.1	Wire material development plan	R	T0+4
D2.2	Manufacturing of new aluminium wire material – Initial delivery and report	HW+R	T0+14
D2.3	Manufacturing of new aluminium wire material – Final delivery and report	HW+R	T0+20
D3.1	Additive Manufacturing process development and test plan	R	T0+21
D3.2	Specimen manufacturing by Additive Manufacturing	HW+R	T0+24
D4.1	Specimen testing and characterization	R	T0+30
D4.2	Additive Manufacturing process definition for demonstrator manufacturing	R	T0+30
D5.1	Demonstrator manufacturing by Additive Manufacturing	HW+R	T0+36
D5.2	Manufacturing and verification of demonstrator	R	T0+36

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	New aluminium compositions and wire manufacturing plan defined	R	T0+4
M2	New aluminium wire material available - Initial	HW	T0+14
M3	New aluminium wire material available - Final	HW	T0+20
M4	Specimens manufactured by Additive Manufacturing	R+HW	T0+24
M5	Characterization of specimens completed	R	T0+30
M6	Additive Manufacturing process defined	R	T0+30
M7	Demonstrators by Additive Manufacturing available	HW	T0+34
M8	Demonstrators by Additive Manufacturing verified	R	T0+36

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

4. Special skills, capabilities, certification expected from the applicant(s)

Expected skills by the applicant are:

- Skill 1: Proven competence in aluminium alloys and metallurgy, especially in aeronautic grade aluminium alloys.
- Skill 2: Proven competence and experience in the development and production of aluminium wire material.
- Skill 3: Proven competence in aluminium wire based Additive Manufacturing for aeronautic parts.
- Skill 4: Experience in modelling and design of parts produced by Additive Manufacturing.
- Skill 5: Proven competence and experience in experimental testing.
- Skill 6: Proven competence and experience in non-destructive inspections (NDI).

In addition, the applicant(s) is required to have access to the following capabilities:

- Capability 1: Suitable facilities for aluminium wire development, production and packaging.
- Capability 2: Suitable facilities for wire deposition based Additive Manufacturing process development.
- Capability 3: Suitable heat treatment facilities for aeronautic grade aluminium alloys.
- Capability 4: Laboratory facilities for mechanical testing (static, fatigue), metallographic analysis, corrosion testing, …
- Capability 5: Suitable non-destructive testing equipment/facilities.

VI. Development of an eco-friendly selective stripping for exterior surfaces of airframe structures

Type of action (RIA or IA)	IA		
Programme Area	AIR		
(CS2 JTP 2015) WP Ref.	A-3.4		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Hellenic Aerospace Industry	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[28]	Q4 2018

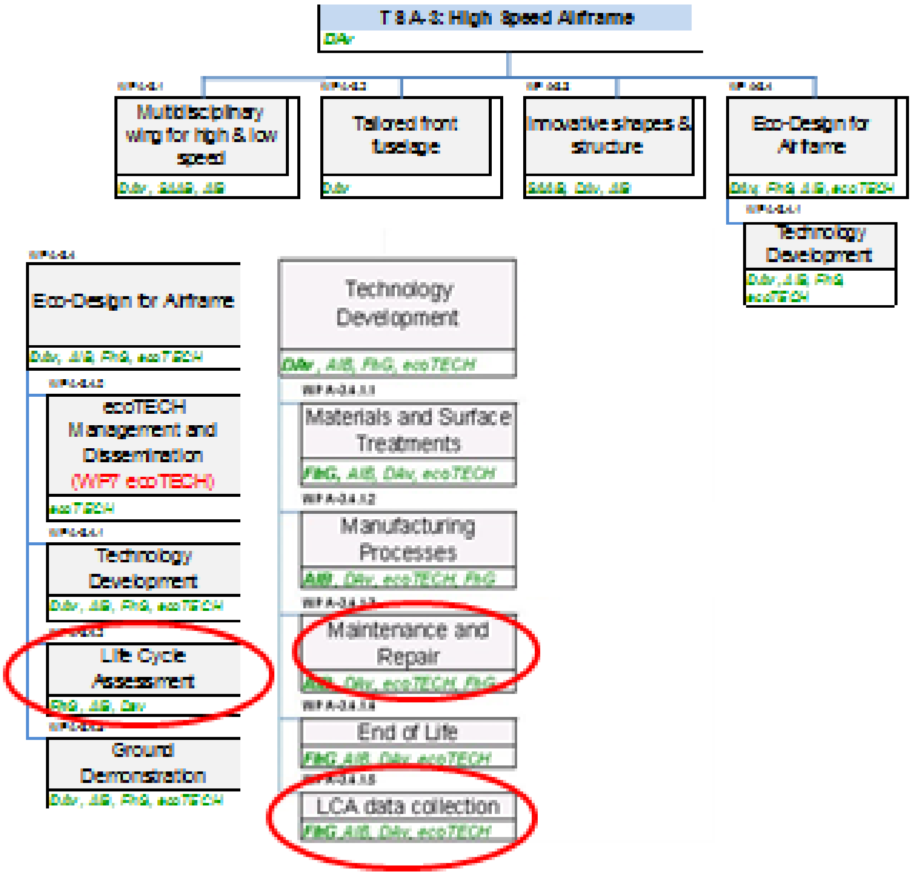
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-01-35	**Development of an eco-friendly selective stripping for exterior surfaces of airframe structures**
Short description	
The topic aims to develop an innovative dry selective stripping methodology which will combine the environmental safety, the dual use for both metallic and composite substrates and the removal of a limited and controlled thin layer (top coat of the paint system) without affecting the substrate material, the anticorrosion surface treatment and the primer. The new methodology shall be able to enhance the industrial automation of paint stripping. The media applied for the selective stripping shall be dry (e.g. laser stripping or starch media stripping or other) in order to avoid the use of chemicals and liquid solutions.	

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

1. Background

The work in AIR ITD WP A-3.4.1.3 is dealing with the development of new efficient and environmentally friendly technologies related to the maintenance and repair of aircrafts. One of these activities is the "Selective Stripping" of new surface treatments, primers and top coats developed within the ecoTECH project (Core partners consortium led by IAI).

The environmental impact of the new technology will be evaluated through the collaboration of the applicant with the Topic Manager, representing ecoTECH, within WP A-3.4.1.5 "LCA data Collection" and WP A-3.4.2 "Life Cycle Assessment.



Selective stripping is a coating removal technique where the top-coat is removed and the base primer coat is largely left intact. There are several advantages to this technique dealing with environmental and productivity benefits.

Leaving the primer coat intact eliminates surface effects on various substrates by reducing the mechanical effects (surface roughness (R), residual stress as measured by Almen Arcs, safe on composites since the resin matrix may degrade from too aggressive stripping chemicals), and substantially increases the productivity in case of automated application. Also, selective stripping decreases the production of coating waste.

Another advantage of selective stripping technique is that it may be applied as a **universal solution** for all airframe substrates, since the top coat and primer films to be separated may have dual **use for**

both metals and composites.

In the case of composite, this means there is no risk of damaging the top layer and/or fibers of the composite.

In the case of metal, it means the base corrosion protection scheme stays intact. Regarding the corrosion sensitive alloys such as high-strength aluminium for the aerospace industry, the most durable corrosion protection, after repainting cycles, is believed to be obtained when the original anodic film of the anodizing process (or an alternative anticorrosive film developed in ecoTECH) and the subsequent layer of corrosion inhibiting primer (commonly referred to as the 'basic primer' or 'structural primer') is left intact. Anodized aluminium combined with a high-performance corrosion inhibiting primer typically gives better protection against corrosion than typical maintenance and repair surface treatments and paint systems starting from the bare metal. (e.g. using conversion coatings / sol-gel treatment + corrosion inhibiting primer, or making use of wash-primer / etch primer based paint systems).

Ideally, the same settings of the equipment should be able to be used on the entire aircraft. This reduces the chances of errors during maintenance further in the lifetime of the aircraft

The environmental impact will be enhanced through the selection of a dry method for the selective stripping with the use of starch media (e.g. wheat) or Laser or another dry and environmentally friendly method. The target is to further reduce the production of hazardous waste and the consumption of water through the application of an effective technology. As an alternative to chemical strippers, dry stripping eliminates worker exposure to toxic and hazardous substances. Also, dry stripping drastically reduces hazardous material disposal costs.

The new technology will be accepted only if it will be confirmed that its application does not cause deformations or any kind of damages on the surface of the metallic or composite substrate.

In addition, the environmental impact should be demonstrated through the Collection of LCA data as well as the collection of process data for LCA analysis and the evaluation of the results by the comparison with conventional technologies.

2. Scope of work

The objectives of the call are described below after:

- Development of innovative selective stripping methodology (using blasting media or laser application or another dry method) which will combine the environmental safety requirements and the removal of a limited and controlled thin layer (top coat of the paint system) without affecting the substrate material, the anticorrosion surface treatment and the primer.
- The innovative system(s) shall be applicable on both metallic and composite substrates.
- The innovative system(s) shall be compatible with the new surface treatments and painting systems developed within the ecoTECH project.
- An NDI technology will be applied on de-painted samples to investigate the integrity of substrate material.
- The new paint removal system shall be efficient and cost effective. Emphasis is placed on :
    - Strip rate (square meter per minute) or system acquisition cost,
    - Repaint adhesion characteristics

- Actual operating cost per square meter
- Versatility of the process and compatibility with other maintenance activities

- The new paint removal system shall:
  - Minimize pre-strip preparation, e.g., aircraft washing, drying, masking touch labour, and materials costs.
  - Minimize post strip rinse, mask removal, hand abrasion of masked areas, removal of penetrating media from internal structure, and structural sealant repair
  - Minimize the production of hazardous waste
- Automation Potentiality of new methodology shall also be considered
- Characterization and validation of the stripped samples (including NDI of substrate integrity without removing the primer)
- The stripping technology shall be TRL 6 by the end of the project.

The indicative structure of the project is described below after:

Tasks		
Ref. No.	**Title – Description**	**Due Date**
WP1	Feasibility study and first screenings	T0+6
WP2	Development of paint removal systems	T0+18
WP3	Validation test	T0+30
WP4	LCA analysis and Cost and application Study	T0+36
WP5	Management	T0+36

WP 1: Feasibility study and first screenings

The objective of this work package is firstly, to carry out a literature review regarding available dry selective stripping technologies that could help to fulfil all the technical requirements. Compatibility with new green surface treatments, new paint, as well as environmental parameters will be emphasized. The applicant(s) shall first lead a screening to investigate several solutions that could be adequate for the development of the stripping process. After the screening, at least one solution shall be selected for further steps. A matrix shall be defined for process parameter development/definition and process optimization.

The following approaches shall be at least address:

- environmentally friendly blasting technology
- laser application

WP 2: Development of paint removal system(s)

This work package is the core activity of the proposed topic; the development of the selective stripping technology itself. The technical requirements being challenging, the proposal and development of the route shall be pursued, in order to avoid dead ends.

The applicant(s) will have to interact continuously with Topic Manager since the development is strongly related with the innovative surface treatment-primer-top coat system elaborated from ecoTECH consortium as well as the development and use of new Al alloys and composite substrates.

The first step shall be the laboratory scale experiments. Stripped and repainted specimens will be tested and characterized (physical-chemical, measurements and characterization of remaining primer, examination of corrosion, adhesion, deformation, fatigue testing, micrographic, EDX, SEM etc.) in accordance to a test plan that will be conducted in synergy with Topic Manager.

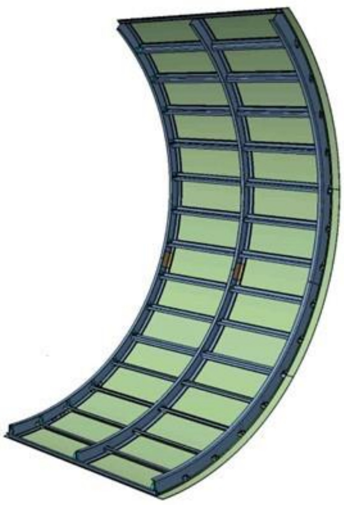
Also, the potentiality of automatization should be addressed within this WP, if applicable.

WP 3: Validation test

The next step of the research will be applied on samples with details simulating real exterior airframe structures (curvature and other configuration complexities) by composite and metallic substrates. The test plan will be defined in collaboration with the Topic Manager and will include among other:

- Inspection for possible deformation and NDI of substrate integrity:
    - In the case of composite substrate, the external layer of stripped structure will be examined for possible damages (e.g. fibers should remain intact and the primer coat should not be affected)
    - In the case of aluminium substrate, the surface and the form of the structure should remain intact and the anticorrosive layer (either from anodization or Sol-Gel) and the primer coat should not be affected.
- Checking paint removal from all surfaces (micrographic, EDX, SEM evaluation)
- Measuring removal rate
- Repaint experiments and corrosion, adhesion testing (adhesion on substrate and adhesion of top coats on the primer) on specimens with curvatures

The most satisfying process will be selected by the Topic Manager and a test run will be performed on a representative panel of the ecoTECH demonstrator which will be selected and specified by the Topic Manager. The approximate size of the panel will be 2 x 1 m. The panel will be internally stiffened. An indicative geometry (not the final one) is given in the Figure below after.



WP 4: LCA analysis and Cost and application Study

LCA (including LCA data collection and process data for LCA) analysis will be performed and the impact of new technology will be evaluated and compared with conventional technologies. This step will be performed in collaboration with the Topic Manager.

The cost of the selected technology will be evaluated taking into account recurring and non-recurring costs as well as a quantitative estimation of environmental benefit in comparison to the conventional methods applied by Topic Manager.

A study to extrapolate the technology to industrial conditions will be also requested.

Task 5: Management

Reporting, management of activities and interaction with Topic Manager and JU will be conducted during the full duration of the implemented project.

Substrate materials, surface treatments and painting systems will be provided by the Topic Manager

3. Major Deliverables / Milestones and schedule

Deliverables			
Ref. No.	**Title – Description**	**Type**	**Due Date**
D 1.1	Literature review report	R	T0+3
D 1.2	Development of work plan	R	T0+6
D 2.1	Stripping approaches status	R	T0+12
D 2.2	Results and characterization tests on specimens	R	T0+18
D 3.1	Results and characterization test on up-scaled samples	R	T0+24
D 3.2	Testing on a representative panel of ecoTECH demonstrator	R	T0+30
D 4.1	Report describing LCA evaluation & cost and application studies	R	T0+36
D 5.X	Periodic Reports	R	Every year

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Definition of Processes and Work Plan	R	T0+6
M2	Stripping approaches evaluation	R and RM	T0+18
M3	Evaluation of stripping efficiency on samples simulating real complexities	R and RM	T0+30
M4	LCA and cost Evaluation	R	T0+36
M6	Final Evaluation	R and RM	T0+36

*Type: R=Report, D=Data, HW=Hardware, RM= Review Meeting

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

The applicant or the consortium must prove the following capabilities:

- Good background and experience in stripping technologies applied on aircraft parts proven by adequate certifications
- Good background and experience on possible tests conducted on coatings proven by adequate certifications
- Facilities to conduct tests on coated specimens/parts (either directly or through a partner/subcontractor)
- Adequate equipment and facilities for the stripping process to be investigated and quality control system

VII. Hybrid Aircraft Seating Manufacturing & Testing

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	WP A-3.4		
Indicative Funding Topic Value (in k€)	900 k€		
Topic Leader	Fraunhofer	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[29]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-01-36	**Hybrid Aircraft Seating Manufacturing & Testing**
Short description	
The objective of the topic is the design and manufacturing of the moulds for manufacturing the seat structure. The seat structure will consists out of hybrid material having less weight, high degree of function integration. The design output from HAIRD project will be used. The parts will be produced in an industrial equivalent process. Furthermore, the mechanical tests and fire safety regulations need to be defined and the testing applied.	

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

1. Background

In large passenger aircrafts several hundred aircraft seats ensure comfort and safety of the passengers. The seats are replaced over the life time of an aircraft several times. These two facts demonstrate that aircrafts seats are a major component in all passenger aircrafts and a fast disassembling and dismantling is needed to recycle all parts of the seating structures.
Aircraft industry faces massive challenges in the next years. Despite the fact that air traffic is responsible for less than 2% of the global CO_2-emissions, industry is forced to reduce fuel consumption and emissions. For example each kilogram of weight reduction in all A320 aircrafts worldwide results in a reduction of fuel consumption of about 0.7 Mio. liters per year. High production rates for future aircrafts require effective production methods beside the high degree of integration of different components and functions. Hybrid materials and structures offer the potential for achieving both mentioned key challenges, but recycling of the materials after use has not been solved satisfactorily yet. To reduce the environmental footprint of the aircraft it is necessary to develop a dismantling concept for hybrid materials & structures and in addition efficient manufacturing processes with high degree of functions integration.
The specification of future seatings with regard to technical and comfort aspects will be the basis for the design of the innovative hybrid seating structure. From the design, materials and process will be derived to manufacture the hybrid seating structure. Materials and functional integration will be selected with the substantive criteria of weight reduction and effective processes. Special attention will be given to the dismantling possibility of the different materials to simplify the recycling process.
The overall objective of the project in Clean Sky 2 Airframe ITD WP A-3.4, to which this call is related, is the set-up of a demonstrator of a hybrid seating structure with:

- max. 10 kg weight for seating in economy class
- functional integration in light-weight design e.g. compact design, multi-functionality (electric conductive, optical transparent, actuating elements), energy and material efficient during use phase, cost efficient production by reducing complexity of components and manufacturing time
- Easy dismantling of the seat
- Recyclability of at least 90% of the weight of the seating structure
- Metal components of the structure should be replaced by carbon-fibre based parts

Additionally, LCA data will be collected for technologies currently used and the new technologies which will be developed. This data will be provided to the Data Collection team responsible of the task “Eco Design Database for Life Cycle Assessment in Commercial Aviation (EDA DB)” of the eco-DESIGN Transversal Activity.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	**Design and manufacturing of the moulds for structural parts and cushions**	T0+12
Task 2	**Delivery of LCA data of materials and processes**	T0+48
Task 2.1	Interim LCA Data	T0+27
Task 3	**Testing**	T0+48
Task3.1	Test results of generic samples	T0+36
Task 3.2	Test results of the complete seating structure	T0+48

The project duration is scheduled to 48 months. The 48 months are necessary for the success of the complete project. In the first 12 months the moulds are designed and built by the applicant. The applicant delivers the moulds to the Topic Manager. The Topic Manager develops the manufacturing process for the seat structure using these moulds. Generic samples are derived from produced parts and tested by the applicant. These test results are used in a loop to optimize the manufacturing process.

At the end of the optimization process (about T0+30) the complete seat structure is produced by the Topic manager and tested by the applicant.

Task 1: Manufacturing of the moulds for structural parts and cushions

According to the optimised design, seat components and cushions moulds will be manufactured.

Seat structure mould

To produce aircraft seating structures in compression moulding a mould has to be manufactured. The concept of the seating structure in terms of materials and processing technologies is shown in Figure 5. The mould shall be capable of combining the process of SMC-compression-moulding with the process of wet-compression-moulding within one single process step. The interface between SMC and prepreg shall be produced by over-moulding of SMC. Furthermore metallic inlays have to be implemented. The support structure will be mounted later on and is thus not relevant for the production of the mould.

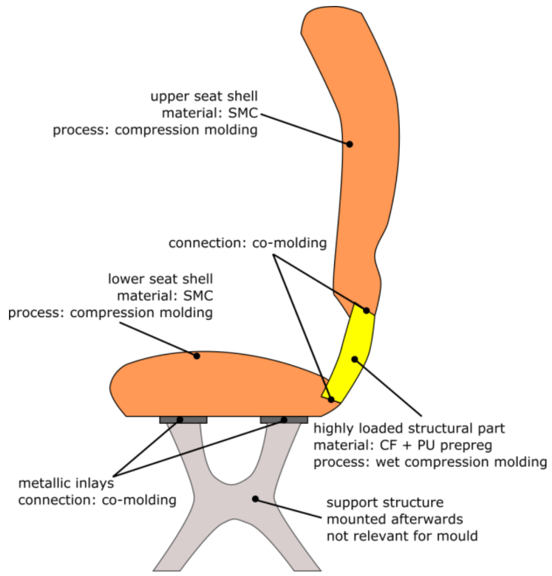


Figure 5: Connect of the seat structure

Rough seating dimensions: Upper seat shell: 700 mm, 400 mm, 60 mm; lower seat: 500 mm, 400 mm, 100 mm.

Cushion moulds

Cushion moulds will be specified in detail at the beginning of the project with the topic manager. The foaming polymer is based on polyurethane. Rough cushion dimensions: Upper cushion: 700 mm, 400 mm, 60 mm; lower cushion: 500 mm, 400 mm, 100 mm

Task 2: LCA Data

The energy and material consumption of the mould production needs to be delivered. The applicant collects the amounts of needed materials to manufacture the mould (e.g. steel, consumables etc.) and measured the electrical power consumption during mould manufacturing. These data are delivered to the Topic Manager where a Life Cycle Assessment for each mould is done.

Task 3: Testing

With the moulds Topic Manager manufactures samples for tests and finally the seat structure. The samples are tested from the applicant to deliver data for optimization of the manufacturing process.

In detail generic samples have to be tested according to standard aviation (FAR 25) fire safety regulation. Furthermore the mechanical properties of the single material systems (SMC and prepreg) has to be determined on coupon level (such as bending, tensile, impact, fiber content, DMA etc.). Additionally the interface between SMC and prepreg as well as SMC to metallic inserts is of special interest (e.g. shear strength, pull-out force, G_{IC} etc.). In particular microscopic and analytic investigations of the interface between SMC and metal are important.

After the optimization loop the complete seat structure is manufactured by the Topic Manager and has to be validated according to SAE ARP5526D, SAE ARP5765A, and SAE AS8049C by the applicant.

Additional Technical requirements for seat structure mould
The following services and components are requested:

Description	Amount
Design of the mould	1
Design of the fixation concept	1
Manufacturing of mould including fixation	1 (upper + lower tool)

1. **Process:**
   - Compression moulding of FRP (SMC and wet-compression-moulding)
   - Internal pressure at standard operation: up to 200 bar
   - Internal pressure at overload: max. 300 bar

2. **Specification of the mould**:
   - 4 guide pillars
   - Circumferential mounted insulation plates
   - Mould shall be directly mountable at a hydraulic press:
     - groove interval: 200 mm
     - groove width: 28 mm
   - Circumferential hardened flash faces
   - Surface hard chrome-plated or ATC-coated
   - Hydraulic ejectors
   - Fixation device for the prepreg

3. **Installation specifications of the total mould:**
   - min. height: 750 mm
   - max. height: 1500 mm
   - max. length: 2900 mm
   - max. width: 1900 mm
   - max. total weight: 30 tons

4. **Temperature management:**
   - Active temperature control of both mould sides by oil circuits
   - Oil circuits have to be cleanable by the help of compressed air
   - Mould surface temperature up to 160 °C, normal condition 150 °C
   - Homogeneous temperature distribution of max +/- 5 °C at the mould surface

5. **Connections:**
   - Temperature circuits: G ½“ plug-clutch (type: HK-A)
   - Compressed air: Rapid-connect coupling NW 7,2 G ½“ (10 bar)

6. **Mould material:**
   - Hardened and tempered plastic-mould steel (950 - 1100 MPa)
   - Surface roughness: Ramin=0.35

7. **Mould assembly and disassembly**

- Assembly and disassembly of the mould shall be possible with standard metrical tools
- Suitable handling devices for assembly and disassembly are needed
- Suitable fixing points for a lifting device are needed for transport, mounting on hydraulic press and for assembly and disassembly (e.g. Eyebolts)
- A transportation lock is needed
- Permanent labelling of all connections (temperature out/in, sensors, air)
- Type plate with important tool information (weight, size, steel type, etc.)

8. **Design**

- Use of standardized components wherever possible
- Complete and final drawings including 3D-CAD files have to be released to the Topic Manager

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Manufactured Moulds	HW	T0+12
D2	Interim LCA Data	R	T0+21
D3	Delivery of LCA data of materials and processes	R	T0+48
D4	Specified Tests performed for Parts	Report	T0+48

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Manufacturing of the moulds for structure parts and cushions	Maturity Gate	T0+12
M2	Testing of generic samples	Maturity Gate	T0+48

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

Time schedule:

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
T 1				D1 M1												
T2																D3
T2.1									D2							
T 3																
T 3.1																
T 3.2																D4 M2

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

The applicant shall have a proven strong background and expertise in production of moulds.

- Expertise in design of compression and foaming moulding.
- Capabilities for mould manufacturing.
- Expertise in testing of composite and foam parts according given standards.
- The applicant shall provide adequate information necessary for an effective and efficient project management during the course of the project.

5. Abbreviations

SMC	Sheet moulded compound, fiber reinforced thermoset
DMA	Dynamic mechanical analysis
G_{IC}	Measurement method for crack

VIII. Light weight, certifiable airframe structures through combination with high performance materials

Type of action (RIA or IA)	IA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-0.3		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Airbus Helicopters	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	18	Indicative Start Date[30]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-AIR-02-51	Light weight, certifiable airframe structures through combination with high performance materials
Short description	
A further step towards more light weight airframe parts is the combination of existing materials with new high performance materials such as lighter adhesive films, high modulus fibers and high performance honeycomb cores. A weight saving potential which could be as high as 15% is expected.	

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

1. Background

The new rotorcraft architecture developed by the Topic Manager and which will be demonstrated under FRC IADP 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) such as Airframe 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 about 15% for general airframe parts (monolithic and sandwich) and particularly shell structures like side shells, tailboom, horizontal and vertical stabilizer and the wings. Some of these shell structures, like the tailboom and wings have mainly stiffness driven designs, were materials with higher stiffness increase directly the performance. By a combination of the standard structural materials with new high performance materials in the relevant areas, a weight saving potential is obvious.

These new materials are

(1) a lighter adhesive film for skin to core joints,

(2) a high modulus unidirectional carbon fiber prepreg providing nearly factor 2 in stiffness and

(3) a high performance honeycomb core showing minimum 50% higher allowable values.

With these materials, replacing the today used standard adhesive film, the standard unidirectional HTA/HTS fiber prepregs and the standard honeycomb core, the stiffness of the part can be significantly increased. This leads, using the original requirements, to either less material use or the possibility to go for higher performances at the same weight.

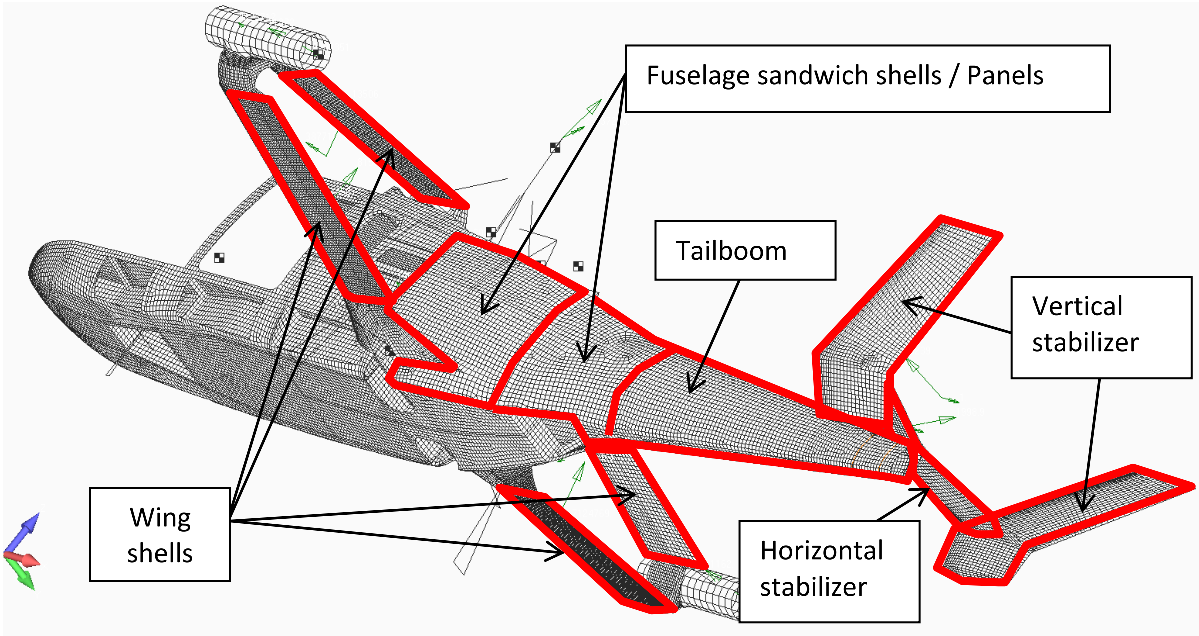
The aim of the Topic is to address all the activities needed for:

(1) The generic and structural feature characterization of the new materials. This means small and medium specimen test program series within the CMH17 building block approach testing pyramid levels 1, 2 and 3 (see illustration below). In detail: several coupon/element and detail specimen series must be manufactured, prepared, conditioned, partly instrumented and finally tested. For the larger specimens special test rigs might become necessary to build.

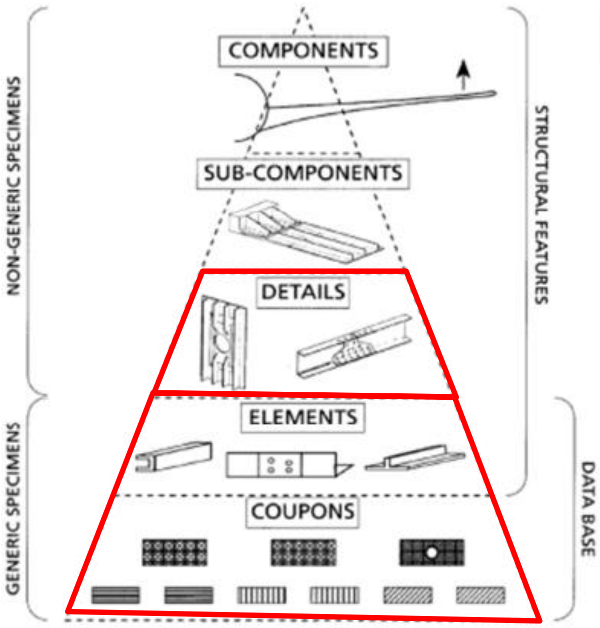
(2) After testing is completed, a statistical analysis has to be done which leads to new material allowables and design values which are required for the implementation of the new materials in the components and necessary for a “permit to fly” or certification in case a component with these new materials will be used in the ITDs.

Therefore activities such as engineering activities (design and stress analysis), composite

manufacturing, sample conditioning, and testing have to be performed.
In addition to the technical activities the relevant management activities have to be performed also.



Relevant structures having weight saving potential by the proposed material replacement



Building block approach (BBA), testing pyramid (from CMH17)
red marked are the levels to be investigated

The Topic Manager anticipates that significant access to the Topic Managers' background may be needed by the successful applicant. If the case, the applicant has to describe in the proposal the type of background he will need to perform his tasks.
In return, the topic manager requests shared access to the foreground generated during the project. This will be subject of a specific agreement between the Topic Manager and the successful applicant to be signed during the negotiation phase.

A synthesis of the activities to be performed is as below:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Development of the Qualification Test Plan QTP for the material properties to be evaluated (BBA level 1, 2 and 3 tests). It lists all the test orders created to describe the tests in detail to fulfil the test plan. All the test matrices for the key material- and performance parameters are defined. Such as: Physical- and chemical properties, uncured/cured properties, cured lamina mechanical properties, test methods and standards.	T0+2
2	Manufacturing- and Preparation of Test Specimens for the purposes of obtaining a reasonable evaluation of material variation, a material per environment and loading direction. Test panels are nondestructively evaluated. Parts of the specimens are conditioned to obtain allowable data as well for other than ambient environment conditions.	T0+5
3	Perform Material Qualification Testing The objective is a quantitative assessment of the variability of key material properties and structural features, leading to various statistics that are used to establish material acceptance, equivalence, quality control, and design basis values.	T0+17

Weight:

A reduced weight of the mentioned components by material replacement can only be reached in case all the basic material data and structural features are determined according to the valid standards (CMH17). This topic generates the basics for use of the identified materials in an airframe structure.

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. The identified materials (b) and (c) are basically 50 – 100% more expensive than the current baseline materials. The material (a) is about 50% cheaper than the currently used one. Since only a part of the materials are replaced, the RC of the structural components getting this material replacement will be less than 50 % more compared to the baseline.

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 the identified materials and processes 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 the Topic Manager.

Furthermore, since the schedule of the project and the budgetary framework don't allow for larger unanticipated changes in the middle of the project, it is required that at the start of activities the partner demonstrates his capability to manufacture the required items with a baseline technology (carbon fiber reinforced sandwich and monolithic components like panels, shells and frame structures).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Qualification Test Plan for coupons / element / detail test specimens (QT**P**)	R	T0+02
D2	Material Specification (TN 1)	R	T0+02
D3	Drawing sets of element / detailed specimens	D	T0+08
D4	Detailed test report for coupons (TR 1)	R	T0+11
D5	Detailed test report for elements (TR 2)	R	T0+15
D6	Detailed test report for details (TR 3)	R	T0+16
D7	Qualification test report showing all test results (QT**R**)	R	T0+17
D8	Summary of static / dynamic allowables and design values incl. damage tolerance characteristics (TN 2)	R	T0+18

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	QT**P** release	R	T0+02
M2	Material specification release (TN 1)	R	T0+02
M3	Drawing set for generation of element tests	D	T0+08
M4	Drawing set for generation of detail tests	D	T0+09
M5	Coupon testing finished (detail report (TR 1))	R	T0+11

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M6	Element testing finished (detail report (TR 2))	R	T0+15
M7	Detailed testing finished(detail report (TR 3))	R	T0+16
M8	QT**R** release	R	T0+17
M9	TN 3 release	R	T0+18

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

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 composite materials/processes and component manufacturing. Therefore the Partner has to provide all documentation necessary to achieve "Permit to Fly" and take action allowing this goal to be reached in case a component with these new materials will be used in the ITDs:

- Providing material data (test reports and data)
- Using material, processes, tools, calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities;
- 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;

Data management:

The following tools for drawing and data management are recommended in order to optimally interact with the Topic Manager:

- CATIA V5 R21
- VPM
- Windchill
- MS Word / Excel
- Acrobat Professional

The Partner will provide drawings and 3D models 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 to monitor and decrease the use of hazardous substances e.g. compliant with REACh regulation will be appreciated.

Certification:

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

Special Skills synthesis:

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

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

IX. Helicopter carbon composite engine deck

Type of action (RIA or IA)	IA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-0.3		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Airbus Helicopters	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[31]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-AIR-02-52	**Helicopter carbon composite engine deck**
Short description	
The aim of the topic is to develop, design and test an engine deck using advanced carbon composite solutions. Different concepts and material configurations have to be tested and evaluated with respect to mechanical and fire proof requirements. The development aims a considerable structural weight reduction and fatigue resistance improvement in comparison to conventional metallic designs.	

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

1. Background

The new rotorcraft architecture developed by the Topic Manager and which will be demonstrated under FRC IADP 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) such as Airframe will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

2. Scope of work

The structural weight is one of the major items impacting the high speed capabilities and hence the operational efficiency of the aircraft. Strong efforts have to be done in order to reduce the structural weight whilst ensuring adequate cost efficiency and a maximum safety characteristic. Innovative light-weight architectures and design approaches in combination with modern construction materials are deemed the key for outstanding airframe weight efficiency. It is an overall goal to force the structural weight to be reduced by 10% in comparison to traditional, state-of-the-art solutions.

Modern airframe constructions feature a mixture of materials aiming the most efficient exploitation of their characteristics with regard to their main functions and their compatibility with their corresponding perimeter. Modern airframes for medium-to-heavy helicopters show the trend of combining composite shells with metallic supporting structures (frames, spars). The metallic frames allow for an effective integration and adaptation of load introduction points whilst reaching advantageous cost efficiency and safety capabilities (crash behaviour). Fuselage side shells, upper shells, lower shells and tail-boom are designed as composite sandwich panels allowing for a clean aerodynamic surface, whilst allowing for the integration of low-to-moderately loaded attachments, hatches and walkable areas without the need of additional supporting back-structures. Due to the inherent large buckling resistance, sandwich shells are allowed to feature large structural unsupported bays.

The engine deck represents one large panel area which is however still being designed in traditional semi-monocoque metallic design. This engine deck is typically arranged behind the gear box which is allocated at the mechanical deck. Engine decks are, for medium-to-heavy helicopters, typically above the cargo compartment or even above a portion of the passenger's cabin. The engine deck represents the airframe platform at which the engines are attached to the fuselage (Fig. 1). The engine compartment is hence delimited by the engine deck, the cowlings and the firewalls. Due to the engine high service temperature, the engine deck is subjected to high service temperatures with hot spots ranging up to 150°C. Moreover, the engine deck is requested to cope with stringent fire proof requirements in case of an engine fire and burning fuel leakage, in order to prevent fire flames or burning fluids penetrating into the cabin.

As a consequence, the engine deck is typically designed as a stringer stiffened skin construction (semi-monocoque) which is made in total out of titanium material exploiting its outstanding fire proof properties. However, the use of titanium leads to severe drawbacks in terms of structural weight, fatigue sensitivity, costs and thermal mismatch with respect to the composite airframe. This solution leads to important penalties in terms of the structural weight efficiency. The same deficiencies are present for the firewalls, which represent a fire barrier between the engine compartments to the mechanical deck on the one hand, and between the engines on the other. This avoids flames penetrating into the mechanical deck and/or impacting on the adjacent sound engine.

Several concepts have been conceived in order to avoid the drawbacks of a titanium engine deck and reduce the required weight whilst ensuring fire proofness and compatibility with high service temperatures. The motivation is to introduce a composite solution for the engine deck, exploiting its light-weight characteristics as well as the possibilities of combining different layered materials with synergetic properties. Such an exemplary lay-out entails the combination of carbon fibre reinforced composites with integrated functional layers of ceramic and even elastomeric materials. Preliminary studies on laboratory level have indicated large potential of semi-monocoque composite designs with integrated ceramic layers. A corresponding translation into a design of an engine deck and a pre-size under consideration of the service mechanical loads lead to a weight reduction of 30% in comparison to a traditional titanium design.

It is the scope of the project to screen, define, develop, design and test different composite, ceramic or hybrid solutions for the engine deck and firewalls. The test campaign addresses in the first instance the fire proof capabilities and the compatibility with service temperature maps of the engine compartment. The test specimens must be defined according to an overall structural design of the engine deck including the back-structural elements. The tests must be performed according to certification parameters including vibration during fire exposure. The effects of fire/smoke/toxicity shall be addressed if considered applicable. Mechanical tests shall be included for materials featuring susceptibility to impact, environment, aging, drilling or the like which could affect the mechanical and long-term behaviour of the materials.

The subject of this Call for Partners are all the activities needed for developing and manufacturing non-metallic engine deck structures for future serial application in the high speed Rotorcraft LifeRCraft (renamed now to RACER). Therefore activities such as engineering activities, manufacturing and testing are to be performed in this call. In addition to the technical activities the relevant management activities have to be performed as well.

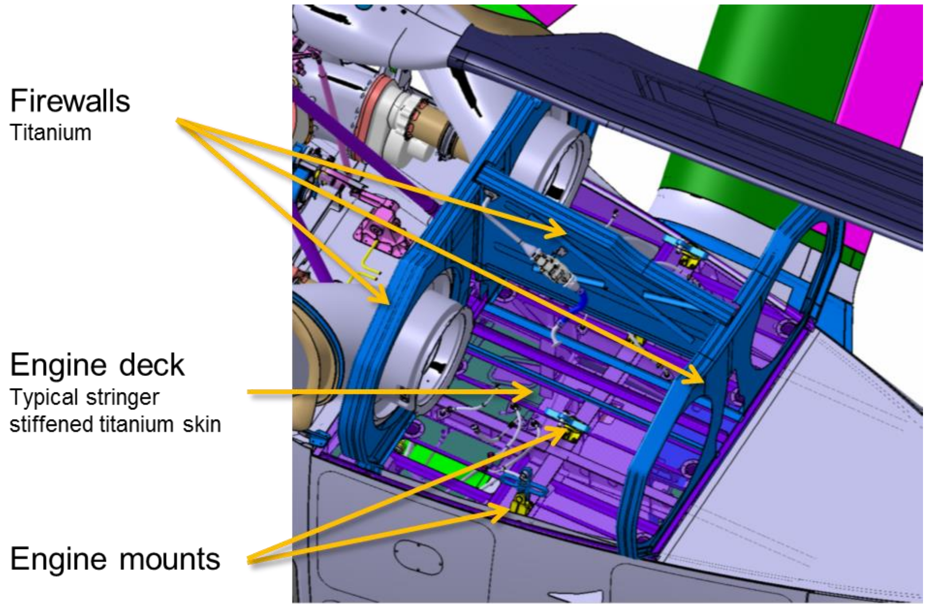


Fig. 1: Engine compartment with engine deck and firewalls

In addition, with respect to weight, the main driving parameter is the total structural weight of the engine deck compartment. The solutions must be hence tailored targeting a minimum weight in comparison to a traditional titanium engine deck as reference. The reference is provided by the Topic Manager. The weight must include all relevant items which have to be considered for a safe operation in service, including, if any, additional layers against moisture absorption, paints, mats, joints, dopplers, etc.
With respect to recurring cost estimation, an estimation of RC must be performed as well in comparison to the reference, including raw materials, processing, QA and assembly. Maintenance efforts must be estimated.

The topic manager anticipates that significant access to the topic managers' background may be needed by the successful applicant. If the case, the applicant has to describe in the proposal the type of background he will need to perform his tasks.
In return, the topic manager requests shared access to the foreground generated during the project. This will be subject of a specific agreement between the topic manager and the successful applicant to be signed during the negotiation phase.

A synthesis of the activities to be performed is as below:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Definition of the all the requirements (fire proofness, service temperatures, weight targets, areal temperature mapping (peak temperatures & hot spots), FST if applicable, environmental resistance) and constraints (loading, joining, geometrical periphery, structural periphery, systems integration, architecture…) to be considered for the development of the engine deck compartment	T0+1
2	Definition of an engine deck in traditional titanium semi-monocoque construction.	T0+2
3	Theoretical Material screening and definition of potential solutions	T0+4
4	Definition and testing of test samples at coupon level for a first assessment of fire behaviour, basic mechanical behaviour and technological feasibility	T0+6
5	Selection of potential composite materials and material compounds for engine deck airframe shell applications	T0+7
6	Selection of potential composite materials and material compounds for firewall applications	T0+7
7	Pre-design and pre-size of an engine deck airframe panel according to the architectonical and service requirements under consideration of the specific characteristics of the material	T0+10
8	Pre-design and pre-size of the firewalls according to the architectonical and service requirements under consideration of the specific characteristics of the material. Evaluation of the expected structural improvement (overall weight) against a traditional design.	T0+12
9	Definition and test of coupons for mechanical characterization (strength, damage resistance/tolerance, joints (bearing)). Determination of design rules and sizing allowables.	T0+14
10	Definition and design of representative full-scale fireproof test specimens according to certification requirements including back-structure.	T0+15
11	Manufacturing of fire proof test panels	T0+17
12	Fire proof tests according to certification procedure including vibration. Assessment of fire-proofness and FST behaviour if applicable.	T0+18
13	Project management	T0+18

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Material screening report	R	T0+4
D2	General handling, processing & manufacturing instructions for composites	R	T0+2
D3	Definition of coupons, manufacturing process & test planning for preliminary fire testing	R	T0+3
D4	Coupons for preliminary fire behaviour test campaign	HW	T0+5
D5	Results of preliminary fire behaviour coupon test campaign	R, D	T0+6
D6	Preliminary design and sizing of engine deck (shell and firewalls) with selected materials. Digital mockup.	R, D	T0+12
D7	Definition of coupons, manufacturing process & test planning for mechanical characterisation	R	T0+10
D8	Coupon test results for mechanical characterization of the material	R, D	T0+14
D9	Design of fire proof full scale panels & respective test planning	R, D	T0+15
D10	Full scale fire-proof test panels	HW	T0+17
D11	Test results on fire proofness	R, D	T0+18

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	Material selection done	R	T0+4
M2	Material characterization done	R, D	T0+14
M3	Engine Deck design and sizing done	R, D	T0+10
M4	Firewalls design and sizing done	R, D	T0+12
M5	Full scale test specimens manufactured	HW	T0+17
M6	Full-scale Fire-proofness tests done	R, D	T0+18

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

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

Data management:

The following tools for drawing and data management are recommended:

- CATIA V5 R21
- NASTRAN
- VPM
- Windchill

Material and Processes

- Using materials, processes, tools, manufacturing means etc. which are commonly accepted by the aeronautic industry and certification authorities
- Proven experience in composite material manufacturing and related processes (preferably POA)
- Non-destructive testing capabilities & skills
- Composite machining capabilities
- Experience in test specimen preparation, mechanical testing of composite materials and analysis of results for aerospace applications
- Test equipment and skills for high temperature mechanical testing
- Quality System acc. international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)

Certification:

DoA, PoA are not mandatory. In case no DoA/PoA exists, the successful applicant needs to supply all documents required by the TM to obtain flight clearance.

Other Skills

- <u>Experience in light weight structures (not mandatorily aeronautical)</u>
- Experience in design, sizing, manufacturing and testing of composite/layered/ceramic materials.
- Experience in research topics related to engineered materials characterization
- Experience in fire proof materials (not mandatory)
- Experience in fire proof testing (not mandatory)
- Proven experience in collaborating with reference aeronautical companies with industrial air vehicle developments with "in – flight" components experience and knowledge of helicopter specific requirements
- Capacity to specify material and structural tests along the design and manufacturing phases of aeronautical components, including: material screening, panel type tests and instrumentation
- Capacity to perform coupon and structural and functional tests of aeronautical materials and components: test preparation and analysis of results

5. Abbreviations

DoA	Design Organisations Approvals
PoA	Production Organisations Approval
TM	Topic Manager

X. Innovative & Flexible pilot plant Means for highly integrated AFP infusion wing box aiming at flying demonstrator manufacturing

Type of action (RIA or IA)	IA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-2.2		
Indicative Funding Topic Value (in k€)	2500		
Topic Leader	Airbus Defence & Space	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[32]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-02-53	**Innovative & Flexible pilot plant Means for highly integrated AFP infusion wing box aiming at flying demonstrator manufacturing**
Short description	
The topic addresses an innovative & flexible industrial pilot system, based on lightweight tooling to develop flyable structure for two 4 m long semi-wings demonstrator (L/H & R/H). Such a system shall predict, control, manufacture, monitor and record manufacturing process. It aims at removing destructive and non-destructive test for further mass productions integrated component. The Assembly process will take advantage of jig-less methodology.	

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

1. Background

Within AIR WP B-2.2, a integrated R/H and L/H composite wing box structure, consisting of a stiffened lower skin and rear and front spars, shall be manufactured and assembled on a turboprop aircraft to validate the component by means of flight test. The structure will be manufactured by dry carbon fibre by using Liquid Resin Infusion (LRI)

The preliminary TRL levels have been reached by pre-industrial means, suitable for coupons, sub-components and maturity demonstrators. A further industrial step requires a smart innovative integration of current state of the art for LRI, taking advantage of the best practices relying on:

- Systems adapted to AFP lay up for dry fibre.
- Lightweight moulds, ancillary tooling and caul-plates
- Modular sub-tooling to save cost and lead time, combining L/H and R/H segments
- Component manufacturing targeting easy and jigless assembly
- Energy efficient self-heating devices, to minimise large industrial means such as autoclaves and big ovens.
- Smart circuits for vacuum bagging, component demoulding, transfer and transportation.
- Reliable systems to master the component shape and thickness uniformity along the manufacturing operations.
- Cost-efficient and flexible metallic and non-metallic tooling able to correct and modify subsequent dimensional deviations due to the composite manufacturing process.
- Rapid prototyping for tooling based on ALM and infusion technologies.
- Sensorization and monitoring to control and record the main key process parameters: thermal, fluid mechanics, vacuum, pressure, cure, dimensional and non-destructive testing parameters.
- Contactless techniques to monitor and inspect the carbon fibre component.
- Compatibility with low cost materials aiming at reproducing and predicting manufacturing reliability for aerospace structural materials, speeding up trial and error loops prior to the final structure manufacturing.

There is then the need to develop a Innovative & Flexible pilot plant Means system for highly integrated AFP infusion wing box aiming at flying demonstrator manufacturing. The resulting system shall be validated by means of full scale mock ups manufactured by similar (but lower cost) materials. This system and its methodology will be used to manufacture the targeted flying wing components. A set of full scale validation articles shall be manufactured to prove the suitability of the system to manufacture and deliver ground and flight test demonstrators for L/H and R/H semi-wing boxes.

2. Scope of work

The innovative system has to address the following points:

Innovative system target: The mission of the innovative system is to enable the manufacturing of flyable components belonging to a wing box carbon fibre composite structure, which shall be manufactured by infusion (LRI)

The above mentioned components consist of a set of L/H and R/H integrated structure of co-infused skins, stringers and spars (front and rear). The span of the wing box segments is about 4 meters long.

All the structural elements shall be manufactured by AFP lay-up in a compatible way with the designed system, minimizing the tooling and taking advantage of flexibility and synergies of the main operations for the intended manufacturing process.

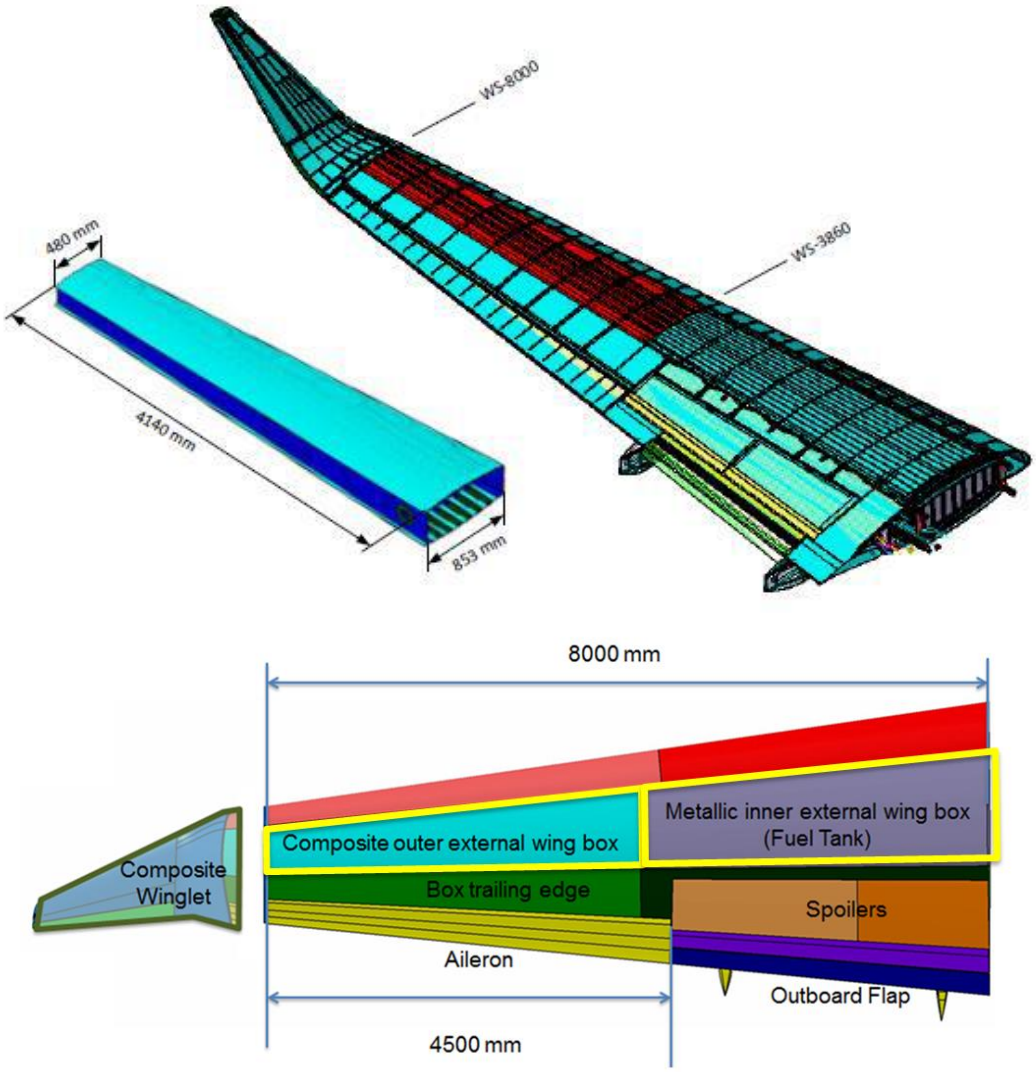


Figure 1: Composite wing box whose lower skin and rear / from spars shall be infused by means of the innovative system defined within the present document.

Dry fibre raw material: The typical format for dry fibre raw material consists of spools of ¼ or ½ inch width carbon fibre tape in aeronautical grades. This format is typically bindered with high temperature hot forming materials. Skins, stringers and spars are automatically fibre placed and hot formed, when required. The dry fiber parts are usually transferred from AFP machines into moulds to finally integrate separate components within a continuous structure to be co-infused. Therefore, the tooling chain shall be as light as possible in order to get an ergonomic and simple way of handling. A smart approach of tooling definition shall be implemented in order to minimize costs, logistics and hardware storage. Ground tooling displacements are preferred to crane-based ones.

Other multifunctional materials shall be implemented within the manufacturing process such as lightning strike protective (LSP) raw materials as well as corrosion prevention fibres (e.g. glass fibre)

High temperature hot forming and infusion: The system shall be running for aeronautical structural materials using resins at high hot forming and cure temperatures. Other equivalent materials might be used to set up the system aiming at reducing R&T costs, taking into account that the final performances shall be reached for the high temperatures manufacturing behaviour.

Optimization of system size and logistics: Innovative concepts shall drive to the smallest industrial means sizes. The design and the manufacturing of the system shall aim at flexible and easy implementation concepts, allowing further adaptation to other part designs and their modifications. In addition, it has to be conceived as an easily "nomad and portable" system prepared to come back to R&T facilities to upgrade it as a pilot system to implement state of the art advances based on mould materials, heating systems, monitoring and sensoring technics and advances on inspection and big data management. Online, wifi and long distance control parameters control should be fostered.

Light materials shall be implemented within the moulding design and manufacturing, defining manufacturing strategies, its risk management and back-up solutions. Fast manufacturing techniques and fast dimensional corrections, when required, shall be explored and implemented.

Energy saving: Minimum energy approach shall be conceived and implemented, using eco-friendly methodologies based on energy saving, low cost heating systems and minimizing thermal losses.

The system shall include a sensors system to enable further monitoring, controlling and recording as well as simulation validation.

Fast training: The system shall include a cutting edge IT system to understand, run training and simulate further manufacturing approaches. The training shall be performed in an innovative way (e.g. simulation approach to shorten operator skills achievement). Simulation shall be oriented to final user purpose, beyond design and engineering tasks. Simulations shall be friendly for operators.

The system shall minimize the trial and error loop by using digital tools as well as a proper methodology of dummies (material and shape equivalent to the final aeronautical structural parts), but at a very lower cost. This approach applies to lay-up, handling, infusion, heating, cure, inspection, demoulding and final operations and treatments.

Cost efficient ancillary materials approach: A compatible approach of the system shall aim at studying compatible ancillary materials to focus on minimum hand operations as well as best practices to minimize scrap and ancillary materials wasting. Potentially reusable materials, to enable recurring costs savings (raw materials and operations) are preferred. Customizing and kitting are a must.

Documentation: All the documentation shall be generated in a full 3D format, with paperless technology, intended for design, system manufacturing, system user and maintenance documentation, training and simulation.

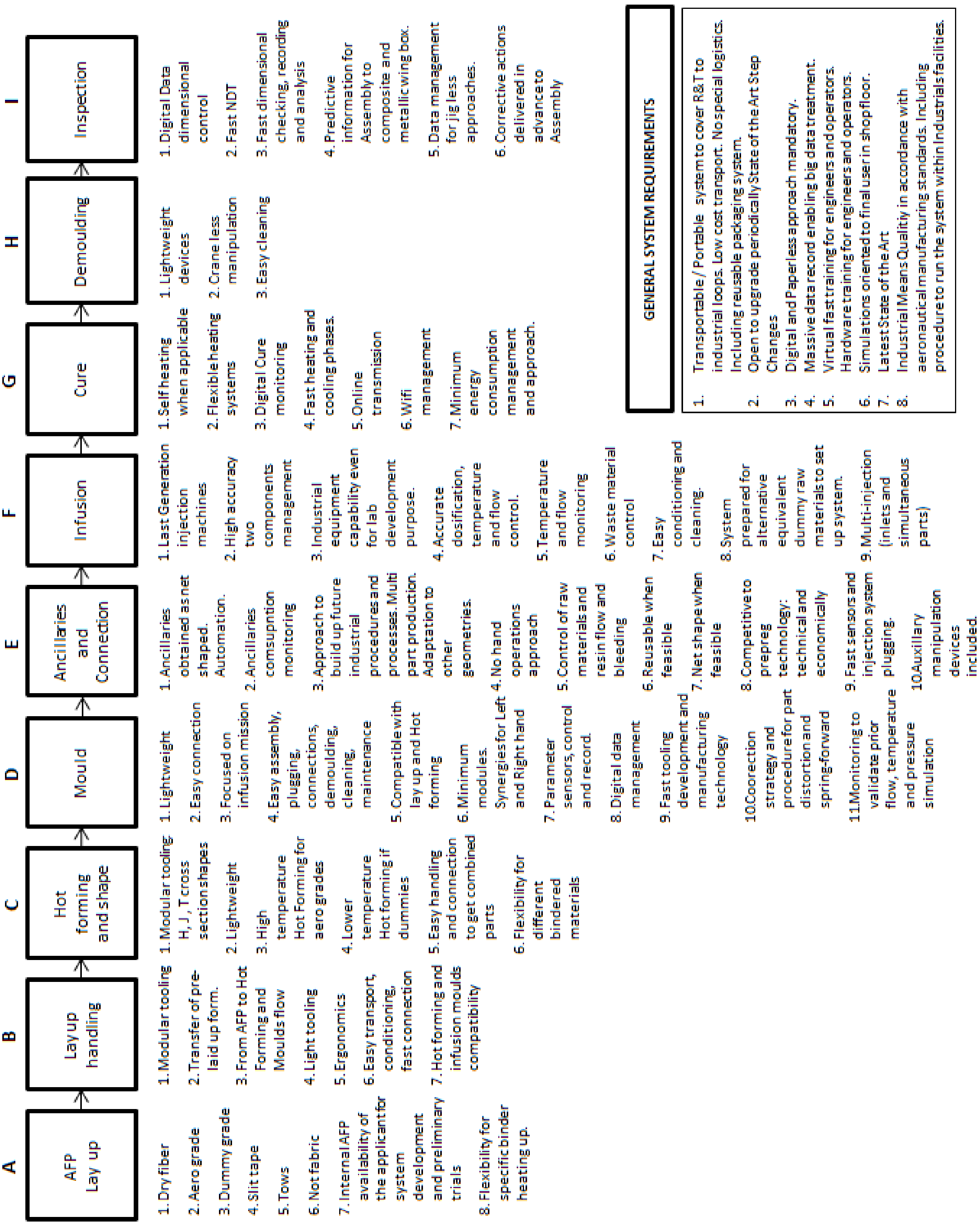


Figure 2: General system requirements breakdown at a glance, based on manufacturing process operations.

Tasks		
Ref. No.	Title - Description	Due Date
T1	Conceptual definition of methodology and design of a key turn pilot system to integrate innovative and flexible means to accomplish development phase and low cost trials to enable manufacturing phase of ground test and flyable components	T0 + 01
T2	Conceptual design of integrated industrial means General Requirements. Requirements and Technical Specifications for: Moulds Transfer devices and transportation Heat transfer systems Injection systems, simulation and its monitoring. Cure systems and its monitoring Dummy parts and low cost specimens to ensure flyable components manufacturing Inspection systems, monitoring, recording, data analysis and simulation. Transportation and set up of the system to an industrial manufacturing environment. Smart logistics, rapid assembly and disassembly (Modular assembly) Training system: Virtual and hardware operation. Training certification procedure. User and Maintenance handbook.	T0 + 02
T3	Full Design of key turn innovative and flexible industrial means system	T0 + 06
T4	Manufacturing and set up of the full system at R&T facilities	T0 + 12
T5	Transportation and set up of the full system to industrial environment. Baseline: Plant located in Cadiz Province. Back up: Madrid.	T0 + 13
T6	Manufacturing of low cost dummy parts at industrial environment	T0 + 16
T7	Manufacturing of panels to validate mechanical behaviour obtained at industrial manufacturing environment	T0 + 18

3. Schedule for Major Deliverables/Milestones (Estimate)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D1	Conceptual definition of methodology and Innovative Industrial Means Integration	R	T0 + 01
D2	Conceptual Design of Industrial Means, Manufacturing and Set up. • General Requirements • Moulds • Transfer and Logistics • Heat transfer • Injections • Cure systems and its monitoring • Dummy components • Simulation • Inspection, Monitoring and Recording • Transportation and Implementation of mobile innovative industrial means system. • Training	R	T0 + 02
D3	Final Design of Innovative Integrated System	R D (CATIA full 3D)	T0 + 06
D4	Innovative Integrated System	HW R (Learning by Digital training and simulation)	T0 + 12
D5	Set up at R&T facilities	R	T0 + 13
D6	Set up at Industrial facilities Manufacturing of dummy parts at Industrial environment	R H	T0 + 16
D7	Manufacturing of panels with structural raw materials at industrial environment	H	T0 + 17

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

Milestones (when appropriate)			
Ref. No.	Title - Description	Type*	Due Date
M1	Feasibility Design Review (FDR)	R	T0 + 01
M2	Preliminary Design Review (PDR)	R D	T0 + 02
M3	Critical Design Review (CDR)	R D	T0 + 06
M4	System Acceptance at R&T facilities	H D R	T0 + 14
M5	System Implementation at Industrial environment	H D R	T0 + 15
M6	Manufacturing of dummy parts and panels at Industrial environment.	H R	T0 + 17

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

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

Proven experience in:

- **R&T Management**
  - Management of complex R&T and industrial projects for aeronautical composite components by automated manufacturing processes.
  - Management of key turn Industrial Means projects.
  - High experience on international R&T projects
  - Experience on international R&T projects for infusion components for aeronautical industry.
  - Risk management experience, proven within prior aeronautical industrial projects
- **R&T Methodology**
  - Fast track trial and error methodology
  - Low cost development trials based on equivalent raw materials and system prototyping.
  - Experience on simulations to reduce R&T lead time.
- **Design and Data Management**
  - High competence for managing aeronautical 3D design software, structural analysis for aeronautical industrial means and composite materials lay-up design and lay up simulation.
  - Strong Structural and thermal FEM competences.
- **Materials & Processes**
  - High experience on AFP raw materials. Specially, dry fibre AFP.
  - Experience on infusion raw materials internal development: fibres, resins and binders.
  - Experience on automated lay-up and infusion manufacturing processes for aeronautical parts manufacturing.
  - Mastering of heating system integration for automated lay-up devices, hot forming and tooling thermal profiles.
  - Experience on oven and self-heating devices.

- Experience on fast Non Destructive Inspections.
- Ecological approach based on Optimization of accurate infusion systems to minimize dry fibre and resin scrap / waste to get optimal buy-to-fly ratio.
- Cost efficient and energy saving innovative integrated manufacturing systems.

- **Manufacturing**
  - AFP industrial means design and manufacturing for dry fibre materials (tows, slit tape, UD tape, fabrics)
  - Design and manufacturing of infusion moulds made by light materials: lay-up, cure, machining, trimming, milling, surface treatment, geometrical corrections, spring-back corrections, heating systems and instrumentation.
  - Design and manufacturing of infusion moulds made by low CTE metallic and polymeric materials: lay-up, forming, cutting, welding, machining, milling, geometrical fine tune, stress relief, surface treatment and finishing.
  - Manufacturing of large components (highly integrated) of carbon fibre composites for industrial and aeronautic application.
  - Manufacturing of high cadence industrial and aeronautic prototypes.
  - Rapid prototyping based on low cost materials prior to industrial components set up.
  - Experience on RTM, LRI, vacuum assisted and similar manufacturing processes.

- **Industrial Means Innovation**
  - Design, development, manufacturing, integration, set up of key turn pilot plant systems for dry carbon fibre composite manufacturing by AFP and infusion.
  - Injection and heating system development
  - Monitoring and recording of infusion manufacturing processes parameters.
  - Integration of automated injection systems.
  - Innovative and online approaches for customer service for key turn industrial means.

5. Abbreviations

AFP	Automated Fibre Placement
FEM	Finite Element Methods
HF	Hot Forming
IT	Information Technologies
L/H	Left hand
LRI	Liquid Resin Infusion
LSP	Lightning strike protection
R/H	Right Hand
RTM	Resin Transfer Moulding

XI. Seals for FTB#2 Wing with Additive Manufacturing Technologies

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-2.2		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	Airbus Defence & Space	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[33]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-02-54	**Seals for FTB#2 Wing with Additive Manufacturing Technologies**
Short description	
FTB#2 Wing Seals design, optimization according to the requirements, manufacturing (by means of additive manufacturing technologies) and qualification to obtain the Permit to Fly of the seals. Also including all necessary materials, processes and seals components research, development and qualification tests to ensure the satisfactory performance of the parts in flight and on ground tests. Seals shall be delivered for the complete wing flight demonstrator and for the left hand external wing on ground full scale test.	

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

1. Background

Several flexible seals usually produced with silicone rubbers are required for the wing of FTB#2 regional aircraft flight demonstrator and for the full scale test on ground demonstrator of the external wing. Among others, some of the Seals needed will be installed in the following joints:

- **FIX-FIX JOINTS**

  Seals will be installed in the Fix Component (Wing Box).

  - Wing Box – Flap Fairings. Compression on the Seal.
- **FIX-MOVABLE JOINTS**

  Seal will be installed in Fix Component (Wing Box, Flap).

  - Wing Box – Control Surfaces (Ailerons). Mainly drag on the seal.
  - Wing Box – High Lift Surfaces. Drag and compression on the seal.
  - Wing Box – Lift Dumper (Spoilers). Mainly compression on the seal.
  - Flaps – Flap Tabs. Drag and compression on the seal.
- **MOVABLE-MOVABLE JOINTS**

  Seals will be installed in one or in both components.

  - Between High Lift Surfaces. Mainly drag on the seal.
  - High Lift Devices – Spoilers. Drag and Compression on the seal.

Existing standard Seals do not completely fulfil all the requirements imposed for these joints in terms of geometry, mechanical properties, aero performances, durability, maintainability, etc. This lack of properties sometimes leads to degraded performances and non-optimized designs (due to accessibility issues, for example), having a relevant impact on the components final weight and cost (more parts and assemblies, less structural integration) and also on supportability maintenance schedules and related costs.

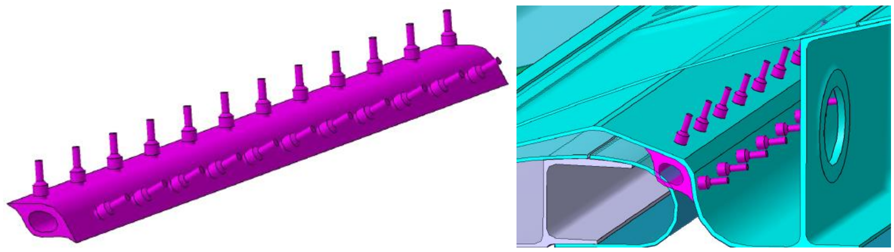


Figure 01.- *Concept of Flap-Tab Seal (As a reference only).*

Typically flexible silicon rubber parts are manufactured by injection moulding. The lead-time and cost associated to this process in usually a problem is usually a problem, especially taking into account that rapid prototyping during design/sizing loops and/or short series manufacturing required in aeronautical Industry Research and Technology.

Moreover, for Series Aircraft development it is quite common that these parts do not work as expected during airborne, mainly due to the difficulty of predicting how these parts will behave in flight conditions. These are the reasons why modifications to improve Seals performances are needed. In this context, the use of Additive Technologies to manufacture these parts could represent flexibility, lead-time and cost reductions essential for the rapid prototyping and optimization loops during flight tests campaign.

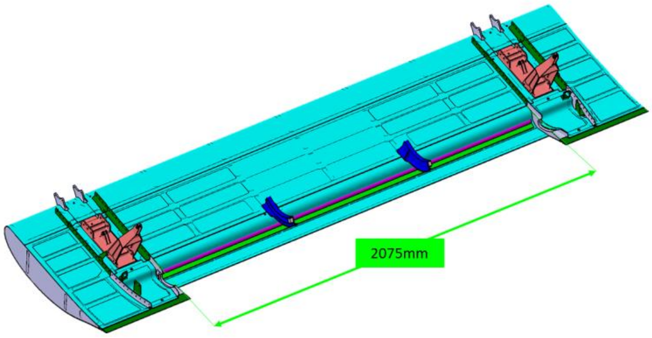


Figure 02. *Seal Typical length Inboard Flap (As a reference only. Split the seal in several parts may be allowed).*

Additive manufacturing technologies could be potentially used directly to produce the part obtaining complex and optimized shapes for each particular seal, or in the production of injection moulds for quick and low-cost prototyping of rubber seals.

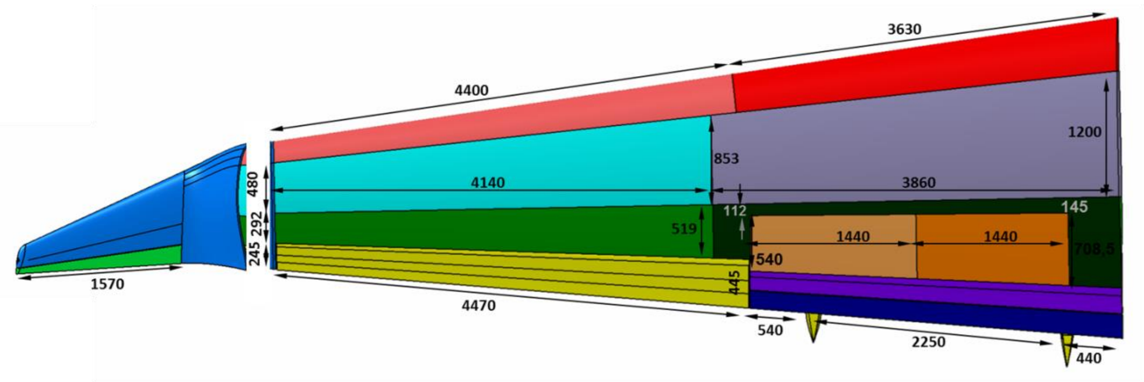


Figure 03.- *FTB#2 External Wing. Plan View Dimensions (As a reference only. Split the seal in several parts may be allowed).*

2. Scope of work

In order to improve the performances associated to these components, activities regarding detailed design, manufacturing and qualification tests of these seals will be launched. The design of these components will be adapted to the wing of FTB#2 Regional Aircraft Flight Demonstrator and for the Full Scale Test On-Ground Demonstrator of the External Wing.

Two steps of FTB#2 flight tests are expected: first step during 2020 and second step in 2022. FTB#2 Step 2 external wing on ground full scale tests will be in 2020. In every step, 2 different Wing configurations will be installed in the Flight Demonstrator FTB#2, even though the geometry will be identical. The differences come from the composite Outer External Wing Box part in Step 2 with respect the Wing configuration of Step 1.

Although Step 1 & Step 2 share the same set of aerodynamic surfaces, Wing arrangement might be slightly different. Some seals might be reused from one Step 1 to Step 2 (that will depend on the final Detailed Design of each component), but most of them might need to be geometrically tuned to fit properly in the Aircraft, keeping the same design concept. Design Solutions that fit in both Step configurations or even in LH/RH positions shall be also considered.

A first full set of wing seals components has to be delivered during 2019 (fix dates to be provided by the Topic Manager depending on the status of the Program), for Step 1 FTB#2 wing flight test demonstrator. A second set (with the optimized design coming from the results of Step 1 test campaign), only for left hand external wing full scale test, is needed at the end 2019. A third set (with the optimized design coming from the results of the Full Scale) will be needed for Left and Right Hand for the Wing to be installed during Step 2 Flight Test Campaign. The optimization is required when needed, i.e., applicable for those seals that are not compliance with the requirements; that is means that not all the seal might be impacted by the optimization process.
In addition, based on firsts installation on wing and feedback of the seals behaviour during flight tests and external wing full scale tests, new optimized and improved versions of these seals might be required in order to enhance their performances if those proven during testing understate the requirements.
Therefore, it is expected the optimization process after the analyses of the results coming from the following trials on the wing:

1- Step 1 Wing Configuration Flight Tests (Left and Right Hand)
2- Step 2 Wing Configuration (Composite Outer Wing Box) Full Scale Static Test On Ground (Left Hand Only)
3- Step 2 Wing Configuration (Composite Outer Wing Box) Flight Tests (Left and Right Hand)

The activities shall cover research, design, manufacture, testing and qualification of the seals involving innovative solutions using additive manufacturing technologies in components production.

Tasks		
Ref. No.	Title - Description	Due Date
[T1]	Requirements Collection	T0+1
[T2]	ALM techniques and Materials for Seals (State-of-the Art)	T0+1
[T3]	Materials and Manufacturing Techniques Trade-Offs	T0+1
[T4]	Seals Material and Manufacturing Process Characterization [1]	T0+2
[T5]	Design Trade-Offs	T0+2
[T6]	Detailed Design	T0+4
[T7]	Qualification Program Definition	T0+4
[T8]	Qualification Tests	T0+8
[T9]	Step 1 Wing configuration: Seals Manufacturing (LH+RH)	T0+9

Tasks		
Ref. No.	Title - Description	Due Date
[T10]	Step 1 Wing configuration: Seals Optimization and Manufacturing (LH+RH) after Step 1 Flight Tests	T0+18[2]
[T11]	Step 2 Wing Configuration: Full Scale Test: Seals Manufacturing (LH)	T0+10
[T12]	Step 2 Wing Configuration: Seals Manufacturing (LH+RH)	T0+18

[1] Compliance with environmental & operational requirements shall be demonstrated.
[2] First Flight Dates for Step1 and Step2 are based on the current program schedule dependant on the status of the program

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
[D1]	Technical Specification [3]	R	T0+1
[D2]	Seals Materials/Manufacturing Process State-of-the-Art and proposed alternatives for the Wing Seals	R,D	T0+1
[D3]	Trade-Offs, preliminary design and qualification strategy	R,D	T0+1
[D4]	Detail Design, Analysis & Optimization	D, R	T0+3
[D5]	Qualification Program Plan (QPP) [4]	R	T0+3
[D6]	Qualification Test Procedure (QTP)	R	T0+4
[D7]	Qualification Test Results	R,D	T0+8
[D8]	Seals Qualification Report [5]	R,D	T0+8
[D9]	Design Performance Declaration [6]	R	T0+9
[D10]	Step 1 Wing Configuration: Manufactured Seals (LH+RH)	HW	T0+9
[D11]	Step 1 Wing Configuration: Manufactured Optimized Seals (LH+RH) after Step 1 Flight Tests	HW	T0+18[2]
[D12]	Step 2 Wing Configuration Full Scale Test: Manufactured Seals (LH)	HW	T0+10
[D13]	Step 2 Wing Configuration Full Scale Test: Manufactured Optimized Seals (LH+RH) After Full Scale Tests	HW	T0+18

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

[3] Based on requirements defined by A/C Designer and by the Seal Supplier.
[4] Including Means of Compliance Matrix (MoC Matrix).
[5] Including demonstration of compliance by similarity with already qualified Parts.
[6] Compliance with Technical Specification and with Functional Requirements.

Milestones (when appropriate)			
Ref. No.	Title - Description	Type*	Due Date
[M1]	Technological Readiness Level (TRL) Review	R,D	T0+1
[M2]	Preliminary Design Review (PDR)	R,D	T0+1
[M3]	Critical Design Review (CDR)	R,D	T0+3
[M4]	Qualification Test Readiness Review (TRR)	R,D	T0+4
[M5]	Qualification Tests Results Review	D,HW	T0+8
[M6]	Step 1 Wing Configuration: Seals FAI First Article Inspection (FAI)	D,HW	T0+9
[M7]	Step 1 Wing Configuration: Optimized Seals FAI	D,HW	T0+18[2]
[M8]	Step 2 Wing Configuration Full Scale Test: Seals FAI [2]	D,HW	T0+10
[M9]	Step 2 Wing Configuration Full Scale Test: Optimized Seals FAI	D,HW	T0+18

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

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

- Previous experiences in Aerospace Sector (Familiar with Standards, Procedures, etc.).
- Sound knowledge in Seals Design & Sizing for aircraft lifting and control surfaces uses.
- Previous experiences in rubber seals manufacturing and seals tooling design.
- Sound knowledge in CAD/CAE Design. Own CAD/FEM Software & Licenses (incl. Hardware). Capability to work with CATIA V5 design models and NASTRAN FEM models.
- Sound knowledge in Additive Manufacturing Techniques & Materials. Including materials and processes suitable for seals.
- Previous experiences in Qualification/Certification for Aerospace Sector.
- Previous experience in characterization and qualification of materials suitable for Seals.
- Sound knowledge in Testing procedures (incl. previous experiences).
- Testing facilities
- Manufacturing facilities.

5. Abbreviations

CAD	Computer Aided Design
FEM	Finite Element Models
FTB#2	Flight Test Bed 2 Regional Aircraft Demonstrator
KOM	Kick off Meeting
PDR	Preliminary Design Review
CDR	Critical Design Review
TRM	Technical Review Meeting
TRL	Technological Readiness Level
TRR	Tests Readiness Review
FAI	First Article Inspection

XII. Thermal conductive coating providing self-limitation of heating power at a selected temperature level

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-3.3.2		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[34]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-02-55	**Thermal conductive coating providing self-limitation of heating power at a selected temperature level**
Short description	
The aim of the project is to develop innovative thermal coating with optimal material characteristic providing self-limitation of heating power at a selected temperature level, as well as to develop associated automated manufacturing processes demonstrating performances and compliance with aircraft requirements.	

[34] 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 of large passenger aircraft (LPA) through large scale integrated demonstrators. This call is related to activities running under the *ITD Airframe WP B-3.3* oriented towards highly integrated cockpit but more specifically towards *WP B-3.3.2 "LPA Cockpit innovative structural components"* as presented in the work breakdown structure below.

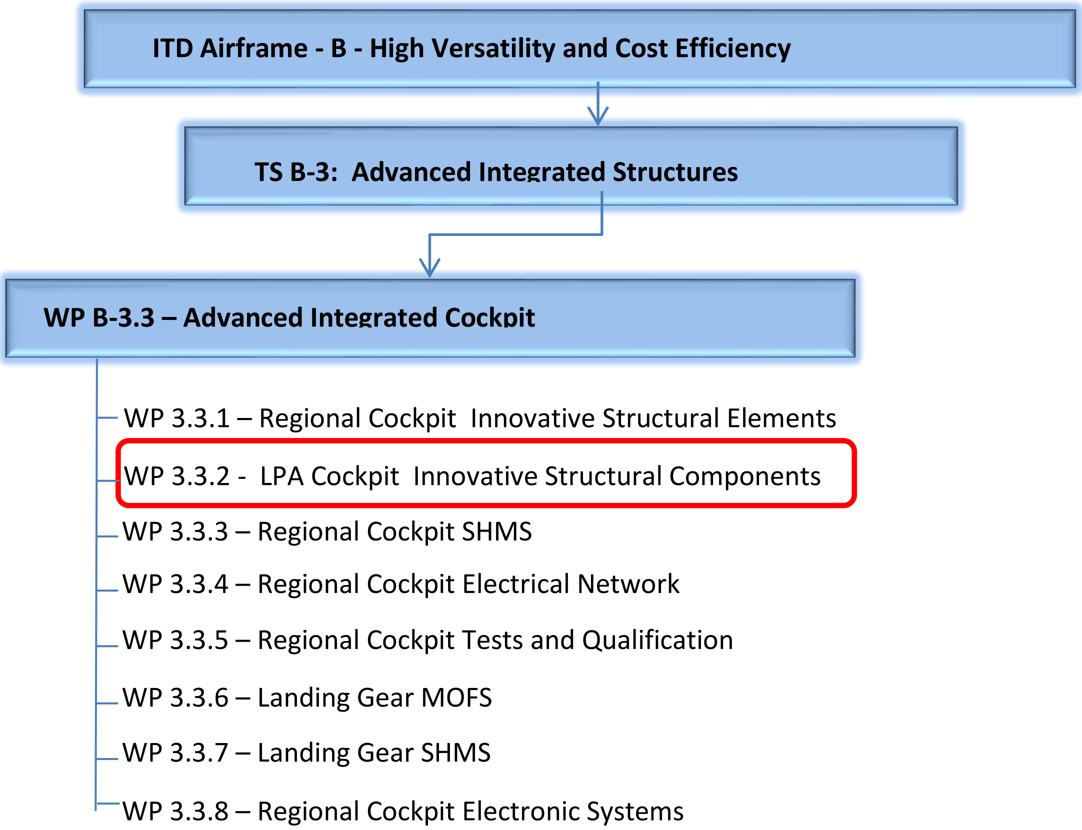


Figure 1: Work Breakdown Structure of AIR WP B-3.3 "Advanced Integrated Cockpit"

The current Call outcome will be an input to the LPA technology demonstrators developed within LPA 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.

The target is to validate an innovative heating technology based on conductive coatings. Among different potential field of applications the project will be oriented on cabin elements such as the typical configuration of the multifunctional fuselage from Large Passenger Aircraft Platform 2.

In that context with space limited aircraft sections, thermal insulation behind lining can be partially or completely removed to extend the lining towards the outer skin and thus to provide more space for passengers, pilots and cabin attendants.

Thermal comfort will be maintained by active heating of the concerned cabin surfaces.

A major benefit of this approach is to significantly increase space and thermal comfort for passengers, pilots and cabin attendants at minimum power consumption, weight and cost impact. This must be achieved by the development an application of industry 4.0 principles, such as intelligent automated/robotized manufacturing processes.

2. Scope of work

The focus within this topic lies in the development and manufacturing of an innovative, self-limiting heating system integrated in lining elements and fully compatible with cabin 3D contour and appearance as defined for the multifunctional demonstrator. The typical context including geometry and industrial boundaries will be delivered by the Topic Manager.

The project will develop a full scale lining demonstrator with complete integrated heating system, decorative layer and inspection. The project will include demonstration tests in a suitable environment to verify the functional behaviour and thermal comfort.

A synthesis of the requested tasks is provided hereunder, as well as proposed schedule.

	Tasks		
Ref. No.	***Title – Description***	***Start date***	***Due Date***
1	Management	T0	T0+36
2	Development of conductive coating	T0+2	T0+14
3	Development of manufacturing process	T0+4	T0+22
4	Prototype manufacturing and testing	T0+12	T0+30
5	Thermal simulation	T0+14	T0+20
6	Investigations and reports	T0	T0+36

Task 1: Management

This task is usually devoted to:

- Report project progress on a regular basis;
- Manage and coordinate the progress meetings;
- Manage and coordinate project activities on related subjects;
- Support and coordinate the reviews;

Task 2: Development of Conductive Coating

Development of an optimal conductive coating composition and material properties, which:

- Provide self-limiting behavior at 60 °C;
- Provide as an additional alternative feature self-limitation at 20 °C;
- Is fully compatible with the materials used in cabin linings, such as lining prepregs and

decorative layers/top coatings;

- Fulfills (in combination with the lining design) the heat release and fire, smoke and toxicity requirements applicable in civilian aeronautics;
- Fulfills environmental requirements for large passenger aircraft in accordance with RTCA-DO 160 (humidity, temperature, vibration, EMI, …).

Task 3: Development of Manufacturing Process

Development of an automated, robotized manufacturing process, which:

- Applies the metallic conductors on both ends of the heated surface on complex 3d geometries;
- Applies the conductive coating (and, if applicable: a protective top coating) with uniform surface thickness on complex 3D geometries;
- Can be applied on existing lining elements;
- Provides a suitable surface pretreatment, if necessary.

A hardware demonstrator (refer to figure 1) shall be developed to demonstrate the manufacturing method.

A non-destructive test method **integrated on the lying tool for** verification of the surface thickness and uniform temperature distribution shall also be developed.

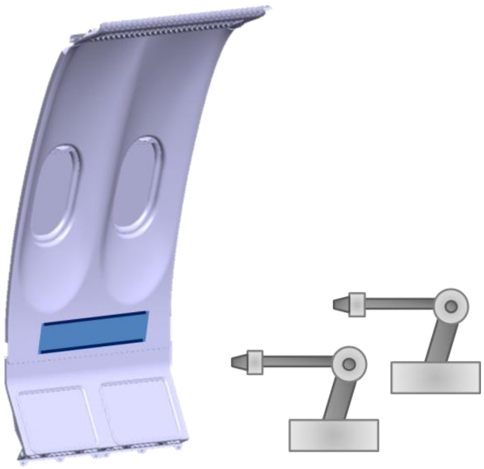


Figure 1: Hardware demonstrator with typical cabin lining element and robot(s) for the individual manufacturing steps (i.e. surface pretreatment, application of metal conductors, application of conductive coating, …)

Task 4: Prototype Manufacturing and Testing

The activities to be performed consist in:

- Design of an integrated heated lining unit, where conductive coating and electrical conductors are fully integrated in the lining contour and do not impact the design and appearance of the element;
- Manufacturing of representative prototypes (coupons) needed to verify the functional,

material and operational requirements (self-limitation, endurance, heat release, fire, smoke, toxicity, …); Perform the corresponding tests;

- Manufacturing of a full scale lining demonstrator: Typical serial production part (i.e. side wall lining element, door lining element etc.) with complete integrated conductive coating heating system, covered by decorative layer or decorative surface finish as typically used by airlines. Inspection and tests shall be performed to validate the physical appearance and to tests the functional performance and thermal comfort in a suitable environment

Task 5: Thermal Simulation

Perform a thermal simulation of a representative aircraft cabin in order to determine the impact of heating on the entire cabin environment and overall thermal comfort. This task will be supported and validated by the Topic Manager.

Task 6: Investigation and Reports

The activities to be performed consist in:

- Establishing equipment requirements and provide a compliance document based on inputs provided by the Topic Manager;
- Preparing risk and opportunity matrix;
- Investigating material compatibility, i.e. between lining, conductive coating and decorative layer;
- Investigating possible misuse by passengers and develop requirements and solutions to prevent misuse and increase physical robustness;
- Providing figures for weight, material, production cost and power consumption;
- Outlining the way to industrialization and implementation.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Requirements and compliance document	Report	T0+2
2	Conductive coating proposal for chemical composition and behavior	Report	T0+3
3	Manufacturing process concepts	Report	T0+4
4	Risk and opportunity matrix	Report	T0+5
5	System and manufacturing description document including details of the proposed solution	Report	T0+22
6	Verification of material properties conductive coating (testing)	Hardware	T0+16
7	Hardware prototypes validated in laboratory environment	Hardware	T0+30
8	Test report	Report	T0+32

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
9	Manufacturing demonstrator for coating and electrical conductor application	Hardware	T0+28
10	3D prototypes manufactured	Hardware	T0+30
11	Functional full scale lining demonstrator	Hardware	T0+30
12	Manufacturing and test report validated in relevant environment	Report	T0+32
13	Technical and functional description of integrated heated lining system incl. bill of material, manufacturing method, etc.	Report	T0+34
14	Thermal simulation and report	Report	T0+20
15	Final report incl. lessons learnt	Report	T0+35

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Kick-off Meeting	Review	T0+1
2	Specification Review	Review	T0+2
3	Preliminary Design Review – Conductive Coating	Review	T0+4
4	Preliminary Design Review – Manufacturing Process	Review	T0+6
5	Evaluation Test Readiness Review – Conductive Coating	Review	T0+13
6	Evaluation Readiness Review – Manufacturing Process & Demonstrator	Review	T0+22
7	Critical Design Review – Hardware Prototypes	Review	T0+28
8	Evaluation Test Results Review	Review	T0+31
9	Thermal Simulation Baseline Review	Review	T0+14
11	Thermal Simulation Results Review	Review	T0+20
12	Final review	Review	T0+36

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

Proven experience in:

- Aircraft lining elements design and manufacturing
- Automated/robotized application of coatings/surface technology
- Automated/robotized application of metal layers (conductors)
- Conductive coatings & behavior
- Materials & processes (compatibilities, characteristics, physical and chemical behavior, endurance, robustness, surface properties…)
- Electrical/human safety requirements
- Thermal simulation
- Test benches & procedures (fire, smoke, toxicity, heat release, robustness, humidity …)
- Airworthiness requirements
- Verification management
- Supply chain management
- Fire, smoke and toxicity requirements applicable in civilian aeronautics.

5. Abbreviations

RTCA-DO 160	Environmental procedures and test Conditions for Airborne Equipment
EMI	Electromagnetic Interference

XIII. Advanced Integrated Testing Methods development

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	B-3.3		
Indicative Funding Topic Value (in k€)	1200		
Topic Leader	Airbus	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	24	Indicative Start Date[35]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-AIR-02-56	Advanced Integrated Testing Methods development
Short description	
The aim of the project is to develop an Advanced Integrated Testing Methods with multi interface conditions. Through their prototypes, it will demonstrate the readiness of the different functionalities of the integrated measurement systems for possible implementation in the testing of a multifunctional fuselage integrating cabin and system elements demonstrator.	

[35] 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 WP B-3.3* oriented towards highly integrated cockpit but more specifically towards *WP B-3.3.2 "LPA Cockpit innovative structural components"* as presented in the work breakdown structure below.

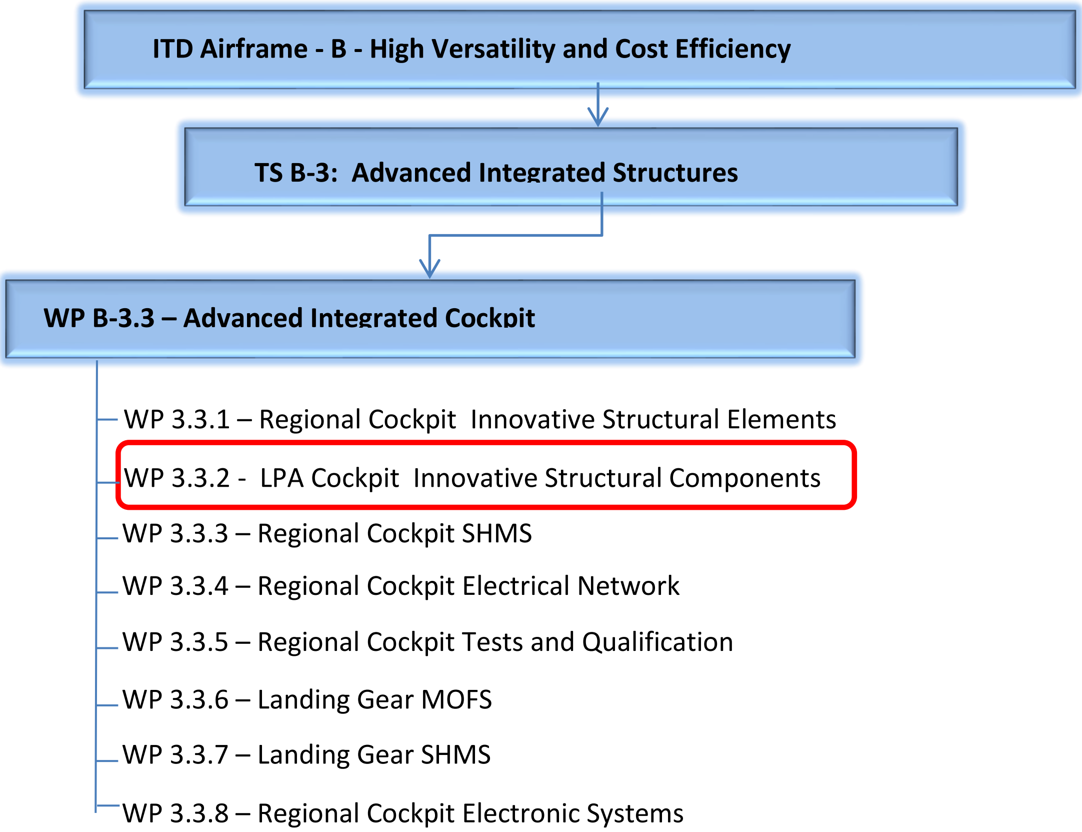


Figure 1: Work Breakdown Structure of AIR WP B-3.3 "Advanced Integrated Cockpit"

The current Call outcome will be an 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, in relation to the Large Passenger Aircraft platform demonstrators. Specificities are driven by integration of cabin and, or, systems into the structure design.

In addition, the Topic Manager will define the boundaries conditions of the mechanical test and capabilities expected with a minimum of 3 stress directions. The testing technologies to be integrated must be able to detect crack or delamination propagation open to surface or in depth, such as at hidden junction on metallic and composite assemblies, taking account that cabin element will be already integrated.

Typical structure to be tested is described in figure 2, combining composite material with metallic electrical system or composite component used for cabin functionalities or air conditioning.

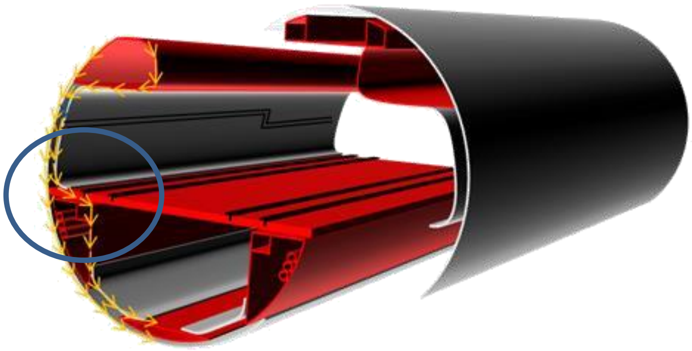


Figure 2: Centre fuselage with integrated cabin and system elements, the area of interest in the circle is at the floor junction to fuselage with integrated systems.

The project will develop all the facility capable to test without dismantling element and during mechanical test run.

2. Scope of work

The project will develop an advanced integrated testing methods with multi interface conditions and through their prototypes, it will demonstrate the readiness of the different functionalities of the integrated measurement systems for possible implementation in the testing bench unit for the demonstrator described in figure 2. The test will be realized on one bench combining different measurements and introducing at least 3 mechanical deformation directions related to the specific condition of the area of interested highlighted in figure 2. The entire test will be conducted without dismantling element for measurement or damage follow up.

Damage detection tools must include full field optical Infrared –interferometric and/or x-ray, and embedded sensing where hidden damage must be detected and its propagation followed into the assembly. Typical damages to be detected are crack propagating in metallic and/or delamination in composite structures and will be defined by the Topic Manager. The use of manually operated testing methods is not to be considered, the test measurement systems must be automated and must be in operation during the test running conditions. Downtime for the test in order to take measurements is not to be considered. An automated link to the test control system or condition led inspection functionality is desired.

The system must not intervene with Health and Safety rules or legislation surrounding test operation management. In addition, it must be of multi-interface design in concept to accept different COTS measurement technologies depending on the measurement requirements. The system must be operated through a user interface.

The Topic Manager will deliver a typical structure of 3x3 metres representative of the area of interest identified on figure 2, which will be with both composite and metallic components.

The project will be implemented with the following tasks and proposed schedule:

	Tasks		
Ref. No.	Title – Description	Start date	Due Date
1	Management	T0	T0+24
2	Concept of integrated testing	T0	T0+4
3	Design, fabrication of a testing bench	T0+4	T0+18
4	Prototype demonstration and evaluation	T0+18	T0+24

Task 1: Management

The applicant(s) will manage the project to reach the following objectives:

- Provide timely communication for the project with the Topic Manager and the CSJU Executive Team
- Perform risk evaluation analysis and regularly update the contingency plans
- Ensure that the agreed project objectives and deliverables are achieved, and ensure quality of work
- Monitor the compliance of beneficiaries with their obligations under the grant project agreement
- Facilitate communication and co-operation between project participants

Task 2: Concept of integrated testing

Based on the scope of work previously detailed by the Topic Manager about the context of tests to be implemented to demonstrate the multifunctional structure behaviour, the applicant will develop a test concept consistent with the scope of work and the objective of an on-board optical SHM system in term of performance, reliability, mass, footprint, power consumption, automated operation and cost. In particular the following elements shall be described:

- Tests scenarios
- Testing capabilities and performances
- Size, weight and power requirements
- Reliability metrics
- Maintainability requirements

Task 3: Design, fabrication of a testing bench

Based on outcomes from Task 2 and scope description, the applicant will design, manufacture and assemble all elements needed, adapted to the structure that will be delivered by the Topic Manager. The testing bench must combine different measurements and introduce at least 3 mechanical deformation directions. It must be designed for static and fatigue testing. An example of application is the typical fuselage section described in the area limited by the red circle visible on figure 2, where load paths are shown by yellow arrows.

The testing facility will be implemented at the Topic Manager site.

Task 4: Prototype demonstration and evaluation

The applicant(s) will develop and perform an evaluation test program able to assess robustness of the integrated testing capabilities. It will cover typical static and fatigue test loadings, including deformation measurements and damage follow up during loading cycles. The evaluation test program will be defined with the Topic Manager and aligned with the project duration

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date
1	Project and activity reports	Report	On a six months basis
2	Integrated testing capability concept	Report	T0+4
3	Integrated testing capability design Report	Report	T0+8
4	Testing capability prototype	Report	T0+18
5	Evaluation test plan	Report	T0+20
6	Evaluation test report	Report	T0+22
7	Final report	Report	T0+24

Milestones (when appropriate)			
Ref. No.	Title – Description	Type	Due Date
1	Kick-off meeting	Review/Minutes of Meeting with Actions	T0
2	Specification review	Review/Minutes of Meeting with Actions	T0+4
3	Preliminary Design review	Review/Minutes of Meeting with Actions	T0+6
4	Intermediate review of the test bench capabilities review	Review/Minutes of Meeting with Actions	T0+20
5	Final review	Review/Minutes of Meeting with Actions	T0+24

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

- Mechanical testing and inspection technologies for metallic, composite and hybrid structures skills
- Design and manufacturing capabilities for both mechanical and non-destructive inspection technologies

- Experience in definition and management of tests campaigns
- Capability to develop complex test benches for non-destructive inspection and testing for characterization screening purpose
- Knowledge and experiences in typical non-destructive testing technologies such as: X-rays, Eddy current, Thermal stress waves, Shearography and Ultrasound.
- Familiar with standards applicable in the field of testing in aerospace
- Design of automated test measurement systems
- Design of integrated control systems for the automated test measurement system

XIV. Tests and Modelling for reliability characterization and robustness of optoelectronic transceivers for optical SHM systems

Type of action (RIA or IA)	RIA		
Programme Area	AIRFRAME		
Joint Technical Programme (JTP) Ref.	WP B-3.3		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Airbus	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[36]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-02-57	**Tests and Modelling for reliability characterization and robustness of optoelectronic transceivers for optical SHM systems**
Short description	
The project will develop test benches and models in order to sustain qualification process of optical transceivers integrated in sensing systems used for Structure Health Monitoring. It will be done through Design of Experiments (DOE) for reliability model validation. Dedicated specific test bench prototypes will be designed and developed to allow full characterization of safe operating area and products robustness.	

[36] 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 of large passenger aircraft (LPA) through large scale integrated demonstrators.

This call is related to activities running under the *ITD Airframe WP B-3.3* oriented towards highly integrated cockpit but more specifically towards *WP B-3.3.2 "LPA Cockpit innovative structural components"* as presented in the work breakdown structure below.

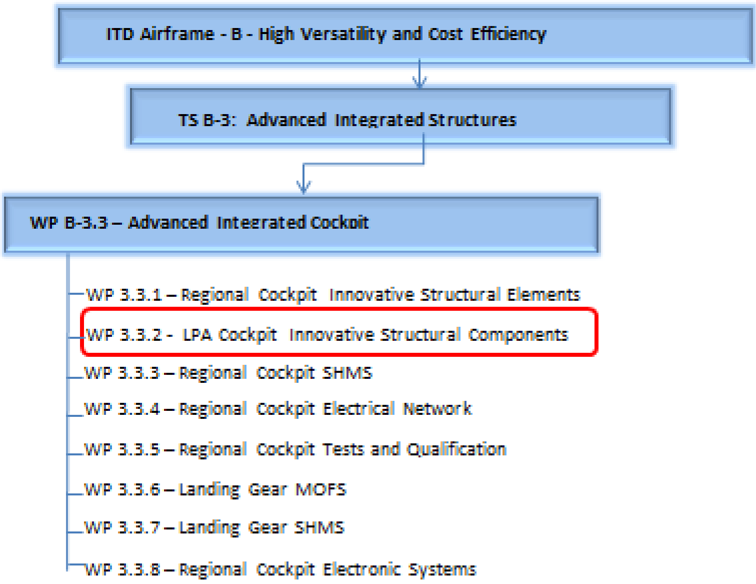


Figure 1: Work Breakdown Structure of AIR WP B-3.3 "Advanced Integrated Cockpit"

The current Call outcome will be an input to the *LPA technology demonstrators* developed within LPA *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.

In-service Structural Health Monitoring (SHM) is fundamental to assess the performance and integrity of composite aircraft structures. Fiber optics sensors have recently proven to be extremely efficient for real-time in situ monitoring of these structures because of their numerous advantages compared to alternative technologies such as immunity to electromagnetic interference, high bandwidth, high sensitivity, light weight, small size, and high reliability. Indeed, optical sensors such as embedded Fibre Bragg Gratings (FBG) have already been used to monitor both strain and temperature in aircraft structures and it has been demonstrated that these low speed signals can be efficiently connected to a scalable, modular optical network of new generation aircraft networks (see Figure 2).

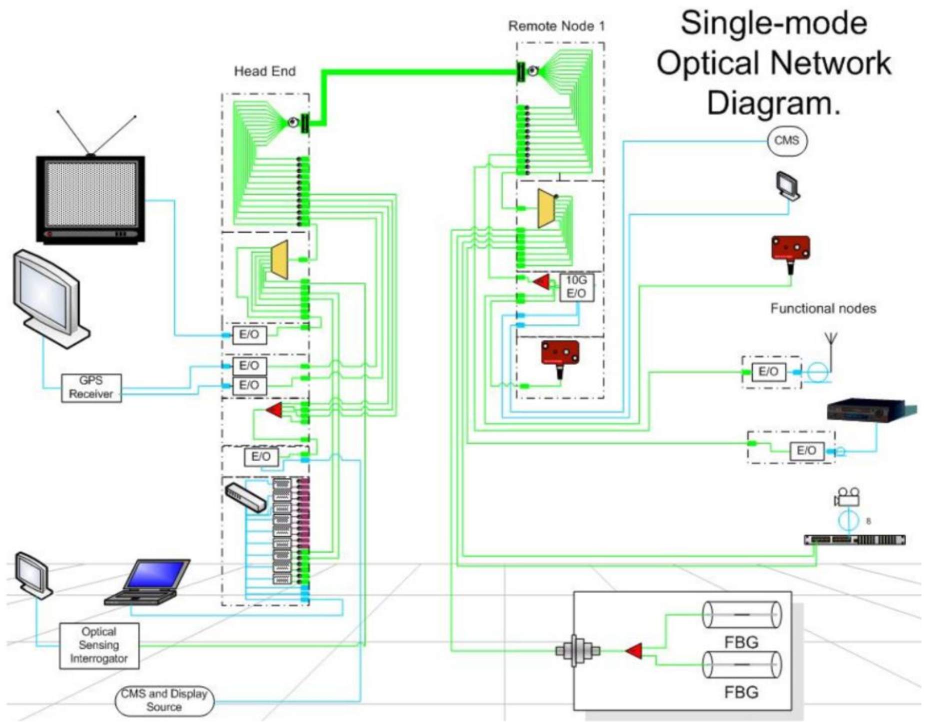


Figure 2: Schematic view of an optical network including FBG sensors for SHM.

It has been previously shown in the framework of the DAPHNE FP7 project that among the key active devices required for the implementation of Prognostic Health Monitoring sensors in a fibre network, optoelectronic transceivers are of paramount importance. Even if these transceivers are already extensively used on ground in terrestrial telecommunication networks, the possibility of using them in harsh environmental conditions is still questionable.

2. Scope of work

The aim of the proposed action will be to develop an optoelectronic transceiver module able to be reliably used in aircraft environments. To reach that goal, the applicant(s) shall, first of all, establish a set of requirements specifying the performance, environmental and reliability needs that will drive the design of the optoelectronic transceiver module. Then, after the design and the fabrication phase, the applicant(s) shall carry out an extensive electro-optical characterization test programme to assess the optoelectronic performance as well as the safe operating area of the modules. Afterwards, a thorough reliability evaluation will be conducted to address the relevant environmental constraints. Finally, the applicant(s) will propose a probabilistic model able to predict the reliability of the optical transceiver modules depending on their life profile.

A synthesis of the requested tasks is provided hereunder, as well as proposed schedule.

	Tasks		
Ref. No.	Title – Description	Start date	Due Date
1	Management	T0	T0+36

	Tasks		
Ref. No.	Title – Description	Start date	Due Date
2	Electro-optical transceiver specifications	T0	T0+4
3	Design, fabrication and electro-optical testing	T0 + 4	T0+18
4	Prototype reliability evaluation	T0 + 18	T0+34
5	Technology exploitation, standardization, roadmap	T0	T0+36

Task 1: Management
The applicant(s) will manage the project to reach the following objectives, but not only:

- Provide timely communication for the project with the Topic Manager and the CS2JU Executive Team
- Perform risk evaluation analysis and regularly update the contingency plans
- Ensure that the agreed project objectives and deliverables are achieved, and ensure quality of work
- Monitor the compliance of beneficiaries with their obligations under the grant project agreement
- Facilitate communication and co-operation between project participants

Task 2: Electro-optical transceiver specifications
The applicant(s) will establish specifications to make sure the transceiver architecture is consistent with the objective of an on-board optical SHM system in term of performance, reliability, mass, footprint, power consumption and cost. In particular the following elements shall be provided:

- Applications scenarios
- Targeted electro-optical performances
- Size, weight and power requirements
- Reliability metrics
- Maintainability requirements
- Envelope environmental constraints (e.g. expected lifetime, mechanical shocks and vibrations, temperature cycles, pressure, radiation)

A review of the existing devices will be performed to identify which new developments or design modifications will be required to address the requirements previously established.

Task 3: Design, fabrication and electro-optical testing
The applicant(s) will propose a transceiver design able to meet the specifications established in Task 2. As far as possible the applicant(s) will take advantage of developments already performed to address other environmental demanding applications (e.g. space, defence). A manufacturing and process description document will be generated by the applicant(s) to establish the list of the manufacturing, testing and quality control procedures that will be required for the fabrication of the modules. The procurement requirements applicable for piece parts and the associated incoming tests shall also be presented.
After fabrication, the applicant(s) shall design and develop dedicated test benches in order to carry out extensive characterisation tests whose objectives will be to assess the electro-optical performances of the transceiver modules within their operation temperature range. Tests will be performed at different temperatures and the safe operating area will be determined. The

applicant(s) shall take special care of the metrology of the test benches used for that purpose. Metrology studies (e.g. gage R&R) will be conducted and error budget shall be provided for each measured parameter.

Task 4: Prototype reliability evaluation
The applicant(s) will provide an evaluation test program able to assess robustness margins of the transceiver modules. These tests shall cover the whole set of environmental constraints identified in Task 2. For that purpose, dedicated ageing test benches will be set up by the applicant(s). Evaluation tests will be carried out not only on a set of assembled modules but also on individual piece parts in order to identify all possible design and fabrication weaknesses. To do so, advanced reliability testing approaches based on multiple stress accelerated degradation tests (e.g. Design of Experiments (DoE), Highly Accelerated Life Test (HALT), Highly Accelerated Stress Screening (HASS), Highly Accelerated Stress Test (HAST)) will be proposed with the objective, at the end of the evaluation phase, to derive predictive probabilistic models authorizing a sound modelling of the transceivers reliability metrics in use conditions (Mean Time To Failure, Mean Time Between Failure, Mean Time To Repair, Remaining Useful Life, …). Here again, advanced reliability modelling approaches, addressing both constant and non-constant failure rates, shall be evaluated (e.g. stochastic process models, Bayesian approach). The results shall be compared to those obtained from classical reliability standards (e.g. MIL-HDBK-217, FIDES, RTCA DO-160) and from new predictive reliability models related to multiple simultaneous failure mechanisms (e.g. High Temperature Operating Life (HTOL)).
The Topic Manager will supply specific use cases for which the applicant(s) shall carry out a detailed reliability analysis. Typical examples are temperature minimum / maximum values concerning the different tests specified in the RTCA DO-160 E depending on the application scenario, such as:: operating low temperature: -55 °C, short time operating high temperature: 85 °C, ground survival high temperature: 85 °C, with maximum heating rate 5 K/min, maximum cooling rate 5 K/min and temperature stabilisation time of1000 h.

Task 5: Technology exploitation, standardization, roadmap
The applicant(s) will map the technology development activities to exploitation opportunities of the project. A roadmap toward a full-certified version of the transceiver module shall be established with a detailed estimate of the various effort required. The applicant(s) shall also take advantage of any possible exploitation of the innovations generated during the project that would create opportunities in other field of activity (e.g. space, defence). Exploitation activities will also target standardisation organisations for guiding the technology development according to upcoming standards.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title – Description	Type	Due Date
1	Electro-optical transceiver specifications	Report	T0+4
2	Electro-optical transceiver design Report	Report	T0+8
3	Transceiver characterization test plan	Report	T0+14
4	Characterization report	Report	T0+18
5	Evaluation test plan	Report	T0+20
6	Evaluation test report	Report	T0+30
7	Reliability assessment report	Report	T0+34
9	Final report	Report	T0+36

Milestones (when appropriate)			
Ref. No.	Title – Description	Type	Due Date
1	Kick-off meeting	Review/Minutes of Meeting with Actions	T0+1
2	Specification review	Review/Minutes of Meeting with Actions	T0+4
3	Preliminary Design review	Review/Minutes of Meeting with Actions	T0+6
4	Critical Design Review	Review/Minutes of Meeting with Actions	T0+8
5	Electro-optical test readiness review	Review/Minutes of Meeting with Actions	T0+14
6	Electro-optical characterization results review	Review/Minutes of Meeting with Actions	T0+18
7	Evaluation test readiness review	Review/Minutes of Meeting with Actions	T0+20
8	Evaluation test results review	Review/Minutes of Meeting with Actions	T0+30
9	Reliability assessment review	Review/Minutes of Meeting with Actions	T0+34
10	Final review	Review/Minutes of Meeting with Actions	T0+36

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

- Electro-optical transceiver design and fabrication heritage
- Optoelectronic devices characterization capabilities
- Definition and management of tests campaigns
- COTS and high reliability parts procurement management
- COTS reliability upgrading methodology knowledge
- Capability to develop complex test benches for electro-optical (pulsed/AC/DC) and environmental (temperature, moisture, vibration, mechanical shocks , radiation, low pressure, …) testing for characterization, screening and ageing purpose
- Radiation hardness assurance capability for embedded aircraft electronics
- Familiar with high reliability standards applicable to optoelectronic devices (e.g. Telcordia)
- High reliability application heritage (aeronautics, space)
- Capability to perform an evaluation/qualification tests for harsh environment applications (aeronautics, space, defence, marine, …)
- Capability to perform reliability analysis and modelling
- Failure analysis capability

5. Abbreviations

COTS	Commercial Off-The-Shelf
DoE	Design of Experiments
FBG	Fibre Bragg Gratings
HALT	Highly Accelerated Life Test
HASS	Highly Accelerated Stress Screening
HAST	Highly Accelerated Stress Test
HTOL	High Temperature Operating Life
IPR	Intellectual Property Rights
SHM	Structural Health Monitoring

XV. Optimization of hybrid joining (Refill Friction Stir Spot Welding + adhesive bond) for increasing mechanical properties and corrosion protection of the joints [SAT]

Type of action (RIA or IA)	IA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	B-3.4		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	PZL Mielec	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[37]	Q1 2019

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-AIR-02-58	**Optimization of hybrid joining (Refill Friction Stir Spot Welding + adhesive bond) for increasing mechanical properties and corrosion protection of the joints**
Short description	
The scope of the topic is to develop optimal parameters of welding lap joints with use of friction stir spot welding FSSW (RFSSW) process to weld fuselage thin skins (<2 mm) and aircraft skins with stringers. The optimization of the FSSW (RFSSW) parameters will be based on the selection of adequate parameters for the skin thickness, such as tool rotational speed, tool insertion time, mixing time, time of tool returning, etc. An important part of the work will be research on the choice of suitable adhesive bond for effective RFSSW lap joints. The adhesive layer should fill the gaps of a joint, protecting the inner surfaces from corrosion	

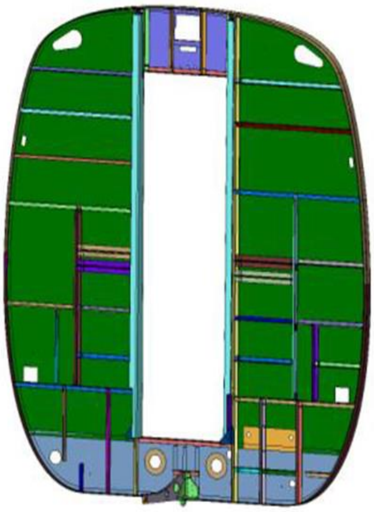
[37] The start date corresponds to actual start date with all legal documents in place.

1. Background

According to the SAT-AM project under AIR ITD, the implementation of FSSW (RFSSW) process for aerostructures appears to be especially suitable for welding the fuselage in high-strength aluminium alloys that can maintain the excellent properties in the weld seams. This has an impact on potential weight savings compared to the conventional riveting techniques for fuselage assembly.

The aim of the topic is to develop optimal parameters of welding lap joints with use of friction stir spot welding FSSW (RFSSW) process to weld fuselage thin skins (< 2 mm) and aircraft skins with stringers. The optimization of the FSSW (RFSSW) parameters will be based on the selection of adequate parameters for the skin thickness, such as tool rotational speed, tool insertion time, mixing time, time of tool returning, etc. The outcome will be the technological guidelines and the instruction/methodology of the welding procedures, allowing for the selection of process parameters taking into account the thickness of the joined elements. The developed methodology for technological tests shall ensure selection of optimal parameters of the FSSW (RFSSW) process with the smallest number of tests executed, which will result in obtaining fault-free joints with proper mechanical properties. Next part of the work will be research on the choice of suitable adhesive bond for effective RFSSW lap joints. The adhesive layer shall fill the gaps of a joint, protecting the inner surfaces from corrosion. Adhesive application technology shall be characterized by low labour intensity. It is recommended to apply the adhesive layer before the welding process. The properties of the adhesive (such as viscosity) shall ensure its proper displacement from the weld zone during welding, and any traces of an adhesive shall not have any negative effect on the weld strength. The chosen adhesive shall be resistant to the temperature impact during the welding (RFSSW) and during the operation of the aircraft an adhesive shall not exhibit a decrease of its strength within a min. 40k flight hours. The adhesive will also have to be resistant to factors that may potentially decrease its strength (atmospheric conditions: UV radiation, temperature changes, humidity, etc.). Adhesive shall also be resistant to operational fluids and aviation fuel. Development of guidelines for surface preparation and adhesive application is also an important aspect. Proposed adhesive shall be developed for aviation industry and shall meet the requirements of the REACh Regulation.

The demonstrator for this technology will be a frame of a part of a fuselage made by thin (< 2 mm) aluminium sheet of metal, stringers and extruders. Example of such frame is presented on figure below.



Size: 1879 x 2080 mm

2. Scope of work

Tasks		
Ref. No.	Title - Description	Due Date
WP1	Testing of FSSW (RFSSW) joints	T0 + 9
WP2	Selection of adhesive bond for FSSW (RFSSW) process	M4 + 6
WP3	Optimization of parameters for FSSW (RFSSW) joints	M10 + 3
WP4	Comparative test of FSSW (RFSSW) joints too conventional joining technologies	M13 + 6
WP5	Develop manufacturing and inspection specification and requirements for FSSW (RFSSW) joints	M7 + 9
WP6	Design, manufacture and tests of the demonstrator fixtures	M13 + 6
WP7	Design, manufacture and tests of demonstrator produced by FSSW (RFSSW) with adhesive bond	M19 + 6

Mx is intended as first day of month x.

A synthesis of the requested activities in the different WPs is provided as follows:

WP1 – Testing of FSSW (RFSSW) joints

Develop standards for assessing quality of joints produced for aluminium 2024 and 7075:

- Design specimens representative of FSSW (RFSSW) joints in different configurations (2024-2024, 7075-7075 and 2024-7075)
- Manufacture of specimens
- Create FSSW (RFSSW) joints of specimens
- Conduct quality assessments including corrosive tests
- Conduct quality assessments of joints including material properties

- Documentation with results and analysis

WP2 – Selection of adhesive bond for FSSW (RFSSW) process

Develop adhesive bond dedicated to FSSW (RFSSW) process to apply before welding process:

- Selection of adhesive bond for FSSW (RFSSW) process
- Adhesive bond tests: resistance to the temperature in FSSW (RFSSW) process, resistance on atmospheric conditions (UV radiation, temperature changes, humidity, etc.) and operational fluids and aviation fuel
- Documentation with results and analysis

WP3 – Optimization of parameters for FSSW (RFSSW) joints

Develop optimal process parameters for joining of aluminium 2024 and 7075 with adhesive bond:

- Optimize FSSW (RFSSW) process parameters to obtain appropriate mechanical properties of joints with adhesive bond
- Conduct quality assessments of FSSW (RFSSW) joints with adhesive bond including material properties
- Documentation with results and analysis

WP4 – Comparative test of FSSW (RFSSW) joints to conventional joining technologies

Develop FSSW (RFSSW) joint designs that replace fusion welded, resistance welded, adhesive bonded and riveted joints:

- Design specimens for comparative tests
- Manufacture specimens
- Conduct comparative analysis of FSSW (RFSSW) joints and joints created using other joining technologies
- Synthesize and analyse experimental results
- Determine optimal configurations of welded parts and kinds of FSSW (RFSSW) joints that can replace the existing joints created using other welding technologies
- Documentation with results and analysis

WP5 – Develop manufacturing and inspection specification and requirements for FSSW (RFSSW) joints

Understand root causes for defects and process controls necessary to eliminate them:

- Develop knowledge base about defects and inconsistencies occurring during FSSW (RFSSW) processes and their impact on the strength properties of the joints
- Develop of control procedures for FSSW (RFSSW) joints
- Develop of methodology for the monitoring of the quality of FSSW (RFSSW) joints
- Documentation with results and analysis

WP6 – Design, manufacture and tests of the demonstrator fixtures

Develop fixtures required to manufacture demonstrator:

- Design fixtures required for demonstrator
- Manufacture demonstrator fixtures
- Verify functionality of fixture operation
- Conduct a study to determine potential simplification approaches of the fixtures
- Complete documentation of fixture and potential simplifications

WP7 – Design, manufacture and tests of demonstrator produced by FSSW (RFSSW) with adhesive bond

Demonstrate achievement of program goals and objectives for aerostructures produced by FSSW (RFSSW) process:

- Develop design guidelines for FSW and FSSW demonstrator
- Develop 3D models of demonstrator based on design guidelines
- Manufacture the FSSW (RFSSW) technology demonstrator
- Develop test plan
- Perform tests
- Preparation of documentation of FSSW (RFSSW) technology demonstrator

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title - Description	Type*	Due Date
D1	Report containing results of development of FSSW (RFSSW) process parameters for aluminium alloys	R	T0 + 9
D2	Report containing results of selection of adhesive bond for FSSW (RFSSW) process	R	T0 + 9
D3	Report containing results of development of optimal FSSW (RFSSW) process parameters for joints with adhesive bond	R	T0 + 12
D4	Report containing results of comparative research performed for aluminium alloys joints made by FSSW (RFSSW) method and conventional joining technologies	R	T0 + 18
D5	Knowledge base about defects and inconsistencies occurring during FSSW (RFSSW) process and their impact on the strength properties of the joints	R	T0 + 15
D6	Special fixtures with documentation dedicated to producing of demonstrator	R + HW	T0 + 18
D7	Demonstrator presenting the parts of aircraft structure produced using FSSW (RFSSW) technologies	R + HW	T0 + 24

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

Milestones (when appropriate)			
Ref. No.	Title - Description	Type*	Due Date
M1	Development of preliminary FSSW (RFSSW) process parameters for aluminium alloys and preliminary selection of adhesive bond	D	T0 + 6
M2	Presentation of conception for optimization FSSW (RFSSW) process parameters and selection of control procedures for FSSW (RFSSW) joints	D	T0 + 10
M3	Approval for selected tests method and presentation of conception for comparative tests of the joints and preliminary design review for fixtures	D	T0 + 14
M4	Presentation of design guidelines for FSW and FSSW demonstrator	D	T0 + 19

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

	2019												2020											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
WP1						M1			D1															
WP2						M1			D2															
WP3										M2		D3												
WP4														M3				D4						
WP5										M2				M3	D5									
WP6														M3				D6						
WP7																			M4					D7

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

Special expected skills are:

- Proven experience in FSSW (RFSSSW) process (preferably <2 mm aluminium)
- Solid knowledge in design of joined aluminium structures consisting of sheet and frames
- Proven experience in structural and fatigue analysis of weld joints and complete component
- Proven experience in manufacturing of aluminium structures for the aerospace industry
- Knowledge in material selection and welding metallurgy for aluminium alloys
- Knowledge in strength and fatigue testing of riveted, resistant spot welded and welded samples and test pieces of this joints
- Proven experience of research in adhesive bonds selection to different application in industry
- Proven experience in technological research and development for innovative products and processes
- Proven experience in methodological optimization of production processes
- Proven experience of working with airframe designers, tooling design and joint design
- Proven experience in deformation and damage mechanisms of metallic materials
- Proven experience in collaborating with aeronautical companies on Research and Technology programs

In addition, the applicant(s) are required to have access to the following capabilities:

- CATIA CAD software, V5 R21 or later
- Suitable manufacturing and machining laboratories for FSSW (RFSSW)
- Suitable prototype workshop
- Laboratory facility for mechanical testing, residual stress measurements, metallurgical examinations and corrosion testing
- Laboratory facility for adhesive bond tests with equipment dedicated to temperature resistance of adhesive bond, resistance of adhesive bond on atmospheric conditions (UV radiation, temperature changes, humidity, etc.) and different fluid (like operational fluids and aviation fuel)
- Laboratory facility for strength and fatigue testing of welds and welded joints
- Non-destructive testing equipment (radiographic, ultrasonic, eddy current and penetrant testing)

5. Abbreviations

FSSW	Friction Stir Spot Welding
RFSSW	Refill Friction Stir Spot Welding
REACh	Registration, Evaluation and Authorisation of Chemicals

XVI. Breakthrough design concept solutions and technologies for Regional Aircraft Cabin Interiors innovative configuration

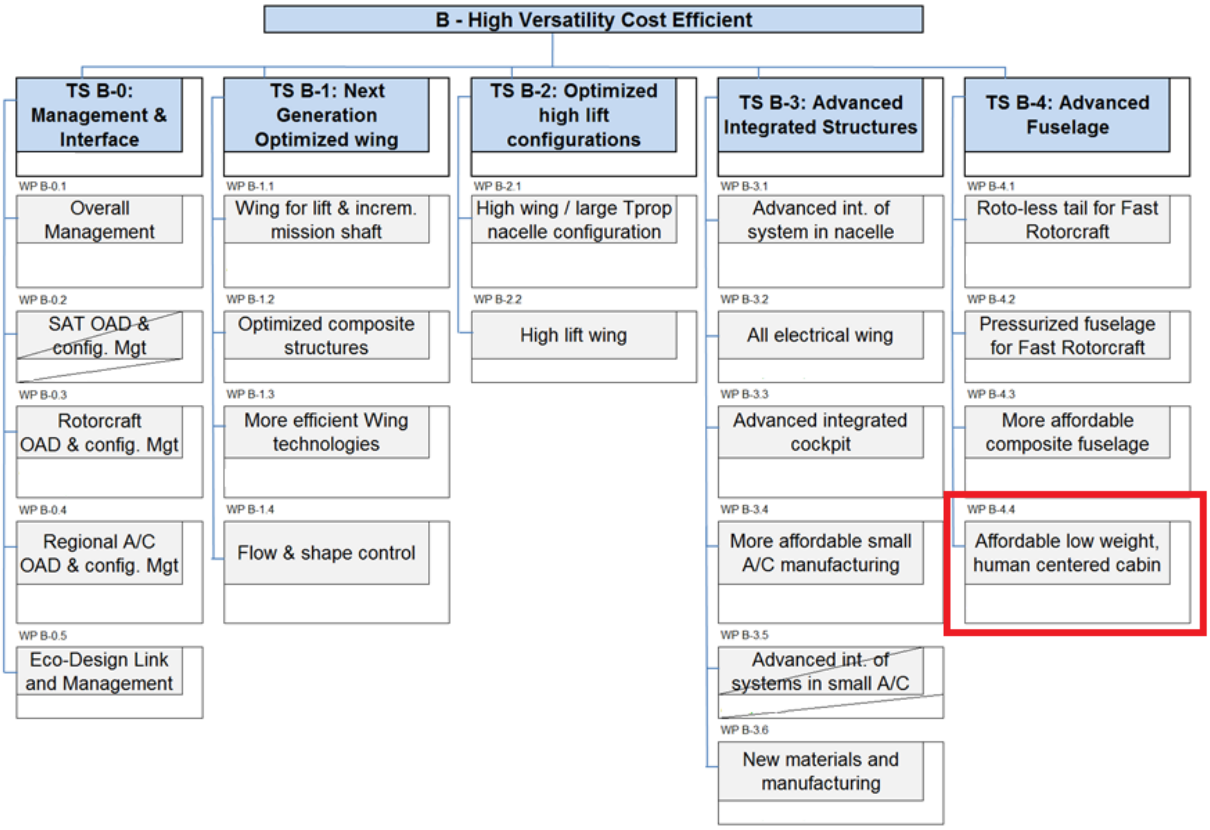
Type of action (RIA or IA)	RIA		
Programme Area [SPD]	AIR		
(CS2 JTP 2015) WP Ref.	B-4.4		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Leonardo Aircraft	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[38]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-AIR-02-59	**Breakthrough design concept solutions and technologies for Regional Aircraft Cabin Interiors innovative configuration**
Short description	
Development of breakthrough design concept solutions and technologies for cabin interiors of Regional Aircraft innovative configurations (EIS beyond 2035) highly oriented to maximize the passenger flight experience in terms of comfort/wellbeing and aiming to the future airline transport needs.	

[38] 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-4.4 "Affordable Low Weight, Human Centered Cabin" is incorporated within the Technology Stream B-4 "Advanced Fuselage" placed in the Activity Line B "High Versatility and Cost Efficiency" 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-4.4:



More in detail, the activities of the WP B-4.4 will pursue to develop and validate innovative technologies and solutions to improve the physical cabin environment in terms of comfort on board w/r to a civil regional aircraft platform, through ***human-centered-design approach (HCDA)***:

- ➢ considering Human Factor as key design driver;
- ➢ integration of optimized passenger cabin Noise&Vibration reduction solutions;
- ➢ improving well-being, on board and socially, by weight saving solutions and/or Environmental Friendly Materials, also reducing aircraft cabin carbon footprint.

2. Scope of work

The scope of the present Topic is the development and assessment at TRL 3/4 of breakthrough design concept solutions and technologies for cabin interiors of Regional Aircraft innovative configurations (entering the market in a timeframe extended well beyond 2035, when breakthrough technologies under study in Clean Sky 2 will be available) highly oriented to achieve the passenger flight needs in terms of comfort/wellbeing and aiming to the future airline transport requirements for a regional aircraft in the 110-130 seat class cabin; to attain a suitable passenger comfort, the cabin height has been chosen to measure at least 2092.5 mm and the aisle width to be not lower than 19.0”. Seat width (between armrest) measure 18” or 18.5” in a 5-abreast configuration and the length of the internal cabin has been chosen to accommodate a seat’s pitch of 32” (130 seat configuration) – Note: this data could be subject to updating.

Main requirements, based on the Human Centered Design Approach (HCDA), are:

1) Development of aircraft interiors cabin solutions with conceptual breakthrough design enhancement in terms of cabin passenger comfort/needs starting from a basic aircraft configuration and LOPA provided by the Leader;
2) The innovative and striking solutions/technologies shall be particularly referred to pax cabin (EC Seat, Lining, Stowage Bin, Lighting, PSU) and Service Area (FAS, Galley, Lavatory);
3) Fast turn-around time with particular reference to (dis-)embarkment of the passengers, time cleaning and galley/lavatory re-filling. Target is 15 min;
4) Optimization and volume maximization of the baggage loading/unloading before/after the flight for the passengers (e.g. no separation between them and the belongings);
5) Increase of provisions adoption for best and latest Wi-Fi integration with respect to interiors (seat, partition, etc.) for an improved air travel services quality regarding the use of pax electronic personal devices (smartphone, tablet, laptop, etc.);
6) Improvement of the comfort pax standards up to mainliners levels without increasing the weight of the interiors parts – reference platform will be provided by the Topic Manager at the start of the project;
7) Improvement of the comfort standards up to mainliners levels without increasing the operating costs (maintenance labour, maintenance parts, useful life, impact of the weight on the flight fuel consumption, etc.) – reference platform will be provided by the Topic Manager at the start of the project;
8) Max Pax Payload of reference = 110 - 130 pax @ 32" pitch, 108 kg/pax including catering;
9) The technologies and solutions proposed by the Applicant might be requested to concur to the integration, with other aircraft performance parameters not object of this call, to the achievement of an Internal Noise at head level threshold at max cruise flight level;
10) Achievement of TRL 3/4 (experimental proof of concept or technology validated at small level).

The most promising solutions might be chosen for integration and visual demonstration in the R-IADP WP 3.2 On-Ground Pax Cabin Demonstrator.

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

- acknowledgment of the constraints, in accordance with the aircraft platform of reference and relevant requirements, influencing the design process for the comfort and wellbeing of the passengers with particular reference to the human needs related either to each cabin major item and aspect of the living space;

- determination of the state-of-art for typical market regional aircraft platform in terms of operative cost for airliners;
- acknowledgment and deployment of the above key cabin drivers on the affected major cabin items;
- formulation of conceptual design solutions to be proposed as breakthrough technologies in compliance with the HCDA requirements and aircraft cabin constraints;
- virtual simulation / CATIA V5 digital model / 3D rendering of the most promising solutions in order to verify the correspondence with respect to the technology expectations;
- identification of a small scale test matrix and manufacturing of relevant physical prototypes. The dimensions shall be feasible to evaluate the proof of concept;
- Preliminary Design Review as gate in order to filter/select the technologies/solutions worthy to be further developed;
- design loops in order to optimize the technologies/solutions under development, focusing about application the capability to be integrated in the aircraft cabin interiors environment;
- definition of the manufacturing processes supporting the proposed technologies and major cabin items solution;
- Critical Design Review as final gate in order to select the technologies/solutions worthy to be further manufactured, to be validated and brought into the R-IADP WP 3.2 On-Ground Pax Cabin Demonstrator;
- identification of a physical small scale test matrix and manufacturing of relevant coupons;
- physical testing and/or virtual simulation refinement of the selected solutions in order to verify the correspondence with respect to the technology expectations. The prototype dimensions shall be feasible to be adopted on the R-IADP WP 3.2 On-Ground Pax Cabin Demonstrator;
- verification and assessment of the achieved results.

The activities to be performed are divided in the tasks listed in the following table:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Kick-Off Meeting (KOM)	T0 + 1
2	State-of-Art detailed determination as terms of reference	T0 + 3
3	Identification of the HCDA key cabin drivers	T0 + 4
4	Formulation of conceptual design solutions	T0 + 5
5	Identification of a physical small scale test matrix	T0 + 6

Tasks		
Ref. No.	***Title - Description***	***Due Date***
6	Physical small scale testing and/or virtual simulation of preliminary solutions	T0 + 9
7	Preliminary Design Review (PDR)	T0 + 9
8	Design Loop refinement for the most breakthrough solutions	T0 + 11
9	Manufacturing of test coupons	T0 + 12
10	Definition of the final manufacturing processes	T0 + 13
11	Critical Design Review (CDR)	T0 + 13
12	Identification of a physical test matrix for the final solutions	T0 + 14
13	Manufacturing of test coupons	T0 + 15
14	Laboratory testing and/or virtual simulation of final solutions	T0 + 16
15	Verification and assessment	T0 + 18

The following inputs will be provided by the Topic Manager, in accordance to the different design loops that will be executed:

- Innovative A/C preliminary sizing, configuration and weight definition;
- List of the main requirements to be respected with reference to the Human-Centered-Design-Approach;
- Main aircraft reference configuration typical characteristics;
- Technologies requirements for the innovative configuration;
- Validation approach;
- pre-acceptance/acceptance/qualification minimum requirements;
- Final Evaluation of the TRL achievement for the technologies proposed.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Kick-Off Meeting minute	R	T0 + 1
D2	State-of-Art definition	R	T0 + 3
D3	HCDA key cabin drivers	R	T0 + 4
D4	Conceptual design solutions	R	T0 + 5

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D5	Physical small scale test matrix and plan	R	T0 + 6
D6	Physical small scale testing and/or virtual simulation of preliminary solutions report	R / D	T0 + 9
D7	Preliminary Design Review minute	R	T0 + 9
D8	Breakthrough solutions technical note	R	T0 + 11
D9	Manufacturing of test coupons	HW	T0 + 12
D10	Final manufacturing processes specification	R	T0 + 13
D11	Critical Design Review minute	R	T0 + 13
D12	Laboratory test matrix and plan for the final solutions	R	T0 + 14
D13	Manufacturing of test coupons	HW	T0 + 15
D14	Laboratory testing and/or virtual simulation of final solutions report	R / D	T0 + 16
D15	Verification and assessment	R	T0 + 18

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Definition of the preliminary conceptual design solutions	R	T0 + 5
M2	PDR	R	T0 + 9
M3	Final breakthrough solutions determination	R	T0 + 11
M4	CDR	R	T0 + 13
M5	Final Assessment	R	T0 + 18
M6	Final physical representative technologies concepts	HW	T0 + 18

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

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

- Skill 1: ability to support and bring major contribution to the main activities listed and described in the paragraph 2 and 3.
- Skill 2: support (manufacturing of sample, prototypes etc.) and perform various small-scale test activities (structural analysis, integrated system, acoustics, FST, manufacturing process

repeatability etc.) to validate the proposed concept(s) and solution in a local context according to type of application, constraints and specification requirements. Performance, operability and the acceptability of operational aspects will be the primary concerns.

- Skill 3: proven capabilities, and high experience in the design of the aircraft cabin interior/components and environment with competence in leading conceptual design with emphasis on comfort and styling aspects;
- Skill 4: acknowledged competence in the management of very articulated programme and capability of technical conduction of complex project;
- Skill 5: proven experience in international R&T projects cooperating with industrial partners, institutions, technology centres, universities;
- Skill 6: quality and risk management capabilities demonstrated through applications on international R&T projects and/or industrial environment;
- Skill 7: experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects for aeronautical industry.

5. Abbreviations

A/C	AirCraft
AIR	AIRframe
AL	Activity Line
CfP	Call for Proposal
CDR	Critical Design Review
CS2	Clean Sky 2
CS2JU	Clean Sky 2 Joint Undertaking
EIS	Entry In Service
FAS	Flight Attendant Seat
FL	Flight Level
FST	Flammability, Smoke & Toxicity
HCDA	Human Centered Design Approach
HVE	High Versatility and cost Efficiency
ITD	Integrated Technology Demonstrator
JTP	Joint Technical Program
KOM	Kick-Off Meeting
LOPA	Layout of Passenger Accommodation
pax	Passenger
PDR	Preliminary Design Review
PSU	Passenger Service Unit
R-IADP	Regional Innovative Aircraft Demonstration Platform
R&T	Research & Technology
SOA	State Of Art
TRL	Technology Readiness Level
TS	Technology Stream
WBS	Work Breakdown Structure
WP	Work Package

8. Clean Sky 2 – Engines ITD

I. Improvement of high speed low pressure turbine performance through reduction of secondary effects

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP2.4		
Indicative Funding Topic Value (in k€)	2000		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	40	**Indicative Start Date**[39]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-23	**Improvement of high speed low pressure turbine performance through reduction of secondary effects**
Short description	
Due to higher Mach number on high speed LPT, secondary effects have different impact and structure compared to a conventional turbine. The detailed informations obtained from representative models in high speed test facilities, advanced instrumentation and CFD simulation is definitely contributing to improve the performance of next generation high speed LP turbines by providing high-resolution (time and space) experimental data at engine-scaled conditions (Mach and Reynolds numbers, wake/boundary layer interaction, leakages, cavities….). Several key technologies to reduce secondary flows, thus improving turbine performance are expected to be investigated in this representative environment.	

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

1. Background

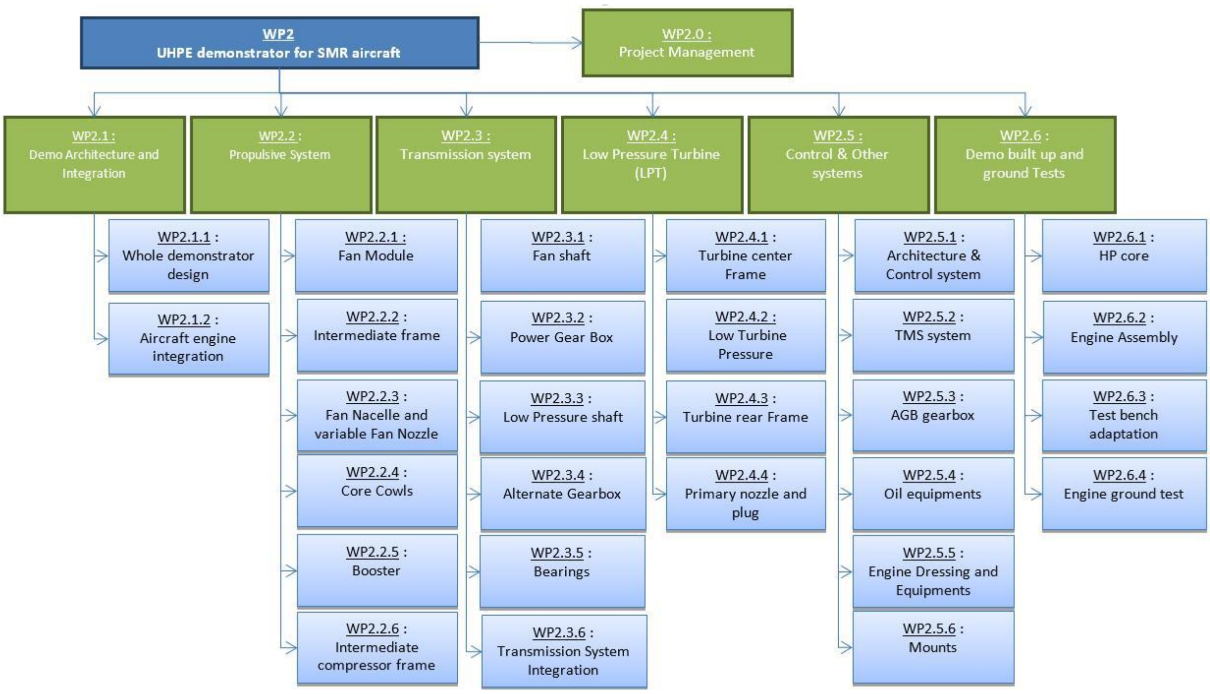
Overall presentation

The UHPE Demonstration Project aims at designing, manufacturing & testing an Ultra High Propulsion Efficiency Engine Demonstrator. It involves most of the European Engine Manufacturers.

The UHPE requires an innovative Low Pressure Turbine aerodynamic design. The aim of the work proposed here is to test various configurations of LPT cavities in an experimental environment and in an engine representative environment in order to :

- Capture impact on performance of secondary flows (leakages) interaction with the main flow
- Understand the flow structure and its modification according to geometry changes
- Test new technologies to reduce the interaction between secondary flows and main flow

The breakdown in this WP2 is the following :



Description of the environment

Today's engines are achieving high level of efficiency to improve fuel consuption of new aircrafts. Improving components of such an engine becomes more and more difficult, thus requiring new technologies as well as advanced testing and calculation (URANS,LES …) .

Airfoil design of high speed low pressure turbine has been studied for the past decades. Conversely, impact of secondary flows for such configuration has been scarcely investigated and very few experiments are available in this field despite the fact that it could lead to significant improvement in turbine efficiency.

The picture hereinafter (see figure 1) gives an overview of the location of these secondary flows in a low pressure turbine for a jet engine.

The environement is mainly made up of two parts:

- One rotating part, called the rotor part, that includes one or several stages of rotating airfoils (e.g. blade1) and their disk, and a shaft connected to the low pressure compressor located at the front of the engine.
- One non rotating part, called stator,that includes a casing, one or several stages of stationary airfoils (e.g. vanes 1 & 2) and various parts that are used for sealing the hot gas of the main flowpath.

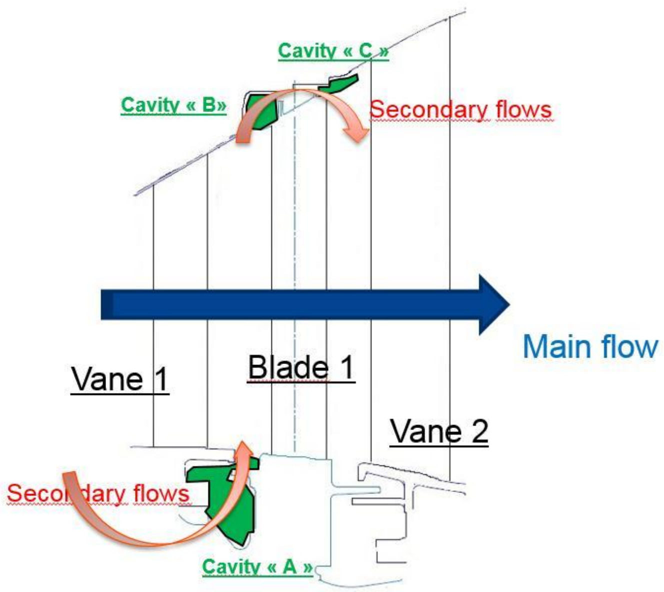


Figure 6: overall view of jet engine low pressure turbine

A high velocity flow (typicaly Mach number between 0.4 and 1.2 downstream of each airfoils) passes through the main section of the flowpath (main flow). Due to the non contact between the rotating and the non-rotating parts, some leakage flows appear. These leakage flows, additionally to secondary flows, are responsible of extra losses in the LPT.

Overall description of facilities required

The work presented here requires two sets of test facilities:

- Some tests will be performed in a 2D cascade facility. It will include a set of 2D non rotating airfoil profiles, the “A”,”B” & “C” cavities + wake generators upstream of the airfoils and at least instrumentation mentioned in §4.2. One of the objectives of these tests is to study the impact of the cavities on airfoil performance by means of cost effective and flexible tests. The other one is to be able to use advanced instrumentation that cannot be implemented into a rotating rig to understand flow structure & interactions, and then being able to perform some code calibration (CFD …).

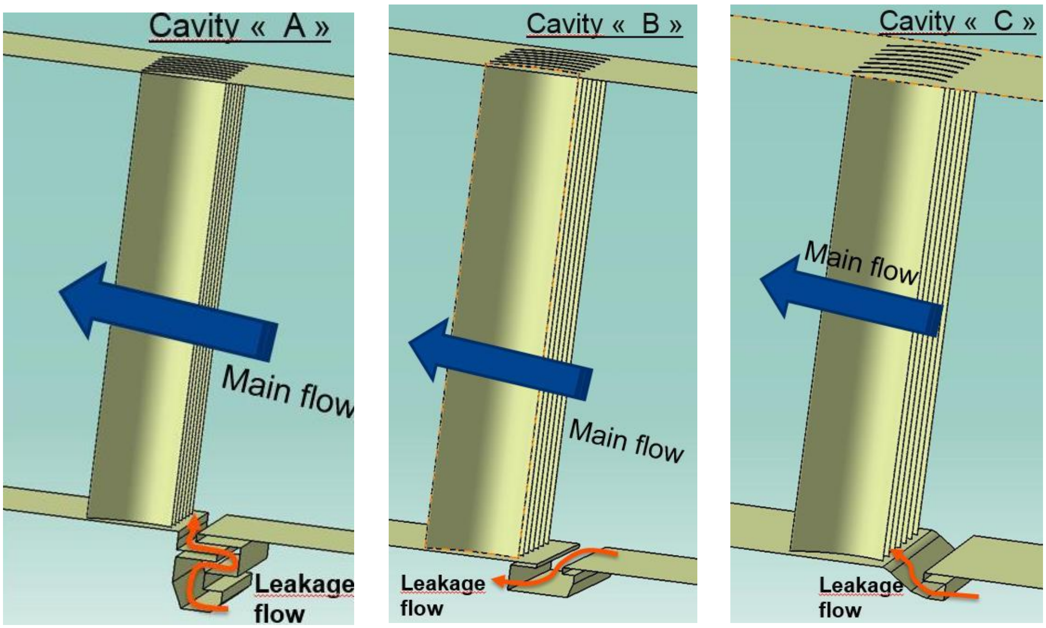


Figure 7: overview of cascade facility with cavities A, B & C

- The other tests require a 1,5 stage rig (2 stages of stator & 1 stage of rotor) as seen on figure 1. These tests will enable to validate and consolidate conclusions drawn with previous tests in an engine representative environment.

2. Scope of work

Tasks		
Ref. No.	Title – Description	Due Date
C1.1	Preliminary design of adaptation parts for cascade test with cavities	T0 + 2 months
C1.2	Detailed design of adaptation parts for cascade test with cavities	T0 + 6 months
C2.1	Manufacturing parts for reference configuration of cascade test with cavity A (airfoils + cavities + adaptation parts + instrumentation ….)	T0 + 14 months
C3.1	Test of reference configuration for cavity A (2D airfoils + reference cavity A)	T0 + 16 months
C4.1	Manufacturing dedicated parts for cascade configuration #C1 + tests (3 geometries)	T0 + 18 months
C5.1	Manufacturing dedicated parts for cascade configuration #C2 + tests (reference + 3 geometries)	T0 + 21 months
C6.1.	Manufacturing dedicated parts for cascade configuration #C3 + tests (reference + 3 geometries)	T0 + 24 months
C7.1	Writing final report and conclusions of cascade tests	T0 + 26 months
C8.1	Preliminary analysis of innovative technology to reduce secondary flow impact on performance	T0 + 28 months
C8.2	Adaptation of cascade facility for innovative technology	T0 + 35 months
C8.3	Test of the innovative technology on cascade facility + report	T0 + 39 months
R1.1	Preliminary design of rig design parts for rig tests	T0 + 9 months
R1.2	Detailed design of parts for rig test for reference and #R1 configuration	T0 + 15 months
R2.1	Manufacturing parts for reference configuration of rig test + assembling	T0 + 27 months
R2.2	Test of reference configuration on rotating rig + analysis	T0 + 29 months
R3.1	Manufacturing & mounting parts for rig test configuration #R1	T0 + 33 months
R3.2	Test & analysis of conf. #R1 on rig	T0 + 37 months
R4.1	Writing final report and conclusions of rig tests	T0 + 39 months

<u>Task C1.1:</u> Preliminary design of adaptation parts for cascade test with cavities

Based on input data from SAFRAN AE (airfoils, cavities size and shape, average values of flow properties in the test section ….), the partner will perform a preliminary design of the adptation parts and instrumentation of an existing cascade facility. The main objectives of this task are to verify that installation and tests planned by the partner will meet SAFRAN AE overall specification, mostly:

- Capability of the cascade test facility to test an airfoil configuration with 3 differents cavity configurations (tested separately):

- One configuration with only cavity “A“ upstream of the tested airfoil including some injection within the cavity.
- One configuration with cavities “B“ upstream of the airfoil. No injection is needed here but the flow passing through the cavity needs to be aspirated and should be discharged away the test section.
- One configuration with cavity C located upstream of the airfoil including some injection within the cavity.
- 2 airfoil profiles will be considered : one for tests with cavity A, and a different one for tests with cavities B & C.

- capability of test facilities (Mach number , reynolds number, size, shaft speed ….) to meet aerodynamic specifications within the main test section and in cavities. See §4.1 for more details.
- Instrumentation used and post-processing. See §4.2 for more details.
- Hardware design and especially how to be able to modify cavity geometries easily
- Test sequence

A risk analysis is also expected.

The end of this task will be validated after a formal Preliminary Design Review with SAFRAN AE.

<u>Task C1.2 :</u> Detailed design of adaptation parts for cascade test with cavities

Based on the conclusion of previous PDR, test specifications and SAFRAN AE input data (cavity shape and modifications to be tested …), the partner will carry out a detailed design of the adaptation parts to ensure :

- Adequation with detailed SAFRAN AE specification (test sequence, data collected during the tests, operating points …)
- Mechanical integrity
- Mounting of the parts, especially ensuring that cavity configurations can be implemented easily
- Instrumentation choice, design and calibration required
- ……

It is to be noted that tolerances and surface finish of all parts in contact with the main & secondary flows (airfoils, cavities ….) will need to be validated by SAFRAN AE beforehand.

An update of the risk analysis is also expected.

The end of this task will be validated after a formal Critical Design Review with SAFRAN AE.

<u>Task C2.1 :</u> Manufacturing parts for reference configuration of cascade test with cavity A

In this task,the partner will manufacture all parts required for the test of the reference configuration with cavity “A“. The partner will need to provide at least the following parts (non-exhaustive list):

- Airfoils
- Cavity geometry A + adaptation parts
- Instrumentation
- ……

A list of controls on critical parts will be provided by SAFRAN AE (e.g. airfoil profiles, gaps, surface finish …). The partner will have to demonstrate that these controls match specifications, or review with SAFRAN AE that they do not affect the objectives of the test.

<u>Task C3.1</u> : Test of reference configuration for cavity A (2D airfoils + reference cavity A)

In this task , the partner will perform some cascade test of an airfoill profile + reference configuration of the cavity “A“ geometry. The test will consist in acquiring data sample with instrumentation validated at PDR (see §4.2).

Test will be done for 2 aerodynamic points:

- Design point whose conditions are given in §4.1 with reference leakage massflow within cavity.
- Design point + increased leakage mass flow within the cavity

This task will be achieved by providing a report of these tests, including at least tests results, analysis and uncertainty on test results.

<u>Task C4.1</u> : Manufacturing dedicated parts for cascade configuration #C1 + tests

In this task , the partner will need to manufacture the three different configurations of the cavity “A“ that are going to be tested on the cascade facility. As for task 2.1, a list of controls on parts will need to be validated.

Then these three geometries will need to be tested with the same test sequence and instrumentation as specified in Task C.3.1. A final report will be requested. In this report, it is requested to compare and use all instrumentation data available on the reference + 3 extra configurations to understand flow structure and impact on downstream cascade airfoil.

<u>Task C5.1</u> : Manufacturing dedicated parts for cascade configuration #C2 + tests (reference + 3 geometries)

The second test configuration will be made up of the cascade section test (new airfoil profile) + “B” cavity located upstream of the airfoil.

The partner will need to manufacture the various parts as described in Tasks C.2.1 & C.3.1. The test sequence and overall instrumentation requested are the same as in Tasks C.3.1 & C.4.1. A final report will conclude this task with a special emphasis on comparing test data for the 4 tests and highlight differences in flow structure.

Task C6.1 : Manufacturing dedicated parts for cascade configuration #C3 + tests (reference + 3 geometries)

As described in task C1.1, the third and final cascade test configuration will be made up of the cascade section test (same airfoil as in Task C.3.1 or C.5.1) + some "C cavity adders" located upstream of the airfoil.

The partner will need to manufacture the various parts as described in Tasks 2.1 & 3.1. The test sequence and overall instrumentation requested are the same as in Tasks 3.1 & 4.1. A final report will conclude this task with a special emphasis on comparing test data for the 4 tests and highlight differences in flow structure.

Task C7.1 : Writing final report and conclusions of cascade tests

Writing final report and conclusions of cascade tests

Task C8.1 : Preliminary analysis of innovative technology to reduce secondary flow impact on performance

Tasks C8.1, C8.2 & C8.3 will aim at testing an innovative technology to reduce impact of secondary flows on turbine performance. This could be achieved by modifying cavity geometry or using a completely new option (flow control, local wake control …..) The partner & SAFRAN AE have the ability here to propose any new technology that could be of interest.

Task C8.1 will aim at downselecting the innovative technology. If required some CFD calculations could be used to make preliminary assessment of the technologies. A joint agreement between SAFRAN AE & the partner is required to carry on this activity.

Once done, the partner will be in charge of making a preliminary integration study with the selected technology, to prove its feasibility in the cascade facility. Task C8.1 will be terminated by a dedicated PDR.

Task C8.2 : Adaptation of cascade facility for innovative technology

Once task C8.1 done, the partner will have the responsibility to perform detailed studies, manufacturing and assembling of the required parts to test the new technology. The deliverables expected are the same as for Tasks C4.1, C5.1 & C6.1.

Task C8.3: Test of the innovative technology on cascade facility + report

In this task , the partner will perform some cascade tests of an airfoil profile + cavity ("A", "B", or "C") enhanced with the new technology selected in task 8.1. The test will consist in acquiring data sample with instrumentation validated at PDR (see §4.2).

Test will be done for 2 aerodynamic points:

- Design point whose conditions are given in §4.1 with reference leakage massflow within cavity.
- Design point + increased leakage mass flow within the cavity

This task will be achieved by providing a report of these tests, including at least tests results, analysis and uncertainty on test results.

<u>Task R1.1</u> : Preliminary design of rig design parts for rig tests

This task initiates the work for the rig tests that are going to take place after the cascade tests. As described in §1.3, their purpose is to confirm and complete previous conclusions in an engine representative environment.

The environment proposed here is a 1,5 stage (inlet vane, rotor blade, outlet vane) rig, as shown hereinafter. The capability of the rig and instrumentation are given in §4.1 and §4.3.

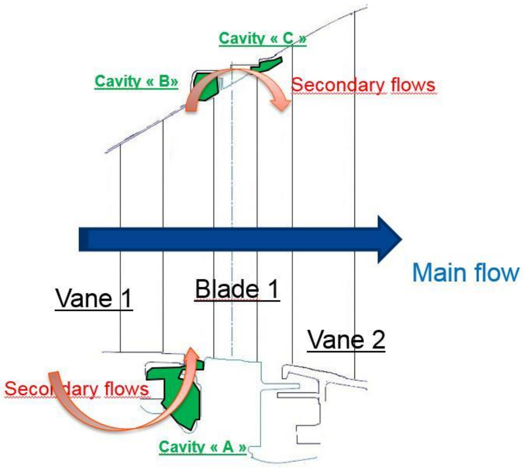


Figure 8: Overall configuration of the 1.5 stage rig

The main objectives of this task are to verify that installation and tests planned by the partner will meet SAFRAN AE overall specifications, mostly:

- o Capability of the test facility to test a 1,5 stage configuration with 2 differents cavity definitions (reference and new configurations for cavities "A", "B" & "C"). The changes in cavities shape between reference and new definition, will be done by only modifying stator parts or by machining rotor parts (no new definition of critical rotating parts or airfoils). Some exemples of the modification of the cavities are given here:
  - Modification of the overlap area between the rotating and the non rotating parts
  - Modification of the volume of the cavity by changing surrounding parts
  - Modification of the length of the cavity (axial gap)
  - …….
- o capability of test facilities (Mach number , reynolds number, size, shaft speed ….) to meet

aerodynamic specifications within the main test section and in cavities. See §4.1 for more details.
  - Instrumentation used and post-processing. See §4.3 for more details.
  - Hardware design and especially how to be able to modify cavity geometries easily
  - Test sequence

The end of this task will be validated after a formal Preliminary Design Review with SAFRAN AE.

A risk analysis is also expected at the end of this task.

<u>Task R1.2</u> Detailed design of parts for rig test for reference and #R1 configuration

Based on the conclusions of previous rig PDR, test specifications and SAFRAN AE input data (cavity shape, airfoils, shaft speed…), the partner will carry out a detailed design of the adaptation parts to ensure :

- Adequation with detailed SAFRAN AE specification (test sequence, data collected during the tests, operating points …)
- Mechanical integrity
- Mounting of the parts, especially ensuring that cavity configurations can be implemented easily
- Instrumentation choice, design and calibration required
- ……

It is to be noted that tolerances and surface finish of all parts in contact with the main & secondary flows (airfoils, cavities ….) will need to be validated by SAFRAN AE beforehand.

An update of the risk analysis is also expected.

The end of this task will be validated after a formal rig Critical Design Review with SAFRAN AE.

<u>Task R2.1:</u> Manufacturing parts for reference configuration of rig test + assembling

This task consits in producing hardware previously validated during CDR for the reference configuration of the rig test. It is to be noted that tolerances used for manufacturing should be reviewed & agreed with SAFRAN AE. SAFRAN AE will also provide a list of controls to perform on hardware to ensure compliance with requirements for the tests.

The partner will need to provide at least the following parts (non-exhaustive list):

- Rotating blades and stator parts (airfoils, sealing, cavities …)
- Adaptation parts
- Instrumentation
- ……

The partner will have to demonstrate that controls match specifications, or review with SAFRAN AE that they do not affect the objectives of the test.

Task R2.2: Test of reference configuration on rig + analysis

These tasks consist in testing the reference geometry with the parts and instrumentation validated at PDR & CDR. Data will be acquired for 3 aerodynamic points specified by SAFRAN AE with instrumentation as described in §4.3 :

- Design point with reference leakage flow
- Off design point (modification of shaft speed and rotor specif work) with reference leakage flow
- Design point with increased leakage flow for each cavity (below stator and above rotor blade). The process to perform this operation needs to be agreed with the partner (increased clearances or extra purge within cavity, other …)

This task will be achieved by providing a report of this tests, including at least tests results, analysis and uncertainty on test results.

Task R3.1: Manufacturing & mounting parts for rig test configuration #R1

This task is similar to task R2.1 but will be limited to parts required to modify cavities "A","B" & "C". Same deliverables are expected for this tasks (controls, non conformances …).

Task R3.2: Test & analysis of conf. #R1 on rig

This task consists in testing the new geometries of cavities with the parts and instrumentation previously used for task R2.2. Data will be acquired for the same 3 aerodynamic points specified by SAFRAN AE with instrumentation as described in §4.2 :

- Design point with reference leakage flow
- Off design point (modification of shaft speed and rotor specif work) with reference leakage flow
- Design point with increased leakage flow for each cavity (below stator and above rotor blade). The process to perform this operation needs to be agreed with the partner (increased clearances or extra purge within cavity, other …)

This task will be achieved by providing a report of this tests, including at least tests results, analysis and uncertainty on test results.

Task R4.1: Writing final report and conclusions of rig tests

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
DC1.1.1	SAFRAN to provide general description of geometries as well as tests required for the cascade tests	D	T0
DC1.1.2	Partner to propose hardware configurations, facility, instrumentation & test sequence for the cascade test. Need SAFRAN AE agreement before carrying on. Risk analysis should be part of this deliverable.	R	T0 + 2 months
DC1.2.1	SAFRAN AE to provide airfoil geometries as well as cavities definition to partner for manufacturing	D	T0 + 1 months
DC1.2.2	Partner to propose to SAFRAN AE hardware configuration and test sequences to fulfil all the tests specified Update of risk analysis should be part of this deliverable.	D + R	T0 + 6 months
D0.1	Annual report year 1. Update of risk analysis should be part of this deliverable.	R	T0 + 12 months
DC2.1	Hardware for reference configurations + list of controls	D + HW	T0 + 14 months
DC3.1	Test report for the reference configuration including analysis and data of all instrumentation available	D+R	T0 + 16 months
DC4.1.1	Hardware for 3 cavities conf #C1 + list of controls	D + HW	T0 + 16 months
DC4.1.2	Test report for the cascade #C1 configurations including analysis and data of all instrumentation available	D+R	T0 + 18 months
DC5.1.1	Hardware for 3 cavities conf #C2 + list of controls	D + HW	T0 + 18 months
DC5.1.2	Test report for the cascade #C2 configurations including analysis and data of all instrumentation available	D+R	T0 + 21 months
DC6.1.1	Hardware for 3 cavities conf #C3 + list of controls	D + HW	T0 + 21 months
D0.2	Annual report year 2. Update of risk analysis should be part of this deliverable.	R	T0 + 24 months
DC6.1.2	Test report for the cascade #C3 configurations including analysis and data of all instrumentation available	D+R	T0 + 24 months
DC7.1.1	Final report of cascade activities	R	T0 + 26 months
DC8.2	Hardware for the innovative technology test	D + HW	T0 + 35 months
DC8.3	Test report for the cascade test with innovative technology including analysis and data of all instrumentation available	D+R	T0 + 39 months
DR1.1.1	SAFRAN to provide general description of geometries as well as tests required for the rig tests	D	T0 + 6 months

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
DR1.1.2	Partner to propose hardware configurations, facility, instrumentation & test sequence for the rig tests. Need SAFRAN AE agreement before carrying on. Risk analysis should be part of this deliverable.	R	T0 + 9 months
DR1.2.1	SAFRAN AE to provide airfoil geometries as well as cavities definition to partner for rig CDR	D	T0 + 7 months
DR1.2.2	Partner to propose to SAFRAN AE hardware configuration and test sequences to fulfil all the tests specified Update of risk analysis should be part of this deliverable.	R + D	T0 + 15 months
DC2.1	Hardware for reference configurations of rig test + list of controls	D + HW	T0 + 27 months
DC2.2	Test report for the reference configuration of rig test including analysis and data of all instrumentation available	D+R	T0 + 29 months
DC3.1	Hardware for configurations #R1 of rig test + list of controls	D + HW	T0 + 29 months
D0.3	Annual report year 3. Update of risk analysis should be part of this deliverable.	R	T0 + 36 months
DC3.2	Test report for the configurations #R1 of rig test including analysis and data of all instrumentation available	D+R	T0 + 37 months
DR4.1	Final reports of rig activities	R	T0 + 39 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
PDR1	Preliminary Design Review of cascade tests: freeze overall definition of rig, instrumentation, test sequence ….	R	T0 + 2 months
CDR1	Critical Design Review of cascade tests : freeze parts definition	R	T0 + 6 months
TRR1	Test Readiness Review of cascade tests : ensure instrumentation and parts produced as well as rig facility comply with specifications of CDR	R,D	T0 + 14 months
EOT1	Completion of cascade tests + reports & analysis of test data	R,D	T0 + 26 months
EOT1b	Completion of cascade test + report & analysis for the innovative technology.	R,D	T0 + 39 months
PDR2	Preliminary Design Review of rig tests: freeze overall definition of rig, instrumentation, test sequence ….	R,D	T0 + 9 months
CDR2	Critical Design Review of rig tests : freeze parts definition	R,D	T0 + 15 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
TRR2	Test Readiness Review of rig tests : ensure instrumentation and parts produced as well as rig facility comply with specifications of CDR	R,D	T0 + 27 months
EOT2	Completion of rig tests + reports & analysis of test data	R,D	T0 + 39 months

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

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

Capabilities of the test facility

The test facilities should at least ensure the following caracteristics to fullfil test requirements. The data here are provided at scale 1. A scale factor could be applied but need to be validated with SAFRAN AE (typical scale factor acceptable is > 0.6).

Table 1: test facilities main characteristics

Rig configuration	1 row of inlet stator 1 row of blade rotor 1 row of outlet stator 'engine like' cavities (definition provided by SAFRAN AE)
Cascade facility	Airfoil + wake generator upstream achieving Strouhal number ϵ [0.8 ; 1.2]
Shaft corrected speed ($\frac{N1}{\sqrt{Tinlet}}$) for rig	ϵ [240;300] rpm/$K^{0.5}$
Corrected mass flow at inlet $\frac{W\sqrt{T/Tref}}{P/Pref}$ for rig	ϵ [13.70; 16.70] kg/s
Relative outlet Mach number for airfoils	ϵ [0.6;1.0]
1.5 stage expansion ratio (total to total)	ϵ [1.8;2.2]
Reynolds number at inlet ($\frac{\rho V}{\mu}$) for cascade tests	ϵ [2.10^6; 15.10^6]
Reynolds number at inlet ($\frac{\rho V}{\mu}$) for rig tests	ϵ [10.10^6;25.10^6]
Airfoil deviation (average)	ϵ [80°;100°]
Airfoild count (rig)	ϵ [60 ; 110]
Airfoil mean radius	ϵ [350mm , 450 mm]
Airfoil height (average)	ϵ [100mm;200mm]
Cavity height (average)	≈ 25 mm
Inlet turbulence	≈ 5%
Leakage flow for each cavity (A,B&C)	[0.5% ; 1%] of main flow Capability to increase it independently

Instrumentation required for cascade tests

Since the objective of these tests is to quantify impact of local leakages on the main flow structures, advanced instrumentation will be required in order to :

- Understand the structure of the flow within the cavities and its unsteady interaction with the main flow.
- Estimate accuratly the impact on airfoil performance of the various configurations tested.

Therefore, the aftermentioned list of instrumentation is expected to fulfill test requirements. Partner could also propose any other instrumentation hardware that seems relevant:

- Traverse measurement downstream of airfoil profile (time resolved pressure; steady temperature, flow angles) at airfoil outlet + inlet conditions. Probes should be able to cover most of the spanwise direction, especially close to the hub and/or tip since it is the location of interest. Probes should be able to move tangentially to cover more than one pitch of the upstream airfoil.
- Optical flow visualization for each cavity (cavity zone + interaction with main flow). If possible flow vizualization within airfoil passage close to the cavity location.
- Time resolved pressure measurements on airfoil surface & plateforms (50 on plateform, 30 on airfoil pressure side, 30 on airfoil suction side).
- Time resolved pressure measurements within cavities. 10 measurements per cavity are expected.
- Measurement of inlet boundary layer (steady pressure) upstream of the cavity.
- Measurement of inlet turbulence

Instrumentation required for rig tests

The aftermentioned list of instrumentation is expected to fulfill test requirement in a representative engine environment. Partner could also propose any other instrumentation hardware that seem relevant:

- Traverse with 5 holes probes (steady pressure, temperature,flow angle) at vane 1 inlet & blade outlet and vane 2 outlet (3 planes). Probe should be able to cover most of the spanwise direction, especially close to the hub and tip since it is the location of interest. Probe should be able to move tangentially to cover more than one pitch of the upstream airfoil**s**.
- Traverse equiped with time resolved pressure probe (unsteady). Probe should be able to cover a defined portion in the spanwise direction especially close to the hub and tip since it is the location of interest. Probe should be able to move tangentially to cover more than one pitch of the upstream airfoil**s**.
- Unsteady pressure measurements on airfoil surface & plateformes (number and location will be confirmed during preliminary phase, since highly dependent on scale factor).
- Unsteady pressure measurements within cavities. Between 5 and 10 measurements per cavity are expected (i.e. between 15 and 30 in overall)
- Measure of inlet turbulence (upstream of stator 1).

- Clearance-meters below stator and above rotor blades to measure radial clearance during test. 8 clearancemeters in total are expected. Clearancemeters will be located on stator parts.
- Optical flow visualization within cavities would be appreciated. To be discussed between SAFRAN AE and partner.
- Torque measurement on rotor to estimate blade efficiency.

Special skills and capabilities

- Experience in High speed cascade tests and rig tests for turbine airfoils is **mandatory.**
- Ability to perform test independently and facing every issues usually met during test campaign (instrumentation failure, rig stability …..)
- **Existing facilities** as described in the present document (see figure 1 and table 1).
- Capability of airfoil and part manufacturing (even through subcontracting).
- Capability of choosing / designing / producing instrumentation validated jointly with SAFRAN AE.
- Capability of hardware modification to design system that ensure flexible & simple modification of cavity geometries "A", "B" & "C"
- Tests benches and equipment compliant to international standard
- English language is mandatory
- Produce risk analysis before detailed design phase and update it.

5. Abbreviations

SAFRAN AE	SAFRAN Aircraft Engines (previously Snecma).
LPT	Low Pressure Turbine
SFC	Specific fuel consumption of the engine
PDR	Preliminary Design Review
CDR	Critical design Review

II. Crowned spline surface treatment and modelling

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[40]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-24	**Crowned spline surface treatment and modelling**
Short description	
UHBR required highly loaded crowned spline. Specific surface treatment to reduce risk of wear and improve loading capacity is to be investigated and characterized by test (specimen or component). Dynamic model of such assembly is to be developed.	

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

1. Background

Beyond 2020, new efforts are required to improve engine efficiency and fuel burn to meet reduction in CO2 and NOx emission target. The Ultra High Bypass Ratio (UHBR) technology has the potential to significantly reduce such emissions.

UHBR technology is based on the geared turbofan concept. This concept requires a reduction gearbox between the fan and the turbine in order to reduce Fan speed and allow for implementation of larger Fan diameter.

Gearbox main technical requirements are

- Layout: 1 input / 1 output
- Power to weight ratio : >100 kW/kg

Main gearbox challenges are

- High power density (see above)
- Low maintenance, high reliabilty, long life (design lifetime = 60 000 cycles)
- High efficiency (> 99.5%)

To simplify gearbox integration and so reduce weight, topic leader has conducted a technology evaluation. Crowned spline has been identified as a one of the potential solution to achieve gearbox integration. Such spline will sustain main engine torque and experience high misalignement (>0.3 degrees). This technology is known from other industrial application and its tendency to wear is not consistent with the low maintenance and high reliability requirements cited above. Thus investigation on modeling and surface treatment is to be carried out.

2. Scope of work

The applicant is asked to evaluate surface treatment and/or heat treatment which could reduce the risk of wear and minimize the friction in the spline.

All the work will be done for a spline definition as per ANSI B92.1-1996 with 50 teeth and modulus 3.175 made from gear steel alloy. The applicant can propose another geometry as long as he demonstrates that reconciliation is possible with such dimensions.

In the beginning, a detailled technical specification will be issued by topic leader.

The work is to be divided in 4 stages:

- First: investigate and propose surface and/or heat treatment which would minimize the friction coefficient and allow high contact pressure (> 500 MPa) on the spline teeth.

- Second: realize full characterisation of the selected treatments on test sample and propose a short list of adequate treatment
- Third: produce and test full size spline with short listed treatment
- Fourth: test full size spline under max continuous torque and misalignement.

Following tasks shall be performed by the applicant:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	investigate surface treatment state of the art for spline application	T0+1months
T2	Produce test sample and realise full characterisation	T0+12months
T3	Proposed test plan for full scale spline	T0+8months
T4	Production of full size spline (number to be defined) with short listed treatment	T0+18months
T5	Provide adequate test bench	T0+18months
T6	Test of sample (lifetime, stiffness, …)	T0+24months
T7	Test correlation (models vs test results)	T0+24months

Task 1

The applicant shall explore the state of the art of available surface treatment for steel spline teeth to minimize friction coefficient under running condition and allow for high contact pressure. This analysis shall include at least:

- Analysis of technological readiness level
- Prediction of friction coefficient
- Prediction of max acceptable contact pressure for design lifetime.

Spline material will be gear steel alloy.

Task 2

In order to select the appropriate treatment to be tested on full size spline, a full characterisation of each proposed treatment will be carried out on sample (not necessary full scale spline). The applicant will propose a characterisation plan which will be validated by the topic leader. The applicant will produce a report of each treament characterisation including process parameters, test conditions and test results. A minimum of 5 treatments is required.

Task 3

The applicant will proposed a test plan to validate on full scale spline the short listed treatment based in tasks 2 test results. The test plan will be approved by the topic leader.

Test plan shall include at least the following stages.

- Static and dynamic stiffness characterisation: stiffness evaluation can be made directly by force/displacement curve measurement for the static or by vibration analysis for the analysis. The applicant shall validate its means of measurement with the topic leader prior to launch test bench design. Test will follow the following steps:
    - Control all spline characterisitcs.
    - Set misalignement and temperature and nominal oil flow
    - Increase speed and torque to achieve following requirements
        - [0-9000] rpm by 500 rpm steps
        - Contact pressure [0-600] MPa by 50 MPa steps
    - Record stiffnesses at each step.
    - Repeat the operation for each temperature and misalignement
        - Temperatures [30 – 160] °C
        - Misalignement [0 – 0.4 °]
- Fatigue test
    - Control all pline characteristics
    - Set misalignement and max temperature and nominal oil flow
    - Achieve 10^7 cycles on teeth flank at max speed and contact pressure
    - Control spline integrity
    - Repeat operation with new spline for each misalignement (see above)
- Robustness test
    - Control all pline characteristics
    - Proceed to fatigue test limited at 104 cycles with variation of oil flow
        - Lubrication [0 – 50] L/h by 5L/h step
    - Controle spline integrity after each step, depending on the results spline will be changed between steps
    - Oil contamination: proceed to fatigue test at max with ships in oil.

Task 4

The applicant is asked to produce a sufficient number of full scale spline to sustain the test plan agreed on task 3. It means that spares should be in adequation with risk analysis.

Based on topic leader estimation 45 specimen will be required.

Task 5

To carry out the test plan, the applicant is asked to provide a dedicated test bench. Validation of the test bench performance and its characterisation is under supplier responsibility but characterisation plan will be approved by topic leader. Test bench design shall be shared with the topic leader to prove its relevance for the project.

Task 6

The applicant will run the test according to the agreed test plan and present results on regular basis and alert the topic leader of any deviation compared to expected results

Task 7

The applicant is asked to provide all test data and correlations with models used in task 1. Test results will be presented at a dedicated meeting and in a report.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	State of the art analysis	R	T0+3months
D2	Characterisation test plan		T0+3months
D3	Treatment characterisation report and test data	R & D	T0+12months
D4	Test plan for full scale spline	R	T0+8months
D5	Full scale spline	HW	T0+18months
D6	Test bench validation	R	T0+18months
D7	Test results of full scale spline	R	T0+24months
D8	Test report	R	T0+24 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Kick-off meeting	R	T0
M2	State of the art analysis presentation	R	T0+3months
M3	Characterisation test plan review	R	T0+3months
M4	Full scale spline test launch review	R	T0+18months
M5	Test results review	R	T0+24months

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

Project schedule

	2018				2019			
TASKS	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
T1	■							
T2		■	■	■				
T3			■					
T4					■	■		
T5			■	■	■	■		
T6							■	■
T7								■
DELIVERABLE								
D1	■							
D2		■						
D3				■				
D4			■					
D5						■		
D6						■		
D7								■
MILESTONES								
M1	■							
M2	■							
M3		■						
M4						■		
M5								■

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.

Capabilities of the test facility

The applicant test facility shall at least ensure the following characteristics for the endurance test. No scale factor acceptable.

Characteristics	Target values
Configuration	Minimum 1 spline at a time
Max torque	TBD depending on the spline size
Max speed	9000 rpm
Max oil flow to the spline	50l/h
Oil temperature	[30 – 160]°C
Max misalignement between input and output shaft	0.4°
Measurements not including stiffness test (these are to be defined by applicant)	- Input and output torque - Input and output speed at high frequency - casing vibration - Inlet and outlet oil temperature of the spline sump

Special Skills and capability

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

- Extensive experience in surface treatment characterisation
- Extensive experience in spline design
- The Applicant needs to demonstrate to be in the position to have access to the test facilities required to meet the Topic goals.
- Experience in aerospace R&T and R&D programs.

Special Skills:

- Experience in spline design
- Experience in Supply Chain management
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution).

5. Abbreviations

CDR	**Critical Design Review**
IP	**Intellectual Propriety**
PDR	**Preliminary Design Review**

III. Gearbox bearing design & testing

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[41]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-25	**Gearbox bearing design & testing**
Short description	
Highly loaded gearbox requires high capacity planet bearing. Rolling element bearing technology is to be investigated for such application. The scope of the activities is to develop bearing technologies for highly loaded gearbox, including: scout for new high loaded materials, development of models to predict bearing behavior (thermal, dynamic, lubrication, lifetime), producing samples and test it in a dedicated test bench.	

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

1. Background

Beyond 2020, new efforts are required to improve engine efficiency and fuel burn to meet reduction in CO2 and NOx emission targets. The Ultra High Bypass Ratio (UHBR) technology has the potential to significantly reduce such emissions.

UHBR technology is based on the geared turbofan concept. This concept requires a reduction gearbox between the fan and the turbine in order to reduce Fan speed and allow for implementation of larger Fan diameter.

Gearbox main technical requirements are

- Layout: 1 input/ 1 output
- Power to weight ratio : >100 kW/kg

Main gearbox challenges are

- High power density (see above)
- Low maintenance, high reliabilty, long life (design lifetime = 60 000 cycles)
- High efficiency (> 99.5%)

To achieve gearbox design key technology identification has been performed by topic leader. One of these technologies is the bearing to be installed in the gearbox.

2. Scope of work

The applicant is asked to design and test a rolling element bearing for such gearbox. Topic leader will periodically meet the applicant to track evolution of the tasks and will participate to all planned reviews.

Prior to design work, a convergence loop will be performed with the topic leader to freeze the detailed technical specification.

The bearing characteristics may be as follows (deviation can be suggested by the applicant as long as correlation means are demonstrated). All other bearings dimensions have to be defined by the applicant.

- Dimension: Ø180 mm
- Radial load: [5-200] kN
- Misalignement : [0-3.5] minute
- Speed: [1000-9000] rpm
- Oil temperature: [0-160]°C (oil as per MIL-L-PRF 23699 type II)
- Target design life: 60 000hr or 10^7 cycles the most strigent

The work is to be divided in four stages:

- First stage: design of a bearing to be mounted in a high power gearbox. This activity will include sensitivity analysis on the bearing geometry and interface, and on the materials. A complete evaluation of high loaded material is to be carried out. If a new material (compared to topic leader legacy) is identified at this stage all following activies will be carried out with this material.
- Second stage: detailed design of the bearing according to sensitivity analysis conclusions

- Third stage: production and test of the bearings
- Fourth stage: model correlation based on test results

Following tasks will be performed by the applicant.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T0	Convergence loop on technical requirements	T0+2months
T1	Bearing preliminary design including sensitivity analysis and scouting for new high loaded material	T0+6months
T2	Bearing detailed design including thermal analysis	T0+12months
T2.1	Bearing in context dynamic analysis	T0+12months
T2.2	Bearing in context thermal analysis	T0+12months
T3	Production of sample (number to be defined)	T0+18months
T4	Provide adequate test bench	T0+18months
T5	Test of sample (lifetime, thermal behavior,…)	T0+24months
T6	Test correlation (models vs test results)	TO+28months

Task 0: convergence loop

The aim of this task is to launch the project with the Topic leader and to prepare the work to be done. It will include:

- Kick-off meeting
- Work on detailled requirements between topic leader and selected partner(s).

Task 1

The applicant shall at least explore the following items for the sensitivity analysis:

- bearing size and number of rows
- rolling element size and shape
- rolling element and ring material

Then the supplier shall conclude on the best bearing characterisitcs (dimensions, materials, etc.) and provide a preliminary design of a bearing optimised in size and perfomance (service lifetime and heat rejection).

Task 2

The applicant shall perform a detailed desing of the bearing. This will include, but not only:

- service life assessment
- thermal analysis (temperature assessment of each component)
- dynamic analysis

- technical risk assessment
- full description and justification of the design
- drawings (including: detailed inner and outer raceways, curvatures, roughness, hardness, case depth, residual stress profile, fillet radii, overall bearing width, shoulder dimensions, roller number and dimensions, roller curvature profile and fillet radius, cage size,…)
- all material characteristics
- proposal of a validation test plan.

  It shall include, but not only, the following stages:
  - Performance characterisation (reference points)
    - Increase lineray speed and loads up to the max normal design point
    - Control bearing integrity
    - Record measurements (temperatures, vibration)
  - thermal characterisation
    - at full load and speed, and at minimum speed and load
    - Increase and decrease (step to be defined) oil inlet flow from nominal. All other parameters are fixed.
    - measure temperature of bearing parts, outlet and inlet oil temperature of the bearing sump
    - compare results to reference point
    - re-do the same process but with oil inlet temperature variation.
  - fatigue test
    - achieve 60 000 cycles 0-max load and speed
    - assess bearing performance evolution during test
    - control bearing integrity at regular frequency between test (number of cycles to be defined)
  - ultimate test
    - on a new bearing, control and characterise all defaults
    - perform reference point
    - perform ultimate test at ultimate load and speed for 5 seconds
    - re- control and characterise all defaults
  - robustness test
    - limit load test
      - perform 30000 cycles as per fatigue test
      - apply limit load to the bearing
      - perfom 30000 cycles as per fatigue test
      - bearing will be controlled and all defaults will be characterised before and after each stage
    - ability to sustain acceptable defaults

- based on applicant catalogue of acceptable defaults, all max acceptable defaults (in term of size) will be generated on a bearing and test as per fatigue test
- Depending on number of defaults and type, number of cycles the applicant can suggest a specific number of cycles to reduce testing time.

All analysis shall be performed taking into account integration constraints.

Design and test plan will be approved by topic leader.

Task 2.2 and 2.1 are sub-tasks of Task 2.

Task 3

The applicant is asked to produce a sufficient number of bearings to sustain the test plan agreed on Task 2. The number of spares will be adjusted accordingly to risk analysis.

According to topic leader estimation, 20 to 25 bearing, including back-ups, are required to carry out the test plan.

Task 4

To carry out the test plan, the applicant is asked to provide a dedicated test bench. Validation of the test bench performance and its characterisation is under supplier responsibility but characterisation plan will be approved by topic leader. Test bench design shall be shared with the topic leader to show its compliance to the requirements of the tests.

Task 5

The applicant will run the tests accordingly with the agreed test plan and present results on regular basis and alert the topic leader of any deviation compared to expected results.

Task 6

The applicant is asked to perform correlations and provide all test data and correlations with models used in task 2. The topic leader will be invited for the final review.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Technical specification (due by topic leader)	R	T0+2months
D2	Preliminary design review + datapackage	R	T0+6months
D3	Critical design review + datapackage	R	T0+12months
D4	Dynamic and thermal analysis	D + R	T0+12months

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D5	Test plan	D + R	T0+12months
D6	Test bench validation	R	T0+15months
D7	Test results	D + R	T0+24months
D8	Bearing samples	HW	T0+18months
D9	Test correlation	R + D	TO+28months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	PDR	R	T0+6months
M2	CDR	R	T0+12months
M3	Parts manufactured	HW	T0+18months
M4	Test readiness review	R	T0+18months
M5	Test correlation presentation	R	TO+28months

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

Project schedule

	2018				2019				2020
Tasks	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
T0	■								
T1	■	■							
T2			■	■					
T2.1			■	■					
T2.2			■	■					
T3					■	■			
T4			■	■	■	■			
T5							■	■	
T6								■	■
deliverable									
D1	■								
D2		■							
D3				■					
D4				■					
D5				■					
D6						■			
D7								■	
D8						■			
D9									■
milestone									
M1		■							
M2				■					
M3						■			
M4							■		
M5									■

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

The above mentioned requirements will be finalised in details during the grant preparation phase.

Capabilities of the test facility

The applicant test facility shall at least ensure the following characteristics. No scale factor acceptable.

Characteristics	Target values
Configuration	Rotating outer ring and inner ring fixed Lubrification by inner ring
Max radial load	200 kN
Max speed	9000 rpm
Max oil flow	600l/h
Oil temperature	[30 – 160]°C
Max misalignement between inner and outer race	3.5 minutes
Measurements	- Bearing outer and inner race temperature - Structure vibration - Inlet and outlet oil temperature of the bearing sump - Bearings speed - Bearing load

Special Skills and capability

The applicant shall describe its experience/capacities in the following subjects:
- 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 bearing is an asset. Availability of technologies at a high readiness level to minimize program risks is an asset.
- The Applicant needs to demonstrate to be in the position to have access to the test facilities required to meet the Topic goals.
- Experience in aerospace R&T and R&D programs.

Special Skills:
- Experience in bearing design
- Experience in Supply Chain management
- Experience in experimental testing and Statistical Methodologies (for Test Plan definition and execution).

5. Abbreviations

CDR	Critical Design Review
IP	Intellectual Propriety
PDR	Preliminary Design Review
R&T	Research & Technology
R&D	Research & Development
UHBR	Ultra High Bypass Ratio

IV. Innovative acoustic fan frame liners technologies for UHBR

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2.2		
Indicative Funding Topic Value (in k€)	2 000		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	42	**Indicative Start Date**[42]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-26	**Innovative acoustic fan frame liners technologies for UHBR**
Short description	
Acoustic fan frame liners are key technological components for Next Gen UHBR to ensure continuous Aircraft noise reduction while architecture evolved on low Fuel Burn and so Low C02 architecture. The objective is to develop innovative acoustic fan frame liner panels able to reduce more efficiently UHBR fan noise signature while satisfying challenging engine integration constraints. Design and manufacture maturation works of tunable fan frame liners is to be performed and performance assessed by tests.	

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

1. Background

The desire for more ecologic and more economic turbofan engines in civil aviation leads to increasing "Bypass Ratios" (BPR) and lower "Fan Pressure Ratios" (FPR). Next generation of engines with significantly higher Bypass Ratios (UHBR) are being developed to further reduce fuel consumption. These engines have a larger fan diameter, a lower rotational speed and a reduced number of blades. Drag and weight penalties induced by the increased engine diameter are typically being offset by means of shorter and thinner nacelles and extensive use of composite materials.

These architecture evolutions are having several consequences on the engine noise signatures, affecting the ways and means by which the noise reduction can be achieved on such engine designs. Fan noise becomes even more the predominant acoustic source of the engine and its signature tends to shift towards low frequencies. Another consequence of the engine concept evolution concerns the reduction of the nacelle treated area. These trends lead to advanced expectations regarding acoustic liners performance and especially on Fan frame liners located inside the engine.

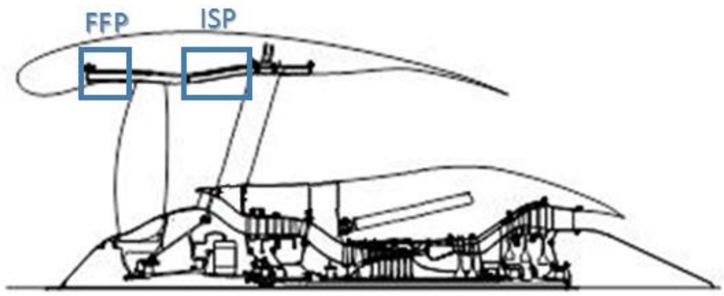


Figure 1 : Acoustic FFP (Forward Fan Frame Panel) and ISP (Inter Stage Panel) typical baseline locations

The current generation of acoustic liners presents some limitations for UHBR application, as they are no more sufficiently effective at such low frequencies for a constrained thickness. Consequently, solutions are required to improve existing liner technologies, or to mature innovative technologies allowing to improve liner performance at low frequency and circumvent the depth limitation. To make up for lost space associated with limited nacelle dimensions, it is also anticipated that such liner solutions could be further integrated in propulsion systems parts that were not considered before, facing to adverse integration constraints. Such acoustic liner technological breakthrough, could potentially allow to optimize further the overall propulsive efficiency.

Tunable membrane structure absorbers liners concepts, recently developped in the frame of EU OPENAIR and ENOVAL program, present interesting perspectives to overcome conventional liner limitations. The technology requires further maturation studies to reach good prospects for their application in future UHBR products. Room exists to further develop advanced membrane absorber solutions (considering especially transducer technology components and dissipation strategy /control) in a perspective to maximise attenuation performance while better meeting engine fan frame integration constraints and requirements.

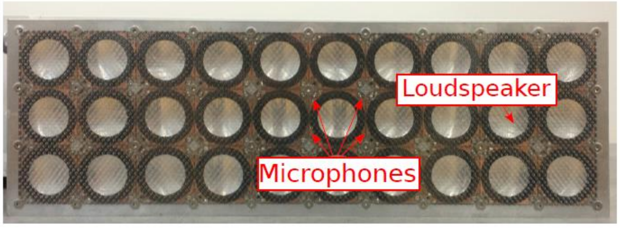
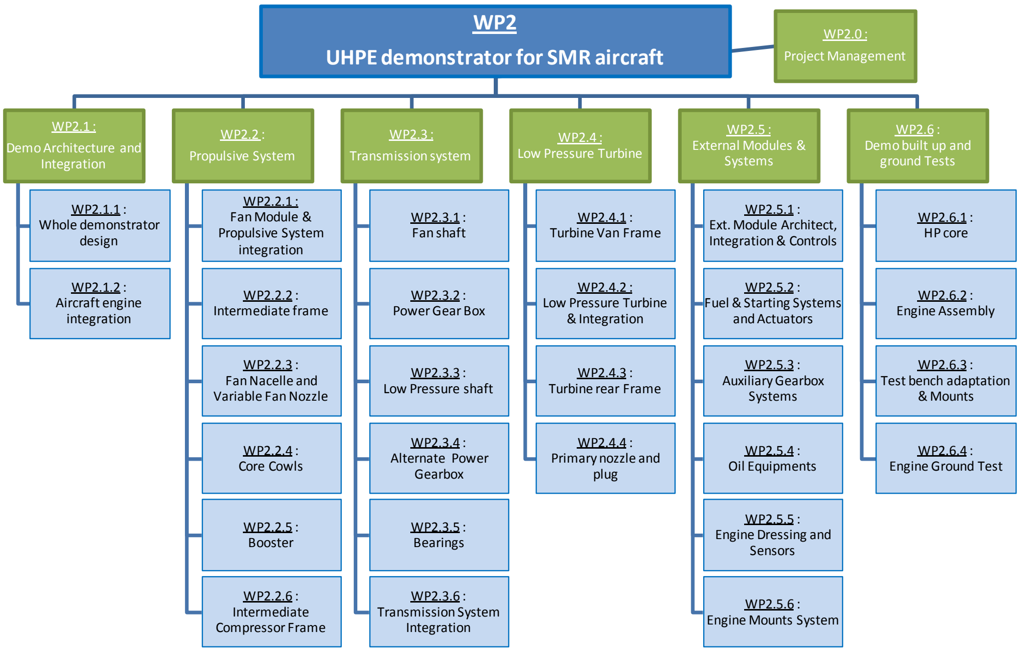


Figure 2 : ENOVAL acoustic membrane liner 2D prototype

The subject of this CfP concerns the development of reliable tunable innovative fan frame liners able to withstand UHBR engine integration and specifications. The activities include an acoustic demonstration on a UHBR large scale fan rig test to assess the potential of innovative tunable fan frame liners under representative environment.

The breakdown in this WP2 is the following:



2. Scope of work

maturation and integration design are necessary in order to reach targeted performance (attenuation over a wide frequencies range, with a performance improvement on low frequencies to achieve 1BPF reduction even under 500Hz) as well as engine application on UHBR Next GEN.

From now, it is assumed that this innovative liner will be based on tunable membrane technology concept, the energy of the acoustic waves being then dissipated either by mechanical and/or electrical systems. Liner concept and associated technology will be described during design reviews.

A gradual stage maturation approach will be pursued to mature the tunable fan frame liner technology.

Firstly, three 2D plane prototypes will be designed, manufactured and tested to demonstrate acoustic performance under representative high grazing aeroacoustics flow conditions.

Following these outcomes, two 3D tunable acoustic (forward and aft) fan frame liner panels will be produced and tested on UHBR large scale fan rig demonstrator. These innovative fan frame liner panels will include control loop abilities used for local acoustic liner properties optimisation, leading thus to in-situ experimental design feedbacks from large scale tests. Performance will be furthermore assessed thanks to a back to back test matrix including comparison with other available state of the art liner panels.

In parallel, advanced modelisation will be investigated to better predict membrane liner performance and allow design optimization. Detailed Fluid / Structure interaction will have to be at first simulated. Then a whole modelisation including membrane liner and fan aeroacoustics fields will be completed.

All along the project, the partner will have to study full scale integration aspects in order to further increase the technology readiness level and prospects for future aircraft engine application. A full scale tunable liner concept demonstrator (panel portion), with miniaturised components and a dedicated integration inside fan frame composite structure, will be developed and manufactured. Compliance with specification will have to be validated through partial tests.

Tasks		
Ref. No.	Title – Description	Due Date
Task 0	Innovative Fan Frame Liners – Management and reporting Related deliverables : D0.1	T0+35 months
Task 1	Innovative Fan Frame Liners - Risk reduction plan Related milestones : M1.1, M1.2 and deliverables : D1.1, D1.2	T0+21 months
Task 2	Innovative Fan Frame Liners – Requirements Related milestones : M2.1, M2.2 and deliverables : D2.1, D2.2	T0+15 months
Task 3	Innovative Fan Frame Liners - Advanced components screening Related milestones : M3.1, M3.2 and deliverables : D3.1, D3.2	T0+30 months
Task 4	Innovative Fan Frame Liners – 2D prototypes detailed design for grazing flow test bench demo Related milestones : M4.1, M4.2 and deliverables : D4.1, D4.2	T0 +12 months
Task 5	Innovative Fan Frame Liners – 2D prototypes manufacturing for grazing flow test bench demo Related milestones : M5.1 and deliverables : D5.1	T0 +16 months
Task 6	Innovative Fan Frame Liners – Grazing flow Test bench demonstration and performance analysis Related milestones : M6.1,M6.2 and deliverables : D6.1	T0 +20 months

Tasks		
Task 7	Innovative Fan Frame Liners – Advance modelling and simulations Related milestones : M7.1,M7.2 and deliverables : D7.1, D7.2	T0 +42 months
Task 8	Innovative Fan Frame Liners – 3D prototypes detailed design for large scale demo Related milestones : M8.1, M8.2 and deliverables : D8.1, D8.2	T0+24 months
Task 9	Innovative Fan Frame Liners – 3D prototypes manufacturing for large scale demo Related milestones : M9.1 and deliverables : D9.1	T0+30 months
Task 10	Innovative Fan Frame Liners – Performance evaluation and analysis on large scale demo Related milestones : M10.1, M10.2, M10.3 and deliverables : D10.1	T0+39 months
Task 11	Innovative Fan Frame Liners – Smart components and technologies integration demonstrator Related milestones : M11.1, M11.2, M11.3, M11.4 and deliverables : D11.1, D11.2	T0+42 months

Task 0: Innovative Fan Frame Liners – Management and reporting
The applicant has to ensure management and reporting activities. A management plan has to be delivered and partner’s progresses regularly reported. The applicant has also to support all project tasks monitoring and coordination.

- Progress Reporting & Reviews:
  - Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation.
  - Monthly coordination meetings shall be conducted via telecom.
  - The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information.
  - The review meetings shall be held at the topic manager’s facility.
- General Requirements:
  - The partner shall work to a certified standard process.

Task 1: Innovative Fan Frame Liners - Risk reduction plan
To provide and achieve a plan including test and capability demonstration for each technical task and element. The applicant has to establish and deliver the related risk reduction plan. Mitigation actions and status shall be adequately monitored.

Task 2: Innovative Fan Frame Liners – Requirements
To contribute to the UHBR innovative liners specifications written under Safran Aircraft Engines leadership. The applicant has to support in particular the requirements break down into detailed technical elements to ensure compliance assessment capacity at components level.

Task 3: Innovative Fan Frame Liners - Advanced components screening
The applicant has to perform a screening of the best tunable liners concepts and associated components allowing to develop prototypes and provide a first background analysis / scorecard.

The applicant has to identify technological solutions allowing to further improve tunable membrane absorber efficiencies (impedance tuning and attenuation performance) while satisfying integration requirements. In this perspective, there is a need to explore advanced solutions and technology transfer opportunities regarding transducer technology components, dissipation strategy and control through mechanical and/or electrical systems.
The screening works shall allow the applicant to select components for 2D plane panels and 3D large scale panels demonstrators (to be designed respectively in task 4 and task 8). Selections shall be performed considering also compliance abilities regarding engine integration requirements (energy efficiency, miniaturization, lightweight, adverse environmental functioning conditions, structural integration prospects,…), including for the 3D full scale demonstrator (panel portion) to be developped in task 10.

Task 4: Innovative Fan Frame Liners – 2D prototypes detailed design for grazing flow test bench demo
To develop innovative tunable liners concepts and perform detailed design of 2D liners panels prototypes complying with the specifications provided by Task 2.
Considering advanced components and solutions identified in task 3, the applicant has to design 2D prototypes.
A gradual design and validation approach has to be pursued to ensure progress towards a relevant innovative solution: starting from component level prototypes (membrane and structure absorber,…), 2D small prototypes, up to full 2D networks membrane absorber structural panels. Models of the novel absorber and dissipation systems have to be developed and used to allow 2D prototypes design optimization. Results from partial tests will be exploited to reinforce modelling accuracy.
The applicant has to consider several potential solutions identified in task 3 to develop efficient membrane absorber panels. Liner concept and associated technologies will be precised during design reviews (component selection, PDR and CDR for 2D panels) considering several acoustics and integration prospects criteria (IL attenuation, wide band frequency performance, control and related strategy, stability...). At CDR, applicant has to present detailed design definitions for three 2D panels prototypes (around 150 mm by 800mm) to manufacture (task 5) for grazing flow tests (task 6).

Task 5 : Innovative Fan Frame Liners – 2D prototypes manufacturing for grazing flow test bench demo
To manufacture 2D innovative tunable membrane liner panels complying with the 2D detailed definitions provided by Task 4.
Applicant has to manufacture three 2D plane prototypes (around 150 mm by 800mm) according to final CDR definition. Prior to this, applicant has to support 2D graduate maturation prototypes (component level prototypes, 2D small prototypes, up to full 2D networks membrane absorber structural panels) manufacturing for task 4. Applicant will be in charge to make available (acquire, built or transform,...) all components and materials required for 2D prototypes manufacturing and related tests functioning and validation equipment.

Task 6 : Innovative Fan Frame Liners – Grazing flow Test bench demonstration and performance analysis
To characterise 2D innovative liner panels acoustic performance in grazing flow test bench. The acoustics tests will comprise comparisons with reference liner panels. Presentation of the test results & analysis by the partner.
Applicant has to test the three innovative membrane absorber 2D panels delivered by task 5 and compare them with two state of the art reference panels (representative of forward and aft fan frame acoustic panels). High grazing flow tests bench with large test section has to be used to ensure relevant acoustic TRL3 maturation. Each of this 5 configurations will be characterized under around 8 operating flow conditions,

covering Mach number at approach and takeoff operating points (for upstream and downstream propagation).

The grazing flow test campaign will comprise acoustics but also aerodynamics measurements to well establish aeroacoustics flow conditions and to characterize membrane absorber behaviors as well as potential side effects on pressure losses.

Task 7: Innovative Fan Frame Liners – Advanced modelling and simulations

To develop advanced numerical simulation of innovative liner concepts under representative aeroacoustics functioning condition,including 1) fluid structure interaction and fan noise sources modelisation 2) temporal simulation.

Applicant has to develop firstly a relevant fluid structure interaction model allowing to better understand membrane behaviour under representative aeroacoustics conditions; this advanced modelling will be also used to optimize acoustic performance of the absorber membrane solution considering 2D and 3D shape applications.

Full 3D numerical models of the membrane absorber liners inside module fan environment (with relevant noise sources) have to be then established. This modelling will allow to identify advanced optimal distributed characteristics of the forward and aft liner panels and related membrane networks. A temporal approach has to be considered by the applicant to offer opportunities to take into account advanced considerations regarding: system stability, energetic assessment, control strategies,... . Using this numerical model, applicant will have to compare the acoustic performance of the distributed membrane absorber panels vs reference (state of the art liner panels).

Task 8 : Innovative Fan Frame Liners – 3D prototypes detailed design for large scale demo

To perform detailed design of 3D innovative forward and inter-stage fan frame acoustic panels complying with the specifications provided by Task 2.

Based on previous task feedback and lessons learnt, two 3D prototype panels will be specifically designed for forward and inter-stage fan frame noise reduction purpose. Dedicated components and working structures will be designed to ensure acoustic demonstration on 3D large scale rig tests. These innovative fan frame liner panels will include control loop abilities used for local acoustic liner properties optimisation, in view to be able to achieve also in-situ experimental design feedbacks during large scale tests.

Like in task 4, a gradual design and validation approach has to be pursued in task 8 to ensure progress toward a relevant 3D shape solution: starting from 3D component level prototypes (membrane and structure absorber, …), small 3D prototypes, up to full 3D networks membrane absorber structural panels. Models of the novel absorber and dissipation systems have to be further developed and used to allow 3D prototypes design optimization. Results from 3D partial tests have to be exploited to reinforce 3D modelling accuracy.

The applicant has to consider several 3D shape potential solutions identified in task 3. 3D liner concept and associated technologies will be precised during design reviews (component selection, PDR and CDR for 3D panels). At CDR, applicant has to present detailed design definitions for the two 3D forward and inter-stage fan panels prototypes (of around 700mm diameters each) that will be manufactured (task 9) for large scale demo tests (task 10).

Task 9: Innovative Fan Frame Liners – 3D prototypes manufacturing for large scale demo

To manufacture two 3D prototypes : (1) Forward fan case innovative tunable liner and (2) Inter stage (rotor/stator) innovative tunable liner complying with the 3D detailed definitions provided by Task 8.

Applicant has to manufacture these 3D array prototypes (of around 700 mm diameter each) according to final

CDR definitions. Prior to this, applicant has to support 3D graduate maturation prototypes (component level prototypes, 3D small prototypes, up to full 3D networks membrane absorber structural panels) manufacturing for task8. Applicant will be in charge to make available (acquire, built or transform,...) all components and materials required for 3D prototypes manufacturing and related tests functioning and validation equipment.

Task 10 : Innovative Fan Frame Liners – Performance evaluation and analysis on large scale demo
To characterise acoustic performance of 3D innovative tunable fan frame liners panels on UHBR large scale fan rig demonstrator.
Tunable and distributed properties of the innovative concept will be experimentally prospected to maximize fan noise source reduction. The acoustics tests campaign will also comprise a back to back comparisons with other available state of the art liner panels. Each operating line will be described by around 15 operating points surrounding approach and take off conditions. Applicant has to perform acoustic data acquisitions on each configurations. Applicant will be also in charge to perform presentation of the test results & analysis.

Task 11 : Innovative Fan Frame Liners – Smart components and technologies integration demonstrator
To conduct full scale engine integration activities, in particular:

- Miniaturized components definition
- Advanced technological & mechanical components integration inside engine environment (Inc. dedicated integration inside composite structure)
- Technological architecture integration definition and justification of reliability for aircraft engine
- Provide final background analysis / score card

Applicant will have to study these integration aspects in order to further increase the technology readiness level and reinforce prospects for future aircraft engine application.

A full scale tunable liner concept demonstrator (3D panel portion), with miniaturised components and a dedicated integration inside fan frame composite structure, will be developed and manufactured. The full scale liner concept and associated technologies will be precised during design reviews (CoR, PDR and CDR). Compliance with specification provided by task 2 & WP2.1 will have to be validated through partial test. To conclude, a TRL review will be passed by the applicant.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D0.1	Management plan	R	T0 + 2 months
D1.1	Risk reduction plan intermediate status	R	T0 + 3 months
D1.2	Risk reduction plan completion	R	T0 + 21 months
D2.1	Innovative fan frame liners specification - 2D & 3D demonstrators	R	T0 + 6 months
D2.2	Innovative fan frame liners specification completion - UHBR engine integration	R	T0 + 15 months
D3.1	Components screening & preliminary score cards of technologies report	R	T0 + 9 months

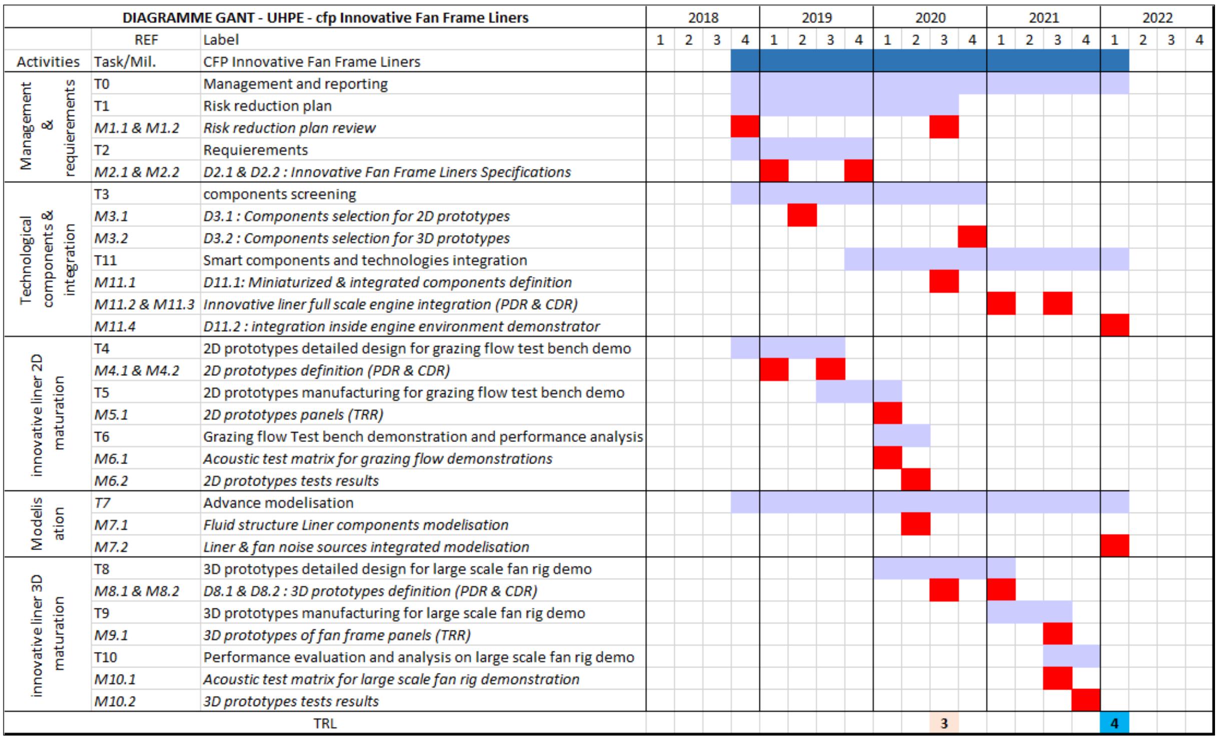
Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D3.2	Advance components screening & score cards of technologies report	R	T0 + 27 months
D4.1	2D prototypes panels definition – PDR	R	T0 + 6 months
D4.2	2D prototypes panels detailed definition - CDR	R	T0 + 12 months
D5.1	2D prototypes panels Hardware delivery	HW	T0 + 18 months
D6.1	2D prototypes tests results & analysis	R & D	T0 + 21 months
D7.1	Advance modelisation intermediate report – components simulation	R & D	T0 + 21 months
D7.2	Advance modelisation final report – full integrated simulations	R & D	T0 + 42 months
D8.1	3D prototypes panels definition – PDR	R	T0 + 24 months
D8.2	3D prototypes panels detailed definition - CDR	R	T0 + 30 months
D9.1	3D prototypes panels Hardware delivery	HW	T0 + 36 months
D10.1	3D prototypes tests results & performance analysis	R & D	T0 + 39 months
D11.1	Miniaturized & integrated liner components definition	R	T0 + 24 months
D11.2	Innovative liner integration inside engine environment demonstrator studies & hardware deliveries	R & HW	T0 + 42 months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M1.1	Risk reduction plan review	RM & R	T0+3 months
M1.2	Risk reduction plan Completion review	RM & R	T0+21 months
M2.1	2D & 3D liner prototypes specification review	RM & R	T0 + 6 months
M2.2	Innovative fan frame liners integrated specification review	RM & R	T0 + 15 months
M3.1	Component selection review 2D prototypes	RM & R	T0+9 months
M3.2	Component selection review for 3D prototypes	RM & R	T0+27 months
M4.1	2D prototypes PDR review	RM & R	T0 + 6 months
M4.2	2D prototypes CDR review	RM & R	T0 + 12 months
M5.1	2D prototypes manufacture & compliance - TRR	RM & R	T0 + 18 months
M6.1	test matrix review for acoustic fan frame 2D panels demonstrations on grazing flow test bench	RM & R	T0 + 19 months
M6.2	2D panels acoustics grazing flow tests results review	RM & R	T0 + 21 months
M7.1	Advance modelisation – components simulation model delivery review	RM & D	T0 + 18 months
M7.2	Advance modelisation – full integrated simulations model delivery review	RM & D	T0 + 39 months
M8.1	3D prototypes PDR review	RM & R	T0 + 24 months
M8.2	3D prototypes CDR review	RM & R	T0 + 30 months
M9.1	3D prototypes manufacture & compliance - TRR	RM & R	T0 + 35 months
M10.1	test matrix review for acoustic fan frame 3D panels demonstrations on UHBR Large scale fan rig	RM & R	T0 + 34 months

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M10.2	UHBR large scale fan rig ready for acoustic fan frame panels 3D prototypes tests	RM & R	T0 + 36 months
M10.3	3D panels acoustics UHBR large scale fan rig tests results review	RM & R	T0 + 36 months
M11.1	Miniaturized & integrated liner components definition – CoR	RM & R	T0 + 24 months
M11.2	Full scale innovative liner integration design and studies – PDR	RM & R	T0 + 30 months
M11.3	Full scale innovative liner integration design and studies – CDR	RM & R	T0 + 36 months
M11.4	Innovative liner integration inside engine environment demonstrator – TRL Review	RM & R	T0 + 42 months

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



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

- Experience in design, manufacturing, testing of acoustic liner membrane concepts is mandatory
- Capacities to specify / identify / develop advanced material components for tunable membrane liner (passive and active transducers components technologies, electronics miniaturization and energetic optimization) is mandatory
- Capacities to specify / identify / develop advance control regulation for tunable membrane liner (data processing, algorithms, local / global /distributed control optimization) is mandatory
- Experience in composite, hybrid design, system and structure integration for Aircraft components
- Experience in grazing flow tests for acoustic liner performance characterization is mandatory. Availability of associated test benches
- Experience in large scale fan rig tests and acoustic liner performance characterization is mandatory. Availability of associated test benches
- Expertise in fluid/Structure and Fan aeroacoustics advanced modelisations
- The applicant shall provide adequate information necessary for an effective and efficient project management during the course of the project
- English language is mandatory

5. Abbreviations

UHBR	Ultra High Bypass Ratio
CoR	Concept Review
PDR	Preliminary Design Review
CDR	Critical Design Reviw
TRR	Technology Readiness Review
GEN	Generation
FFCP	Forward Fan Case Panel
ISP	Inter Stage Panel

V. Composite process modelling and net-shape, complex geometry RTM tool design

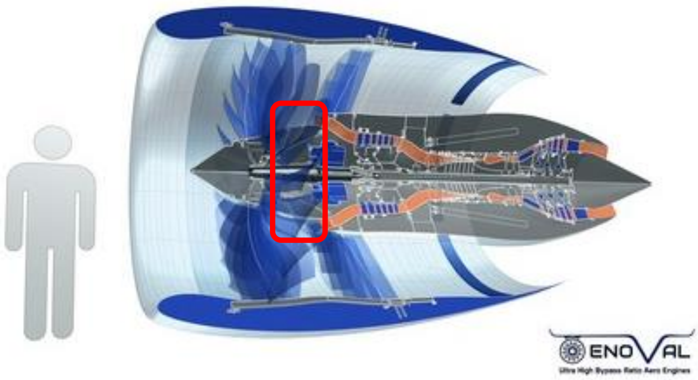
Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2.2.6		
Indicative Funding Topic Value (in k€)	700		
Topic Leader	GKN Aerospace	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[43]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-27	**Composite process modelling and net-shape, complex geometry RTM tool design**
Short description	
Composite process simulation models will be developed that can capture effects of high temperature curing RTM resins and multiple part tools with varying coefficient of thermal expansion on mould tool design. Methods for applying the shape distortion results to automatic tool compensation in CAD software will also be developed. Finally, a tool design concept for high temperature, complex aero-engine component (described by the topic manager) will be proposed and validated by a complete injection/curing/demould trial showing the main principles of the tool concept. The actual part produced will also be used for validating the simulation and compensation methods.	

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

1. Background

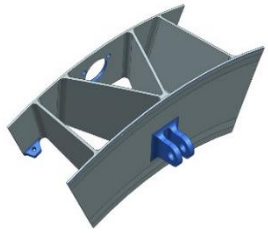
The drive for increasingly efficient jet engines is leading the aeroengine industry to develop engines with higher overall pressure ratios and higher by-pass ratios. The effect on the engine is that the relative size of the core part of the engine decreases and the highest tempreatures in the engine increase. In addition, a geared engine architecture is being adopted by more and more engine manufacturers. The consequence for core engine structural components are that they are becoming more geometrically complex at the same time as the drive for reduced weight is increaing since the overall engine weight of the engine will increase due to its relative increase in size.



The topic manager is developing technologies that can reduce weight of Intermediate Compressor Frames (ICF) while maintaining functionality. One of the technology streams that is under development is the introduction of high temperature polymer composite material in the ICF. The low density and high specific stiffness of carbon fibre composites gives a strong potential for weight reduction while limits in polymer temperature capability, preforming of large and geometrically complex load carrying parts and mould tool design are aspects that so far have inhibited the introduction of this material class.

An ICF structure made in titanium

This CfP topic focuses on RTM (resin transfer moulding) mould tool technologies and the important manufacturing process simulation technologies that will be necessary to ensure a high quality and repeatatable mould design process. Specific challenges will be how to handle temperature control and differential thermal stress in the tool and in the cured part when cruring temperatures may reach +300°C. The part geometry will be highly three dimensional and it will contain thick and thin sections that preferably need to come out at net shape dimensions. A part of the ICF structure geometrys will be used through out the project as a vehicle for driving technology development. This subcomponent contains hollow sections and several load introduction points.



A typical ICF subcomponent 0.5x0.2x0.25 m^3.

The CfP projects end result will be threefold:

1. High temperature mould tool design technologies to ensure temperature control, distortion control, ease of assembly while avoiding tool locking and strategies for connections, sealing etc. The end result will include, the design concept including tool material selection and injection and curing trials at subcomponent level in full scale. Industrial aspects such as production rate and tool maintainability must be considered.
2. Validated simulation methods - including physical property data - necessary for mould filling, cure deformation and tool geometry compensation. The process simulations should consider the correct material behaviour and tool part interaction. Verification should be carried out on smaller features

proving the methodology step by step and the finally validated on the ICF subcomponent. Material models and methods developed should eventually be implemented in ANSYS. The CAD tool should be Siemens NX.

3. A simulation assisted RTM mould tool design process for complex geometry high temperature curing resins. The process should include interaction with the component design organization in a concurrent mode to enable short development lead time for the product from start of design to certified product.

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 the Topic manager about the name/names of this key staff. At minimum the responsibility of the following functions shall be clearly addressed: Programme (single contact point with Topic Manager), Engineering & Quality. **Time Schedule & Work package Description:** – The partner shall work to the agreed time-schedule (outlined in Part 3) and work package description. – The time-schedule and the work package description laid out in this Call shall be further detailed as required and agreed during negotiation based on the Partner's proposal. **Progress Reporting & Reviews:** – Monthly one-pager and quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. – Regular coordination meetings shall be installed (preferred as telecom). – The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. The review meetings shall be held quarterly by WEBEX, at Topic Manager's premises or at the partner's premises.	M36
2	Tool development The topic manager will provide the CfP applicant with a model of the sub-component geometry (see chapter 1) that will be used throughout the project. Two representative high temperature resin systems will also be selected early in the project. The alternative resins will be discussed between the applicant and the topic manager while the final approval of the top two candidates to be done by the topic manager. At least one of the chosen resins will have a cure temperature above 280°C. This work package will go through a classical development phase with a requirement specification phase, a concept generation phase, early trials of specific tool features proving TRL4 (feature examples: control system, heating/cooling devices, seal systems, mould/cure/demould trials of simple geometries), a preliminary design phase and – at the end a manufacturing and tool verification phase leading to TRL 5. Reviews together with the topic manager will be carried out between the different	

Tasks		
Ref. No.	***Title – Description***	***Due Date***
	phases. The tool verification tests will also be used as high level validation test for the methods developed under WP3. After the project is closed the tool will be sent to the topic manager to enable manufacturing of test components for functional testing.	
3	<u>Methods development and validation</u> The applicant is to develop - or adapt - methods that iteratively and accurately can be used within the time limits of a product development project. The foreseen important steps are the efficient transformation of CAD geometry to a calculation domain, mould filling, active and passive temperature change of the tool including its effects on thermal expansion, cure deformation and mould tool interaction of the carbon fibre/high temperature resin part and finally a method to use the simulation results for compensating the initial geometry model. Initially a methods architecture report should be written that describes the methods to be used, the data flow and the important verification activities. The foreseen steps are: • Generation and compilation physical properties • Development/adaptation of the needed methods • Verification on specimen/simple scale of the accuracy of the individual methods • Simulation trials showing that the flow of data and result flows efficiently along the simulation chain • Final simulation of the demonstrator mould tool • Validation of the method by comparing the simulated results with actual results generated in using the mould tool. Methods should be made available to the topic manager as documented subroutines to – or implemented software for– in ANSYS and SIEMENS NX at the end of the project.	
4	<u>Development of a concurrent, simulation assisted tool design process</u> A flow chart process with descriptions of activities and information flow should be developed that captures the selected elements of the tool concept, interaction with the component design organization and the developed simulation activities. If an iterative procedure is proposed or necessary the activities and methods for doing this should also be described.	

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Detailed Project Plan	R	M2
D2	Methods architecture and verification plan	R	M4
D3	Documented tool concept design review	R	M6
D4	Documented tool detailed design review	R	M14
D5	Specimen level methods verification tests and analysis	R	M18
D6	Report on first component manufacturing trials	R	M24
D7	Report on simulation methods verification on component level	R	M32
D8	Concurrent tool design process	R	M34

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	First component injection trail performed in tool	ECM	M2
M2	Tool concept design review	ECM	M5
M3	Tool preliminary design review	ECM	M9
M4	Material Properties	D	M10
M4	Tool detailed design review	ECM	M13
M5	Component mould tool delivery	HW	M35
M6	Subroutine/code containing validated methods	D	M35

*Type: R=Report, D=Data, HW=Hardware, ECM = Engineering Coordination Memo to the topic manager claiming the achievement with a brief description.

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

The applicant should have the following skills, capabilities, equipment and experience:

- Experience in the detail design, development and manufacture of light weight composite parts for aeroengine applications
- The partner/applicant needs to demonstrate that it has the necessary infrastructure e.g. high temperature Injection machine, to meet the goals of the project
- The applicant need to demonstrate skills and previous experience in the area of development and use of multiphysics simulation to perform analysis of shape deformations and residual stresses from curing with the purpose to perform mold compensation
- The access to and experience of using 3D-optic measurment equipment for maesuring geometry distorsions is beneficial
- Documented experience in infusion manufacturing (e.g. RTM) at temperatures above 280°C manufacturing is required
- The organization should have routines for handling high temperature moulds and resins that can be toxic and an issue for health and safety in its uncured form.

5. Abbreviations

CAD	Computer Aided Design
ICF	Intermediate Compressor Framer
RTM	Resin Transfer Moulding
TRL4	Technology Readiness Level 4: Basic examples of the proposed technology are built and put together for testing to offer an initial vote of confidence for continued development.
TRL5	Technology Readiness Level 5: Basic prototype validated in relevant environment. - More realistic versions of the proposed technology are tested in real-world or near real-world conditions, - Further testing is conducted to understand the significance of any variation, on the technologies ability to meet the requirements.

VI. Innovative HPC Flow Treatment Technologies: Design & Experimental Validation Using Advanced Measurement Techniques

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 2.6		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	GE Deutschland	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	42	**Indicative Start Date**[44]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-28	**Innovative HPC Flow Treatment Technologies: Design & Experimental Validation Using Advanced Measurement Techniques**

Short description
The call aims to develop and validate HPC flow treatment technologies to address HPC aerodynamic challenges associated with future UHPE engine architectures, i.e. casing treatment and complementary flow control technologies for increased relative rotor clearances. A high-speed, large-scale multi-stage compressor test facility along with advanced instrumentation equipment and HPC aerodynamic design expertise are required to successfully execute the package.

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

1. Background

Future market requirements and the ambitious environmental objectives set by the aeronautical community, such as the goals outlined in the ACARE 2035 Strategic Research and Innovation Agenda (SRIA), require aircraft engine manufacturers to develop new and innovative aero engine concepts. The geared ultra-high propulsive efficiency (UHPE) engine architecture pursued by Safran Aircraft Engines (SAE) within the Clean Sky 2 programme represents a major step towards the realization of these challenges and aims at a product with significantly reduced fuel burn, pollutant emissions, and noise perception in a 2025+ market for short and medium range (SMR) aircraft. While the Topic leader SAE focuses on the development of the low-pressure spool technologies that will enable a considerably increased bypass ratio and improved propulsion efficiency (large-diameter low-speed fan, gearbox, booster, high-speed low-pressure turbine), GE Germany (GEDE) will provide the high-pressure core for the UHPE demonstrator vehicle and develop innovative technologies for advanced high-pressure aero engine cores to maximize the performance of future UHPE product engines.

Future high bypass ratio turbofan engines that operate with an increased overall pressure ratio (OPR) demand a further reduction of the core engine size, which inevitably introduces design challenges for each core engine module. For example, the high-pressure compressor (HPC) in an UHPE-like application is expected to feature smaller blades compared to those used in current engines. Since rotor tip clearance margins must be provided to avoid rubs and are controlled on an absolute scale, the relative clearance size over span will increase. Similarly, the relative stator shroud clearances over span will grow, leading to low momentum fluid flow near the stator hub due to leakage flows through the shroud seals. These relatively increased rotor and stator clearances, together with relatively increased endwall boundary layer flows, are expected to deteriorate the aerodynamic performance and penalize compressor operability (stall margin).

Within the framework of Clean Sky 2, GEDE addresses these challenges and develops advanced HPC technologies capable of supressing the detrimental effects associated with a reduction in compressor size. The efforts focus on the mitigation of the performance and operability penalties by establishing new blading design strategies and introducing innovative flow treatment technologies specifically targeted to the compact rear stages of high-pressure ratio HPCs in future UHPE engine architectures.

The call for partner supports and complements these HPC technology development efforts. Its main objectives are threefold:

1. To develop flow treatment technologies that suppress the detrimental effects of the increased relative rotor clearances, complement HPC casing treatments, and enhance HPC stability in a multi-stage environment. These development efforts will supplement GEDE-internal technology work.
2. To obtain an experimental assessment, i.e. a detailed quantification of the performance and operability, of the developed most-promising technologies by the means of a compressor rig test under engine-representative conditions.
3. To gain a thorough understanding of the flow physics, including unsteady flow and component interaction as well as aerodynamic loss mechanisms, through the application of advanced measurements techniques.

Advanced flow treatment technologies – together with a 3D blading design specifically tailored to the flow conditions in small HPC rear stages – are key to enable the HPC performance and operability required in future UHPE high-OPR aero engines. For example, casing treatments (CT) are well known to increase the stable operating range of compressors by strengthening the rotor tip flow through the removal of blockage. Especially discrete axial slots have been proven to significantly increase the stall margin of axial compressors while minimizing the aerodynamic performance penalty. However, the potential of CTs is not yet fully leveraged, since the radial flow re-balancing provoked by the CT in a multi-stage environment typically weakens the flow in other span regions, e.g. the downstream stator hub flow, which eventually trigger a premature compressor stall.

Thus, the successful partner of this call will be tasked with the development of innovative CT-complementary flow treatment technologies that strengthen the flow across the entire span. The aim is to further increase the compressor stall margin in a multi-stage HPC environment without compromising efficiency. State-of-the-art computational methods including steady-state and time-accurate RANS CFD simulations are to be used for the design and numerical assessment of the various concepts. Subsequently, the most-promising technologies developed by the partner and GEDE will be validated by the means of a compressor rig test. In a first test campaign, the impact on aerodynamic performance and stall margin will be quantified over a wide range of operating conditions. The partner will support the test preparations, the assembly of the test vehicle as well as its installation into the test facility, the execution of the test, and the post-processing of the data. Finally, in a second test campaign advanced data acquisition techniques will be employed to capture unsteady flow phenomena and to analyse the aerodynamic loss mechanisms and the compressor's stall behaviour in more detail. The goal is to obtain a detailed understanding of the complex flow physics, including the unsteady interactions between the main and secondary flows and how these are affected by the developed 3D blading designs and flow treatment technologies. The measurement of the unsteady entropy variation (by simultaneously measuring unsteady total pressure and total temperature) at various traverse planes is of particular interest.

The successful applicant is expected to provide a high-speed, large-scale multi-stage compressor rig test facility that allows for a test under engine-representative conditions as well as the instrumentation equipment required for health & safety monitoring, a detailed compressor performance assessment, and a thorough unsteady flow investigation including a HF data acquisition system (50kHz sampling rate, 20+ channels). Furthermore, the partner is expected to possess extensive experience in running high-speed compressor rigs under engine-representative conditions. The ability to apply complex data post-processing techniques is to be demonstrated. Long-term expertise in the development of HPC flow treatment technologies and general aerodynamic design experience is highly desired.
A work package structure to support the tasks outlined above is proposed in the following section.

2. Scope of work

Six separate work packages (WP) have been defined to enable the successful execution of this project.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP 1	Numerical Investigation into HPC Flow Treatment Technologies	T0 + 8 months
WP 2	Design of HPC Flow Treatment Technology	T0 + 16 months
WP 3	Test Preparations & Hardware Procurement	T0 + 26 months
WP 4	Test Campaign 1: Performance & Operability Assessment	T0 + 33 months
WP 5	Test Campaign 2: Flow Physics Assessment Using Advanced Unsteady Measurement Techniques	T0 + 37 months
WP 6	Post-Test Numerical Analyses and Report-Out	T0 + 42 months

WP 1 – Numerical Investigation into HPC Flow Treatment Technologies

In this first work package, several innovative HPC flow treatment technologies capable of enabling the axial compressor performance and operability required in future UHPE high-OPR aero engine architectures, will be assessed numerically by the means of steady-state and unsteady, multi-stage CFD simulations. These flow control technologies will be combined with a state-of-the-art CT (which is to be provided by the partner) to strengthen both the compressor tip and hub endwall flows. This work package concludes with the down-selection of the technology that provides the largest operability and aerodynamic performance improvement potential.

WP 2 – Design of HPC Flow Treatment Technology

In this second work package, the selected flow treatment will be further optimized by the means of extensive unsteady CFD simulations to achieve the highest possible compressor stall margin without penalizing the aerodynamic efficiency in a multi-stage HPC environment (at least 5% stall margin improvement and efficiency-neutral with respect to a relevant reference design to be agreed upon with GEDE). To deliver a design relevant for future applications, aeromechanical design aspects as well as mechanical integrity will be considered in collaboration with GEDE.

WP 3 – Test Preparations & Hardware Procurement

This third work package covers all activities related to the hardware procurement and the test preparations needed to be carried out at the partner's test facility, i.e. the rig assembly, the connection of the instrumentation, the balancing and alignment of the rotors and casing, the commissioning of the rig, and the preparation of the data acquisition. Calibration of all instrumentation is also required. The interfaces between the test vehicle hardware and the test facility must be jointly defined by GEDE and the successful partner. The compressor blading, both the rotating blades and stator vanes, as well as the casing will be provided by GEDE, while the partner is expected to provide all other parts of the rig, including the disks, the shaft, as well as all inlet and exhaust parts. The test objectives for the subsequent campaigns will be set by GEDE and the instrumentation plan required for achieving these test objectives must be defined in close collaboration between GEDE and the partner. Test requirements, operating conditions, safety as well as alert limits, and test schedule will be jointly decided upon by GEDE and the partner during the test preparation phase.

WP 4 – Test Campaign 1: Performance & Operability Assessment

The main objective of this first test campaign is to establish the compressor speedlines, i.e. the compressor stall margin and aerodynamic efficiency will be assessed over a wide range of operating points. A comparison against the datum compressor results (provided by GEDE) will allow to clearly quantity the impact of the introduced flow treatment technologies. To allow for a detailed stage performance assessment, GEDE will provide instrumented stator vanes enabling interstage total temperature and total pressure measurements as well as circumferentially-distributed wall static pressure taps that will be placed at the leading and trailing edges of each stator vane. At the same time, the successful partner is expected to provide rakes for total pressure and total temperature measurements at the compressor inlet and exit (minimum four rakes per station and five heads per rake) as well as the inlet instrumentation required for mass flow calculations. Additionally, traverse measurement capabilities are to be provided and will be carried out at all aerodynamically relevant flow path locations to capture the spanwise distribution of velocities and other thermodynamic quantities such as pressure and temperature. Finally, the successful partner is expected to provide a system that allows for the measurement of blade tip clearances and vibrations (e.g. capacitance clearanceometers).

WP 5 – Test Campaign 2: Flow Physics Assessment Using Advanced Unsteady Measurement Techniques

Upon completion of the performance and operability assessment, see first test campaign described in WP 4, this fifth work package aims at a more detailed investigation into the unsteady flow physics within the compressor. In this second measurement campaign, advanced unsteady data acquisitions techniques will be used to study unsteady flow and component interaction as well as the compressor's stall behaviour. The same hardware, i.e. compressor blading and flow treatment technologies, as in the first test campaign will be used. To better understand the aerodynamic loss mechanisms within the compressor, time-resolved entropy measurements will be conducted by simultaneously measuring both unsteady total pressure and unsteady total temperature at several flow path stations. The technology to be used for the unsteady total temperature measurements (e.g. thin film) will be jointly agreed upon by GEDE and the partner.

WP 6 – Post-Test Numerical Analyses and Report-Out

After the completion of both test campaigns, post-test CFD simulations will be conducted. The data collected during the measurement campaigns will be used to identify follow-on design optimization opportunities and calibrate the numerical tools for an improved prediction of the compressor flow and performance characteristics. A thorough comparison of the test results and the numerical predictions is required to obtain a complete understanding of the compressor flow physics as well as a comprehensive assessment of the new blading design and developed flow treatment technologies. Finally, all numerical and experimental results will be documented and lessons learned will be collected in a final report.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1.1	Report Summarizing Outcome of Concept Studies Including Rationale for Down-Selection of one Technology	R	T0 + 10 months
D2.1	Report Summarizing Design of Flow Treatment	R	T0 + 18 months
D3.1	Rig Assembly and Commissioning Report	R	T0 + 27 months
D4.1	Test Campaign 1 Report: Test Data Post-Processed	R	T0 + 34 months
D5.1	Test Campaign 2 Report: Test Data Post-Processed	R	T0 + 38 months
D6.1	Final Project Report Including Comparison of Post-Processed Test Data with Post-Test Numerical Studies	R	T0 + 42 months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M1.1	Review Flow Treatment Concept Studies	Review	T0 + 8 months
M2.1	Review Flow Treatment Detailed Design	Review	T0 + 16 months
M3.1	Hardware Manufactured and Received	HW	T0 + 22 months
M3.2	Rig Assembled & Commissioned: Test Readiness Review	HW, Review	T0 + 26 months
M4.1	Test Campaign 1 Complete: All Raw Data Available	D	T0 + 32 months
M4.2	Test Campaign 1 Results Review	Review	T0 + 33 months
M5.1	Test Campaign 2 Complete: All Raw Data Available	D	T0 + 36 months
M5.2	Test Campaign 2 Results Review	Review	T0 + 37 months

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

All deliverables and milestones of this project are depicted in the work plan below, see Figure 1.

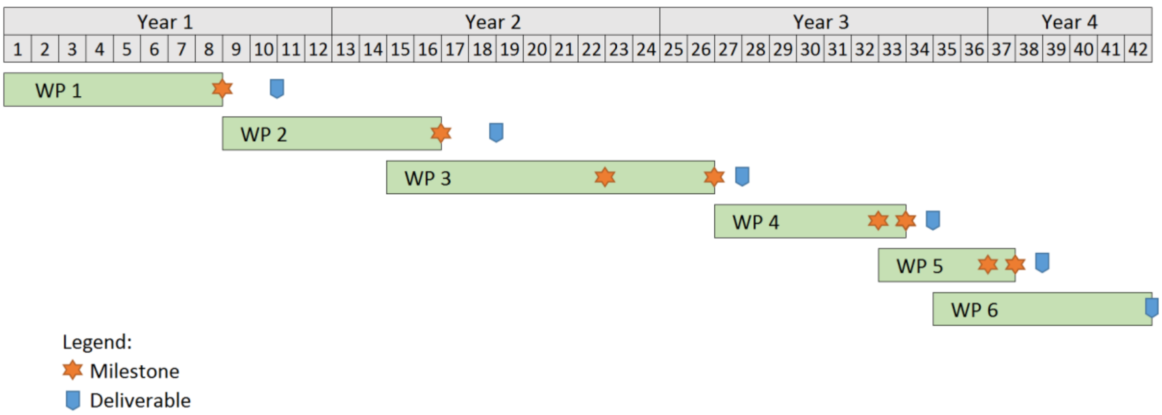


Figure 9. Work plan including Deliverables and Milestones.

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

Specific skills, capabilities, and facilities are required to fulfil the tasks as outlined above. Thus, a response shall address the following areas:

- Demonstrated capability to operate a high-speed, large-scale, multi-stage compressor rig which is representative of HPC rear stages in modern aircraft engines. The rig operation requirements are summarized in the table below. Capability to operate the test rig at stable and repeatable operating conditions.
- Demonstrated capability to acquire detailed three-dimensional flow field measurements using standard rake and five-hole probe instrumentation and data reduction processes that enable HPC performance evaluation.
- The rig must enable the insertion of additional advanced instrumentation, such as fast-response pressure and temperature probes, to enable investigation into unsteady flow interaction and aerodynamic loss mechanisms at multiple stations along the flow path as well as compressor stall behaviour analysis.
- Experience in measuring unsteady velocity and unsteady total pressure in a rotating rig.
- Experience with the assembly of complex test vehicles, implementation of conventional and advanced instrumentation, and assessment of measurement uncertainties.
- Experience in three-dimensional blade design. Long-term expertise in the design of HPC flow treatment technologies, particularly casing treatments (axial slot type), using unsteady CFD.
- Experience in R&T collaborative projects, with demonstrated portfolio of successfully executed compressor test programmes.
- Proven track record with the setup of data acquisition systems and the execution of industry-standard data reduction methods
- Experience in delivering technical and programme planning documentation, risk analyses, post-processed test results and test reports to an industry partner.

Compressor Rig Parameter	Unit	Value
Total Pressure Ratio	-	> 2.0
Mass Flow	kg/s	> 30
Tip Speed	m/s	> 275
Shaft Power	MW	> 2.5
Number of Stages	-	≥ 2
Reynolds Number (based on chord length)	-	> 500,000

5. Abbreviations

ACARE	Advisory Council for Research and Innovation in Europe
CFD	Computational Fluid Dynamics
CT	Casing Treatment
GEDE	GE Germany
HF	High-Frequency
HPC	High-Pressure Compressor
IGV	Inlet Guide Vane

OGV	Outlet Guide Vane
OPR	Overall Pressure Ratio
RANS	Reynolds-Averaged Navier-Stokes
SAE	Safran Aircraft Engines
SMR	Short and Medium Range
SRIA	Strategic Research and Innovation Agenda
UHPE	Ultra-High Propulsive Efficiency
WP	Work Package

VII. Characterization of the resistance of TiAl turbine blades to impact

<table>
<tr><td>Type of action (RIA or IA)</td><td colspan="3">RIA</td></tr>
<tr><td>Programme Area</td><td colspan="3">ENG</td></tr>
<tr><td>Joint Technical Programme (JTP) Ref.</td><td colspan="3">WP 3.2</td></tr>
<tr><td>Indicative Funding Topic Value (in k€)</td><td colspan="3">550</td></tr>
<tr><td>Topic Leader</td><td>Safran</td><td>Type of Agreement</td><td>Implementation Agreement</td></tr>
<tr><td>Duration of the action (in Months)</td><td>24</td><td>Indicative Start Date[45]</td><td>Q4 2018</td></tr>
</table>

<table>
<tr><td>Topic Identification Code</td><td>Topic Title</td></tr>
<tr><td>JTI-CS2-2017-CfP07-ENG-01-29</td><td>Characterization of the resistance of TiAl turbine blades to impact</td></tr>
<tr><td colspan="2">Short description</td></tr>
<tr><td colspan="2">The purpose is to investigate the impact resistance of TiAl turbine blades through original experiments, and to develop a transient dynamics model for the behaviour and rupture of TiAl.</td></tr>
</table>

[45] 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 short range gas turbine engines market (WP3 of Engine ITD). One of the key technology enablers on the core engine is light weight material. The use of Titanium-Aluminium (TiAl) blade for the Low Pressure (LP or Free turbine) is expected to bring additional weight savings and therefore CO2 savings during a mission.

A full TiAL made LP turbine is expected to be ground tested on an engine as part of the overall Clean Sky 2 WP3 demonstration. The engine tests will aim at validating the material in a real engine environnment and on real cycles.

Nevertheless complementary investigations are necessary to validate TRL 5, in particular to assess the material behaviour during the engine operating life under various conditions, including some possible failure cases.

The task of the partner will be to perform the side investigations at specimen level to support the overall study of this material. The purpose will be to validate the resistance of TiAl turbine blades to impact and to provide a numerical model of the fast transient behaviour and rupture of the alloy.

The figure 2 shows the work breakdown structure of WP3 demonstration platform.

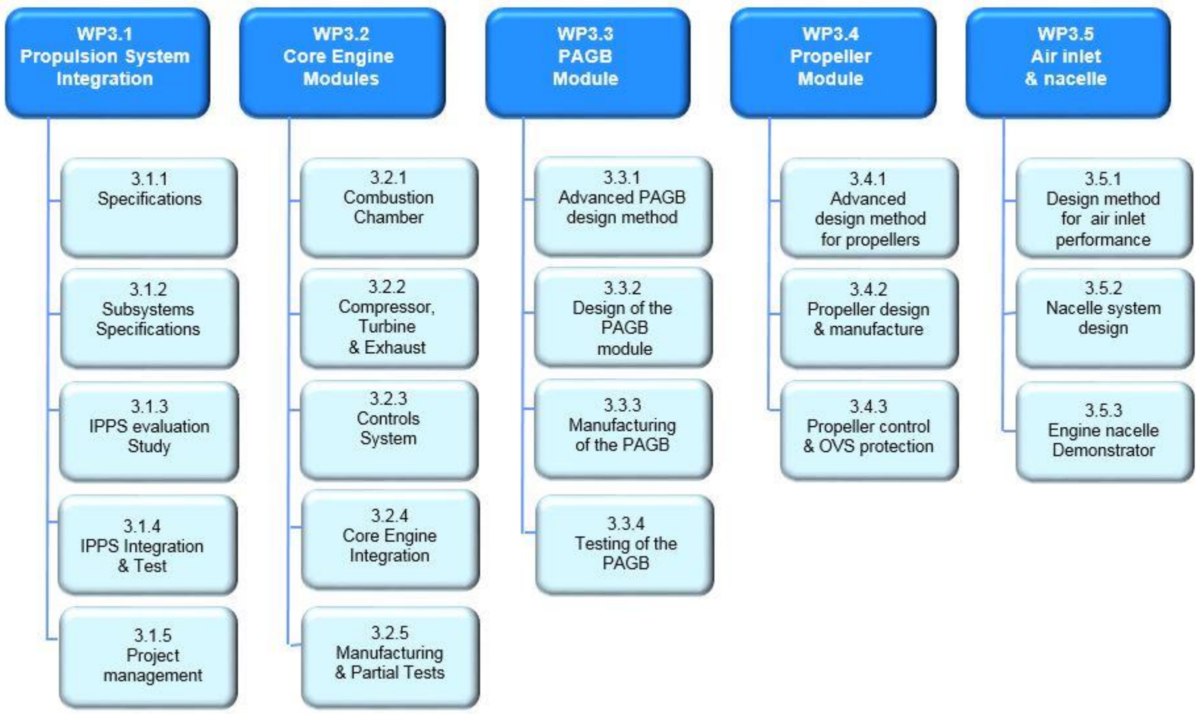


Figure 10: WP3 Work breakdown structure

2. Scope of work

The purpose of the study is to investigate the resistance of TiAl turbine blades to impacts through original experiments, and to develop a transient dynamics model for behaviour and rupture.

Some of the impact tests will also be carried out on a nickel based alloy for comparison purpose.
The alloys will be defined by Safran Helicopter Engines.
This package of work will evaluate the effects of strain rate and also the effects of temperature.

Three activity streams are identified, which are listed hereafter.

Task1: Management

Organization:

- The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name (s) of this key staff

Time schedule and work-package description:

- The partners will work to the agreed time-schedule and work-package description
- Both the time-schedule and the work-package description laid out in this call shall be further detailed and agreed at the beginning of the project.

Progress reporting and reviews:

- Progress reports (i.e. deliverables) will be written over the duration of the programme
- The full experimental database will be made available to the topic manager before the end of the programme.
- For all work packages, technical achievements, timescales, potential risks and proposal for risk mitigation will be summarized.
- Regular coordination meetings shall be conducted via telecom or webex where appropriate.
- The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information.
- The partners shall support, as appropriate, face-to-face review meetings to discuss the progress.

Task 2 : Experimental investigation

This task will be dedicated to investigate experimentally TiAl material. Analysis will be conducted to measure and understand TiAl behaviour during life operation of the turbine.
The experimental program will be agreed with Safran Helicopter Engines which will provide material for manufacturing the test specimen.
For all the tests, blanks of coupon samples will be provided by Safran Helicopter Engines and the coupons will be machined by the partner.

The objective is to confirm experimentally the good behaviour of the TiAl blade under the impact of a blade of the same rotor stage or a debris released from an upstream component, compared to currently used Ni blade alloy.
The experimental investigations detailed herafter will also be used by the partner to identify the parameters of a material model (cf. Task 3).

Main requirements for the experimental investigations:

- Characterization of the behaviour and rupture of TiAl in high-speed traction-torsion-compression at two temperature levels between 500°C and 800°C.
    - The required strain rate levels are 10 - 10^2 - 10^3 s^{-1}.
    - ~20 Low stain rate deformation tests: 3 Temp x 1 speed x 3 Repeat x 2.5 (traction, torsion, compression)
    - ~100 dynamic tests: 3 Temp x 2 speeds x 5 repeat x 3 (traction, torsion, compression)
    - Low rise time Split Hopkinson apparatus : maximum 20 µs in compression and 30 µs in tensile configuration
    - High performance measurements capacity is required: at least 1 MHz-range acquisition requested.
- Experimental programme will be conducted to support comparison of a material model with impact tests.
    - Validation will be achieved taking into account the time and localization of the initial rupture by a high speed video camera.
    - Normal impact tests on plates with representative thickness of the airfoil at 700-800°C will be used as a first step validation.
        - A back face telemetry will be used to measure the displacement of the plates during the impact. The telemetry should have a time resolution of 10 ns.
        - Continuous measurements of the strain field will be performed by IDIC.
        - Comparison to Ls-Dyna modelling (see Task 3)
        - ~10 impacts@700°C + 5-10@800°C on TiAl
        - ~10 impacts@700°C on Ni-based alloy without simulation
    - Impact tests on coupons made of TiAl and Ni alloys with geometries representing bending stresses in the blade will be used to validate the model and to compare TiAl with current materials. The coupons could, for instance, be bone-shaped with a rectangular section.
        - Deformation rate < 10s-1
        - About 20 impacts tests
        - The coupon and impactor geometries will be defined and agreed with Safran HE before the test campaign
        - Comparison to Ls-Dyna modelling (see Task 3)
        - If possible, the bending effort will be imposed with the coupon under a static traction effort representing the centrifugal load.
    - Validation on 10 impact tests on TiAl and Ni-base alloys blade-like samples (Figure 11) at 500°C and 750°C with an impactor representing a fragment of a blade
        - 100 to 300 m/s for a ~10g projectile.
        - High precision of the orientation of the impactor on the 3 axes.
        - Validation of the impact conditions with identification of the time and localization of the rupture by high speed video recording.
        - Comparison to Ls-Dyna modelling (see Task 3)
    - 5 Impacts of blade-like samples (40 mm maximum size) against metal sheets (~1 mm thickness supplied by Safran HE) representing simplified casings at room temperature.
        - 300 m/s-400 m/s to be precised with masses ~30g.
        - High speed video camera (200 kpixel / 90 000 fps).
- Assessment of the indentation sensitivity at the vicinity of the edge of 1 mm thickness plates made of Nickel-based alloy and TiAl under impact of small spherical impactors (~2, 4 mm) at ~350 m/s – 700°C.

- ~30 impact tests on Ni, ~30 tests on TiAl.

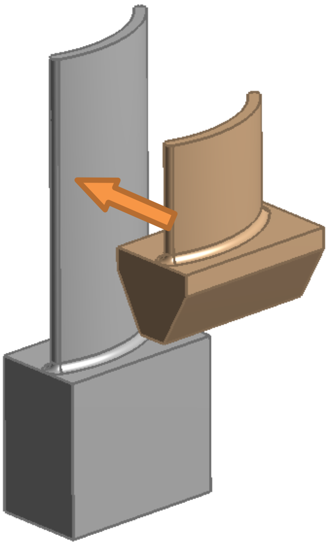


Figure 11: Schematic illustration of impact tests on blade-like samples with an impactor representing a fragment of a blade

	TiAl	Ni-base
Quasi-static	~ 20	
Hopkinson	~ 100	
Plate impact	~ 20	~ 10
Impact-Flexion	~ 20	
Simplified blade impact on blades	~ 5	~ 5
Simplified blade impact on plates	~ 3	~ 2
Impact of sphere on plate edge	~ 30	~ 30

Table 1: Summary of the tests campaign suggestion.

<u>Task 3 : Numerical investigation</u>

The partner will select and identify a material model based on the analysis of the experimental data. Numerical simulations will be performed to verify the accuracy of the criteria by comparison with the experimental data.

The objective of the identification is to be able to model the impact of a released blade on the adjacent blade. The numerical model will use Ls-Dyna with the associated material library.

<u>Main requirements for the numerical study:</u>

- Selection and identification of a behaviour and rupture model taking into account at least a dependance on the triaxiality of the stress state. A more complex model may be proposed as far as it is caracterized and validated.
- The choice of the material model and the correlation between tests and numerical modelling will be carried out in close cooperation with Safran Helicopter Engines.
- Validation of the material model by the means of comparison between the experimental tests results

and simulations on the impact tests identified in task 2. The list and conditions of the impact tests to be modelled will be confirmed in agreement with Safran HE.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	***Management*** • Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. • Monthly coordination meetings shall be conducted via telecon. • The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. • The review meetings shall be held at the topic manager's facility.	T0 + 24 months
Task 2	***Experimental investigation*** • Experimental test campaigns to assess numerical models • Analysis of the results	T0 + 24 months
Task 3	***Numerical investigation*** • Selection and identification of the material model • Validation of the model by simulation of the impact tests identified in task 2	T0 + 24 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Experimental test programme (to be agreed with Safran Helicopter Engines) including description of the test set-up and test specimens.	R	T0 + 2 month
D2	Experimental test results and preliminary analysis	R	T0 + 6 month
D3	Experimental test results and preliminary analysis	R	T0 + 12 months
D4	Experimental test results and preliminary analysis	R	T0 + 18 months
D5	Technical report of the identification of the material model	R	T0 + 18 months
D6	Technical report of the simulations of the impact tests including the models (model databases, Ls-Dyna input files)	R	T0 + 24 months

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D7	Experimental test results, database and final report(s) The database shall include data such as videos and results files for further investigation (format to be agreed with Safran HE).	R	T0 + 24 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
MS 1	1st Progress Review: validation of experimental set-up and test programme	RM	T0 + 2 months
MS 2	2nd Progress Review: Hopkinson bar campaign completed, presentation of the results + ongoing impact tests.	RM	T0 + 12 months
MS 3	Final Review: Model validation, TRL review	RM	T0 + 24 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 Mechanical, Material Testing, Manufacturing and Methods will be required for supporting the experimental investigations. The applicant should be specialized in transient dynamics and shock physics.
A strong experimental expertise in impact testing and high strain rate material characterization is mandatory. The capability for conducting experimental investigations on test specimens is then also mandatory. The applicant should be familiar with high time resolution measures, high speed video recording, digital image correlation and also have a Photonic Doppler Velocimeter system to perform the required tests.
Strong expertise in numerical simulations and analysis with test correlation is required and in particular with LS-Dyna.
Capability to repair in a short timeframe any damage occurring to the test equipment during the test campaign.
Capability to machine or sub-contract the machining of the test samples.

5. Abbreviations

ITD	Integrated Technology Demonstrator
LP	Low Pressure
Ni	Nickel alloy
TiAl	Titanium-Aluminium alloy

VIII. Numerical and experimental study of high speed radial flow compressors

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 3.2		
Indicative Funding Topic Value (in k€)	450		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[46]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-30	**Numerical and experimental study of high speed radial flow compressors**
Short description	
The activity will focus on compressor air flow which will be analyzed in a dedicated compressor test module. The experimental part will investigate in particular the stalling behavior in a high-speed radial compressor. Detailed measurements of the internal flow will be performed to help understanding the transient behavior of the compressor. The effects of stage matching (variable IGV) on the surge limit will be studied and CFD predictions at off-design conditions will be performed.	

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

1. Background

As a part of engine projects in Clean Sky 2, the topic manager will lead the design and development of gas turbine technologies for short range engine market (WP3 of Engine ITD). One of the key technologies developed to meet the goals of WP3 is an efficient low pressure system. One of the goal on compressor component is to assess its stability and efficiency. The need has been thus identified to increase the understanding of internal flow patterns, in particular the stall phenomenum and the effect of inlet guide vanes (IGV).

2. Scope of work

The purpose of the project is to progress on radial flow compressor technology involving inlet guide vanes and passive flow control technologies. The goal is both to increase surge margin by pushing back the compressor surge line and to enhance engine operability by an improved control of the compressor stability.

The activity will therefore focus on compressor air flow which will be analyzed on a high speed radial flow compressor test module. The experimental part will investigate in particular the stalling behavior in a high-speed radial compressor. Detailed measurements of the internal flow will be performed to help understanding the transient behavior of the compressor. The effects of stage matching (variable IGV) on the surge limit will be studied and CFD predictions at off-design conditions will be performed

Four main tasks are identified, which are listed hereafter.

Task1: Management

Organization:

- The partners shall nominate a team dedicated to the project and should inform the consortium program manager about the name (s) of this key staff

Time schedule and work-package description:

- The partners will work to the agreed time-schedule and work-package description
- Both the time-schedule and the work-package description laid out in this call shall be further detailed and agreed at the beginning of the project.

Progress reporting and reviews:

- The progress reports (i.e. deliverables) will be written over the duration of the program
- The full experimental database will be made available to the topic manager before the end of the program
- For all work packages, technical achievements, timescales, potential risks and proposal for risk mitigation will be summarized
- Regular coordination meetings shall be conducted via telecom or webex when appropriate
- The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information
- The partners shall support regular face-to-face review meetings to discuss the progress

Task 2 : Numerical study

It is expected that the partner has already readily available numerical tools to perform the tasks. The numerical simulations and areas of study will be agreed prior to starting the project. But it is already intented to perform RANS and URANS computations.

The partner will propose methodologies to be applied for CFD predictions at off-design conditions. The purpose will be to support and help understanding experimental results.

Task 3 : Experimental test campaign

The partner will propose an experimental installation in order to test a radial flow compressor module. In particular, the test rig shall be heavily instrumented.

The type of measurements, which are listed below, are required to be performed on the test module:

- LDA mesurements
- High frequency pressure measurements (about 50 locations)
- Static pressure measurements (about 100 measures)
- Temperature measurements (about 20 positions)

The partner shall ensure to have appropriate equipment and material for testing the compressor module, measuring the flow and recording the data. The partner will in particular deliver, in adequate format for SafranHE, an experimental database with:

- Unsteady pressure measurements including thermal measurements
- Velocity measurements within the rotating parts.

The LDA database shall in particular be such as to evaluate the capabilities of existing NS3D numerical tools, in particular for off-design conditions.

The detailled test programme will be agreed prior to starting the project. Several isolines will be studied at various configurations (with/without passive air flow control techniques, with/without air bleed, various IGV positions). At this stage, about 600 module running hours are estimated.

Main characteristics of the compressor test module

- Estimated needed power: 1 MW
- Rotational speed : 60000 RPM
- Air mass flow 3.5 kg/s

The preliminary test matrix is presented in table 1 together with the associated legend in figure 1.

	IGV positions			
	Stagger angle 1 - REF	Stagger angle 2	Stagger angle 3	Stagger angle 4
Isospeed 1 - REF	● ● ●	●	●	●
Isospeed 2	●	●	●	●
Isospeed 3	●	●	●	●
Isospeed 4	●	●	●	●
Isospeed 5	●	●	●	●
Isospeed 6	●	●	●	●
Isospeed 7	●	●	●	●

Table 2: Preliminary Test Matrix

●	1D performance
● (red)	air bleed
● (green)	IGV clocking

Figure 12: Legend of table 1

Task 4 : Analysis

The analysis of the results shall enable to progress on the understanding of:

- Influence of compressor air bleed
- Influence of IGV positions
- Influence of IGV clocking
- Radial diffusor behaviour
- Effects of passive flow control

The analysis will be based on both experimental and numerical results; simulations will be assessed based on the experimental data.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	***Management*** • Progress reports 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 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 premise.	T0 + 48 months

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 2	***Numerical study*** • To perform numerical studies to help understanding experimental results and analyzing the air flow behavior (RANS, URANS) • To propose methodologies and rules for CFD computations including meshes	T0 + 48 months
Task 3	***Experimental test campaign*** • To install the compressor test module • To perform the experimental test programme • To deliver the resulting experimental database	T0 + 46 months
Task 4	***Analysis*** • To compare experimental & CFD results • To present & to analyse the test results • To propose methodologies for CFD computations • To propose areas of improvements	T0 + 48 months

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Report on test rig installation	R	T0 + 6 months
D2	First Progress Technical Report (test results)	R	T0 + 12 months
D3	Second Progress Technical Report (test results + CFD computations)	R	T0 + 24 months
D3	Third Progress Technical Report (test results + CFD computations)	R	T0 + 36 months
D4	Experimental database	D	T0 + 46 months
D5	Final Technical Report (including updated methodology, comparison between test results and simulations, analysis)	R	T0 + 48 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
MS 1	Test rig operational	RM	T0 + 6 months
MS 2	First Intermediate technical review	RM	T0 + 12 months
MS 3	Second Intermediate technical review	RM	T0 + 30 months
MS 4	Final Review with TRL evaluation	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 and Methods will be required for supporting the experimental investigations.

Strong expertise in numerical simulations and analysis is required.

The partner will demonstrate to have recognized skills in:

- Conducting aero measurements applied to high speed radial compressor
- Conducting experimental investigations
- Performing steady and unsteady numerical analysis

5. Abbreviations

CFD	Computational Fluid Dynamics
IGV	Inlet Guide Vane
LDA	Laser Doppler Anemometry
NS	Navier Stokes
RANS	Reynolds Average Navier Stokes
URANS	Unsteady Reynolds Average Navier Stokes

IX. Unsteady pressure sensor for high pressure and hot environment

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 3.2		
Indicative Funding Topic Value (in k€)	300		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[47]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-01-31	**Unsteady pressure sensor for high pressure and hot environment**
Short description	
Development and delivery of 8 probes for unsteady pressure measurements in harsh conditions: 15bars, 1400K and a 5kHz+ bandwidth. The probes will be dedicated to combustion chamber walls measurements.	

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

1. Background

As a part of engine projects in Clean Sky 2, the topic manager will lead the design and development of gas turbine technologies for short range engine market (WP3 of Engine ITD). One of the key technologies developed to meet the goals of WP3 is the effective management of combustion instabilities and noise.
In order to develop knowledge around combustion instabilities and combustion noise, measuring pressure fluctuations within the harsh environement of the combustion chamber is essential. Previous experiments with cooled microphone probes have shown that high pressure is also a real obstacle in obtaining reliable pressure measurements.
The designed probes will be dedicated to combustion chamber walls measurements.

2. Scope of work

The purpose of the project is to develop a new wall-mounted pressure probe design, to measure from the combustor wall unsteady pressure with good reliability over a bandwidth greater than 5kHz.
This probe will be able to deal with the harsh environmental condition of the combustor (15 bars, 1400K).
Prototype(s) will be manufactured and tested under representative conditions.
8 final probes will be delivered, once capability has been demonstrated.

4 main tasks are identified, which are listed hereafter.

Task1: Management

Organization:

- The partners shall nominate a team dedicated to the project and should inform the consortium program manager about the name (s) of this key staff

Time schedule and work-package description:

- The partners will work to the agreed time-schedule and work-package description
- Both the time-schedule and the work-package description laid out in this call shall be further detailed and agreed at the beginning of the project.

Progress reporting and reviews:

- Four progress reports (i.e. deliverables) will be written over the duration of the program
- The full experimental database will be made available to the topic manager before the end of the program
- For all work packages, technical achievements, timescales, potential risks and proposal for risk mitigation will be summarized
- Regular coordination meetings shall be conducted via telecom or webex where appropriate
- The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information
- The partners shall support quarterly face-to-face review meetings to discuss the progress

Task 2 : Probe Design

A specification document will be issued listing:

- Environmental conditions

- Mechanical interfaces
- Expected performances

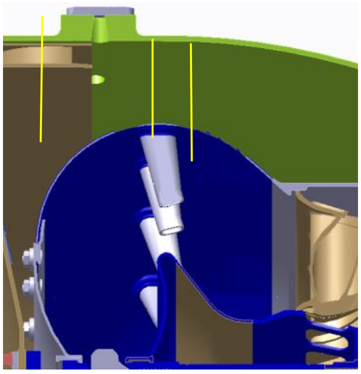


Figure 13 : 3 potential locations of pressure probes on an engine combustor

A scientific survey will be performed to select the more appropriate design to meet specifications.
A preliminary design will be proposed as a result.
A preliminary test plan, where the means of compliance with respect to the specifications will be described. Special care will be taken on demonstrating acoustic performance (sensitivity, bandwidth) under the requested environmental conditions (15 bars, 1400K).
These two upper items will be submittted / discussed / amended / approved during a Preliminary Design Review (PDR) Meeting.
Probe Design and test plan will be finalised, manufacturer and manufacturing processes identified and delivery and prototypes test schedule secured for the Critical Design Review (CDR) Meeting. Reception tests schedule will also be proposed.

Task 3 : Prototype Probes Manufacturing and testing
The required number of Prototype Probes to achieve the test plan will be manufactured, controlled and tested. Potential shortcomings will be adressed, should they lead to modifications in probe design.
A performance assessment will be performed and presented during a Post Test Review (PTR), together with potential design modifications.

Task 4 : Manufacturing of final probes and reception tests
8 final probes will be manufactured, taking into account potential changes from PTR, controlled and tested according to the reception plan before delivery. Their documentation will include final drawings, and reception test results.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	***<u>Management</u>*** • Progress reports 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 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 + 30 months
Task 2	***<u>Probe Design</u>*** • A survey will be conducted listing the former realisations of such probes. After a pros and cons status a new probe design will be proposed. • Acoustic modelling of the behaviour of the probe is highly encouraged. • A preliminary test plan will be proposed to demonstrate how envirnmental conditions will be met. • Partners will show why this new concept should respect the specifications during a PDR Meeting. • If successful, probes design will be launched. • In the meantime, qualification tests will be listed, defined and scheduled in order to verify how specifications will be met. • End of design will be pronounced during a CDR Meeting, where verification tests and manufacturing schedules will also be proposed.	T0+12months
Task 3	***<u>Probe Prototypes manufacturing and testing</u>*** If CDR is successful, a sufficient number of prototypes will be realised to ensure the test plan. According to tests results, the possibility for a design modification loop must be kept. A performance assessment will be realised at the end of the test plan, and the needed design modifications validated.	T0+20months
Task 4	***<u>Manufacturing of final probes and reception tests</u>*** • Manufacturing of the 8 final probes according to final plans • Control • Reception tests (with documentation) • Probes Delivery	T0+30months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	Probes survey	R	T0 + 3 months
D2	Preliminary Design	R	T0 + 6 months
D3	Critical Design	R	T0 + 12 months
D4	Tests Description and Qualification Schedule	R	T0 + 12 months
D5	Prototypes	D	T0 + 20 months
D6	Tests Results	R	T0 + 20 months
D7	Final Design Report	R	T0 + 30 months
D8	Final Probes and Compliance test results	D	T0 + 30 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
MS 1	Preliminary Design Review (PDR)	RM	T0 + 6 months
MS 2	Critical Design Review (CDR)	RM	T0 + 12months
MS 3	Post-Tests Review	RM	T0 + 20 months
MS 4	Final Meeting	RM	T0 + 30 months

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

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

Skills such as Acoustics, Aerodynamics, Thermo-Mechanics and Materials will be required for supporting the design step of this project.

Strong manufacturing capability will also be necessary to ensure repeatability in the manufacturing process.

Capability of control is needed to identify potential deviations in manufacturing from the design expectations.

Testing is also a strong point in this project, and reaching the probes environmental targets will dictate adapted capabilities and skills on how to operate them.

X. Experimental investigation of aerodynamic and heat transfer properties for a next generation turbine frame and nozzle

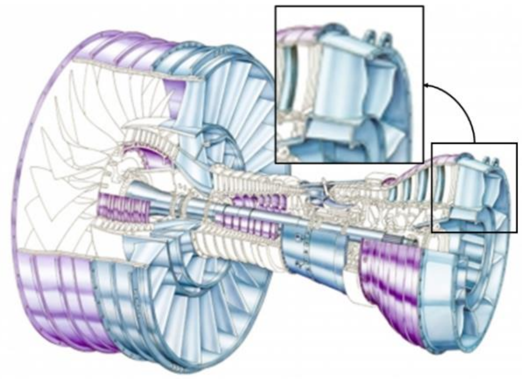
Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP4.4.4 - Lightweight TEC / Exhaust System		
Indicative Funding Topic Value (in k€)	800		
Topic Leader	GKN Aerospace Sweden	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[48]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-02-06	**Experimental investigation of aerodynamic and heat transfer properties for a next generation turbine frame and nozzle**
Short description	
Experimental aerothermal investigation of novel integrated concepts of low-pressure turbine frame and nozzle for the next generation geared aeroengines	

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

1. **Background**

The demands for reduced environmental impact of air transport in combination with increasing global competition on all supplier levels in the aero engine business drives innovation and improvement in component design.



The goal of this work is to demonstrate the feasibility and benefits of novel aerodynamic concepts of the turbine rear structure (TRS) and the gains of the aerodynamic integration of the TRS with the core exhaust nozzle. The results of this work should lead to better TRS/integrated TRS-core exhaust nozzle designs which allow for enhanced engine performance, in terms of optimized aerodynamic performance and high temperature capability, and for reduced component weight.

The turbine rear structure (TRS) is the annular structure located downstream of the low-pressure turbine (LPT) which has as main function to support the engine rear bearings. It is comprised of an outer ring, an inner ring and radial struts connecting them both. These struts may be aerodynamically shaped as outlet guide vanes (OGV) or may be placed inside thin walled fairing OGVs. In addition, a number of struts also serve as passages for oil and air transport. The TRS also incorporates the engine mounts by which the rear of the engine attaches to the engine pylon in an under-the-wing arrangement.

Aerodynamically, the OGVs remove the swirl or the LPT exit flow as it passes through the TRS. A good aerodynamic design is crucial for achieving low pressure losses, minimum disturbances to the upstream LPT and a well-behaved core jet flow. Downstream of the TRS the air enters the core exhaust nozzle which accelerates the flow before it exits as the core jet. The TRS together with the core exhaust nozzle can be seen as to function together as a unit and are hereafter denominated as “engine exit module (EEM)”.

The Topic Manager is developing innovative engine exit technologies for a second generation geared aeroengine architecture. Selected technologies will be demonstrated in a downscaled engine test but the aerodynamic technologies being developed need separate component validation and thermal characterization in dedicated rig tests where detailed measurements of significant aerothermal features are possible.

2. Scope of work

The second generation geared aeroengines will require engine exits that are lighter, have improved aerodynamic performance in cruise conditions and that can withstand the wider temperature range product of the smaller core engine design.

An approach to meet these conflicting requirements is to use a separated functionality configuration (i.e., a configuration where the aerodynamic function is realized by a fairing enclosing the structure which fulfils the load-carrying structural function), and take advantage of not having the structural and manufacturing constrains of the structural struts in the design of the OGVs. In addition, in a separated functionality configuration, the aerodynamic design of the TRS can also be integrated with that of the core engine nozzle allowing for even more design alternatives.

Based on this approach, a number of innovative aerodynamic concepts have been proposed. However, as they depart in some cases substantially from the current designs, experimental proof-of-concept and further development is needed before they can be incorporated into the Topic Manager product offer.

The work proposed here aims to validate experimentally the performance of novel aerodynamic designs and generate an experimental database to be used in the design of the engine exit module by the Topic Manager. Effects on the flow of construction details particular to separated functionality configurations need also be studied. Also, the convective heat transfer for these designs needs to be measured so that the thermomechanical behaviour of the engine exit can later be assessed.

The following paragraphs describe the type of experimental investigation needed, the conditions required for the tests, the engine exit module builds to be investigated, and the requirements for the experimental facility and measurements. Finally, a test matrix is proposed.

Experimental investigations:

1. Flowfield and aerodynamic performance measurements: flowfield in terms of pressure and velocities at a number of planes, total pressure loss, turbulence intensity and lengthscale, static pressure distribution on OGV and endwalls, flow visualization on OGV and endwalls.
2. Mapping of convective heat transfer: Heat transfer coefficient (HTC) on OGV and endwalls. HTC on the OGVs leading edge is critical.

Test conditions:

1. On and off-design conditions: performance of the engine exit in a range of LPT operating conditions (in terms of mass flow rate/Reynolds number, rotational speed, flow swirl angles at the outlet[49]).
2. LPT cavity purge flow: with and without purge flow from the LPT cavity into the gas path.

Engine exit module builds:

Four different builds are planned to be studied;

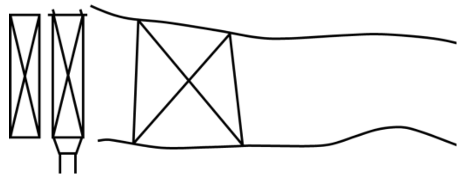
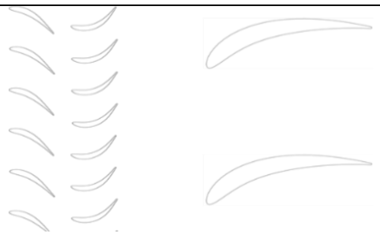
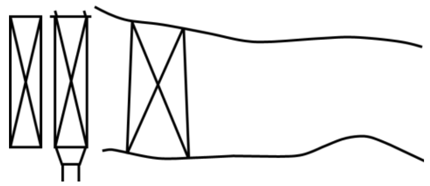
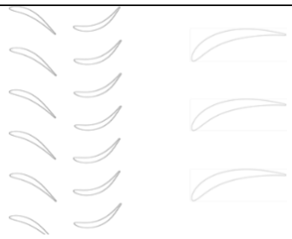
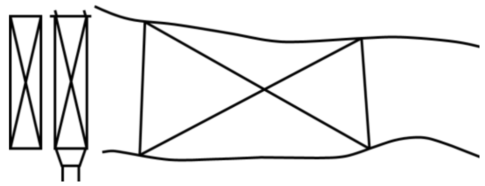
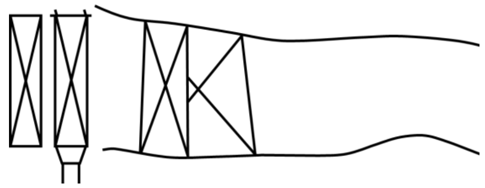
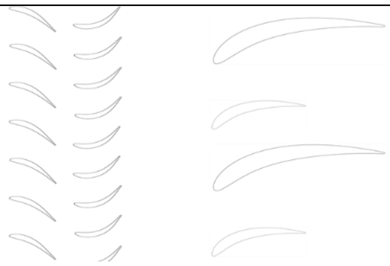
1. Ultra-low loss EEM
2. Compact/short EEM: High vane count and short/aggressive plug (increased slope angle and/or tailored curvature)
3. Integrated EEM: Low or ultra-low vane count
4. Circumferentially non-uniform vane pattern EEM: Thick/thin vane arrangement or structural/splitter

[49] Values and ranges are given in " *Experimental facility and required measurements"*

vane arrangement

Also the effect of real geometry effects such as fastening devices, steps, gaps and surface imperfections on the flow and heat transfer will be studied in one or several of the configurations.

Table below shows sketches of how configurations 1-4 could potentially look like.

1.		
2.		
3.		
4.		

Experimental facility and required measurements

It is necessary for the studies to be performed in an engine realistic environment. The experimental facility should include a low-pressure turbine (LPT) stage in order to generate realistic inflow to the test EEM. The characteristics needed for the facility are:

- The size of the LPT should be such that high spatial resolution for the measurements in the TRS is possible. It is estimated that an LPT blade height of at least 100 mm at the outlet is needed for the required highly spatially resolved flowfield measurements.
- The approximate Reynolds number (based on the LPT exit height and the axial speed) at the aerodynamic design point (ADP) should be 400000.
- The upstream LPT stage should be representative for a geared aeroengine configuration in terms of flow coefficient, load coefficient and turbine exit swirl angle ($\alpha = atan(V_\theta/V_x)$); in accordance with: Φ ~

0.65, Ψ ~ 1.70, α ~ 20 deg., all at ADP.

- The LPT stage should be of a shrouded design and have a hub-to-tip ratio of approximately 0.6 (The LPT exit mean radius is estimated to be of about 400-500 mm).
- In order to be able to cover the needed OGV off-design points, the range of LPT outflow swirl angle at midspan should at least be: ADP+10 deg. to ADP-30 deg. (30 deg. to -10 deg.)[50].
- The facility should be able to vary the inlet conditions so that Reynolds numbers in the range of 50% ADP to 125% ADP (200000 to 500000) can be obtained.
- The facility should have the capability of providing realistic sealing/purge flow between the LPT platform and the TRS inner casing. The geometry of the seal should be representative of a real engine. The flowrate of the sealing/purge flow should be adjustable where values of between 0% and at least 1.5% of the main mass flow rate can be achieved. It should be possible to regulate the temperature of this flow at least in the range of -10K to 10K relative to the main flow temperature. .

Regarding the required measurements, it is of significant importance that necessary flowfield details can be resolved and that total pressure losses can be assessed based on the test data acquired. It is also important that the experimental data can be used to verify the design robustness in terms of off-design performance. The test should be designed to include the following instrumentation:

- Traverse using a 5-hole probe or similar able to covering a complete OGV pitch (20-60 deg. depending on configuration vane count) at EEM inlet and preferably 180 deg. or more at EEM exit in order to capture features of circumferentially non-uniform vane pattern EEM (build 4).
- Radial hot-wire traverse at EEM inlet and at least one station downstream to determine turbulence level and decay.
- Surface pressure measurements on OGV and endwalls.
- Heat transfer measurements: One of the goals of the study is to correlate secondary flows, flow separation, boundary layer transition to turbulence and convective heat transfer on the surfaces. Therefore the experimental technique uses should have the capability of mapping the heat transfer distribution on the surfaces (outer casing, inner casing and OGV).
- Possibility to apply surface oil flow visualization or similar to capture average surface streamlines on OGV and endwalls.
- Means to determine the extent of the region where the flow is “unattached” (where the boundary layer separates) for off-design inlet conditions.
- Means to obtain the location on the OGV where the laminar boundary layer transitions to turbulent.

[50] Swirl angle defined positive in the direction of rotation of the LPT.

Test matrix

The cases to be investigated are shown in the following table:

	Test	Conditions		Real geometry effects	Aero measurements		Surface flow vis	Heat transfer	
		Operating points	Leak-age		HW	5HP		Radial T profile inlet	Surface HTC
Build 1	1	ADP	Y	-	Inlet	2-4 planes	Y	Y	Y
	2	ADP	N	-	-	2-4 planes	Y	Y	Y
	3	ADP	Y	Y	-	2 planes	-	-	-
	4	ADP	N	Y	-	2 planes	-	-	-
	5	OD1	Y	-	-	2-4 planes	Y	Y	Y
	6	OD1	N	-	-	2-4 planes	Y	Y	Y
	7	OD2	Y	-	-	2-4 planes	Y	Y	Y
	8	OD2	N	-	-	2-4 planes	Y	Y	Y
Build 2	9	ADP	TBD	TBD	-	2-4 planes	Y	-	-
	10	OD1	TBD	TBD	-	2-4 planes	Y	-	-
	11	OD2	TBD	TBD	-	2-4 planes	Y	-	-
Build 3	12	ADP	TBD	TBD	-	2-4 planes	Y	-	-
	13	OD1	TBD	TBD	-	2-4 planes	Y	-	-
	14	OD2	TBD	TBD	-	2-4 planes	Y	-	-
Build 4	15	ADP	TBD	TBD	-	2-4 planes	Y	-	-
	16	OD1	TBD	TBD	-	2-4 planes	Y	-	-
	17	OD2	TBD	TBD	-	2-4 planes	Y	-	-

The test matrix is preliminary and it will be updated and further detailed based on proposal by Partner. Also changes might arise from evaluation of the results of the tests.

The data will be processed, analysed and shared with the Topic Manager directly after being produced. A decision on how to proceed and eventual changes in the test plan and test matrix will be made if necessary. The format of the data files and the service used to share them shall be agreed at the beginning of the project.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T0.1	Management ● The Partner shall nominate a team dedicated to the project and should inform the Topic Manager about the name/names of key personnel. ● The Partner shall follow the agreed time-schedule and work package description. The time-schedule and work package description outlined in Section 3 will be further detailed and agreed during negotiation based on the Partner proposal. ● Quarterly progress reports in writing shall be provided by the Partner, referring to Work Packages, technical achievement, time schedule and potential risks and mitigations. ● Regular coordination meetings (face-to-face, Webex, link-call, etc.) shall be scheduled and held.	M30
T1.1	Build 1 test object design ● Design of the experimental setup is to be performed by the Partner ● Mechanical design of the test object is to be performed by Partner. ● Specifications and CAD geometry of the LPT and experimental facility (relevant areas) will be shared with the Topic Manager. ● Aero-design will be supplied by Topic Manager at M03. A representative geometry will be provided earlier in order for the partner to perform the design of the experimental setup.	M04
T1.2	Manufacture and setup of test build 1 ● The Partner is responsible for CAD models and/or drawings required for procurement and manufacturing of the necessary rig hardware to perform the test. ● The Partner is responsible for manufacture/purchase of the test hardware.	M07
T1.3	Test of build 1 ● The aerodynamic testing shall be performed in accordance with the Partner's expertise and based on the requirements of the study detailed in Section 2. ● Heat transfer measurements shall be performed using a previously demonstrated technique and the method needs to produce heat transfer surface maps (surface distribution). ● Instrumentation and test matrix shall be in accordance with details outlined earlier in Section 2.	M14
T2.1	Build 2 test object design ● Mechanical design is to be performed by Partner. ● Aero-design will be supplied by Topic Manager.	M12

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T2.2	Manufacture and setup of test build 2 • The Partner is responsible for CAD models and/or drawings required for procurement and manufacturing of the necessary rig hardware to perform the test. • The Partner is responsible for manufacture/purchase of the test hardware.	M15
T2.3	Test of build 2 • The aerodynamic testing shall be performed in accordance with the Partner's expertise and based on the requirements of the study detailed in Section 2. In addition any lessons-learned from build 1 testing shall be considered. • Instrumentation and test matrix shall be in accordance with details outlined earlier in Section 2.	M19
T3.1	Build 3 test object design • Mechanical design is to be performed by Partner. • Aero-design will be supplied by Topic Manager.	M17
T3.2	Manufacture and setup of test build 3 • The Partner is responsible for CAD models and/or drawings required for procurement and manufacturing of the necessary rig hardware to perform the test. • The Partner is responsible for manufacture/purchase of the test hardware.	M20
T3.3	Test of build 3 • The aerodynamic testing shall be performed in accordance with the Partner's expertise and based on the requirements of the study detailed in Section 2. In addition any lessons-learned from build 1 & 2 testing shall be considered. • Instrumentation and test matrix shall be in accordance with details outlined earlier in Section 2.	M25
T4.1	Build 4 test object design • Mechanical design is to be performed by Partner. • Aero-design will be supplied by Topic Manager.	M22
T4.2	Manufacture and setup of test build 4 • The Partner is responsible for CAD models and/or drawings required for procurement and manufacturing of the necessary rig hardware to perform the test. • The Partner is responsible for manufacture/purchase of the test hardware.	M25

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T4.3	<u>Test of build 4</u> ● The aerodynamic testing shall be performed in accordance with the Partner's expertise and based on the requirements of the study detailed in Section 2. In addition any lessons-learned from build 1-3 testing shall be considered. ● Instrumentation and test matrix shall be in accordance with details outlined earlier in Section 2.	M29

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D0.1	Project management plan - detailed schedule, description of team structure and communication plan.	R	M02
D1.1	Design of test build 1 – complete CAD model of test object, including LPT stage	D	M04
D1.2	Manufacture and setup of test build 1	HW	M07
D1.3	Test of build 1. Aero – data set	D, R	M11
D1.4	Test of build 1. Heat transfer – dataset and experimental report (Aero+Heat transfer)	D, R	M14
D2.1	Design of test build 2 – complete CAD model of test object	R	M12
D2.2	Manufacture and setup of test build 2	HW	M15
D2.3	Test of build 3 – data set and experimental report	D, R	M19
D3.1	Design of test build 3 – complete CAD model of test object	D	M17
D3.2	Manufacture and setup of test build 3	HW	M21
D3.3	Test of build 2 – data set and experimental report	D, R	M24
D4.1	Design of test build 4 – complete CAD model of test object	D	M22
D4.2	Manufacture and setup of test build 4	HW	M25
D4.3	Test of build 4 – data set and experimental report	D, R	M29

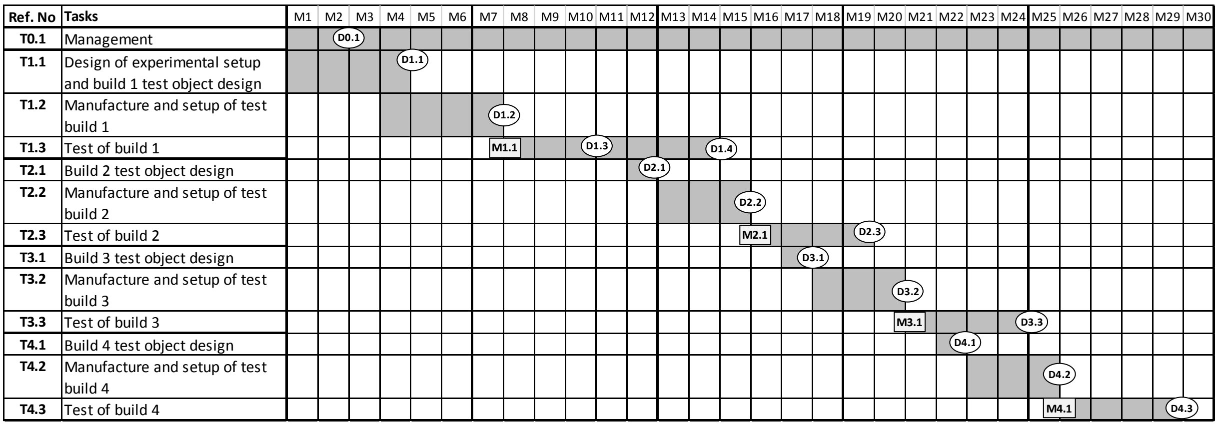
*Types: R=Report, D=Data, HW=Hardware, ECM=Engineering coordination memo

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1.1	Rig commissioning for test build 1	ECM	M07
M2.1	Rig commissioning for test build 2	ECM	M15
M3.1	Rig commissioning for test build 3	ECM	M20

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M4.1	Rig commissioning for test build 4	ECM	M25

*Types: R=Report, D=Data, HW=Hardware, ECM=Engineering coordination memo

All tasks, deliverables and milestones are represented graphically in this overall time-schedule.



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

General:

- The CfP Partner should have a proven track-record in experimental research of the aerodynamics and heat transfer of LPT-OGVs.
- Experience in performing applied collaborative industrial research in international environment is considered essential.

Experimental facility:

- The CfP Partner should have access to an experimental facility which can reproduce engine-realistic conditions for the required operational range:
  - The experimental facility shall have a LPT which provides the inlet conditions to the LPT-OGV. The LPT should have the characteristics described under section "2. Scope of work- Experimental facility and required measurements"
  - The facility should be able to accommodate test objects with a length of up to 5 times the OVG-LPT inlet height.
  - At least one of the configurations to be tested will incorporate endwalls that are not axisymmetric. The facility should be able to test this configuration.
  - The instrumentation of the experimental facility should at least include what is described in section "2. Scope of work- Experimental facility and required measurements" and be able to perform the measurements also mentioned there.

- The complete geometry of the LPT and test section should be shared with the Topic Manager at the start of the project (for CFD validation purposes).

- The CfP Partner should have an established in-house capability or supply chain for the mechanical design and manufacturing of the test objects and modifications of the facility. Short turnaround time for the mechanical design and manufacturing of the test object is essential for the success of the project.

Experimental capabilities

- The CfP Partner should have long experience in flowfield measurements using standard and multi-hole pressure probes and hot-wire anemometry. The partner should also have experience in boundary layer transition measurements in turbomachinery applications.
- The CfP Partners should have proven experience in the measurement of convective heat transfer in turbomachinery flows. IR-thermography is strongly recommended as the choice of experimental technique for these measurements.

5. Abbreviations

5HP	Five-hole (or more general, multi-hole) pressure probe measurements
ADP	Aerodynamic design point
CAD	Computer aided design
EEM	Engine exit module
HTC	Heat transfer coefficient
HW	Hot-wire (anemometry)
IR	Infrared
LPT	Low-pressure turbine
OD1/2	Off-design points 1 and 2
OGV	Outlet guide vanes
T	Temperature
TBD	To be determined
TRS	Turbine rear structure

XI. Aircraft design and noise assessment for a regional application

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 4 Geared Engine Configuration		
Indicative Funding Topic Value (in k€)	400		
Topic Leader	MTU	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	48	**Indicative Start Date**[51]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-ENG-02-07	**Aircraft design and noise assessment for a regional application**
Short description	
The task is to develop aircraft models for the topic manager´s CleanSky2 regional aircraft engine platform. These models shall provide aircraft requirements (e.g. thrusts, offtakes, etc.) as well as trade factors for specific fuel consumption, engine drag and engine weight on fuel burn for both a year 2000 reference aircraft and a CS2 target aircraft, the latter equipped with a geared turbofan engine . In addition an aircraft noise method has to be developed and applied to all A/C designs.	

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

1. Background

In CleanSky2 an environmental assessment on mission level has to be performed by the Technology Evaluator (TE). The role of the TE is to assess the environmental impact of the innovative technologies under development in Clean Sky when integrated into concept aircraft and rotorcraft. It serves to determine the extent of Clean Sky's contribution to the environmental objectives for CO2, NOx, and noise.
As an ITD leader in CleanSky2 the topic manager supports the TE with a geared turbofan engine for a regional aircraft application. The design of an aircraft system (A/C and engine) is an iterative process as both require information from the other. Typically a conceptual aircraft design defines the top level requirements for the engine such as thrusts, offtakes or geometric constraints. This information is then used as boundary condition for a first engine design. This design may in turn have an influence on the initial aircraft assumptions applied for the conceptual design, e.g. in case the engine mass requires adaptations in wing structures. In such cases additional design loops are required until the optimum design is found.
Environmental aspects become more and more important. Therefore an early assessment not only in terms of CO2 but also for NOx and noise is inevitable especially when trying to keep the need for additional design loops low.

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 the topic manager about the name/names of this key staff. At least the responsibility of the following functions shall be clearly addressed: Program (single point contact with the topic manager), 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).	During the whole Project

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	• The partner shall report and organise review meetings and provide adequate level of information. • The review meetings shall be held in the topic manager´s facility. **General Requirements:** • The partner shall work to an established standard process.	
WP2	**WP2 Development of year 2000 reference A/C models:** The aim is to develop two aircraft models, one underwing and one rear-mounted configuration for regional application to be used as a reference for the assessment of CS2 technology achievements. The models shall represent a year 2000 state of the art aircraft with a confidence level of 50%. A comparison between the two configurations in terms of emissions shall be conducted. This includes efficient basic assessments of aircraft noise with minimum required user input on the level of semi-empirical methods. These methods shall be implemented as a stand-alone tool that is provided to the topic manager including the source code and an unrestricted right of exploitation. It shall be possible to easily integrate engine designs provided by the topic manager. Therefore a generic engine/aircraft-interface shall be developed and applied allowing for fast design iteration loops ideally on a continuous integration basis. A profound experience of the effects of engine cycle, mechanical and aerodynamic design parameters on overall aircraft design and performance is indispensable. Sensitivity studies shall be applied to valuate these effects in order to end up with the optimum A/C system design. As the reference A/C models are used in WP3 as basis for a delta fuel burn assessment trade factors have to be provided accounting for the influence of changes in engine design on aircraft level. As the application of linear trade factors may not be sufficiently accurate anymore when moving further away from the reference, an advanced trade factor methodology shall be developed. The data to be provided to the TE for mission analysis has to meet the requirements defined by the TE in terms of metric and format.	T0+12M
WP3	**WP3 Development of CS2 target A/C models:** The aim is to develop two aircraft models, one underwing and one rear-mounted configuration for regional application implying CS2 target technology level. Reasonable technological improvements in aerodynamics, structures and A/C systems shall be implied. Therefore the target design shall include representative technology assumptions for the envisaged timeframe of 2025+. In addition the target A/C	T0+48M

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	designs shall incorporate future realistic operational conditions and the interconnection of other transportation modes for the anticipated timeframe. Under consideration of future passenger requirements additionally different scenarios based on general market forecast information shall be investigated on a global scale. A best and balanced payload/range A/C design shall be elaborated and compared to the basic CS2 target design in order to illustrate the impact of such influences on the overall system design. As for the reference all A/C designs shall be modelled with a confidence level of 50%. During the project phase CO2, NOx and noise assessments have to be carried out implying adaptations in predicted technology improvements. A comparison between the updated target design and the fixed reference has to be conducted in order to illustrate the influence of adapted improvements on CS2 target parameters on overall system level. For the aircraft noise assessment the method developed in WP2 shall be applied. The data to be provided to the TE (DLR) for mission analysis has to meet the requirements defined by the TE in terms of metric and format. On request a documentation of the current status for public presentation shall be provided.	

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Final Report	R	T0+48M
D2.1	Description of reference aircraft designs and results of the comparison between the two configurations. A/C data set for both configurations.	R, D	T0+15M
D3.1	Description of the target aircraft design (underwing mounted engines). A/C data set for the respective configuration to support the 1st TE global assessment report.	R, D	T0+20M
D3.2	Aircraft noise assessment method.	R	T0+24M
D3.3	Software sources and program documentation.	S, R	T0+24M
D3.4	Description of the target aircraft design (rear-mounted engines). A/C data set for the respective configuration to support the 2nd TE global assessment report.	R, D	T0+38M

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D3.5	Report of the comparison of the two different target A/C configurations.	R	T0+46

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Specification of reference A/Cs is finalized.	R	T0+06M
M2	Reference A/C models (report and data sets) and comparison are delivered to the topic manager.	R, D	T0+15M
M3	Target A/C model for underwing mounted engine configuration (report and data set) is delivered to the topic manager.	R, D	T0+18M
M4	Aircraft noise assessment method is developed and validated in terms of functionality and accuracy.	R	T0+20M
M5	Aircraft noise assessment method software and documentation is delivered.	S	T0+24M
M6	Target A/C model for rear-mounted engine configuration (report and data set) is delivered to the topic manager.	R, D	T0+40M
M7	Comparison of the two different target A/C configurations is finalized.	D	T0+44

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

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

The applicant has to have profound experience in the conceptual design of state of the art and future aircraft. A validated aircraft design program is key for the success of the project and has to be available and in use in the organization of the applicant at the start of the project. For the valid assessment of the possible overall aircraft benefits, practice in the extrapolation from current research topics to future technical applications is required. This necessitates a team consisting of multiple, technical and scientific disciplines.

For the creation of sensitivity studies the capability of the exploration of a vast number of designs is essential and the methods applied by the applicant have to be able to create and assess these amount of aircraft designs fast and several times during the project duration.

Since the project requires a close cooperation with the topic manager the applicant shall have experience in working with an industrial aircraft engine manufacturer. This includes the means to set up the contractual framework for the cooperation as well as familiarity with the exchange of confidential data sets.

For the task of the stand-alone noise tool the applicant has to be willing and capable to develop, share and support the application and its source code with the topic manager.

The findings of the project shall be made available to the industrial and scientific community. Therefore the applicant has to have ample experience in scientific publishing.

The applicant(s) should be able:

- To conduct overall aircraft assessment with a validated (preferable commercial) integrated design tool which is already available to the applicant and with which he has profound experience
- To create and assess aircraft designs with technologies reflecting the state of the art, near term technologies and the technologies extrapolated from current developments to time frames including and beyond 2025
- To rapidly design a great number of aircraft designs based on changing design parameters
- To cooperate with a commercial engine manufacturer including experience in the contractual set up and the handling of intellectual property and the exchange of detailed data sets
- To develop, openly share and support applications and their source code of specific modules within the applicable H2020 IPR Framework and during the execution of the project
- To publish and distribute knowledge in the industrial and scientific community

5. Abbreviations

A/C	Aircraft
TE	Technical Evaluator

XII. Optimization of TiAl CALPHAD databases of respective material systems

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP4 Geared Engine Configuration		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	MTU	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[52]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-02-08	**Optimization of TiAl CALPHAD databases of respective material systems**
Short description	
The intent of this call is to develop an advanced CALPHAD database for TiAl materials. Available thermodynamic databases are not capable to calculate the newest generation TiAl alloys as accurate as necessary and therefore need to be improved by further experimental investigation of missing ternary phase diagrams. The resulting simulation capability will enable to optimize and tailor TiAl compositions and manufacturing processes more efficiently to widen the application range of light weight TiAl turbine engine components.	

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

1. Background

First aero engine parts manufactured out of TiAl material have succesfully been introduced into series production. To make use of all benefits of this new class of light weight, heat resistant TiAl alloys, further optimization of composition and microstructure has to be achieved. Experimental trial-and-error procedures are not appropriate to achieve this goal due to the interaction of more than 7 major elements and multiple phases in next generation TiAl alloys.
It has been proven in the field of widely used Nickelbase Superalloys that this challenge of efficient alloy optimization can be solved by the CALPHAD approach. Also the so called “TNM” TiAl alloy was designed and optimized in that way. The key to success is a precisely assessed thermodynamic database. The fundament of these databases are experimentally determined binary and ternary phase diagrams which enable the extrapolation of properties for more complex compositions.
It has been found that there are many lacks of high quality experimental phase diagram data to improve the accuracy of previously mentioned databases. The objective of this call is to generate thrustable experimental data of missing systems and to optimize respective thermodynamic descriptions.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
WP 1	**Management** **Organisation:** The partner shall nominate a team dedicated to the project and should inform MTU Aero Engines´ project manager about the name/names of this key staff. At least the responsibility of the following functions shall be clearly addressed: Program (single point contact with MTU Aero Engines), Techniques & Quality. **Time Schedule & Work package Description:** • The partner is working to the agreed time-schedule & work package description. • Both, the time-schedule and the work package description laid out in this call shall be further detailed as required and agreed at the beginning of the project. **Progress Reporting & Reviews:** • Quarterly progress reports in writing shall be provided by the partner, referring to all agreed work packages, technical achievement, time schedule, potential risks and proposal for risk mitigation. • Regular coordination meetings shall be installed (preferred as telecon). • The partner shall support reporting and agreed review meetings with reasonable visibility on its activities and an adequate level of information. • The review meetings shall be held in MTU Aero Engines´ facility. **General Requirements:** • The partner shall work to a established standard process.	During the whole Project
WP 2	WP2 sample preparation • Levitation melting of high purity melt buttons	T0+24M

Tasks		
Ref. No.	***Title - Description***	***Due Date***
	• Detailed analysis of the 5 main ternary systems Ti-Al-x (x=Nb, Mo, W, O, B), additional investigations on the 2 quaternary Ti-Al-Nb-Mo and Ti-Al-Nb-W systems to determine the impact of the Mo and W addition on the stability of the B82 (ordered Omega) phase and determination of missing data points in the 3 ternary systems Ti-Al-y (y= Zr, C, Si) with high impact on accuracy of databases for TiAl alloys which contain up to 5 at.% Zr, C, Si. • Equilibrium heat treatments in oxygen free atmosphere up to solidus temperature • Composition analysis on different length scales after melting and heat treatment	
WP 3	WP3 Metallographic inspection of low temperature regimes • LOM, SEM, EBSD and XRD for the determination of phase fractions • Calorimetric investigations of respective material systems • ESMA for the determination of phase compositions • DTA for the determination of phase transition temperatures	M3+27M
WP 4	WP4 Phase analysis at high temperature • In-situ high energy X-ray inspection of phase fractions and phase transition temperatures	M6+30M
WP 5	WP5 High resolution phase analysis • Transmission electron microscopy and atom probe tomographie on new and/or small scale microstructural features	M9+33M
WP 6	WP6 Thermodynamic assessment • Literature study on newly published CALPHAD conform data in TiAl materials • Assessment of generated experimental data into thermodynamic description • Implementation of newly identified phases/ phase structure informations into the CALPHAD description	M12+36 M

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.1	Overview of ternary systems to be manufactured along with individually planed heat treatments and investigation methods	R	M3
D2.1	Interim report on WP2 and provision of the first half of the planned ternary systems	R, HW	M12
D2.2	Final report on WP2 and provision of the second half of the planned ternary systems	R, HW	M24
D3.1	Interim report on WP3 and provision of metallographic data for CALPHAD assessment	R	M15
D3.2	Final report on WP3 and provision of metallographic data for CALPHAD assessment	R	M27

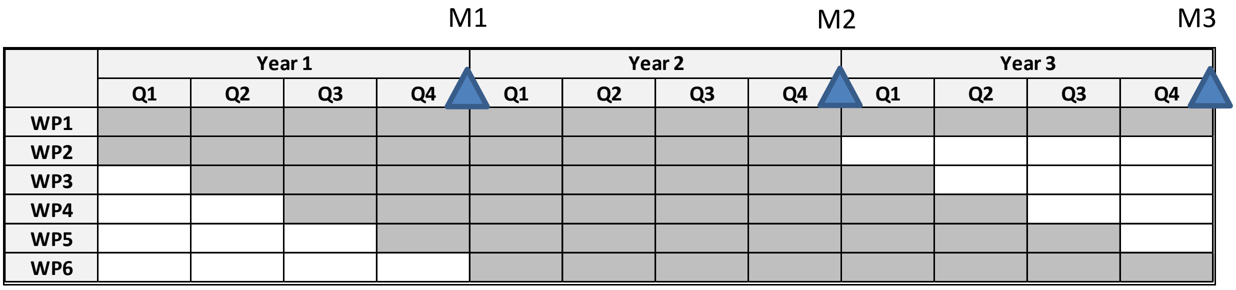
Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D4.1	Interim report on WP4 and provision of high temperature in-situ phase information for CALPHAD assessment	R	M18
D4.2	Final report on WP4 and provision of high temperature in-situ phase information for CALPHAD assessment	R	M30
D5.1	Interim report on WP5 and provision of high resolution phase information for CALPHAD assessment	R	M21
D5.2	Final report on WP5 and provision of high resolution phase information for CALPHAD assessment	R	M33
D6.1	State of the art thermodynamic and mobility TiAl database for MTU internal validation (readable in any standard CALPHAD software)	R, D	M0
D6.2	Optimized CALPHAD databases (readable in any standard CALPHAD software)	R, D	M24
D6.3	Final CALPHAD databases (readable in any standard CALPHAD software)	R, D	M36

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1-	Start thermodynamic assessment and interim report of experimental progress	R	M12-
M2-	Complete sample preparation and final report on WP2	R,D	M24-
M3-	Complete thermodynamic assessment and final report of experimental results-	R,D,HW	M36-

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

Estimated Schedule



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

- Detailed / very good understanding of the TiAl material system, especially the group of TNM™ alloys
- Strong background regarding the derivation of binary and ternary phase diagrams from experimental heat treatment and quenching experiments as well as in situ synchrotron data
- Melt button manufacturing techniques guaranteeing minimum oxygen contamination and high chemical homogenity
- Appropriate measurement methods for the determination of quantitative chemical compositions on different length scales
- Capability to prove the accuracy of chemical analysis by appropriate material standards for TiAl alloys
- Established high quality heat treatment capabilities for TiAl alloys which allow reproducible process conditions, especially in respect to quenching experiments
- Highly skilled in the analysis and combination of metallographic information from different lengthscales generated by various experimental analysis methods
- Expertise in TEM and APM with TiAl alloys for the determination of crystallographic relations, microstructures and compositions of small scale precipitates and phases.
- Expertise in the generation and interpretation of in-situ high energy X-ray inspection data
- Outstanding experience in the field of CALPHAD modelling for metallic and intermetallic materials
- Willingness to give full insight into the developed CALPHAD database, phase-models and parametrization
- Established business concepts for the long term maintenance of developed database

5. Abbreviations

ATM	atom probe microscopy
CALPHAD	calculation of phase diagrams
DTA	differential thermal analysis
EBSD	electron backscatter diffraction
EPMA	electron probe micro analysis
LOM	light optical microscopy
SEM	scanning electron microscopy
TiAl	Titanium Aluminide
TNM	Ti-(42--45)Al-(3-5)Nb-(0.1-2)Mo-(0.1-1)B
XRD	X-ray diffraction

XIII. Emissions prediction for very large bypass ratio turbofans

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 5 – UltraFan® – Middle of Market Technology – WP6 – UltraFan® – Large Engines		
Indicative Funding Topic Value (in k€)	1800		
Topic Leader	Rolls-Royce	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	36	Indicative Start Date[53]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-ENG-03-20	Emissions prediction for very large bypass ratio turbofans
Short description	
Future emissions regulations will dictate limits to smoke mass concentrations as well as particle sizes. Current methods are not able to predict the soot emissions and particle sizes distributions accurately. Existing measurements show that lean burn architectures to be featured in geared large and medium civil turbofan engines can lead to very large numbers of small particulates. Moreover, lean burn calls for operation in pilot and pilot/main modes; the switch from pilot to main operation has to be based on accurate estimation of pollutant species like smoke, CO, and UHC. A programme of work is proposed to deliver accurate and reliable predictive methods for all pollutant species, based on development of advanced emissions and spray models, as the spray has a major effect on emissions.	

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

1. Background

As a part of engine projects in Clean Sky 2, the topic manager will lead the design and development of UltraFan ® technologies for middle of market (WP5 of Engine ITD) and engine demonstrator (WP6 of Engine ITD) for large engine market.

One of the key technologies developed to meet the goals of WP5 and WP6 is a low emission combustion system. 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, which will feature lean burn combustor design concepts.

Whereas at full power conditions soot emissions of lean burn systems are bound to be low, at intermediate power conditions smoke emissions can be significant. Availability of accurate and reliable soot models is required to speed up the combustion system design process with emphasis on usage of realistic fuel surrogates and soot oxidation effects.

The aims of this proposal can be summarized as follows:

Further development of soot models will be based on detailed reaction mechanisms of fuel surrogates closely resembling the properties of kerosene and tested on a wide range of benchmark cases and on existing aero engine combustion systems for which experimental data is available. Particular emphasis will be put on the prediction particle size distribution and oxidation effects. Different soot modelling approaches will be developed and tested. It is expected that two-equation, methods of moments and sectional models will be explored. Comparisons will be carried out to assess trade-offs between predictive accuracy and computational cost offered by these models.

Generation of soot validation data on low TRL test facilities will be required. Measurements have to be performed on laminar and turbulent counter-flow diffusion and swirling flames based on kerosene like fuels. While the current soot models have been developed using experimental data from mainly ethylene flames, ethylene will be used only to provide baseline validation data in the proposed programme. By moving to kerosene like fuels the impact on the soot emissions and underlying kinetics will be investigated.

As spray characteristics have a strong impact on formation of pollutant species, primary break-up models will be developed for use in combustion CFD simulations. Since it is too computationally expensive to resolve all details of the primary break-up as part of the fuel injector design process, as this would imply a spatial resolution of a few µm, phenomenological models will be developed and validated. These models will be validated against experiments and highly resolved numerical simulations, like Volume of Fluid (VOF) and Smoothed Particles Hydrodynamic (SPH).

2. Scope of work

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Project management	M36
2	Development of soot models	M36
3	Assessment of soot models	M36
4	Soot validation experiments	M24
5	Modelling of primary spray break-up	M30

Task 1: Management

Organisation: The partners will nominate a team dedicated to the project and should inform the consortium programme manager about the name/names of this key staff.

Time Schedule & Work package Description: the partners will work to the agreed time-schedule and work-package description. Both the time-schedule and work-package description laid out in this Call will be further detailed as required and agreed at the beginning of the project.

Progress Reporting & Reviews: three progress reports (at the end of every year) will be written over the duration of the programme. For all work packages technical achievements, time schedule, potential risks and proposal for risk mitigation will be summarised.

The partners will support reporting and agreed review meetings with reasonable visibility on their activities and an adequate level of information.

Periodic, 6 monthly, face to face review meetings will be held to discuss progress description. Furthermore, coordination meetings will be conducted via telecom where appropriate.

Task 2: Development of soot models

The requirements for low specific fuel consumption and low emissions lead to large bypass ratio engine architectures and lean burn combustors. While at high power conditions when operating in pilot and main mode lean burn combustors are sufficiently lean that smoke emissions are very low, for operability reasons such combustors operate in pilot only mode at low power conditions. In this case, significant smoke emissions can be produced. Accurate and reliable soot models are required to speed up the design process by means of CFD. This is currently limited due to insufficient accuracy and computational affordability of smoke models. Soot formation and oxidation are dominated by complex physical-chemical processes. Detailed chemistry is important to predict the correct level of soot precursors and Polycyclic Aromatic Hydrocarbons (PAH). Furthermore, an accurate model for the particle size distribution is required. For practical turbulent flames also the chemistry-turbulence interaction has to be taken care of, for both combustion and soot. As the current soot models have been developed mainly on the basis of ethylene experiments, moving to kerosene as fuel can be regarded as an important as well as challenging step forward. In this context, development of accurate kinetics for kerosene fuel surrogates is one of the key areas of focus of the programme of work proposed. Another key area of interest is the soot oxidation. As the surface area of the soot particles depends strongly on the particle size, an accurate prediction of the particles size distribution is required for an accurate prediction of soot oxidation. For the description of the soot particles size distribution different approaches have to be followed; a methods of moments approach and a sectional approach have to be followed and results obtained with these relatively advanced models will have to be compared at least in terms of soot mass concentration with results obtained with simpler two-equation models. The starting point for the methods of moments approach should be the hybrid methods of moments. From a chemistry standpoint, the oxidation pathways and reaction rates have to be examined in detail, especially for aero engine operating conditions.

For the implementation within the ITD leaders CFD code different approaches will be followed. As the soot formation depends strongly on chemistry and in turn has an effect on the chemistry itself as soot pre-cursors species are converted into soot, ideally soot and chemistry should be solved simultaneously. However, detailed reaction mechanisms include a large number of species and reactions, which could lead to very high computational costs. Therefore, reduced reaction mechanisms have to be developed either by the reduction of species and reactions by perturbation methods or by more advanced methods such as Rate Controlled Constrained Equilibrium (RCCE), in which fast species are assumed to be in steady-state. The interaction between chemistry and turbulence should be investigated as well through comparison between stochastic field PDF methods and methods based on a presumed PDF approach. Where the PDF is assumed, a comparison will have to be carried out between tabulated and finite rate chemistry approaches.

The approach of employing detailed or reduced chemistry including soot within CFD will have to be compared with the standard combustion model currently used by the ITD. The standard combustion model is the Flamelet Generated Manifold (FGM) approach in which the soot is largely decoupled from the main combustion process. Since the FGM approach is computationally cheap, trade-offs between predictive accuracy and computational cost associated with the different approaches will be investigated.

The soot models have to be developed and implemented into the in-house combustion CFD code of the ITD leader (PRECISE-UNS).

Task 3: Assessment of soot models

Validation exercises will be carried out by using a range of experimental datasets. Low Technology Readiness Level (TRL) experiments to be performed in task 4 will provide fundamental data for validation of the chemistry and soot models. Furthermore, the ITD leader will provide measurements taken on an in-house intermediate pressure single sector rig, which will allow assessing the models' capability at intermediate pressures. Eventually, detailed simulations will be performed of aero-engine combustors tested in full annular configurations, for which the ITD leader will provide soot and gas temperature exit measurements. The intermediate pressure and full annular rig data, together with the corresponding geometric data, will be provided by the ITD leader under specific conditions to be defined in the Implementation Agreement.

Task 4: Soot validation experiments

In order to support the development of soot models, accurate soot validation data is required. Therefore experiments have to be performed at three TRLs:

- Laminar counter-flow diffusion flames, using different fuel compositions. The objective is to provide validation data for the development of reaction mechanisms suitable for kerosene. A counter flow diffusion flame is established by opposite jets, of fuel and air, forming a stable laminar flame. As most soot models are based on data of ethylene flames, reference measurements for ethylene with performed as well. Next surrogate components of kerosene will be added; finally a kerosene surrogate will be used. The experiments will be performed at elevated pressure up to 10 bar. Measurements will be performed for intermediate species and soot by means of Laser-Induced Incandescence (LII). Furthermore, intermediate species will be determined using a gas chromatograph.
- Turbulent counter-flow diffusion flames. In comparison to the laminar counter flow diffusion experiments, here the flow velocities of the jets are considerable higher and consequently creating a turbulent flame. In these flames the chemistry-turbulence interaction plays an important role. Initially, measurements will be performed using ethylene for comparison with existing results from DLR and Sandia . In a following phase, a kerosene surrogate will be used. The following measurement techniques will be applied: PIV, OH PLIF, CH2O PLIF, LII including particle size distribution as well as gas chromatography-mass spectrometry. Measurements will be performed at atmospheric conditions.
- Surrogate kerosene experiments on swirling flames at atmospheric conditions. A rig generating a swirl stabilised primary zone will be used. The rig will include mixing jets in order to quench the primary zone flame and foster oxidation. Different rig configurations will be tested, which will be associated to different swirl angles, position of mixing ports and flow distributions. Measurements will be performed for: PIV, OH PLIF, CH2O PLIF, LII including particle size distribution.

Task 5: Modelling of primary spray break-up

As spray characteristics have a large impact on the engine emissions, the break-up process of the liquid fuel has to be captured with sufficient accuracy. On the other hand fully resolving the liquid fuel primary break-up is too computationally expensive, as a spatial resolution of a few µm would be required. In the past correlations for air blast injectors have been derived for the primary velocity magnitude and particle size. These correlations have been implemented in a primary break-up model. However, the model has to be further developed to estimate the location at which the primary particles are formed, the primary particles velocity components and the injection frequency. Furthermore, the model should provide representative results for all kind of break-up processes, such as film instabilities, ligament elongation, flapping of the liquid sheet, liquid accumulation and bag break-up. The spray break-up model should be based on either existing experimental data or on detailed numerical simulations based on SPH simulations. The model will be implemented in the CFD code of the ITD leader.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1a, D1b, D1c	Yearly management reports	R	M12, M24, M36
D2	Detailed reaction mechanism including PAH's, and soot	R	M18
D3	Implemented advanced methods of moments soot model	R	M24
D4	Validated advanced methods of moments soot model	R	M36
D5	Implemented sectional soot model	R	M24
D6	Validated sectional soot model	R	M36
D7	Assessment of soot models on low TRL test rigs and aero engine combustors	R	M36
D8	Measurement data from laminar counter-flow diffusion flames	R	M20
D9	Measurement data from turbulent counter-flow diffusion flames	R	M24
D10	Measurement data from swirling flames	R	M30
D11	Implementation of stochastic fields-based soot model	R	M18
D12	Comparison on chemistry-turbulence interaction models	R	M30
D13	Phenomenological spray break-up model for air-blast fuel injectors, developed and implemented.	R	M20
D14	Validated phenomenological spray break-up model for air-blast fuel injectors	R	M36

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Concept plan for hmom soot model development and implementation	R	M8
M2	Concept plan for sectional soot model development and implementation	R	M8
M3	Concept plan for phenomenological spray break up model development and implementation	R	M8
M4	Laminar counter-flow diffusion flame set-up commissioned	R	M6
M5	Turbulent counter-flow diffusion flame facility commissioned	R	M6
M6	Swirling flame facility commissioned	R	M6

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

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

- Availability of detailed kinetics to model combustion processes including soot.
- Proved track record with regard to the development and application of hybrid methods of moments and sectional soot models for prediction of smoke and the soot particles size distribution in gas turbine engines
- Demonstrated capability to reduce chemical kinetics, including the RCCE approach
- Experience with the stochastic field method.
- Experience with the Conditional Moment Closure combustion model.
- Proven track record on the application of Smoothed Particles Hydrodynamics methods to predict primary break up. The mentioned capabilities should already be available, demonstrated and suitable for performing large scale simulations.
- Demonstrated capability in the development of two-phase models and primary break-up models for kerosene, suitable for aero engine air-blast injectors.
- Availability of the required computational resources to perform the required numerical simulations.
- Experimental facilities available and demonstrated functionality to perform soot and species measurements on laminar counter-flow diffusion flames at elevated pressure up-to 10 bar, turbulent counter-flow diffusion flames and swirling flames at atmospheric conditions.

5. Abbreviations

BPR	By-pass Ratio
CO	Carbon monoxide
CFD	Computational Fluid Dynamics
CMC	Conditional Moment Closure
FGM	Flamelet Generated Manifold
HMOM	Hybrid Methods of Moments
ITD	Integrated Technology Demonstrator
OPR	Overall Pressure Ratio
LII	Laser-Induced Incandescence
PAH	Polycyclic Aromatic Hydrocarbons
PDF	Probability Density Function
PIV	Particle Image Velocimetry
PLIF	Planar Laser Induced Fluorescence
RCCE	Rate Controlled Constrained Equilibrium
SPH	Smoothed Particles Hydrodynamics
TET	Turbine Entry Temperature
TRL	Technology Readiness Level
UHC	Unburned Hydrocarbons
VOF	Volume of Fluid
WP	Work-Package

XIV. Novel Bearings

Type of action (RIA or IA)	RIA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 5.0		
Indicative Funding Topic Value (in k€)	2500		
Topic Leader	Rolls-Royce	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	30	**Indicative Start Date**[54]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-ENG-03-21	**Novel Bearings**
Short description	
Bearings currently proposed for future UltraFan® engine concepts require oil for lubrication and cooling, adding considerable weight and complexity to the engine design. Research is proposed to exploit the superior hardness and thermal conductivity of synthetic diamond materials in the manufacture of bearings that could be air rather than oil lubricated. This proposal will address early TRL challenges associated with diamond bearing design, manufacture, cooling and installation.	

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

1. Background

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for UltraFan® engines.

Within the timescales of Clean Sky 2, Very High Bypass Ratio engines will realize significant environmental benefits:-

- Up to 25% fuel burn and CO_2 emission reduction relative to year 2000 baseline (consistent with 10% reduction relative to year 2014 baseline)
- Noise levels making a significant step towards to ACARE 2035 targets (- 11 EPNdB per operation relative to 2000 situation: including engine, nacelle, aircraft technologies - airframe noise reduction, novel aircraft configurations – and ATM benefits)
- Contribute to delivery of NOX emission reductions through reduced fuel burn. Specific objectives will not be defined owing to the strong dependency on overall core engine cycle decisions.

Development of UltraFan® technology will also maintain European competitiveness in the development and integration of engines for Middle of Market short range commercial aircraft, to ensure capability across the full range of technologies required by geared engines, and develop a world-leading European capability for UltraFan® engines for the large aircraft market, establishing a lead in this emerging market.

Geared turbofans provide a game-changing improvement in aero-engine efficiency by allowing the fan and turbine to rotate at different speeds. This allows for a higher by-pass ratio (larger fan at a lower speed than traditional turbofans) and a lighter, faster and more efficient turbine. With the turbine and fan rotating at different speeds a power gearbox (PGB) is required to transfer a high level of torque within a restricted space envelope to minimise the size of the engine core. Efficient lubrication and cooling or gears and bearings in the PGB and the core engine is essential if benefits associated with the UltraFan® concept are not to be eroded by large and costly oil and heat management systems.

Work already in progress under CleanSky2 funding is developing an intelligent oil system that aims to match supply with demand at all engine operating conditions, (DEVILS project). This complementary proposal aims to reduce oil system cost, weight and complexity still further by exploiting the properties of synthetic diamond material in the design and manufacture of novel bearings. The basic premise is that the surface finish of diamond rolling elements and mating raceways can be improved substantially relative to today's metallic bearing materials such that heat generation and frictional wear is minimised. Diamond also offers superior thermal properties enabling thermal gradients and running clearances to be optimised using air rather than oil as the cooling medium.

The successful Partner will need to demonstrate bearing design expertise, and capability in the manufacture, forming and metrology of synthetic diamond materials. A proven track record in the design and evaluation of air cooling schemes and test facilities for friction and integrity proving will also be essential. Where gaps exist in internal capability, the Partner should consider forming a consortium to ensure that all aspects of the technology development, demonstration and industrialisation can be successfully delivered.

2. Scope of work

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3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Management Report: Provide quarterly status reports on project management aspects of the programme, including deliverables, level of spend and dissemination, with one final summary report on project completion.	R	Quarterly through the project, plus T0 + 30 months
D2	Requirements Capture: report capturing bearing requirements for UltraFan® products.	R	T0 + 4 months
D3	Concept Evolution: report providing details of all concepts generated, including advantages and disadvantages of each, and evaluation against requirements defined in D2.	R	T0 + 10 months
D4	Detailed Design Study: report summarising design solutions and chosen preferred concept	R	T0 + 16 months
D4.1	Report describing stress analysis undertaken on detailed bearing designs	R	T0 + 16 months
D4.2	Report describing air cooling schemes and thermal analysis undertaken on detailed bearing designs	R	T0 + 16 months
D5	Manufacturing and Metrology Technique Development: Report summarising results of manufacturing and metrology trials, including details of manufacturing process control	R	T0 + 20 months
D5.1	Two initial test pieces plus two spares for use in Task 6	HW	T0 + 12 months
D5.2	Four further test pieces for use in Task 6	HW	T0 + 18 months
D5.2	Two final test pieces for use in Task 6	HW	T0 + 24 months
D6	Test Programme: report summarising outcome of test programme, including materials database for us in future bearing designs	R + D	T0 + 30 months
D6.1	Test rig for friction and wear measurements	HW	T0 + 20 months
D6.2	Test rig for air cooling scheme evaluation	HW	T0 + 20 months
D6.3	Test rig for endurance testing	HW	T0 + 20 months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1.1	Launch meeting held and minuted	R	T0 + 1 month
M1.2	Collaboration agreement signed	R	T0 + 2 months
M2	Requirements captured and reported	R	T0 + 4 months
M3	Concept evolution complete: D3 delivered	R	T0 + 10 months

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M4	Detailed design studies concluded: D4, 4.1 and 4.2 delivered	R	T0 + 16 months
M5	Task 5 complete: D5, 5.1, 5.2 and 5.3 delivered	R + HW + D	T0 + 24 months
M6	Task 6 complete: D6, 6.1, 6.2 and 6.3 delivered	R + HW + D	T0 + 30 months

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

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

It is expected that a specific set of skills and facilities are required by the candidate and it is therefore expected that the response will address the following areas of expertise as a minimum:

- **Skill 1: D**emonstrable experience in the research, development and industrialisation of synthetic diamond manufacturing, machining and metrology processes within highly regulated industries.
- **Skill 2:** Access to relevant experience in the design and manufacture of bearings for aerospace applications.
- **Skill 3:** Relevant knowledge and experience in advanced air cooling techniques for thermal gradient control in thermally conducting materials, and the ability to predict associated temperatures.
- **Skill 4:** Relevant knowledge and experience in absolute and differential stress gradient control in components and assemblies, and the ability to predict associated stresses.
- **Skill 5:** Relevant experience in the planning and delivery of manufacturing trials, supported by test facilities where representative and industrialised trials can be performed.
- **Skill 6:** Relevant experience in the planning and delivery of test programmes, including the design, construction and operation of test facilities in accordance with relevant Health and Safety standards.
- **Skill 7:** Relevant knowledge and experience in the Manufacturing Capability Readiness Level (MCRL) or equivalent Technology Readiness Levels (TRL) processes that measures technology maturity would be an added advantage.

5. Abbreviations

ACARE	Advisory Council for Aeronautics Research in Europe
AGB	Accessary Gear Box
CSJU	Clean Sky Joint Undertaking
EPNdB	Effective Perceived Noise in decibels
ITD	Integrated Technology Demonstrator
MCRL	Manufacturing Capability Readiness Level
PGB	Power Gear Box
RIA	Research Innovation Area
TRL	Technology Readiness Level

XV. Development and validation of a Powder HIP route for the manufacture of the UltraFan® Demonstrator IP Turbine casing from high temperature material allowing product enhancements at significantly lower costs and environmental footprint

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 5.2/6.1.1		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	ITP	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[55]	Q4 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-ENG-03-22	**Development and validation of a Powder HIP route for the manufacture of the UltraFan® Demonstrator IP Turbine casing from high temperature material allowing product enhancements at significantly lower costs and environmental footprint**
Short description	
Material development and characterization of a High Temperature (HT) casing alloy manufactured through the Powder HIP route. This with the double goal to demonstrate capability to withstand engine relevant conditions; i.e. with and without exposure, while understanding and assessing its ability to contain. Modelling assisted, optimization (aggregated LOW cost) of a canning system for casing manufacture. Development, manufacturing and validation of casings for the UltraFan® Demonstrator engine development program (2 for engine testing+1 for cutup).	

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

1. Background

Aero engines are systematically affected by a demand to gradually increase their operating temperatures. This technological aspect gives rewards to engine operators through benefits in terms of thermodynamic efficiency but also to mankind through the minimization of emissions of greenhouse effect gases. Though different strategies might exist to respond to it, the more obvious requires the increase of materials temperature capability.

Thus, provided technically feasible material choices are available, the final selection relies on a trade between the benefits at engine cycle level and their associated recurring costs. The selection of a material with a lower material capability such as IN718, though potentially cheaper, could result in higher recurring costs through the need of dedicated cooling or the incorporation of active flow controls. Additionally, it may require having to deal with its metallurgical instability (over-ageing) when temperatures close to its maximum stability temperature $\approx 630^{\circ}$ are reached.

The demand for higher temperatures has relevant implications. Thus, for operating temperatures beyond 630° and up to ≈670°C, in line with the requirements for the UltraFan® Demonstrator, there is a need to resort to materials with higher presence of γ'; i.e. Ni_3Al. The presence of this micro-nano sized constituent raises many challenges as it makes very difficult for the conventional cast and wrought route (C+W) to be feasible; i.e. the established route for materials with lower temperature capability such as IN718, which typically involves Ring Rolling.

Potential choices regarding materials and their associated manufacturing processes might exist for high temperature casings. Among the most promising the Additive Manufacturing and the Powder Metallurgy could be highlighted. Conventional Additives (melting assisted) though, potentially offering benefits from the manufacturing standpoint are not seen as an option, given the inherent low ductility of the deposited materials as this could compromise the intended containment capacity casings shall comply with. With regards to the Powder Metallurgical route, though feasible; in fact, HIP+Forging route is the standard manufacturing route for the manufacture of High Temperature discs, its usage with casings raises relevant dilemmas. In fact, should the Powder HIP consolidation route be followed by a forging operation, this would be incompatible with the usage of Ring Rolling; i.e the naturally competitive choice for casing manufacture. HT Powder Hipped materials are less susceptible to being forged in the inherently non isothermal conditions under which Ring Rolling occurs. Other alternative forging routes involving close die forging, would result in processes with very low throughput. This together with the higher comparatively raw material costs (powder vs. billet) would further challenge the competitiveness of any Powder HIP+ Forging based solution for the manufacture of High Temperature Casings.

Powder HIP (with no subsequent Forging) however, could be technologically valid, and a competitive solution for High Temperature Casing manufacture. There are a number of challenges though, which need to be solved for this potential to be materialized. First there is a need for the material ductility not to be compromised through the presence of PPB´s (Previous Particle Boundaries), which are potentially present within the finished parts. Additionally the usage of competitive canning systems is key for achieving improvements in terms of material usage.

Attempts have been conducted so-far in the frame of various projects to mature Powder HIP technologies. These attempts, which have been successful in building the technology and manufacturing readiness levels, have allowed identifying and developing critical aspects of the technology. First the canning and tooling technology which is key to achieve improvements in terms of material usage (buy to fly). To this end, there is a need for cheap disposable canning systems and reliable process modelling tools to optimize the achievement of dimensional aspects of the consolidated Hipped product. These technologies have been developed within NESMONIC (JTI-CS-2012- 03-SAGE-020) where geometries close to that of the final component have been achieved with significant improvements in terms of material usage. Regarding the HT material, relevant developments have also taken place within HIGH SPEED TURBINE CASING PRODUCE BY POWDER HIP TECHNOLOGY (SP1-JTI-CS-2013-03-SAGE-02-039) with the development of Astrolloy material which would be both; chemically and metallurgically, close to that finally selected for the UltraFan® Demonstrator.

The proposal hereby offers the opportunity to take a step further so that making usage of the background technology, tackles the further technology gaps alongside the material capability; basic mechanical behaviour and impact in the presence of exposure with the ultimate goal for this technology to be fully tested in the relevant UltraFan® Demonstrator engine environment. To this end, a total of 3 IPT casings will be made available to the engine demonstrator program so that 2 could be used in some of the engines undergoing tests whilst the third one will be dedicated to undergo validation activities (NDT´s, metallurgical and mechanical cutup, etc.).

OBJECTIVES

- Based upon the background technology available to theTopic Manager (TM), the project will further develop and optimize a powder HIP processing route for the successful consolidation of a High Temperature material (to be chosen between Astrolloy and RR1000) with a view in optimizing product densification and the resulting mechanical capability. This exercise shall cover all the relevant stages of manufacture; i.e. from powder manufacture and handling, conditioning, Hipping to the final Heat Treatment. The process shall be scalable to the industry environment so that the manufacture of the components for the demonstrator is secured.
- Characterize the basic mechanical behaviour of the resulting material and populate the database in support of component design per the requirements set forth by the TM. This effort shall also feedback materials and process developments.
- Develop an experimental understanding of material behaviour under dynamic and (impact) ballistic conditions as set forth by the TM. This effort shall also feedback materials and process developments.
- Further extend the above understanding of the mechanical capability; i.e. in the as-manufactured condition, to incorporate any exposure effect at temperatures 630°-670°C at the engine operating conditions.
- With TM´s support, develop low cost Canning and Tools systems.
- Develop and Validate Process Modelling Capabilities; powder consolidation in the presence of a can and/or tool to optimise material usage.
- Manufacture canning/toolings to guarantee the compliance of the finish product with the requirements; i.e. full densification, dimensional and NDT requirements.
- Increase the Buy-to-Fly material from the typically achieved 9 through the conventional cast&wrought route to ≤3 through NSHIP.

- Manufacture 3 full sized IPT Casings one for cut up and the remaining 2 to be provided to the demonstrators of the ITD Engine WP6 to support its engine development program. Validate with NDT´s and metallurgical and mechanical cutup. This in agreement with the requirements by the TM.

2. Scope of work

Within the project a total of seven (7) Tasks have been identified with their description per Table I. A chronogram is also provided to easily allow the Tenders to understand the timeframes involved, Fig. I.

Task Number	Task Description	Completion Date
T1	Optimization and validation of the powder cycle (conditioning + HIP + Heat Treatment)	M12
T2	Material design data; without and with exposure	M21
T3	Ballistic tests and numerical simulations for containment capability assessment; without and with exposure	M27
T4	Development and Validations of Process Modelling Capabilities; powder consolidation in the presence of a can and/or tool	M36
T5	Low cost Canning and Tool development; Design and Manufacture	M36
T6	Manufacturing 3 full scale powder HIP casings one for cut up and 2 for the engine development program	M36
T7	Validation Metallurgical, mechanical, NDT and Dimensional	M21

Table I: Task Breakdown and preliminary description and completion dates

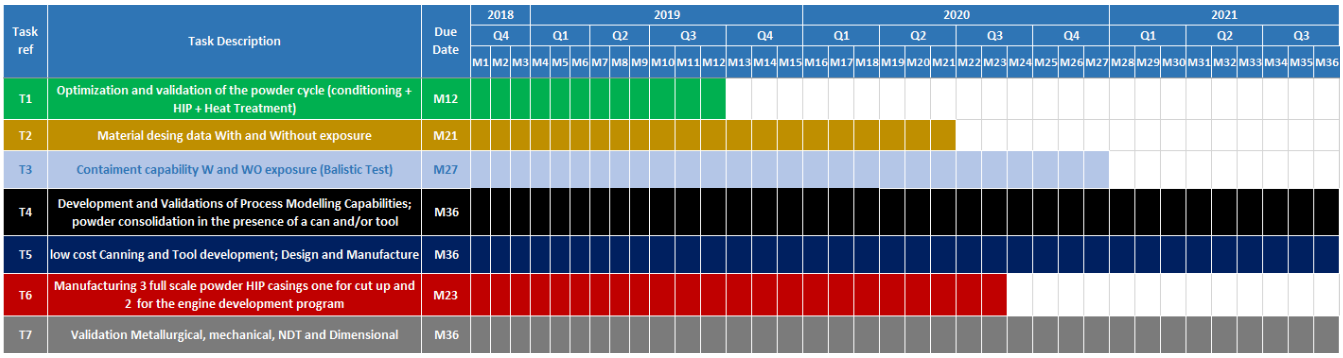


Figure 14 Simple Chronogram intended to allow the timing requirements

Finally and with the ultimate goal for the Tenders of this Project to better align themselves with the requirements and expectations by the Topic Manager and also manage any Potential Consortia the following Table is provided, Table II, with a proposed budget breakdown per Task.

Task Number	Task Description	ExpectedBudget Estimate* (€)
T1	Optimization and validation of the powder cycle (conditioning + HIP + Heat Treatment)	95000
T2	Material design data; without and with exposure	380000
T3	Ballistic tests and numerical simulations for containment capability assessment; without and with exposure	300000
T4	Development and Validations of Process Modelling Capabilities; powder consolidation in the presence of a can and/or tool	100000
T5	Low cost Canning and Tool development; Design and Manufacture	180000
T6	Manufacturing 3 full scale powder HIP casings one for cut up and 2 for the engine development program	345000
T7	Validation Metallurgical, mechanical, NDT and Dimensional	100000

Table II: A proposal of budget breakdown (*proposed)

Specific details about every Task will now be provided.

Task 1: Optimization and validation of the powder cycle (conditioning +HIP+Heat Treatment)

Duration: 12 months

The first task, T1, will target the manufacture of fully dense material with a sound metallurgy, able to deliver the expected mechanical properties. Pre-screening on the resulting material condition shall focus upon porosity and the presence of any deleterious feature such as PPB´s. In order to drive the optimization effort, within this Task basic mechanical tests will be performed; i.e. tensile @RT and HT to assess strength and ductility and impact Charpy tests (or similarly agreed with the TM to qualitatively assess the impact capability. At this stage an analysis of the relevant microstructural aspects present will be required in relation with the active failure mechanisms observed within the tested material. Whilst the bulk of material mechanical characterization activities are going to take place within Tasks T2 (basic properties) and T3 (dynamic and impact properties) proper interaction between them all is a must to secure T1 delivers a material process with optimum properties.

Among the input parameters to be taken into account the following are to be included; incoming powder (chemistry, powder size distribution etc. etc.) as well as the processing involving blending/mixing, conditioning + HIPping + Heat Treatment.

Though the background knowledge will be made available by the TM to the Consortium, the foreground developments within this Task shall take into account the available capability of industry, in particular as it regards to the pressure capability of the HIP vessels in order to undertake the manufacture of the full scale components within Task 6. Also consideration must be made to the cooling down rates achieved during the HIPping cycles as well as the subsequent Heat Treatments by assessing their effect in terms of the resulting microstructure and mechanical properties within this Task.

The mechanical testing hereby is aimed at pre-screening and down selecting the optima in terms of materials (powders) and their processing. As such, the completion of these tests might not require making usage of an accredited Laboratory. However this waiver will require acceptance by the TM once the capabilities, documented procedures etc. are reviewed altogether, these involving also those pertinent for specimen machining/manufacture.

The breakdown of subtasks within Task 1 and details of their timing are shown in Fig.2.

Subtask ref	Subtask Description	Due Date	2018			2019								
			Q4			Q1			Q2			Q3		
			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
T1.1	Agree with TM the trials (HIP/HT) and launch them in parallel	M1	■											
T1.2	Manufacture material for tests	M2	■	■										
T1.3	Agree with TM the mechanical test and physic test for each trial	M1	■											
T1.4	Carried out the test of all HIP and HT trials in parallel	M5	■	■	■	■	■							
T1.5	Report the mechanical test and physic	M9		■	■	■	■	■	■	■	■			
T1.6	microestructural study	M6			■	■	■	■						
T1.7	Powder+HIP+HT parameters fixed	M5					■							
T1.8	Report the test results and the microestructural study of the different HIP and HT trials	M12					■	■	■	■	■	■	■	■

Figure 2 Task I breakdown, subtask description with timing requirements

Task 2: Material design data; without and with exposure

Duration: 21 months (including the procurement of Raw Material)

This Task, will target the material manufacture and subsequent testing so that material allowable are generated by the TM to undertake component design activities which, although taking place in parallel with this Call for Proposal will support the UltraFan® Demonstrator engine program and input Tasks 5 and 7. Additionally, activities within this Task will have a direct link with those pertaining to Task 3.

In addition to the material capability of the as-manufactured material across temperatures the metallurgical stability throughout the intended Life Cycle will be assessed. This will require subjecting the material to HT through the accumulation of times relevant for the intended engine use as a prior activity to testing.

Materials tests, within this Task, must be conducted within approved accredited Laboratory (NADCAP with an approval by the TM) as defined in Chapter 4 Special skills, Capabilities, Certification expected from the Applicant(s). No waiver as in Task 1 will be acceptable. The tests to be conducted will involve typically tensile, fatigue, creep and creep rupture and crack propagation tests. The specific test numbers per the different techniques shall be agreed with the TM. A tentative number of tests together with the associated cost is supplied within Table 3.

Test type	Material Without exposure	Material With exposure
	Nº test	Nº test
Tensile	33	20
LCF kt=1	64	32
HCF Kt=1	64	
LCF kt=1,66	40	
HCF Kt=1,66	40	
LCF kt=2,29	40	
HCF Kt=2,29	40	
Creep	36	
Total estimated cost (€)	280000	

Table 3: Details of the test campaign (NADCAP) within Task 2 and estimated associated commercial costs.

The breakdown of subtasks within Task 2 and details of their timing are shown in Fig.3.

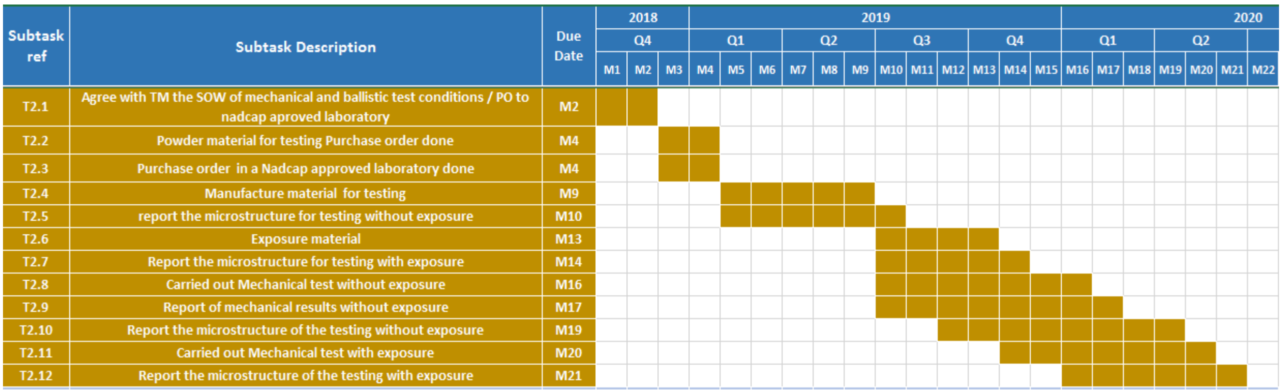


Figure 3 Task 2 breakdown, subtask description with timing requirements

Task 3: Ballistic tests and numerical simulations for containment capability assessment; without and with exposure

Duration: 27 months

This Task will target the material characterization, Impact Charpy, Fracture Toughness, dynamic (Hopkinson Bar) and ballistic testing so that the material capability at the high strain rates is substantiated at engine relevant conditions. This, together with the understanding, will feed numerical simulations to assess the containment capability of the material; without and with exposure relevant for the intended engine use.

Within this Task efforts will be conducted early on to build the knowledge about the cross effects between the metallurgical aspects of the manufactured materials and the resulting mechanical behaviour; in particular under dynamic and impact conditions. Early feedback to the developments taking place in Task 1 from this Task, T3, is a must.

Materials tests, within this Task, in particular, as it regards to Charpy impact tests and fracture toughness must be conducted within approved accredited Labs (NADCAP with an approval by the TM) as defined in Chapter 4 Special skills, Capabilities, Certification expected from the Applicant(s). No weaver of this requirement will be acceptable. The specific test numbers per those two techniques or agreed equivalents shall be agreed with the TM. A tentative cost for their machining and testing would be expected around 45000 €.

In addition to these material tests, some others will need to be performed, which will not require NADCAP approval. This applies to dynamic and ballistic tests. An estimate of the total amount of those tests, which will need to agree with the TM, amounts to ≈100.

The breakdown of subtasks within Task 3 and details of their timing are shown in Fig.4.

Subtask ref	Subtask Description	Due Date
T3.1	Agree with the TM SOW of the mechanical and ballistic test campaign and the exposure conditions	M2
T3.2	Powder material supplier selected and Pourchase order done	M3
T3.3	Manufacture the material for the testing's	M8
T3.4	Report the microstructure of material without exposure before testing	M8
T3.5	Carried out the Mechanical test of material without exposure	M11
T3.6	Report the mechanical results without exposure	M12
T3.7	Carried out the Ballistic test of material without exposure	M13
T3.8	Report the Ballistic test results of material without exposure	M15
T3.9	Exposure the material at different conditions	M13
T3.10	Report the microstructural study of exposed material with different conditions	M14
T3.11	Mechanical test of material with exposure	M17
T3.12	microstructural study of mechanical test of material with exposure	M18
T3.13	Report the results of the Mechanical test of material with exposure	M19
T3.14	Ballistic test of material with exposure with different exposure conditions	M17
T3.15	Report the results of the Ballistic test of material with exposure	M19
T3.16	Report a summary of the results and conclusions	M27

Figure 4 Task 3 breakdown, subtask description with timing requirements

Task 4: Development and Validations of Process Modelling Capabilities; powder consolidation in the presence of a can and/or tool

Duration: 36 months

Developments within this Task, T4, shall focus on gaining fidelity onto the capability of the process modelling tools to predict consolidation driven distortions and to drive can/tool design to avoid them while preserving the overall objective to guarantee the very presence of material for the casings while minimizing the buy-to-fly ratio of the intended NSHIP solution.

Though the background knowledge will be made available by the TM to the Consortium, the foreground developments within this Task, shall allow a significant step forward in terms of the development and optimization of cheap canning systems.

As part of this Task, T4, available models will be reviewed and together with the TM those to be further developed and validated will be down-selected. This exercise will pay attention to the relevance of the physical aspects/phenomena being modelled as contributors to the presence of distortions within components and their potential contribution to the optimization goal. In conjunction with the TM a strategy will be drawn to develop the Process Modelling capabilities which will require undertaking validation activities through the design and manufacture of ad-hoc subscale components.

The activities within this Task will feed Tasks 5 and 7 and will be fed back with the results within Task 6.

The breakdown of subtasks within Task 4 and details of their timing are shown in Fig.5.

Subtask ref	Subtask Description	Due Date	2018			2019															2020															2021								
			Q4			Q1			Q2			Q3			Q4			Q1			Q2			Q3			Q4			Q1			Q2			Q3		
			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
T4.1	Preliminary HIP model to design	M1	■																																			
T4.2	Agree with the TM the material test to feed model	M3	■	■	■																																	
T4.3	Manufacture the material for the testing's	M5			■	■	■																															
T4.4	Carried out the mechanical and physical test to feed the model	M9					■	■	■	■	■																											
T4.5	Report the test results	M10								■	■	■																										
T4.6	Generate a new HIP model with the test results	M11								■	■	■	■																									
T4.7	Define and agree with the TM basic geometries to first trials to feed HIP model	M3	■	■	■																																	
T4.8	Simulate the HIP process with the basic geometries and report the results of the model.	M4		■	■	■																																
T4.9	Manufacture the basic geometries to feed the model (bar/ hollow cylinder/...	M9				■	■	■	■	■	■																											
T4.10	Report the dimensional results of the basic geometries and compared them with the previous modelling results	M10							■	■	■	■																										
T4.11	Modified the model base on the results get from the basic geometries and report the parameter's fixed in the model	M12								■	■	■	■	■																								
T4.12	Model the casing geometry of T6.2	M3	■	■	■																																	
T4.13	Report the model prediction versus the dimensional results of 1st and 2nd casing of T6	M14												■	■	■																						
T4.14	Report the model prediction versus the dimensional results of third casing of T6	M16														■	■	■																				
T4.15	Model the first trial of low cost caning of T5.2	M4		■	■	■																																
T4.16	Report the model prediction versus the dimensional results first trial of low cost caning of T5.2	M13											■	■	■																							
T4.17	Model the second trial of low cost caning of T5.8	M16														■	■	■																				
T4.18	Report the model prediction versus the dimensional results second trial of low cost caning of T5.8	M25																							■	■	■											
T4.19	Model the third trial of low cost caning of T5.14	M28																										■	■	■								
T4.20	Report the model prediction versus the dimensional results third trial of low cost caning of T5.14	M36																																			■	■
T4.21	Validate the HIP modelling using the manufactured hardware and report the results	M36		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Figure 5 Task 4 breakdown, subtask description with timing requirements

Task 5: low cost Canning and Tool development; Design and Manufacture

Duration: 36 months

Though the background knowledge will be made available by the TM to the Consortium, the foreground developments within this Task, shall allow a significant step forward in terms of the development and optimization of cheap canning systems.

Developments within this Task, shall focus on developing cheap, capable and reliable canning systems so that consistency can be secured manufacturing-wise through following specific rules for can/tool material selection, design and its processing. This Task which will align with the efforts made in Task T4 will also be held responsible for the development of joining and inspection techniques as needed.

As design activities will be taking place in parallel in support of the UltraFan® Demonstrator, the TM shall conduct the detailed design activities for the canning system by using the Modelling Capabilities developed in

Task 4.

As part of Task, T5, the feasible canning and tooling systems will be agreed with the TM altogether with down-selected materials and their processing details. Design and process developments taking place within this Task will drive to the generation of design rules for canning and tooling systems. The activities within this Task will feedback T4 in particular as it regards the validation activities undertaken through the design and manufacture of ad-hoc subscale components. Additionally, this Task will drive the Design and Manufacture of Canning and Tooling systems in support of the design and manufacture of full sized component manufacture within Task T6.

The breakdown of subtasks within Task 5 and details of their timing are shown in Fig.6.

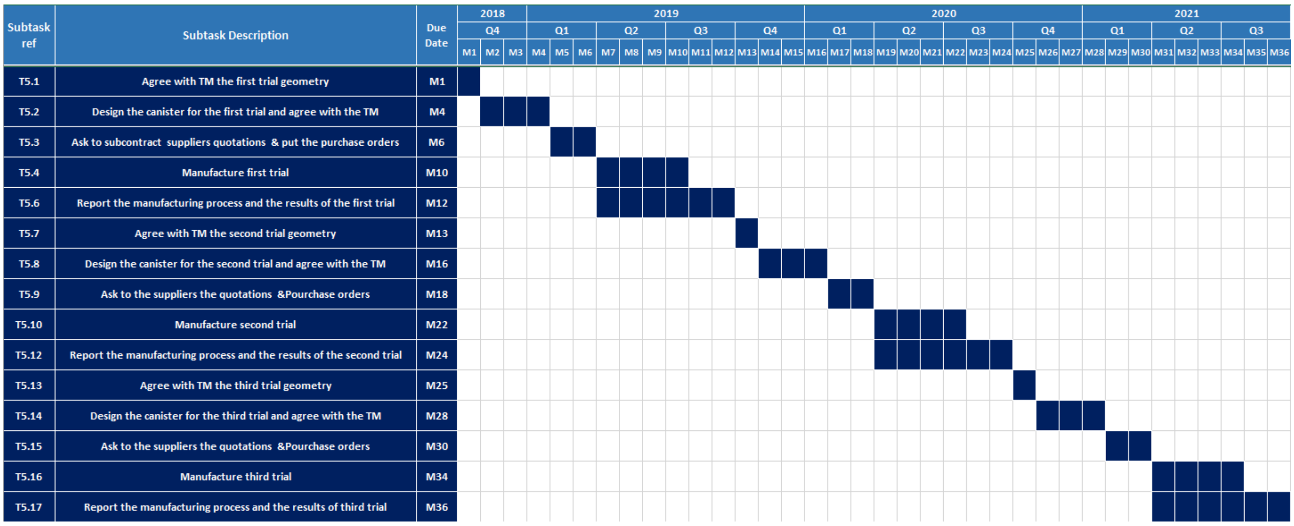


Figure 6 Task 5 breakdown and subtask description with timing requirements

Task 6: Manufacturing 3 full scale powder HIP casings one for cut up and 2 for the engine development program

Duration: 36months

This Task, T6, will have a clear link with T7 on one of the 3 (three) full sized components manufactured within will be devoted to the validation activities per T7. The selection of the specific component undergoing the validation activities will be agreed with the TM.

As a contingency and should results in Task 5 not result in acceptable canning systems or the process be not sufficiently reliable, the usage of conventional; i.e. machined canisters will be considered.

The activities within this Task, T6, will require fully documenting the relevant information at all the stages of manufacture; from the incoming powder and their characteristics (chemistry, powder distribution ...), to their mixing blending, canning details, powder preconditioning up to the geometry of the consolidated can upon hipping and the subsequent machining and final dimensions.

The manufacture of those components shall be conducted in an industry environment per the clauses contained in the related point.

The breakdown of subtasks within Task 6 and details of their timing are shown in Fig.7.

Subtask ref	Subtask Description	Due Date	2018			2019												2020								
			Q4			Q1			Q2			Q3			Q4			Q1			Q2			Q3		
			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24
T6.1	Agree with TM the casing geometry	M1	■																							
T6.2	Design canisters for the three casings, taking into account that the final part has to be ultrasonic inspected and has an integral test ring and agree with the TM	M3	■	■	■																					
T6.3	Report all the design considerations	M12				■	■	■	■	■	■	■	■	■												
T6.4	Ask for quotations, select the powder supplier and put the purchase order for the 3 casings	M4	■	■	■	■																				
T6.5	Powder for the 3 parts available for manufacturing process	M6					■	■																		
T6.6	Ask for quotation to subcontract supplier and put the required purchase order (including material for canister and HIP process)	M5	■	■	■	■	■																			
T6.7	Define the manufacturing route for the 3 parts and agree with the TM	M5				■	■																			
T6.8	Manufacture first full scale part for cut up	M11						■	■	■	■	■	■													
T6.9	Manufacture second full scale part for development engine program	M12							■	■	■	■	■	■												
T6.10	Manufacture thrid full scale part for development engine program	M15									■	■	■	■	■	■										
T6.11	Report all the manufacturing follow steps for the 3 casings	M23															■	■	■	■	■	■	■	■	■	

Figure 7 Task 6 breakdown and subtask description with timing requirements

Task 7: Validation Metallurgical, mechanical, NDT and Dimensional

Duration: 36 months

This Task, T7, will deal with the validation work (dimensional and NDT inspection, metallurgical and mechanical assessment) on one of the 3 (three) full sized components manufactured in T6. The selection of the specific component undergoing validation and its details (Metallurgical, mechanical, NDT and Dimensional) will be agreed with the TM.

The Metallurgical and Mechanical assessment of the resulting material condition will require using a NADCAP accredited source per TM agreed testing techniques. Materials tests; i.e type and numbers shall be agreed with the TM. A tentative cost for their machining and testing would be estimated to +/- 80 000€.

The breakdown of subtasks within Task 7 and details of their timing are shown in Fig.8.

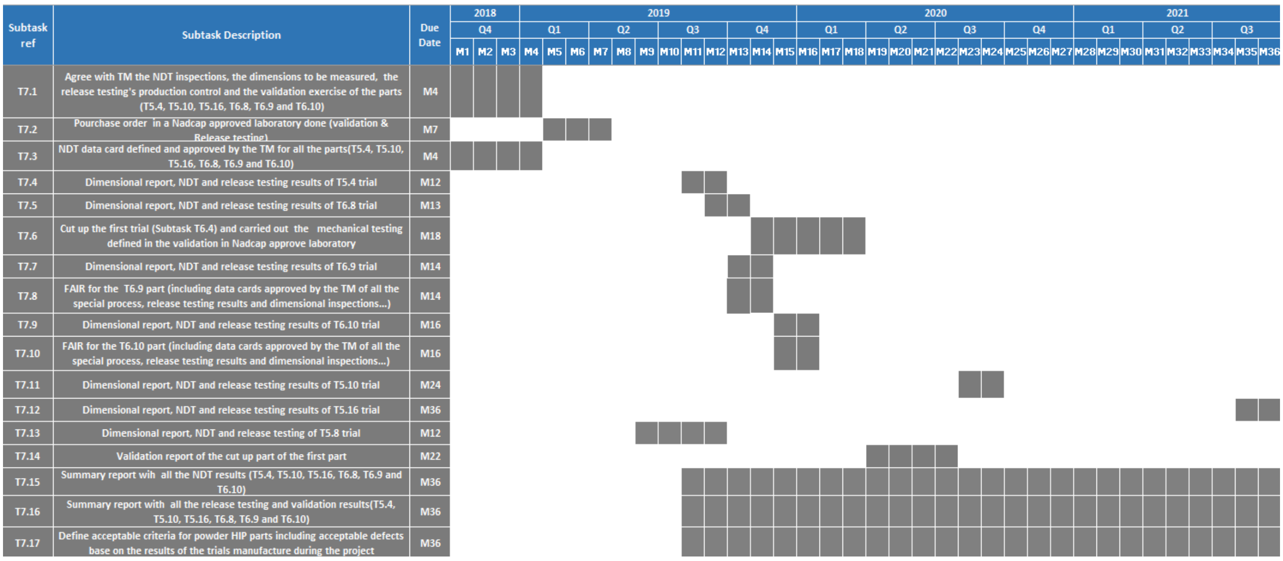


Figure 8 Task 7 breakdown and subtask description with timing requirements

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	**Title – Description**	**Type***	**Due Date**
D1.1	Agree with TM the trials (HIP/HT) and launch them in parallel	R	M1
D1.2	Manufacture material for tests	HW	M2
D1.3	Agree with TM the mechanical test and physic test for each trial	R	M1
D1.4	Report the test results and the microstructural study of the different HIP and HT trials	R	M9
D 1.5	Report the test results and the microstructural study of the different HIP and HT trials	R	M12
D2.1	Agree with TM the SOW of mechanical and ballistic test conditions / PO to nadcap approved laboratory	R	D2.1
D2.2	Manufacture material for testing	HW	D2.2
D2.3	Report the microstructure for testing with exposure	R	D2.3
D2.4	Report of mechanical results with exposure	R	D2.4
D2.5	Report the microstructure of the testing without exposure	R	D2.5
D2.6	Report the microstructure of the testing with exposure	R	D2.6
D3.1	Agree with the TM SOW of the mechanical and ballistic test campaign and the exposure conditions	R	M2
D3.2	Manufacture the material for the testing's	HW	M8

Deliverables			
Ref. No.	**Title – Description**	**Type***	**Due Date**
D3.3	Report the mechanical results without exposure	R	M12
D3.4	Report the Ballistic test results of material without exposure	R	M15
D3.5	Report the microstructural study of exposed material with different conditions	R	M14
D3.6	Report the results of the Mechanical test of material with exposure	R	M19
D3.7	Report the results of the Ballistic test of material with exposure	R	M19
D3.8	Report a summary of the results and conclusions	R	M27
D4.1	Preliminary HIP model to design	R	M1
D4.2	Agree with the TM the material test to feed model	R	M3
D4.3	Manufacture the material for the testing's	HW	M5
D4.4	Report the test results	R	M10
D4.5	Generate a new HIP model with the test results	R	M11
D4.6	Define and agree with the TM basic geometries to first trials to feed HIP model	R	M3
D4.7	Simulate the HIP process with the basic geometries and report the results of the model.	R	M4
D4.8	Report the dimensional results of the basic geometries and compared them with the previous modelling results	R	M10
D4.9	Modified the model base on the results get from the basic geometries and report the parameters fixed in the model	R	M12
D4.10	Report the model prediction versus the dimensional results of 1st and 2nd casing of T6	R	M14
D4.11	Report the model prediction versus the dimensional results of third casing of T6	R	M16
D4.12	Report the model prediction versus the dimensional results first trial of low cost caning of T5.2	R	M13
D4.13	Report the model prediction versus the dimensional results second trial of low cost caning of T5.8	R	M25
D4.14	Report the model prediction versus the dimensional results third trial of low cost caning of T5.14	R	M36
D4.15	Validate the HIP modelling using the manufactured hardware and report the results	R	M36
D5.1	Manufacture first trial	HW	M10
D5.2	Report the manufacturing process and the results of the first trial	R	M12
D5.3	Manufacture second trial	HW	M22
D5.4	Report the manufacturing process and the results of the second trial	R	M24
D5.5	Manufacture third trial	HW	M34

Deliverables			
Ref. No.	**Title – Description**	**Type***	**Due Date**
D5.6	Report the manufacturing process and the results of third trial	R	M36
D6.1	Report all the design considerations	R	M12
D6.2	Manufacture first full scale part for cut up	HW	M11
D6.3	Manufacture second full scale part for development engine program	HW	M12
D6.4	Manufacture third full scale part for development engine program	HW	M15
D6.5	Report all the manufacturing follow steps for the 3 casings	R	M23
D7.1	Agree with TM the NDT inspections, the dimensions to be measured, the release testing's production control and the validation exercise of the parts (T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	R	M4
D7.2	Dimensional report, NDT and release testing results of T5.4 trial	R	M12
D7.3	Dimensional report, NDT and release testing results of T6.8 trial	R	M13
D7.4	Dimensional report, NDT and release testing results of T6.9 trial	R	M14
D7.5	Dimensional report, NDT and release testing results of T6.10 trial	R	M16
D7.6	Dimensional report, NDT and release testing results of T5.10 trial	R	M24
D7.7	Dimensional report, NDT and release testing results of T5.16 trial	R	M36
D7.8	Dimensional report, NDT and release testing of T5.8 trial	R	M12
D7.9	Validation report of the cut up part of the first part	R	M22
D7.10	Summary report wih all the NDT results (T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	R	M36
D7.11	Summary report wih all the release testing and validation results(T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	R	M36
D7.12	Define acceptable criteria for powder HIP parts including acceptable defects base on the results of the the trials manfufacture during the project	R	M36

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

Milestones (when appropriate)			
Ref. No.	Title – Description	Type*	Due Date
M1.1	Powder+HIP+HT parameters fixed	R	M5
M2.1	Agree with TM the SOW of mechanical and ballistic test conditions / PO to Nadcap approved laboratory	D	M2
M2.2	Purchase order in a Nadcap approved laboratory done	D	M4
M2.3	Exposure material	D	M13
M2.4	Carried out Mechanical test without exposure	D	M16
M2.5	Carried out Mechanical test with exposure	D	M20

Milestones (when appropriate)			
Ref. No.	Title – Description	Type*	Due Date
M3.1	Powder material supplier selected and Purchase order done	D	M3
M3.2	Carried out the Mechanical test of material without exposure	D	M11
M3.3	Carried out the Ballistic test of material without exposure	D	M13
M3.4	Mechanical test of material with exposure	D	M17
M3.5	Ballistic test of material with exposure with different exposure conditions	D	M17
M4.1	Carried out the mechanical and physical test to feed the model	D	M9
M4.2	Manufacture the basic geometries to feed the model (bar/ hollow cylinder/…	HW	M9
M4.3	Modified the model base on the results get from the basic geometries and report the parameters fixed in the model	D	M12
M5.1	Agree with TM the first trial geometry	D	M1
M5.2	Agree with TM the second trial geometry	D	M13
M5.3	Agree with TM the third trial geometry	D	M25
M6.1	Agree with TM the casing geometry	D	M1
M6.2	Design canisters for the three casings, taking into account that the final part has to be ultrasonic inspected and has an integral test ring and agree with the TM	D	M3
M6.3	Ask for quotations, select the powder supplier and put the purchase order for the 3 casings	D	M4
M6.4	Powder for the 3 parts available for manufacturing process	D	M6
M6.5	Ask for quotation to subcontract supplier and put the required purchase order (including material for canister and HIP process)	D	M5
M6.6	Define the manufacturing route for the 3 parts and agree with the TM	D	M5
M6.7	Manufacture second full scale part for development engine program	D	M12
M6.8	Manufacture third full scale part for development engine program	D	M15
M7.1	Agree with TM the NDT inspections, the dimensions to be measured, the release testing's production control and the validation exercise of the parts (T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	D	M4
M7.2	Purchase order in a Nadcap approved laboratory done (validation & Release testing)	D	M7

Milestones (when appropriate)			
Ref. No.	Title – Description	Type*	Due Date
M7.3	NDT data card defined and approved by the TM for all the parts(T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	R	M4
M7.4	Cut up the first trial (Subtask T6.4) and carried out the mechanical testing defined in the validation in Nadcap approve laboratory	D	M18
M7.5	Dimensional report, NDT and release testing results of T6.10 trial	R	M14
M7.6	FAIR for the T6.10 part (including data cards approved by the TM of all the special process, release testing results and dimensional inspections…)	R	M16
M7.7	Dimensional report, NDT and release testing of T5.8 trial	D	M12

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

Subtask ref	Subtask Description	Due Date	Deliverable			Milestone			2018			2019								
									Q4			Q1			Q2			Q3		
			Ref	Due Date	Type	Ref	Due Date	Type	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
T1.1	Agree with TM the trials (HIP/HT) and launch them in parallel	M1	D1.1	M1	R															
T1.2	Manufacture material for tests	M2	D1.2	M2	HW															
T1.3	Agree with TM the mechanical test and physic test for each trial	M1	D1.3	M1	R															
T1.4	Carried out the test of all HIP and HT trials in parallel	M5																		
T1.5	Report the mechanical test and physic	M9	D 1.4	M9	R															
T1.6	microstructural study	M6																		
T1.7	Powder+HIP+HT parameters fixed	M5				M1.1	M5	R												
T1.8	Report the test results and the microstructural study of the different HIP and HT trials	M12	D 1.5	M12	R															

Figure 15: Task 1 deliverables and milestones

Subtask ref	Subtask Description	Due Date	Deliverable			Milestone			2018			2019												2020						
									Q4			Q1			Q2			Q3			Q4			Q1			Q2			
			Ref	Due Date	Type	Ref	Due Date	Type	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22
T2.1	Agree with TM the SOW of mechanical and ballistic test conditions / PO to nadcap aproved laboratory	M2	D2.1	M2	R	M2.1	M2	D																						
T2.2	Powder material for testing Purchase order done	M4																												
T2.3	Purchase order in a Nadcap approved laboratory done	M4				M2.2	M4	D																						
T2.4	Manufacture material for testing	M9	D2.2	M9	HW																									
T2.5	report the microstructure for testing without exposure	M10																												
T2.6	Exposure material	M13				M2.3	M13	D																						
T2.7	Report the microstructure for testing with exposure	M14	D2.3	M14	R																									
T2.8	Carried out Mechanical test without exposure	M16				M2.4	M16	D																						
T2.9	Report of mechanical results without exposure	M17	D2.4	M17	R																									
T2.10	Report the microstructure of the testing without exposure	M19	D2.5	M19	R																									
T2.11	Carried out Mechanical test with exposure	M20				M2.5	M20	D																						
T2.12	Report the microstructure of the testing with exposure	M21	D2.6	M21	R																									

Figure 16: Task 2 deliverables and milestones

Subtask ref	Subtask Description	Due Date	Deliverable			Milestone		
			Ref	Due Date	Type	Ref	Due Date	Type
T3.1	Agree with the TM SOW of the mechanical and ballistic test campaign and the exposure conditions	M2	D3.1	M2	R			
T3.2	Powder material supplier selected and Pourchase order done	M3				M3.1	M3	D
T3.3	Manufacture the material for the testing's	M8	D3.2	M8	HW			
T3.4	Report the microstructure of material without exposure before testing	M8						
T3.5	Carried out the Mechanical test of material without exposure	M11				M3.2	M11	D
T3.6	Report the mechanical results without exposure	M12	D3.3	M12	R			
T3.7	Carried out the Ballistic test of material without exposure	M13				M3.3	M13	D
T3.8	Report the Ballistic test results of material without exposure	M15	D3.4	M15	R			
T3.9	Exposure the material at different conditions	M13						
T3.10	Report the microstructural study of exposed material with different conditions	M14	D3.5	M14	R			
T3.11	Mechanical test of material with exposure	M17				M3.4	M17	D
T3.12	microstructural study of mechanical test of material with exposure	M18						
T3.13	Report the results of the Mechanical test of material with exposure	M19	D3.6	M19	R			
T3.14	Ballistic test of material with exposure with different exposure conditions	M17				M3.5	M17	D
T3.15	Report the results of the Ballistic test of material with exposure	M19	D3.7	M19	R			
T3.16	Report a summary of the results and conclusions	M27	D3.8	M27	R			

Figure 17: Task 3 deliverables and milestones

Subtask ref	Subtask Description	Due Date	Deliverable			Milestone		
			Ref	Due Date	Type	Ref	Due Date	Type
T4.1	Preliminary HIP model to design	M1	D4.1	M1	R			
T4.2	Agree with the TM the material test to feed model	M3	D4.2	M3	R			
T4.3	Manufacture the material for the testing's	M5	D4.3	M5	HW			
T4.4	Carried out the mechanical and physical test to feed the model	M9				M4.1	M9	D
T4.5	Report the test results	M10	D4.4	M10	R			
T4.6	Generate a new HIP model with the test results	M11	D4.5	M11	R			
T4.7	Define and agree with the TM basic geometries to first trials to feed HIP model	M3	D4.6	M3	R			
T4.8	Simulate the HIP process with the basic geometries and report the results of the model.	M4	D4.7	M4	R			
T4.9	Manufacture the basic geometries to feed the model (bar/ hollow cylinder/...	M9				M4.2	M9	HW
T4.10	Report the dimensional results of the basic geometries and compared them with the previous modelling results	M10	D4.8	M10	R			
T4.11	Modified the model base on the results get from the basic geometries and report the parameter's fixed in the model	M12	D4.9	M12	R	M4.3	M12	D
T4.12	Model the casing geometry of T6.2	M3						
T4.13	Report the model prediction versus the dimensional results of 1st and 2nd casing of T6	M14	D4.10	M14	R			
T4.14	Report the model prediction versus the dimensional results of third casing of T6	M16	D4.11	M16	R			
T4.15	Model the first trial of low cost caning of T5.2	M4						
T4.16	Report the model prediction versus the dimensional results first trial of low cost caning of T5.2	M13	D4.12	M13	R			
T4.17	Model the second trial of low cost caning of T5.8	M16						
T4.18	Report the model prediction versus the dimensional results second trial of low cost caning of T5.8	M25	D4.13	M25	R			
T4.19	Model the third trial of low cost caning of T5.14	M28						
T4.20	Report the model prediction versus the dimensional results third trial of low cost caning of T5.14	M36	D4.14	M36	R			
T4.21	Validate the HIP modelling using the manufactured hardware and report the results	M36	D4.15	M36	R			

Figure 18: Task 4 deliverables and milestones

Subtask ref	Subtask Description	Due Date	Deliverable			Milestone		
			Ref	Due Date	Type	Ref	Due Date	Type
T5.1	Agree with TM the first trial geometry	M1				M5.1	M1	D
T5.2	Design the canister for the first trial and agree with the TM	M4						
T5.3	Ask to subcontract suppliers quotations & put the purchase orders	M6						
T5.4	Manufacture first trial	M10	D5.1	M10	HW			
T5.6	Report the manufacturing process and the results of the first trial	M12	D5.2	M12	R			
T5.7	Agree with TM the second trial geometry	M13				M5.2	M13	D
T5.8	Design the canister for the second trial and agree with the TM	M16						
T5.9	Ask to the suppliers the quotations &Pourchase orders	M18						
T5.10	Manufacture second trial	M22	D5.3	M22	HW			
T5.12	Report the manufacturing process and the results of the second trial	M24	D5.4	M24	R			
T5.13	Agree with TM the third trial geometry	M25				M5.3	M25	D
T5.14	Design the canister for the third trial and agree with the TM	M28						
T5.15	Ask to the suppliers the quotations &Pourchase orders	M30						
T5.16	Manufacture third trial	M34	D5.5	M34	HW			
T5.17	Report the manufacturing process and the results of third trial	M36	D5.6	M36	R			

Figure 19: Task 5 deliverables and milestones

Subtask ref	Subtask Description	Due Date	Deliverable Ref	Deliverable Due Date	Deliverable Type	Milestone Ref	Milestone Due Date	Milestone Type
		M23						
T6.1	Agree with TM the casing geometry	M1				M6.1	M1	D
T6.2	Design canisters for the three casings, taking into account that the final part has to be ultrasonic inspected and has an integral test ring and agree with the TM	M3				M6.2	M3	D
T6.3	Report all the design considerations	M12	D6.1	M12	R			
T6.4	Ask for quotations, select the powder supplier and put the purchase order for the 3 casings	M4				M6.3	M4	D
T6.5	Powder for the 3 parts available for manufacturing process	M6				M6.4	M6	D
T6.6	Ask for quotation to subcontract supplier and put the required purchase order (including material for canister and HIP process)	M5				M6.5	M5	D
T6.7	Define the manufacturing route for the 3 parts and agree with the TM	M5				M6.6	M5	D
T6.8	Manufacture first full scale part for cut up	M11	D6.2	M11	HW			
T6.9	Manufacture second full scale part for development engine program	M12	D6.3	M12	HW	M6.7	M12	D
T6.10	Manufacture thrid full scale part for development engine program	M15	D6.4	M15	HW	M6.8	M15	D
T6.11	Report all the manufacturing follow steps for the 3 casings	M23	D6.5	M23	R			

Figure 20: Task 6 deliverables and milestones

Subtask ref	Subtask Description	Due Date	Deliverable Ref	Deliverable Due Date	Deliverable Type	Milestone Ref	Milestone Due Date	Milestone Type
T7.1	Agree with TM the NDT inspections, the dimensions to be measured, the release testing's production control and the validation exercise of the parts (T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	M4	D7.1	M4	R	M7.1	M4	D
T7.2	Pourchase order in a Nadcap approved laboratory done (validation & Release testing)	M7				M7.2	M7	D
T7.3	NDT data card defined and approved by the TM for all the parts(T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	M4				M7.3	M4	R
T7.4	Dimensional report, NDT and release testing results of T5.4 trial	M12	D7.2	M12	R			
T7.5	Dimensional report, NDT and release testing results of T6.8 trial	M13	D7.3	M13	R			
T7.6	Cut up the first trial (Subtask T6.4) and carried out the mechanical testing defined in the validation in Nadcap approve laboratory	M18				M7.4	M18	D
T7.7	Dimensional report, NDT and release testing results of T6.9 trial	M14	D7.4	M14	R			
T7.8	FAIR for the T6.9 part (including data cards approved by the TM of all the special process, release testing results and dimensional inspections...)	M14				M7.5	M14	R
T7.9	Dimensional report, NDT and release testing results of T6.10 trial	M16	D7.5	M16	R			
T7.10	FAIR for the T6.10 part (including data cards approved by the TM of all the special process, release testing results and dimensional inspections...)	M16				M7.6	M16	R
T7.11	Dimensional report, NDT and release testing results of T5.10 trial	M24	D7.6	M24	R			
T7.12	Dimensional report, NDT and release testing results of T5.16 trial	M36	D7.7	M36	R			
T7.13	Dimensional report, NDT and release testing of T5.8 trial	M12	D7.8	M12	R	M7.7	M12	D
T7.14	Validation report of the cut up part of the first part	M22	D7.9	M22	R			
T7.15	Summary report wih all the NDT results (T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	M36	D7.10	M36	R			
T7.16	Summary report with all the release testing and validation results(T5.4, T5.10, T5.16, T6.8, T6.9 and T6.10)	M36	D7.11	M36	R			
T7.17	Define acceptable criteria for powder HIP parts including acceptable defects base on the results of the trials manufacture during the project	M36	D7.12	M36	R			

Figure 21: Task 7 deliverables and milestones

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

- Accredited Experience with Powder HIP on Superalloys in a Laboratory environment with the following scope
    - Powder specification and characterization; i.e. chemistry, powder size and morphology distribution per the selected Powder Method of Manufacture.
    - Development of the whole powder consolidation manufacturing process; from powder blending/mixing, to canning, subsequent conditioning (e.g. degassing to avoid the deleterious presence of PPB´s), HIPping and final heat treatment.
    - The above shall focus upon densification while allowing product optimization from a metallurgical (microstructure, presence and morphology of strengthening phases such as γ') and mechanical standpoint.
    - In order to drive process parameter optimizations, capabilities to identify the contribution of

microstructural features resulting of the materials processing in relation with the observed mechanical response.
  - Optimization of the HIP and subsequent Ageing Heat Treatment. This through the usage of thermodynamics based tools such as DICTRA, THERMOCALC.
  - Either internal or external (subcontracted) testing capabilities (NADCAP approved) to metallurgically assess and conduct mechanical testing; Tensile, Charpy, LCF, HCF, Creep, Crack Prop, Charpy, and Fracture Toughness or similar tests per sources and techniques acceptable to the TM.
  - State-of-the-art in Powder Hip Modelling. This accounting for powder consolidation in the presence of the relevant canning and/ tooling / fixturing system and to be able to cope with the TM requirements.
  - Capabilities to conduct furnace exposure tests on manufactured materials.

- Accredited Experience with material dynamic properties and ballistic tests.

  - Capabilities to conduct dynamic and impact/ballistic tests
  - Completing the testing capabilities above, LS Dyna modelling capabilities to account for the effect of different configurations of the impact; target geometry, orientation and speed of the projectile etc.

- Accredited industrial experience with Powder, HIP and overall manufacturing processes (machining, NDT´s etc.), holding aerospace/engine customer approvals affecting to both; Quality System and Technical Control and Documentation of manufacturing process to

  - Manufacture and deliver powders per the defined spec and per an acceptable Powder Method of Manufacture. This in support of all the activities throughout the project.
  - Either internal or external (subcontractor) capabilities to manufacture and deliver tools, fixtures and canning systems in concurrency with the geometry for the required mock ups and the manufacture of (3) parts for the demonstrator and the validation activities.
  - Industrial capability and capacity to handle and operate with powders in the right environment for the manufacture of the hardware for the demonstrator; i.e. blending/mixing, canning feeding, vibratory stages, welding, degassing/conditioning, vacuum sealing).
  - Either internal or external (subcontractor) capabilities to HIP full sized components up to ϕ 1500-1600mm with the relevant NADCAP approval.
  - Industrial capabilities and experience to heat treat (holding NADCAP approval).
  - Industrial capabilities to machine the consolidated product.
  - Equally, NADCAP approved industrial capabilities as it relates to dimensional and NDT inspections: Fluorescent Penetrant, Visual, Xray and Ultrasonic.
  - In co-operation with the rest of the partners, capability to manage and document the evolving maturity level of the technology throughout the project; i.e. record keeping and traceability regarding the internal as well as external processes, their manufacture routers, work-to-part instructions, inspection records, etc. This particularly in support of the full size parts being manufactured in support of the UltraFan® Demonstrator engine development.

- Continuous day-to-day working collaboration with the Topic Manager is a must as
    - The expected inputs from within T1, T2 and T3 will allow the TM to derive the geometry of the component for the ITD demonstrator.
    - Based upon the above, and the developments taking place within T4 and T5, a geometry for the canning system will need to be agreed with the TM.
    - The TM will have to give full visibility on the ITD planning so that the outputs of this Call for Proposal are fully aligned both; technically but also in terms of planning with the hardware requirements of the UltraFan® Demonstrator engine development plan.
    - To this end, scheduled meetings will be held with the attendance of the Consortium every fortnight so that the advancement of the project is properly tracked and risks continuously assessed and mitigated so that the objectives of the project are not jeopardized.

- Capability and accredited experience of resources to manage a consortium.
- A relevant amount of budget within this CfP is devoted to conducting material tests in acceptable accredited sources (NADCAP) which will need to be per acceptable techniques to the TM. If no partners join the Consortium proposal able to bring those accredited testing capabilities, the proposal must make sure this is specifically covered in the budget split through the allocation of resources to subcontracting.

5. Abbreviations

SOW	Statement of Work
RT	Room temperature
HT	High temperature
TM	Topic Manager
C	Cast
W	Wrought
T	Temperature
HIP	Hot Isostatic Presing
Kg	Kilogramme
NDT	Non destructive testing
PPB	Prior particle boundary
ITD	Integrated Technology Demonstrator
IP	Intellectual Property

9. Clean Sky 2 – Systems ITD

I. Development of a system for pilot eye gaze and gesture tracking in the cockpit environment

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 1.2		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Thales	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[56]	Q2 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-SYS-01-07	**Development of a system for pilot eye gaze and gesture tracking in the cockpit environment**
Short description	
The purpose of the proposed work is to develop, test and validate a system for eye and gesture tracking. The system should be able to detect and track posture, gesture and eye gaze of pilot crew under typical cockpit environmental conditions (use of glasses, turbulences, high intensity sun light).	

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

1. Background

Research and development activities in avionics are inspired by the consumer domain. For instance, the avionics actors have the ambition to integrate new devices in the cockpits such as touchscreens or voice and gesture recognition solutions, to offer pilots multimodal interactions. The purpose is to conceive user centric Human Machine Interfaces fully adapted to human abilities, reducing pilot workload and ensuring the safety of the flight.
More precisely the different fields of investigation to do such things could be:

- Tangible interfaces (touch / haptic / deformed screens, physical interactors, …)
- Sound spatialization
- Voice / gesture recognition
- Eye tracking
- Physiological data capture (electrocardiogram ECC, electroencephalography EEG …)

All these activities allow sharing new kind of information between avionics systems and pilots through dedicated languages: vocal commands, gaze / sound localization, heartbeat … Thus new concepts of interaction can be defined to enhance pilot operations. The activities concerned by this new Clean Sky program topic are gesture and eye tracking.
In this field, the state of the art technologies are deployed in consumer domain, mainly in leisure activities such as the video games but also in automobiles for the pilot monitoring. The main actors are Tobii with its eye tracking solutions, or Kinect used for the gesture based Xbox video games. Both of these solutions are based on a set of cameras like infrared cameras.
In the context of SYSTEMS ITD WP1.2.4 Human System Interfaces, the topic manager objective is to find an efficient crew interface and monitoring system based on gesture and eye tracking solutions totally adapted to the operational conditions and to the high valuable use cases he wants to develop. This solution will cover the whole cockpit area and be adapted to pilot and co-pilot use. The final prototype of this CS2 new project will reach the TRL5 level of maturity.

2. Scope of work

The objective of the topic is to develop and demonstrate a crew interface and monitoring system based on gesture and eye tracking solutions. The developed system shall provide to the avionics systems the following parameters:

- The localization of the pilots gaze inside the entire cockpit and also the direction of the gaze outside the window at any time.
- Pilots' face information : At least open / closed eyes, by opportunity head localization / rotation, specific face expressions
- Gesture data : At least fingers / hands / arms locations, by opportunity specific gesture recognition (open / closed hands, finger up, …)

A high resolution solution – in line with current state-of-the-art COTS solution for consumer market - will be appreciated (point of gaze, fingers locations, facial motions).
The real time and accuracy issues shall be assessed during the project to ensure the usability of the different use cases.

In order to reach the targeted level of maturity, the solution shall demonstrate to be compliant with :

- Most of aircraft cockpit installation (specific head up and head down displays, cockpit structure). At the end of the project, sensor positioning requirements shall be defined to easily adapt the solution to any cockpit.
- Operational environment: turbulences, cockpit luminosity (day and night use)

Note: Sensors shall be robust to high solar luminosity (100000 Lux for indirect lighting, worst case solar direct lighting) and turbulences (normal behaviour for more or less 0,5G variation, integrity robustness for more or less 2G)

- Pilots habits: use of sun glasses, wearing of a helmet
- Certification requirements (the solution providers and the topic manager will define together the system definition according to certification constraints)

In order to reach this objective, the following set of tasks is suggested, to be adapted to each applicant in his proposal.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Crew interface and monitoring system definition	T0+2 months
T2	Development of the crew interface and monitoring system for cockpit	T0+16 months
T3	Integration in avionics demonstrator	T0+18 months
T4	Crew interface and monitoring system for cockpit validation	T0+22 month

T1 - Crew interface and monitoring system definition

During this first working session, the topic manager will provide the preliminary specifications including functional and non-functional requirements (in accordance with DO254 standard which defines development constraints for avionics electronic embedded equipment) and envisaged use cases, test and validation scenario. Globally the use cases will cover:

- Interactivity with the cockpit (gaze and gesture interactions)
- Crew monitoring (tiredness, cognitive workload, stress analysis)

The objective is to prove the technical feasibility of the use cases in operational conditions.

In the same time the applicants will present their current solution:

- Product capacities and characteristics
- Interfaces and framework
- Solution maturity (TRL 5 expected at the end of project)

The applicants, with the support of the topic manager, will prepare and provide a complete State of the Art Survey and a compatibility analysis with the preliminary specifications including the schedule of activity to reach the objectives and the risks associated to the technologies used (operational conditions issues : IR level, vibration and turbulences, industrial maturity, latency, accuracy). Mitigation plans shall be proposed.
An iterative approach, with short designing/evaluation cycles, will be advised to verify the fulfilment of the high level requirements in the various evaluation scenarios. A milestone must be scheduled to allow verifying the maturity and the progress beyond the state of the art of the proposed approach.

T2 - Development of the crew interface and monitoring system for cockpit
At this stage, the applicant shall develop the complete crew interface and monitoring system, covering both pilot and co-pilot, integrating:

- The required sensors (camera, …) compatible with avionics cockpit and crew usages
- The software units needed to interpret the raw data.
- The system API and framework allowing connectivity with cockpit systems (the type of connectivity will be specified by the topic manager in the preliminary requirements).

T3 - Integration in avionics demonstrator
The objective is to integrate the applicant solution in The Topic Manager cockpit demonstrator, representative of aircraft.

T4 - Crew interface and monitoring system for cockpit validation
The objective is to demonstrate the compliance of the solution with functional, non-functional requirements, and performance objectives. The use cases feasibility in operational conditions shall be assessed.
The applicant solution will be tested through the dedicated evaluation scenario defined in the step T1. .
The validation process will take into account the iterative approach suggested by the Topic Manager for the T2 / T3 / T4 activities.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Schedule of activities *Objective : Develop and validate a solution compliant with functional / non-functional requirements defined by the topic manager*	R	T0+2 months
D2	Prototype of the applicant solution Version 1 *Objective : standalone solution remote from operational cockpit environment*	HW	T0+3 months
D3	Prototype of the applicant solution Version 2 *Objective : First official solution version integrated in the cockpit demonstrator*	HW	T0+8 months
D4	Prototype of the applicant solution Ultimate version *Objective : Ultimate version of the applicant solution updated after the evaluation results analysis*	HW	T0+16 months
D5	Description of the solution *Objective: Description of the sensors cockpit installation requirements, the functional and physical architectures.*	R	T0+18 months
D6	Validation report of environmental testing	R	T0+22 months
D7	Validation report of functional testing	R	T0+22 months

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

The following skills are required from the applicants:

- Eye tracking and motion sensors expertise

- Crew monitoring state of the art knowledge

Note: Cognitive workload, tiredness, concentration measurement abilities will be appreciated.

- Gesture interactions state of the art knowledge

Note: Multimodality concepts (CARE properties, gesture interaction language) knowledge will be appreciated.

- System and software development and integration expertise

Note: SDK and framework availability will be appreciated

- Knowledge on embedded systems in avionics or other field of activity would be appreciated

5. Abbreviations

CARE : Complementarity Assignment Redundancy Equivalence
HMI : Human Machine Interaction
IR : InfraRed
SDK : Software Development Kit
TRL : Technological Readiness Level

II. Application of machine learning techniques to enhance aircraft performances database and facilitate mission optimization objectives

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 1.3		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Thales	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	24	Indicative Start Date[57]	Q2 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-SYS-01-08	Application of machine learning techniques to enhance aircraft performances database and facilitate mission optimization objectives
Short description	
The objective is to adapt an aircraft performances database with an accuracy level compatible with mission optimization objectives. This topic focuses on the use of machine learning techniques to enable trajectory optimization functions outside avionics and trajectory computations within avionics.	

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

1. Background

Previous studies carried out within the CleanSky project Neural investigated the potential of surrogate modelling techniques using neural networks to achieve fast trajectory integrators. They had the following objectives:

- to use neural network to model generic aircraft performances and compute vertical profiles,
- to prepare for green optimization functions and trajectory computation, with a « smooth » model (continuous derivatives) for on-board avionics products and trajectory optimization tools.

A toolbox was developed that is able to generate surrogate models. Preliminary concept validation activities led to demonstrate that such approach could help achieve fast integrators for trajectory optimization.

Technical limitations were:

- focus only on the modeling of the fuel flow (FF) and Specific Excess Power (SEP) data, whereas aircraft performance data bases can have different structures depending on FMS products (see figure below)
- a single solution for modeling technology (neural networks known as multilayer perceptron) was looked at, no trade-off with respect to other methods was performed,
- input data used to model aircraft performance were only provided through sets of flight simulations involving generic performance data base (no use of flight records).

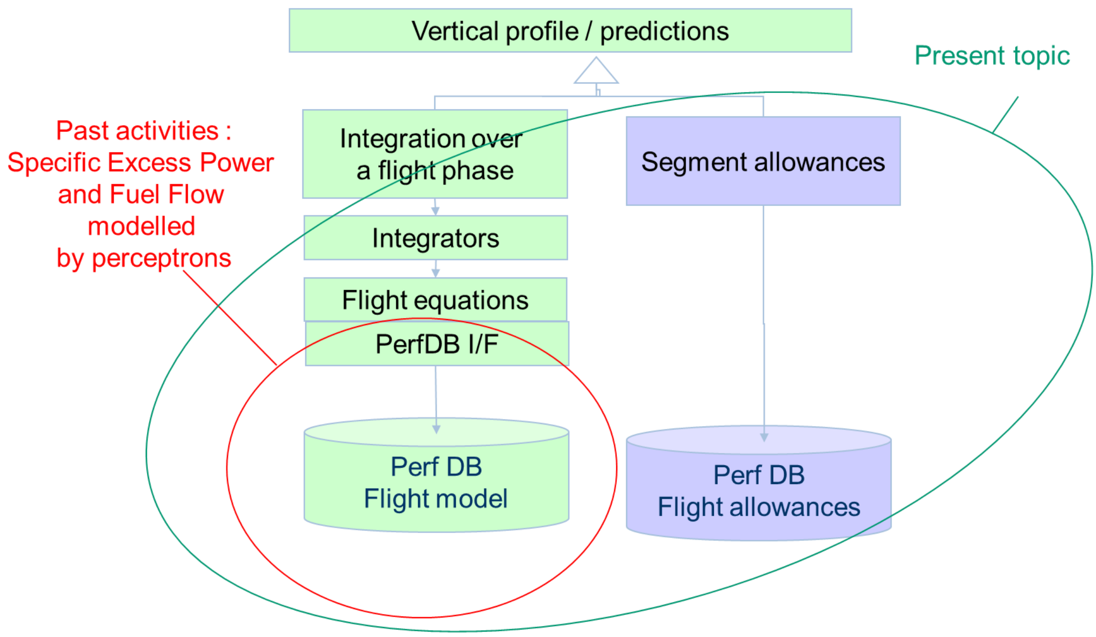
The practical use of the prototype tool highlighted the following additional limitations:

- adjustment of neural networks architecture and characteristic parameters during training phase was difficult ;
- the tools had limitations in network layout.

This topic plans to build on the results of the past activities performed within the CS JU project "Neural". (http://www.cleansky.eu/sites/default/files/documents/Activities/SGO3/Neural.pdf)

The objective is to customize the aircraft performance model, aircraft by aircraft with applications both to avionics (FMS) and to mission preparation, and re-optimization during flight. Other modelling solutions, with modified problem settings are sought that encompass:

- use of real flight data as input for the models,
- adaptability (tail number by tail number) of a generic aircraft performance model (e.g. as established by an airframer during aircraft development),
- use of a basic structure of the underlying dynamic model: evolution equations (left part of scheme below) or polynomial representations of state increments, derived from Flight Manual reference (right part of the scheme below)



Relevant work is carried out in within SESAR as well as in sectors other than aeronautics. Proposals should encompass a survey of existing solutions and/or ongoing projects, highlight the proposed novelties and demonstrate progress beyond state of the art.

2. Scope of work

The topic work will allow to:

- define solutions for modeling functions, associated machine learning process (for instance using non parametric statistical estimation techniques) and validation methods,
- develop prototype tools implementing the proposed solutions
- adapt generic aircraft performance models with the adequate accuracy, under the following conditions :
  - real flight input data: **data collected from airline operation centers, flight data recording**,
  - different types of aircraft performance model to be obtained:
    - through basic physics equations – trajectory is then obtained by numerical integration –
    - or directly through aircraft state increments.

Expected output is:

- prototype tools both for the learning phase and for the validation phase
- adapted models for a few selected commercial aircrafts (at least Airbus aircraft)

Applicant will provide input data required for this work. These could be either available with the applicant or collected from other sources, in which case, applicant should have means to collect, record and process flight data of commercial aircraft

The aircraft performance model to be provided shall be **adaptable to each aircraft (tail number by tail number),** and compatible with trajectory computation and optimization functions (typical level of accuracy in the order of 0.5 %); predicted trajectory computation along a reference flight plan, trajectory optimization (mission preparation, in fight re-optimization), comparison of different trajectory alternatives,

The main activities and deliverables are sketched in the table below, however, applicant are encouraged to propose alternate approach to ensure achievement of the topic objectives.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP1	Technical resources	T1 + 3 months
WP2	Aircraft Performance Model and Learning& Validation tools design	T1 + 7 months
WP3	Flight data collection for Aircraft Performance Model Learning& Validation	T1 + 9 months
WP4	Aircraft Performance Model and Learning& Validation tools development	T1 + 12 months
WP5	Aircraft Performance Model and Learning& Validation tools verification and validation	T1 + 16 months
WP6	Evolution and update	T1 + 18 months

WP1 : Technical resources and problem definition

The objectives of this work package are to:

- describe technical resources (input data, initialization data, validation means),
- define technical problem (data to be modelled, use cases & functional scope, model interface with trajectory-focused functions, modelling technologies: modelling functions and associated learning methods),
- define technical requirements (interfaces, accuracy, performance…) for models and modeling tools,

WP2 : Aircraft Performance Model and Learning& Validation tools design

After the specifications, the model and tools design process should convert them into solutions.

The objectives of this work package are to:

- define and describe mathematical solutions for aircraft performance model (external interfaces, internal parameters, mathematical relations between external interfaces and internal parameters),
- define and describe mathematical solutions for learning tools (external interfaces, internal learning methods/algorithms, learning process),
- define and describe verification and validation tools (scenarii, criteria).

WP3 : Flight data collection for Aircraft Performance Model Learning & Validation

Activities of this work package are:

- establish a flight data collection plan encompassing the list of data to be collected, their sampling characteristics, and the means to collect/record these data
- define and describe the data processing to be performed on collected data for subsequent use by machine learning
- provide the processed data to be used as inputs for aircraft on board model generation.

WP4 : Aircraft Performance Model and Learning& Validation tools development

The objectives of this work package are to:
- develop tools for learning phases according to the design established in WP2,
- develop aircraft performance model by implementing mathematical relations of aircraft performance model according to the design established in WP2,
- generate internal parameters of aircraft performance model with learning tools from flight data.

WP5 : Aircraft Performance Model and Learning& Validation tools

The objectives of this work package are to:
- define model validation test plan and description of associated tools,
- develop tools for model validation,
- apply validation test plan and analyse results.

WP6 : Evolution and update

The objective of this work package is to provide a support for possible tool debugging and/or models and tools evolutions before the delivery of the final version.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1.1	Technical Resources and Requirements	R	T1 + 2,5 months
D2.1	Aircraft Performance Model Description Document	R	T1 + 4 months
D2.2	Modelling Tools Description Document	R	T1 + 5,5 months
D3.1	Aircraft flight data collection report	R	T1 + 8 months
D4.1	Aircraft Performance Model Package	R	T1 + 10 months
D4.2	Modelling Tools Package (first release)	P,R	T1 + 11 months
D5.1	Validation Test Plan	R	T1 + 13 months

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D5.2	Validation Tools Package and Test Report	R	T1 + 15 months
D6.1	Aircraft Performance Model and Modelling Tools Packages final release	P,R	T1 + 17 months

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Prototypes Development Readiness Review		T1 + 7 months
M2	First release Results Review		T1 + 15 months
M3	Final Acceptance		T1 + 18 months

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

Experience and strong background on modelling technologies and trajectory computation/optimization needs. Collaboration with airlines is encouraged to collect, record flight data and to validate model against real flight data

Data collection and processing (flight record)

Capability to collect/record and process flight data. This includes capture, storage, analysis, data curation, search, sharing, transfer, visualization, querying, updating and information privacy.

Modeling technologies (machine learning)

Knowledge and background in the machine learning domain.

Model verification and validation (flight data)

Ability to perform model validation against real flight data and model uodating (including error detaction and analysis).

Trajectory computation and optimization

Experience in aircraft trajectory computation and optimization.

5. Abbreviations

DB Data Base
FMS Flight Management System
WP Work Package

III. Obstruction detection Sensor for Modular surveillance active Trajectory check improvement

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	ITD WP1.3		
Indicative Funding Topic Value (in k€)	850		
Topic Leader	Thales	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[58]	Q2 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-SYS-01-09	**Obstruction detection Sensor for Modular surveillance active Trajectory check improvement**
Short description	
In the context of the Modular Surveillance System development, the introduction of mass market relevant sensor (millimeter wave radar combined or not with video camera) is targeted to perform aircraft active trajectory checks during low altitude flight phases.	

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

1. Background

a) Operationnal Need

Collision is a major threat for all aircrafts. The term collision covers:

- Controlled Flight Into Terrain (CFIT, including natural or man-made obstacles)
- Collision with surrounding traffic. This collision might occur on ground (when the aircraft is performing manoeuver) or in flight.

Past introduction of new system like TCAS or TAWS has allowed reducing the number of accidents. However, collision risk still remains a main concern of aviation authorities.
As an example, it is mentioned as a major axis of improvement by EASA 2020 safety plans for both Commercial Air Transport Airplanes (ground handling is the 4st cause of fatal accidents) and for Helicopters (main cause of accident during take-off and landing).

b) State of the art regarding collision prevention in aeronautical context

Controlled flight into terrain (CFIT) occurrence has been drastically reduced thanks to the introduction of system like TAWS (Terrain Awareness and Warning System).
However, this system needs improvement.
Due to the requested independence between navigation systems and surveillance system, the TAWS does not know the aircraft intended trajectory. It bases its alert computation on the current aircraft parameters. These parameters are used to extrapolate the aircraft current position. This extrapolation is then compared to terrain and obstacle databases.
This mechanism implies that the transition from a straight flight to a turn or from a turn to a straight flight cannot be estimated by the system before the aircraft has initiated the manoeuvre.
Consequence is that the TAWS can raise false alerts (nuisance alerts) in the near vicinity of obstructions (terrain or obstacles).
For this reason, TAWS does not properly cover take-off, landing and (for helicopter) hoover phases in the proximity of an obstacle: during these phase of flight, only a subset of TAWS reactive modes protect the aircraft. This protection is mainly based on radio altimeter and so limited to obstruction located directly below the aircraft.
In addition, the TAWS function is perfectible:

- The process of generating and keeping up to date database of obstacles takes a lot of time. It does not allow including moving or temporary obstacles like crane or vehicles.
- Function’s performances highly depend on:
  - GNSS accuracy: This one is often worse than 5m when close to the ground. When combined with TAWS database uncertainty it can lead to spurious or missed alerts.
  - Obstacle location accuracy and completeness. They may strongly vary from one source data supplier to the other. As a consequence, source data for obstacle database are not fully reliable.

For this reason, collision with obstacles remains a major threat.

For traffic monitoring current system like TCAS works very well with collaborative aircrafts (equipped with transponder). They are not able to handle non collaborative ground vehicles or small aircrafts (not equipped with transponder).

Current aeronautical active detection systems are mainly based on sensor using laser or on radar. These sensors have been specifically developed to meet aeronautical qualification constraints.

Figure 22: Example of radar based Obstacle Detection Systems installed on rotorcraft

These systems have several drawbacks: high price (estimated at more than 100 000$), specific customization to a type of aircraft, complex integration due to size constraints, impact of weight and dimensions on drag and fuel consumption, high power consumption. In addition, some of them cannot be used close to the ground due to the effect of their radiation on the environment.

c) State of the art regarding collision prevention in automotive context

The development of ADAS in automotive industry fostered large investments in sensor technology. A well-known application is for providing assistance regarding blind spot detection or reverse driving.
Current interesting applications are adaptive cruise control, configuration of safety system (seat belt) before crash and auto brake systems. Associated low cost sensors are based on millimetre waves radar combined or not with camera. Radar is in charge of target detection and camera is used to improve detection reliability (ghost echo removal). The achieved level of performances is now very interesting in term of range of detection (200m - 300m), speed (400km/h) as well as in term of simultaneous targets detection (more than 50).
More complex and advanced ADAS solutions (especially the one in development) also use LIDAR or 3D Flash Laser.
Automotive constraints are very high regarding reliability, sensor weight, size, power consumption and cost. This leads to sensor design which can be very helpful to build an attractive solution for aeronautical customer. We can quote as example millimetre waves radar, camera and in a near future 3D Flash Laser sensor.
In addition, associated industrial standards (ISO 26262) seem to be very close to aeronautical ones, especially in term of safety analysis and hardware/software qualification.

Figure 23: Example of automotive radar sensor

d) Objectives and expected benefits

This topic is expected to contribute to the development of the Modular Surveillance System (MSS) in the frame of Clean Sky 2 Systems ITD WP1.3.
MSS is designed to be installed on all kind of aircrafts. Its purpose is to improve current surveillance system like TAWS through additional functions. One of them is the addition of one or several sensors of various

technologies. These sensors could be very helpful to cover phases of flight that are not well managed by TAWS (see §b)).
As described before, existing solution are quite efficient but at a very high cost (estimated around 100 000$ or more) and with some important drawbacks (see b)).
Since system cost is a key element, only few aircrafts are equipped today.
To address helicopter and general aviation market in addition to air transport, it is important to reduce drastically system cost, installation constraints and to offer a good level of performances.

To do so, it is proposed to assess the use of adapted mass markets sensors. By "adapted", we mean that modifications compared to serial version should be limited:

- Sensor hardware changes should be limited to aircraft installation (e.g addition of lightning protection, interfaces…). Sensor itself should not be redesigned. Expected benefits are reduced cost and simplified hardware qualification thanks to the mass market development processes and in-service experience.
- Sensor internal software may be augmented to provide relevant obstacle detection. For instance, compared to an automotive sensor, a lot of new parameters may have to be taken into account (e.g vertical speed, roll…).

So challenges regarding sensor choice will be:

- To limit development compared to large series as much as possible to sensor software. The goal is to be as low cost as possible.
- To cope with high demanding environment of aeronautics (bad weather, brownout phenomenon…) with limited maintenance (e.g cleaning, calibration..),
- To be able to cope with aircraft dynamics (pitch, roll, speed in the 3 axis, pitch and roll variations),
- To be able to cope with aeronautical standards (DO160, DO254, DO178…).
- To be reliable, light with low power consumption in order to ease installation.

Previous studies (e.g French SEFA-IKKY) allow determining that automotive radar and optical technology are promising and that they could cope with bad weather conditions.
However, to the topic manager knowledge, these technologies have only been evaluated in static environment using standard automotive products. This means that sensor internal processing (filtering logics, adaptation to A/C dynamics, obstacle identification…) have not been adapted nor assessed in a flying environment.
Other known studies use dedicated aeronautical sensor (e.g NIAG Sg 167).
So in term of operational performances, current status is that we do not know if such a transfer from mass market is possible. It has also still to be assessed if associated treatment modifications and addition of functionalities are reasonable or if their cost is equivalent to a new sensor design.
It must be noticed that if this development reaches its objectives, the sensor technology might be used for

- Fixed wings aircrafts market
- Rotorcrafts market
- UAV market.

To sum-up, main goals of this call is so:

- To identify proven low cost technology and associated sensor that could satisfy aeronautical needs.
- To find and implement the modifications allowing to transfer the sensor from mass market series to aircraft environment without redesigning the sensor (especially the hardware).
- To integrate the adapted sensor and to evaluate its maturity and its reachable performances in flight (moving environment)

- To find possible synergies between European Aeronautic industry and other fields (e.g. automotive): the topic manager brings aeronautical knowledge regarding operational need and installation constraints; the applicant brings knowledge of mass market sensor performances and associated possible modifications.

2. Scope of work

As a pre-requisite, Topic manager will provide sensor operational need specifications and associated high level test plan. These documents will be refined with the partners during work performed.
Topic manager proposes to divide work in several tasks that may be rearranged with the partners to facilitate their workflow:

1) Identification of potential sensor and preliminary adaptation of its processing (e.g filtering, obstacle identification…) to fit with flight dynamics of an aircraft (Task 1).
2) Sensor evaluation in flight using small flying vehicle in order to collect data regarding dynamic obstacles detection capability (Task 2).
3) Sensor processing refinement using collected data and integration of one or several adapted sensors with Aircraft surveillance system prototype. (Task 3).
4) Flight test using small flying vehicle and representative prototype (e.g 1 sensor instead of 6 in the final system) in order to collect data and to evaluate operational benefits (Task 4).
5) System architecture analysis and refinement using flight test collected information. Analysis of activities to be performed to satisfy aeronautical standards (Task 5).

Identified main requirements for the sensor or set of sensor are the following ones:

- Low cost (ambition is to propose a complete system at least 5 times less expensive than existing solutions).
- Detection capability for a single sensor of 150m as a minimum with horizontal field of view of at least 120° and vertical field of view of at least 14°,
- All weather (rain, fog, snow, sand and dust) detection capability.
- Nuisance rate probability lower than $1*10^{-06}$ per FH.
- Software interface capability to provide following minimum information (or equivalent) for each detected target: Azimuth, Distance, Speed
- Max weight: 3kg for the complete set of sensors.
- Max power consumption: 60w for the complete set of sensors
- Able to work using 28V DC power.
- CAN or Ethernet interface for the link with avionic.
- Sensor internal design adapted to perform detection of obstructions while installed on aircrafts and helicopters operating on ground or close to the ground (below 500ft) at low speed (below 100kts).
- No external cooling in order to allow installation in retrofit without modifying aircraft aerodynamics or aircraft cooling system.
- Development according to standards allowing reaching compliance to DO-254, DO-178 and DO-160 (installation constraints of both fixed wing aircraft and rotorcraft) at low cost.
- Ensuring safety of operator surrounding the aircraft with sensor fully functional and without requiring any protection mean.
- Ability to address all civil markets without export constraint.

- Compatibility with European Table of Frequency Allocations and Applications.

Associated task proposal is the following ones:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
1	Mass Market Sensor selection and adaptation	T0 + 7
2	In flight Sensor pre-evaluation and data collection	T0 + 10
3	Refinement of sensor adaptation	T0 + 18
4	In flight Operational evaluation and data collection	T0 + 22
5	System Architecture definition	T0 + 24

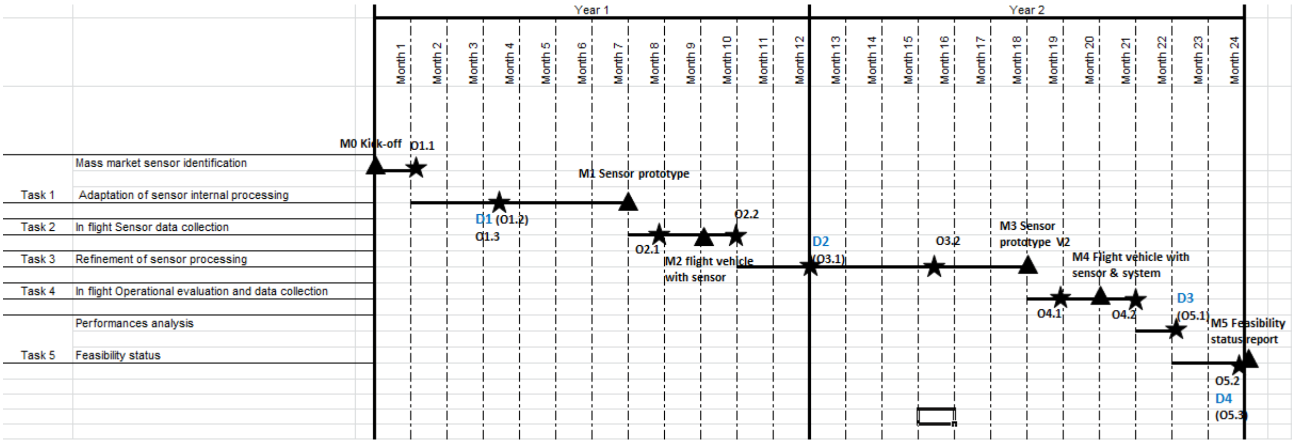


Figure 24: Illustration of the sequence of activities (to be discussed and finalized with the applicant)

d) <u>Task1 : Mass Market Sensor adaptation and integration/flight test support</u>

The applicant will propose a sensor based on mass market technology that fit with operational need definition. Since cost is a key element, the sensor shall share its hardware internal architecture with mass market equipment. In addition, this will also allow reaching maturity quickly.

As a summary, focus will be on:

- Sensor operational need specifications and associated high level test plan (provided by the topic manager as a basis for discussion).
- Series Sensor specifications including installation constraints and performances (it will be used as a basis for discussion).
- Sensor prototypes with internal treatments adapted (if possible).
- Sensor utilities for tests (e.g power sources and recording means)
- Preliminary Compliance matrix to the operational need and to the high level test plan (it will be used to orient test plan and associated effort).

<u>Expected task results:</u> mass market sensor prototype that could satisfy operational needs, preliminary tuning of sensor treatments (if possible)

e) <u>Task 2 : In flight Sensor data collection.</u>

OPerform flight tests (e.g. on a UAV) in order to collect data. This data collection will be used to adapt sensor internal processing (filtering logics, adaptation to A/C dynamics, obstacle identification…) to aircraft flight dynamics.

As a summary, focus will be on:

- Sensor integrated on aircraft
- Refined test plan for data collection and authorizations from regulation authorities
- Recorded data and sensor test results

Expected task results: sensor data corresponding to operational scenarios, identification of operational improvements to be done.

f) Task 3: Refinement of sensor processing

This task is proposed so that the applicant can performed a deep analysis of flight recorded data. Goal is to identify main improvements and new parameters than can be taken into account into sensor internal processing..
The purpose of this task is not to develop a sensor with full detection capabilities in all concerned situations but to perform research and to assess the feasibility of using mass market sensor as a starting point.

As a summary, focus will be on:

- Identification of adaptation to be performed on sensor processing
- Evaluation of reachable performances
- Sensor prototype with internal treatments adapted

Expected task results: adaptations to be done in mass market algorithms to comply with aeronautical needs, addition of new sensor functions and control laws (e.g roll, pitch management…).

g) Task 4 : In flight Operational evaluation and data collection.

This task is proposed to evaluate in flight the complete system made of the adapted sensor integrated with an embedded surveillance system (e.g Modular Surveillance System including HTAWS).
Topic manager is in charge of adapting the surveillance system to take into account data from several sensors. Surveillance system will merge information and provide relevant data to the crew according to the situation (flight phase for instance). The system will also have to handle the transition from long range protection (based on HTAWS) and the one provided by sensors.
Interfaces between sensor and surveillance system is adapted conjointly by the applicant and the topic manager.

The purpose of this task is to assess the operational value of the detection based on such sensors and combined with existing surveillance system.

Expected task results: sensor & system data corresponding to operational scenarios, identification of operational improvements to be done.

h) Task 5 : Architecture definition

The objective is to analyse flight test results and to determine feasibility of a system based on updated mass market sensor.

As a summary, focus will be on:

- Performances analysis
- Identification of sensor implantation and installation constraints
- Identification of remaining activities & feasibility status

Expected task results: operational validation of sensor_adaptations, sensor new functions and control laws, Validation of system concept of use, identification of remaining activities to be done for going from R&T to R&D.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1 (O1.2)	Preliminary Sensor adaptations	Report	T0 + 4
D2 (O3.1)	Identification of modifications to be performed	Report	T0 + 12
D3 (O5.1)	Performances analysis	Report	T0 + 22
D4 (O5.3)	Remaining activities for aeronautical standards compliance & feasibility status	Report	T0 + 24

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M0	Kick-Off	Report	T0
M1	Sensor prototype	Report	T0 + 7
M2	Flight Vehicle with sensor	Report	T0 + 9
M3	Adapted sensor prototype	Report	T0 + 18
M4	Flight Vehicle with sensor and system	Report	T0 + 20
M5	Feasibility status report	Report	T0 + 24

Outputs to the topic manager			
Ref. No.	***Title – Description***	***Type***	***Due Date***
O1.1	Sensor prototypes and associated utilities	Hardware	T0 + 1
O1.3	Preliminary Compliance matrix	Report	T0 + 4
O2.1	Flight Test plans for data collection	Report	T0 + 8
O2.2	Data collection report	Report	T0 + 10
O3.2	Reachable performances evaluation	Report	T0 + 16
O4.1	Flight Test plans for operational validation	Report	T0 + 19
O4.2	Flight Test report	Report	T0 + 21
O5.2	Sensor implantation and installation constraints	Report	T0 + 24

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

- Industrial experience in sensor of the mass market (e.g automotive) and at least a basic knowledge of Aeronautical constraints.
- Capability to perform sensor prototyping.
- Capability to perform software development and adaptation.

5. Abbreviations

A/C	Aircraft
ADAS	Advanced driver-assistance systems
CFIT	Controlled Flight Into Terrain
COTS	Commercial off-the-shelf
HTAWS	Helicopter Terrain Awareness and Warning system
MSS	Modular Surveillance System
R&D	Research & Development
R&T	Research & Technology
TAWS	Terrain Awareness and Warning system
UAV	Unmanned Aerial Vehicle

IV. Development of 94 GHz (W-band) Radar Components

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 1.3.5		
Indicative Funding Topic Value (in k€)	1750		
Topic Leader	SAAB	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[59]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-01-10	**Development of 94 GHz (W-band) Radar Components**
Short description	
The topic aims at significantly improving critical high-frequency mmW building blocks, enabling small-size and affordable 94 GHz radars with multi-km range coverage. Critical building blocks include high-power (≥1 W) amplifier and signal source MMICs as well as surface mount packaging technologies.	

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

1. Background

Previous generation Enhanced Flight Vision Systems (EFVS) used Cooled SW-IR sensors to detect (primarily) filament lamp runway approach light systems, thereby satisfying certification requirements to enable continued visual final approach. Newest generation systems use multi-spectral un-cooled sensors, but IR-sensors alone will never suffice in all weather conditions, nor will it meet the increasing operator and community expectation for performance and expanded functionality.
The CleanSky2 Systems workpackage on Advanced Vision and Awareness, explores a new multi-function approach where a combination of affordable IR-sensors, novel world terrain database sources, image, navigation and computing technologies, will develop and utilize a new generation mm-wave radar to find a total solution to Enhanced Vision, while at the same time creating a complete Awareness function providing e.g. new obstacle and terrain awareness functionality. The components developed under this topic should enable critical steps to a mmW-radar that will be used in combination with IR sensors. This combination will satisfy the new certification requirements being developed for future EFVS-systems, thereby increasing regularity, enhancing safety and enabling the next generation Air Traffic Control systems defined by SESAR (EU) and Nextgen (USA).

The radar will operate in the 93-100 GHz range where the supply of commercial components is very limited. Furthermore, the available components do not fulfill the performance required for a W-band radar with multi-km range coverage. Due to the high frequency, integrated solutions using an advanced GaN Monolithic Microwave Integrated Circuit (MMIC) technology is foreseen to be the preferred choice but the topic is open for any technologies. Three areas of interest are identified in this topic as being the major bottlenecks to develop a small-size and affordable 94 GHz radar with multi-km range coverage.

- Single-Chip Power Amplifier (PA) MMIC
- Single-Chip Signal Source (SS) MMIC
- Surface Mount Packaging Technologies

The PA and SS MMICs will need to be able to operate in both continuous wave (CW) and pulsed mode operation. Required output power level for the PA's is ≥0.5 W in CW and ≥1 W in pulsed mode operation. The main focus of the SS is to deliver an output signal with low phase-noise floor (≤ -155 dBc/Hz) at offset frequencies ≥10 MHz from the carrier. It shall also be possible to phase lock the SS with an external PLL and the output power of the SS need to match the required input power of the PA.
Furthermore, the packaging of these components are particularly difficult where the traditional chip-and-wire technology provides the required technical performance but at a high cost. A significant cost reduction could be achieved if standard surface mount technologies (SMT) could be used also at 93-100 GHz. Thus, a third area covered in this call is the development of a MMIC package where the developed MMICs could be integrated with sufficient RF and thermal performance.
Furthermore, all technologies developed in this topic need to be free of any ITAR (or similar export) restrictions.

The objectives of this call are:

- Demonstrate a single-chip Power Amplifier (PA) MMIC with the following probed bare-die room temperature specification:
    - Frequency range: 93 – 100 GHz

- Output power at 1-dB gain compression: ≥27 dBm (0.5 W) in CW and ≥30 dBm (1 W) in pulsed (20% duty cycle) operation in room temperature
    - S11/22: ≤-16 dB
    - S21: ≥20 dB
    - Proven operational and unconditionally stable over -55 to +85 deg. C. (Possible with somewhat degraded performance compared to room temp.)
    - The PA should be designed to match the design of the SS and SMT package also developed in this topic
- Demonstrate a single-chip Signal Source (SS) MMIC with the following probed bare-die room temperature specification:
    - Frequency range: 93 – 100 GHz
    - Saturated output power: Enough to drive the PA also in this call, i.e. in the 10-100 mW range
    - Phase noise floor: ≤-155 dBc/Hz ≥10 MHz offset
    - Possible to phase lock with a input/output reference signal ≤5 GHz (thus, the PLL does not need to be part of the SS)
    - Small-signal reflection on RF output: ≤-16 dB
    - Proven operational over -55 to +85 deg. C. (Possible with somewhat degraded performance compared to room temp.)
    - The SS should be designed to match the design of the PA and SMT package also developed in this call
- Demonstrate SMT MMIC packages with the following room temperature specification:
    - Frequency range: 93 – 100 GHz
    - Loss per RF transition: ≤1 dB
    - Reflection per RF transition: ≤-16 dB with a 50 ohm load in the package
    - Proven operational over -55 to +85 deg. C. (Possible with somewhat degraded performance compared to room temp.)
    - Three variants of the package should be designed based on the MMICs developed in this call (the package shall be mounted on a suitable PCB when tested):
        - Stand-alone PA
        - Stand-alone SS
        - Combination of PA and SS

Aviation and Non-Aviation Industry type of companies or company/academic clusters are warmly encouraged to participate to the call. The Topic Manager will participate in the technical work and will support the project technical follow-up

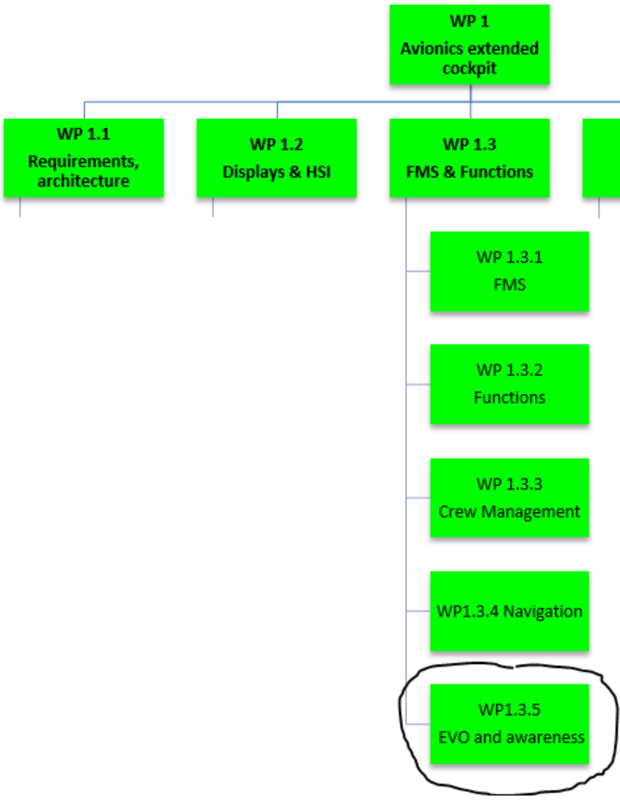


Figure 25: WP 1.3.5 EVO and Awareness in CleanSky 2 Systems ITD WP1

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

	Tasks		
Ref. No.	***Title – Description***	***Deliverable***	***Due Date (month)***
T1	**Specification.** Ending with Written Report	D1	T0 + 1
T2	**Design, 1st run.** Ending with approved Design review, Written Report, and Tapeout #1.	D2	T0 + 5
T3	**Manufacturing, 1st run**	D3	T0 + 8
T4	**Evaluation, 1st run.** Evaluation of first run of MMICs and packages, ending with Review and Written Report.	D4	TO + 12
T5	**Design, 2nd run**. Ending with approved Designreview, Written Report, and Tapeout #2.	D5	TO + 16
T6	**Manufacturing, 2nd run**	D6	T0 + 19
T7	**Evaluation, 2nd run.** Evaluation of second run of MMICs and packages, ending with a Written Report.	D7	T0 + 23
T8	**Final Review and Reporting**	D8	TO + 24

Table 3: Tasks

Detailed description of Task T1:
This task shall define all the requirements and specification for the MMICs and packages designed in this call. The specification points listed in section **Error! Reference source not found.** act as starting point. These points might be subject to minor adjustments and additional requirements might be added after agreement between all partners.
Apart from the specification on the stand-alone bare-die probed MMICs and packages, a specification shall also be provided in case the MMICs are integrated into dedicated SMT packages developed in the project. In this case, individually packaged power amplifiers and signal sources shall be specified as well as the performance of a multi-functional package integrating both the PA and the SS into the same SMT compatible package.
The output of the task is a specification report [Deliverable D1].
Detailed description of Task T2:
This task includes the design and tapeout of the first run of MMICs and packages. Suitable test structures needed for the evaluation of the stand-alone package shall also be designed and taped out in the same MMIC process as used for the PA and the SS.
Prior tapeout, a design review will be held where the MMICs and packages are reviewed by the Topic Manager. This review should be held at least three weeks before the tapeout allowing for updates of the designs prior tapeout if required. A design report [Deliverable D2] will be written with detailed results on the design and simulated performance of the MMICs and packages to be taped out.
Detailed description of Task T3:
The first version of the designed MMICs and packages are manufactured. The final outcome of T3 is the delivery of MMICs and packages [Deliverable D3].
Detailed description of Task T4:
The objective is to have working MMICs and packages with measured performance close to the specification defined in D1 and the simulated performance detailed in D2. Deviations from D2 shall be carefully investigated and the cause of the deviations shall be explained to a level needed for updated designs. A review will be held where the results are reviewed by the Topic Manager.
Both probed bare-die MMICs and packages are tested as well as the integration of these MMICs into packages as described in section **Error! Reference source not found.**.
The output is a test report and result analysis [Deliverable D4].
Detailed description of Task T5:
This task includes the design and tapeout of the second run of MMICs and packages. Suitable test structures needed for the evaluation of the stand-alone package shall also be designed and taped out in the same MMIC process as used for the PA and the SS. All designs should be updated according to D4.
Prior tapeout, a design review will be held where the MMICs and packages are reviewed by the Topic Manager. This review should be held at least three weeks before the tapeout allowing for updates of the designs prior tapeout if required. A design report [Deliverable D5] will be written with detailed results on the design and simulated performance of the MMICs and packages to be taped out..
Detailed description of Task T6:
The second version of the designed MMICs and packages are manufactured. The final outcome of T6 is the delivery of MMICs and packages [Deliverable D6].
Detailed description of Task T7:
The objective is to have working MMICs and packages with performance according to the specification defined in D1 and the simulated performance detailed in D6. Deviations from D6 shall be carefully investigated and the cause of the deviations shall be explained to a level needed for possible future updated designs (not within this project).
Both probed bare-die MMICs and packages are tested as well as the integration of these MMICs into packages

as described in section **Error! Reference source not found.**.
The output is a test report and result analysis [Deliverable D7].
Detailed description of Task T08:
A final review will be held where all of the results obtained will be presented and discussed.
The output is a final technical report [Deliverable D8].

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	Title	Type*	Due Date (month)
D1	Specification	R	T0 + 1
D2	Design report, 1st run	R	T0 + 5
D3	Manufacturing Delivery, 1st run	HW	T0 + 8
D4	Evaluation report, 1st run	R	T0 + 12
D5	Design report, 2nd run	R	T0 + 16
D6	Manufacturing Delivery, 2nd run	HW	T0 + 19
D7	Evaluation report, 2nd run	R	T0 + 23
D8	Final Technical Report	R	T0 + 24

Table 4: Deliverables ***Types: R=Report, HW=Hardware**

Milestones (coincide with Review)			
Ref. No.	Title - Description	Type*	Due Date (month)
M1	Design report, 1st run (D2)	R	T0 + 5
M2	Evaluation report, 1st run (D4)	R	T0 + 12
M3	Design report, 2nd run (D5)	R	T0 + 16

Table 5: Milestones

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

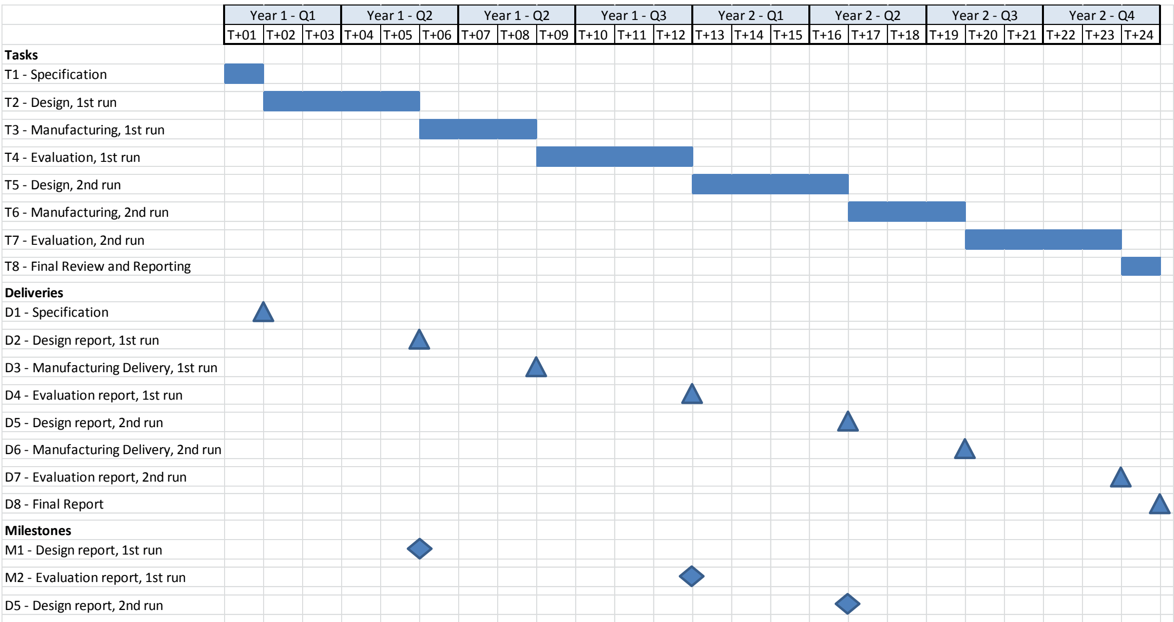


Figure 26: Schedule

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

- Design capability in the chosen MMIC technology (i.e. access to all required software, availability of all relevant experience in design, modelling, etc.)
- Measurement capability in the 93-100 GHz range over -55 to +85 deg. C. (i.e. access to all required small- and large-signal measurement equipment for both on-wafer and waveguide testing, availability of all relevant experience, etc.)

5. Abbreviations

EFVS	Enhanced Flight Vision Systems
MMIC	Monolithic Microwave Integrated Circuit
mmW	Millimeter-Wave
PA	Power Amplifier
SMT	Surface Mount Technology
SS	Signal Source

V. Advanced Load Sensing technology for aerospace applications

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 3.2.2		
Indicative Funding Topic Value (in k€)	700		
Topic Leader	Liebherr-Aerospace Lindenberg (LLI)	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[60]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-36	**Advanced Load Sensing technology for aerospace applications**
Short description	
This topic aims for identification, development, verification and demonstration of load measurement technologies based on improved strain gauge technology for in-flight load sensing inside aircraft components.	

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

1. Background

Flight Control Actuation as well as Landing Gears are dealing with mechanical loads. Safety and functional requirements demand in many cases the measurement of acting forces with load sensors.
With more innovative and 'smart' components and functions this need to measure forces will further increase. Current load sensors in aerospace are based on bonded strain gauge technology, which is state-of-the-art, well known and widely used.

The bonded strain gauge technology has the following main disadvantages:

- manual production process (bonding): hard to control and high costs
- sensitivity to interference with other loads
- large installation space required to integrate strain gauges
- limited long-term stability due to bonding
- limited temperature range
- limited accuracy

This project aims for the development of load measurement technologies based on improvements of strain gauge technology (e.g. thin film strain gauges, semiconductor strain gauges, etc.) or other alternative technologies.
A preferred solution are strain gauge technology based sensors integrated into structural parts by welding or other technologies different to gluing. Using this technology has the advantage of being compatible with existing electric circuits for strain gauge evaluation.

However, the integration into the structural parts needs to be analysed, verified and qualified against the aerospace requirements.

The above mentioned improved strain gauge technologies are well known within industrial applications. However, additional development work is needed to meet stringent aerospace requirements, such as temperature range down to -55°C, EMC robustness, vibration levels (e.g. helicopter main rotor actuators) and concepts for mechanical integration.
Investigation of different technologies with their specific electric circuits for evaluation is equally possible. In this respect, applicants are encouraged to propose solutions meeting aerospace requirements.

2. Scope of work

The topic shall investigate different technologies for load sensing to be used within many different applications including future Health Monitoring Systems for primary actuation, high-lift and landing gear systems and shall identify, develop and verify the best suitable technology for at least one of those applications.

The detailed specifications will be discussed and agreed upon with the Topic Manager.
Some examples of physical and performance requirements are hereby given to illustrate the challenge:

- Measurement range: +/- 100kN
- Accuracy: less than +/- 2.5 kN

Typical environmental requirements according RTCA DO160 are:

	Section	Category
• Temperature	4	D2
• Altitude	4	D2
• Temperature Variation	5	A
• Operational Shock and Crash Safety	7	F
• Vibrations	8	H/R, Curves E/E1
• Salt Spray	14	T
• Icing	24	B
• Lightning Indirect	22	A
• Lightning Direct	23	2B
• Magnetic Effect	15	A
• Audio Frequency Susceptibility Conducted	18	R for DC
• Induced Signal Susceptibility	19	CW / sub.-Cat. SC5
• Radio Frequency Susceptibility Conducted & Radiated	20	W
• Emission of Radio Frequency Energy	21	H/R, Curves E/E1
• Electrostatic Discharge (ESD)	25	A

Based on this set of key requirements within the specification, applicants are encouraged to elaborate on relevant technologies, consider benchmarking of competing solutions and propose their approach to enhance the state-of-the-art load measurement technology.
The topic manager intends to cooperate with the selected partner in assessing the proposed solutions and select (at least) one of them for the subsequent project phases.

Applicability of the selected solution/technology for a specific application shall be verified.
For this purpose detailed design and analysis (e.g. 3D modeling, stress, performance and reliability) will be needed. For electronic development all aspects according RTCA DO254 shall be considered, avoiding use of 'complex electronics'.

Based on a frozen and agreed design, the selected partner shall manufacture test units (incl. sensing element,

simple electronic and integration into a structural part) to perform the tests needed for TRL5 compliance. Additional 10 test units (incl. sensing element and simple electronic) shall be delivered to the topic manager in order to be integrated and demonstrated on the Smart Integrated Wing Demonstrator.
The route to industialisation and serial production in terms of quality and cost shall be elaborated and validated.

The test units shall be tested by the selected partner. A two-phases approach is recommended:
(1) Performance & function test to achive TRL4
(2) Environmental test to achieve TRL5 acc. to RTCA DO-160 requirements

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Collaborate with topic manager to define all requirements for load sensing within a detailed specification.	31.10.2018
T2	Elaborate on available technologies and assess their applicability with regard to performance and integration aspects to allow a joint selection with topic manager.	31.12.2018
T3	Define load sensor and electric circuit design for one specific integration, harmonised with the TM, and create all necessary design documentation.	30.04.2019
T4	Manufacture load sensing units for test purposes (sensor with electronics and integration).	31.10.2019
T5	Perform testing under environmental and EMC conditions.	30.04.2020

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Results of trade-studies/benchmarking for different load sensing technologies, as deemed appropriate, to allow a selection	R	30.11.2018
D2	Detailed Design documentation depending on selected technology	R	30.04.2019
D3	Test Units for demonstration at TM facilities	HW	31.10.2019
D4	Test Reports	R	31.05.2020

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Selection of best technology, in agreement with the TM	R	31.12.2018
M2	Detailed Design Review	R	31.05.2019
M3	Test units acceptance review	HW	30.11.2019
M4	Test Result Review	R	30.06.2020

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

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

- Experience in Load Sensing Applications, including, but not limited to thin film strain gauge technology
- Ability to develop electric circuits according aerospace requirements (RTCA DO254)
- Ability to design and test load sensors according aerospace environmental conditions (RTCA DO160)

5. Abbreviations

EMC	Electromagnetic compatibility
RTCA	Radio Technical Commission for Aeronautics
TM	Topic Manager
TRL	**Technology Readiness Level**

VI. Development of a new backup electronics unit for Smart Inceptor

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 3.2.5		
Indicative Funding Topic Value (in k€)	900		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[61]	Q2 2018

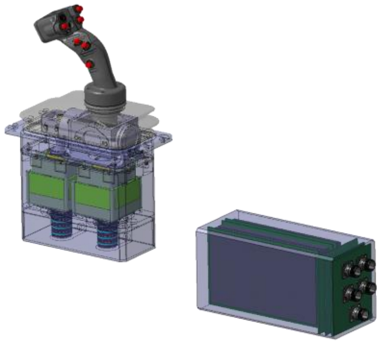
Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-SYS-02-37	**Development of a new backup electronics unit for Smart Inceptor**
Short description	
The Smart Active Inceptor will go to Flight Tests in order to reach TRL 6, and will need Dissimilar Electronic Architecture to support Safety of Flight requirements The aim of the topic is to develop a backup electronic unit (Analogic or Numeric) to provide Active Inceptor with a configurable feel force. The goal is to drive electrical motor with simplified laws compared to nominal behaviour. Innovative supervision functionalities (e.g. monitoring) can be provided by the unit in nominal or backup mode.	

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

1. Background

The activity of WP 3.2.5 Smart Active Inceptors for Tilt Rotor Demonstration is a part of SYS WP 3 Innovative Electric Wing.

The Objective of the WP is to develop an innovative Cockpit control system with the integration of Smart & active Inceptors.



Inceptor Unit with ICU

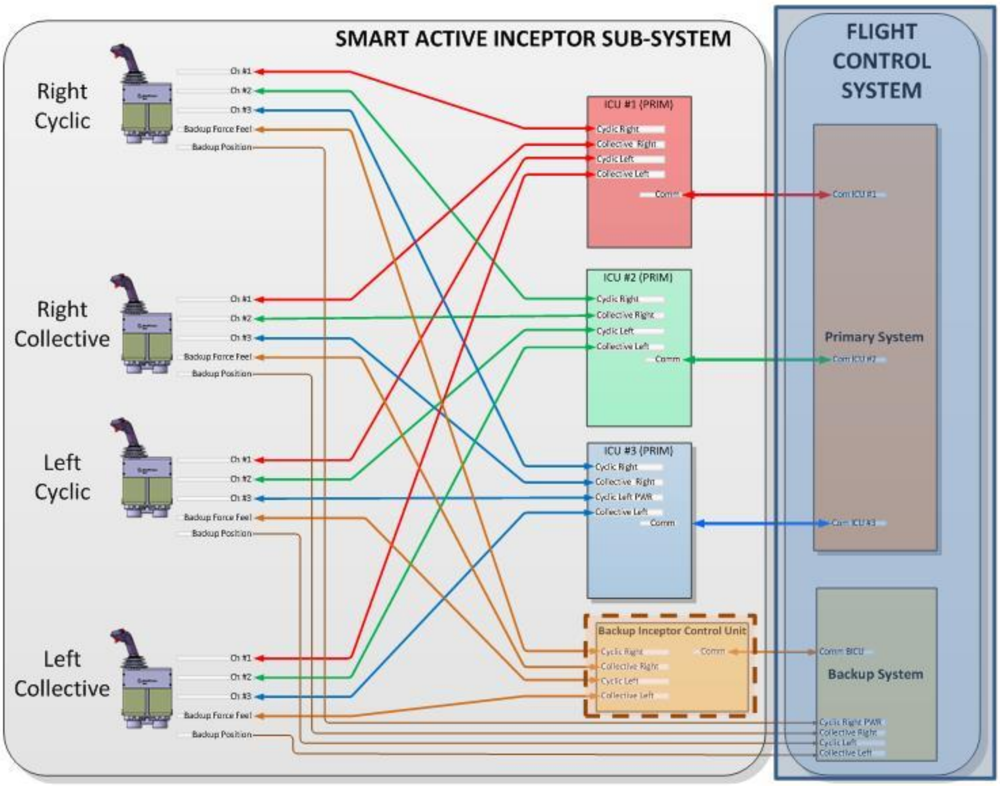
The Smart active inceptors are connected to the Flight Control System through 3 identical Inceptor Control Units (ICU).
Each ICU embeds a COM - MON architecture for Safety Aspect.

In case of global failure in this primary system, the Backup Inceptor Control unit (BICU) shall provide an ultimate and dissimilar mean of applying force feel on sticks.

This topic consists in the design, testing and manufacturing of the Backup Inceptor Control Unit to be embedded in the Technology Demonstrator for flying test.

BICU description

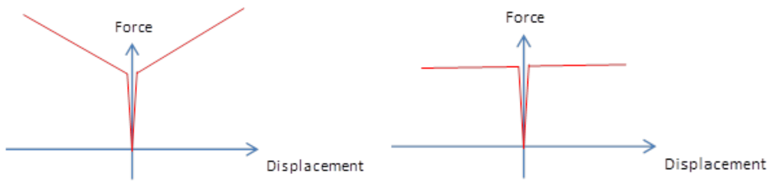
The following drawing presents the global architecture of the Smart Active Inceptor sub-system forseen for fast rotor craft application, as first use case.
This architecture is generic and may be used for other applications.



Global Smart Active Inceptor Stick Sub-System

For each Active Inceptor, the Backup Inceptor Control Unit shall acquire the stick position from potentiometers (or XVDT) and deliver a variable current to the inceptor motors following 3 predefined laws:

- 2 "Spring" laws



- 1 "Friction" Law

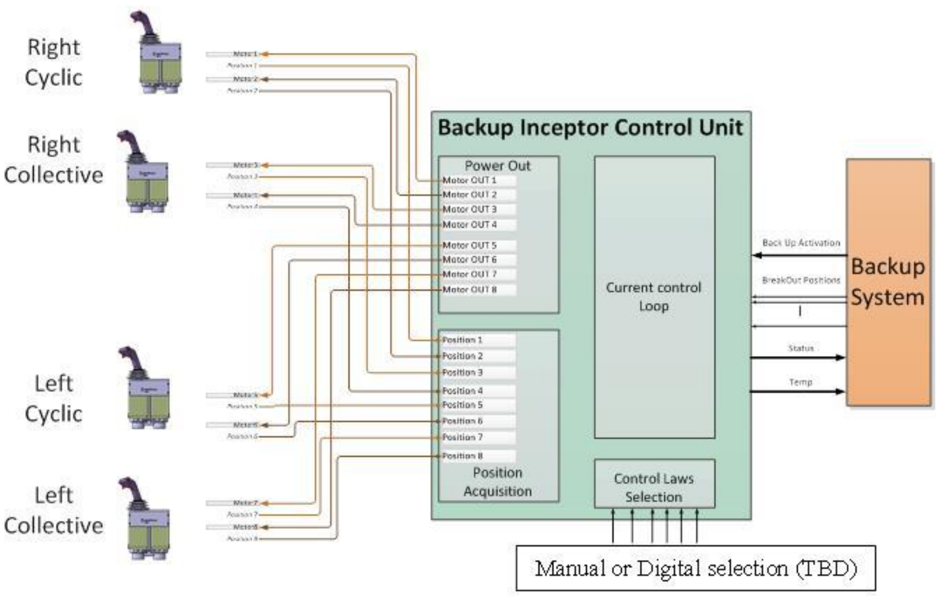
Moreover, it shall be possible to modify the Anchorage position (trim function).

The Backup Inceptor Control Unit shall control up to four Active Inceptors. Each Inceptor includes 2 Axis.The Backup Inceptor Control Unit may be split in 2 identical units if needed.

The preliminary electrical interfaces are :

- Power Inputs : 2 bus 28V DC from Aircraft (with an internal and automatic selection)
- Power Outputs : 8 Filtered Power Outputs variable from -2.5 A to +2.5 A / 60V Max each. Power capabilities :
    - 140W Max per output

    - 500W to the total of 8 outputs
- Position Acquisition : 8 analog acquisitions from potentiometers (or XVDT)
- Static Configuration : 12 Program pins for selection of predefined force feel control Law (3 laws by pairs of outputs)
- Interface with Backup System :
    - 2 discrete IN for Backup Mode Activation
    - 8 analog IN for triming of the Anchorage position
    - 4 discrete Out for BICU Status
    - 1 Temperature Sensor output for BICU Thermal monitoring



Backup Inceptor Control Unit Interfaces

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Joint Development Phase	T0+4 months
T2	Equipment Detailed Design	T0+12 months
T3	Manufacturing	T0+16 months
T4	Qualification	T0+24 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1.	Product Requirement Specification (PRS)	D	T0+8 months
D2.	Reliability & Safety Assessment Report (R&SAR)	D	T0+12 months
D3.	Definition File (DD)	D	T0+12 months
D4.	Qualification Test Report (QTR)	R	T0+24 months
D5.	1st flight Declaration of Design and Performance (DDP)	R	T0+24 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
PR	Design Plan Review	D	T0 + 5 months
PDR	Preliminary Design Review	D	T0 + 8 months
DDR	Detail Design Review	D	T0 + 12 months
CDR	Critical design review	D	T0 + 14 months
TRR	Test Readiness Review	D	T0 + 16 months
QLR	Qualification Launch Review	D	T0 + 20 months
QR	Qualification review	D	T0 + 24 months

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

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

- Design Assurance level : DAL C
- Equipment for a SOF on demonstrator aircraft

5. Abbreviations

BICU	Backup Inceptor Control Unit
COM	COMmand
DAL	Development Assurance Level
ICU	Inceptor Control Unit
MON	MONitoring
SOF	Safety of Flight
TBC	To Be Confirmed

VII. Ergonomic impact and new functions induced by Active Inceptor integration in cockpits

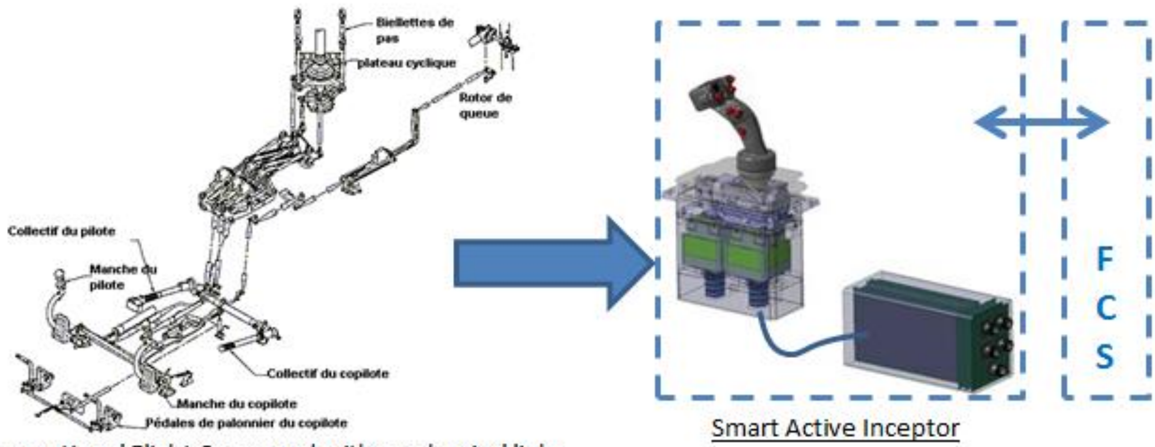
Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP3.2.5		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	Safran	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[62]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-38	**Ergonomic impact and new functions induced by Active Inceptor integration in cockpits**
Short description	
The introduction of new devices for piloting an aircraft is the opportunity to provide to pilots & co-pilots new ergonomics and new functionalities. The aim of the topic is to focus on Pilot/Co-pilot coupling functions and to propose ergonomics improvement in the force-feel laws and tactile cues at stick level. It will also cover specific ergonomics to provide for a tilt rotor application, especially interaction between Autopilot and crew in normal mode and transition phases.	

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

1. Background

The activity of WP 3.2.5 Smart Active Inceptors for Tilt Rotor demonstration is a part of the SYS WP 3 Innovative Electric Wing.
The Objective of the WP is to develop an innovative Cockpit control system with the integration of Smart & Active Inceptors.



Conventional Flight Command with mechanical links

Smart Active Inceptor

With the progressive disappearance of mechanical links between aerodynamic control surfaces and piloting inceptor devices and the wide use of FlyByWire, the image of the aircraft behavior is no longer provided to pilots by passive inceptor devices only. The development of active inceptor allows giving pilots a direct feeling of the aircraft behavior, in particular flight limitations or control surface positions.

The intensive use of passive inceptors (mostly sticks) has led to minimize/suppress the linkage between pilot and co-pilot. Nevertheless, recent studies with pilots have shown the real interest of this coupling and the associated functionalities. The developments of new generations of active inceptors allow recovering such functionalities and improve the Human Machine Interface between crew and aircraft. The coupling of inceptors can be very important in terms of information provided to the PNF. The fact that this coupling is realized by artificial means, offers the capability to provide new functionalities, thanks to haptic feedback providing pilots with information more adapted, more intuitive, more accurate.

The aim of the topic is to focus on Pilot/Co-pilot coupling functions and to propose ergonomics improvements in the force-feel laws and tactile cues at stick level. It will also develop specific ergonomics to address tilt rotor application, such as the interaction between Autopilot and crew in normal mode and transition phases.

Description of activities

This topic encompasses following studies.

a) Functions to be studied and evaluated
   - Pilot/co-pilot interactions

- Establish flight scenarios needing coupling between both inceptors
    - Define interactions between pilot/co-pilot
        - For cyclic application
        - For collective application
    - Specify haptic feedback depending on defined interactions between pilot/co-pilot (for example : conflict management)
- Pilots/auto-pilot interactions
    - Establish flight scenarios needing coupling between pilots/auto-pilot
    - Define interactions between pilots/auto-pilot
        - For cyclic application
        - For collective application
    - Specify haptic feedback depending on defined interactions between pilots/auto-pilot (for example : breakout force override)
- Transition phases
    - Define transition phases
        - For cyclic application :
            - HandsOn/HandsOff (AP mode)
            - Specific transition for Tilt Rotor
        - For collective application
            - HandsOn/HandsOff (AP mode)
            - Specific transition for Tilt Rotor
    - Specify haptic feedback during transition phases
    - Define ergonomic informations to provide in case of failure
        - For cyclic application
        - For collective application
- Model of coupling functions

b) <u>Implementation and means to perform the research</u>

All the functionalities described in §2.1 will be modelled and evaluated on a simulation bench. Ideally, the evaluation and feedback should be gathered from experienced pilots, after dedicated test campains on simulation bench.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Flight scenarios definition & evaluation	T0+14 months
T2	Definition of PF/PNF/AP interactions and transition phases	T0+20 months
T3	Specification of haptic feedback and ergonomic requirements based on evaluations	T0+24 months
T4	Modelling to implement in inceptor control command	T0+28 months
T5	Evaluation of haptic feedback and ergonomic recommendations	T0+36 months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D5	• **Flight scenario evaluations** List of flight scenario Test of flight scenario	R	T0+14 months
D6	• **Interaction & Transition mode description** Definition of all use cases	D	T0+20 months
D10	• **Specification of haptic feedbacks** Haptic feedbacks to apply according use case	D	T0+33 months
D11	• **Models** Matlab Simulink models to implement in inceptor control command	D	T0+34 months
D12	• **Haptic feedbacks evaluation** Test of haptic feedbacks defined according use case Perform on simulator test bench, with pilots	R	T0+36 months

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
PPR	**Planning Process Review** The main objective of the PPR is to define more precisely milestones and DRL expected.	D	T0+2months
PSR	**Preliminary Scenarios Review** The main objective of this milestone is to share scenarios will be used in the study. Scenarios will be input data for interaction & transition mode descriptions and also for specification of haptic feedbacks.	D	T0+6 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
FSR	**Final Scenarios Review** The main objective of this milestone is to establish scenarios will be used in the study. Scenarios will be input data for interaction & transition mode descriptions and also for specification of haptic feedbacks.	D	T0+14 months
SMR	**Specification & Models Review** The main objective of this milestone is to establish a specification of haptic feedback and associated models.	D	T0+28 months
DFAR	**Delivery & Final Acceptance Review** The main objective of this review is to provide final specification and models, coming from pilots evaluation.	R	T0+36months

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

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

- knowledge on Flight Control System Architecture, High level control laws
- Konwledge on Ergonomics
- Modelling capability
- Simulation bench

5. Abbreviations

AP	Auto-Pilot
DRL	Documentation Requirements List
FCS	Flight Control System
PF	Pilot Flying
PNF	Pilot Non Flying

VIII. Development of a High Voltage Lithium Battery

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.1		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Dassault Aviation	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[63]	Q2 2018

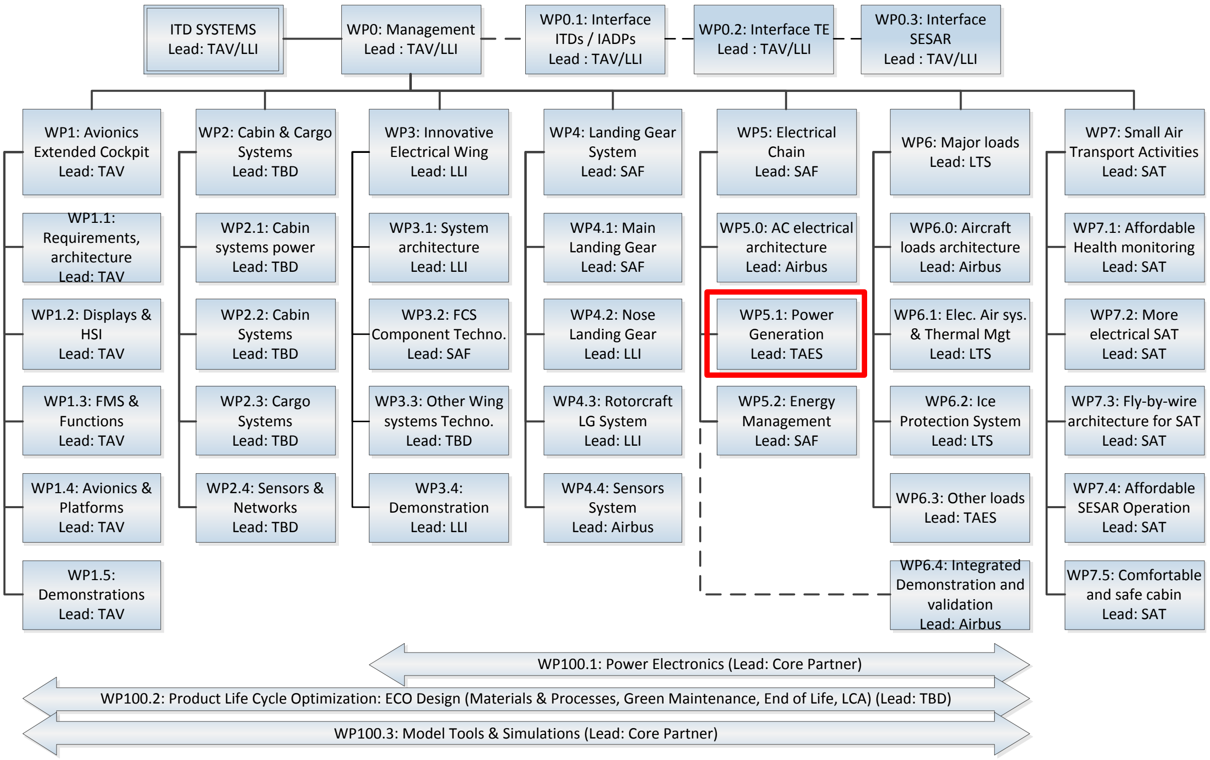
Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-39	**Development of a High Voltage Lithium Battery**
Short description	
The applicant will design and prototype a complete battery pack offering state-of-the-art energy density and easy integration into current aircraft architectures. The final demonstrator will be tested to show the achievement of TRL 4, which means that the targets in terms of mass and electrical performances are met, and the thermal control system protects the lithium cells well.	

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

1. Background

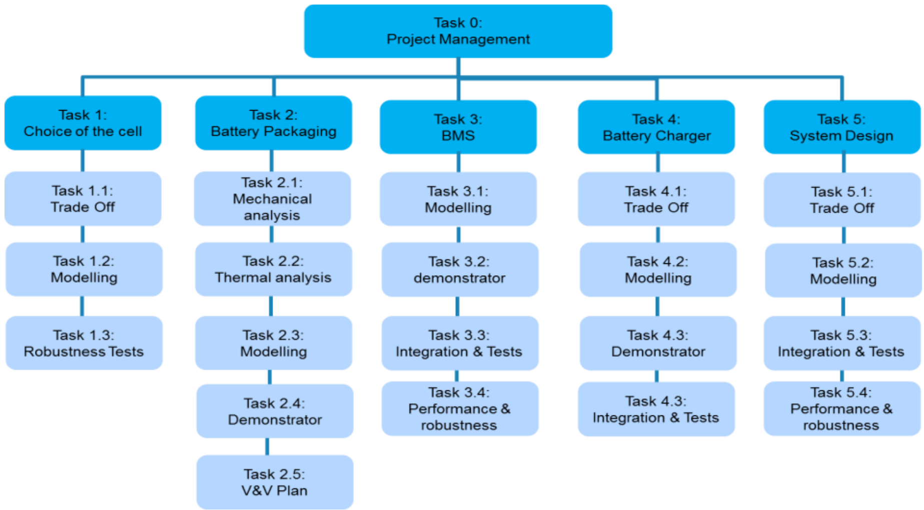
The work contributes to **WP 5.1 Power Generation**, where it will support parallel research activities (e.g. the Core Partner Project EMINEO and other future CfP topic) aimed at selecting the most promising technology to achieve high energy density. It is expected this topic work to reach TRL4 early 2019.

The high voltage lithium battery will be part of the demonstrations of advanced chemistries and architectures. It will focus on LFP, previously tested at TRL 3 in Clean Sky/Eco Design, and lithium sulphur, which is just emerging as a safe, high energy density alternative to LFP.



The Core Partner project is aiming for 400 Wh/kg and 1015 Wh/litre, target to be reached by the end of the SYSTEMS ITD programme. The applicant selected for this topic will develop a first iteration aiming for 200 Wh/kg for a high energy battery capable of sustained 3C discharges. Of course the design will take into account progress towards the final performance goals through several upgrades during the course of Clean Sky 2. The focus will therefore be on ancillary components: housing, interconnections, BMS, balancing, connectors, thermal control, integration, etc. and on alternate ultra safe lithium chemistries such as LFP and Li-S, which are not in scope of the Core Partner's work in Task 1.1.

To ensure good integration of the activity, the selected applicants will propose a suitable interface with the ongoing Core Partner project, whose WBS is thereby shown:



2. Scope of work

The goal of this topic is to deliver to the Core Partner a battery system that reaches TRL 4. The battery system is designed such as to allow iterative upgrades, with a view to achieve the goals of the Core Partner.
The battery system will meet the following functional and system requirements:

- a single battery pack weighting a maximum of 55 kg including the interconnections, housing, battery cells, connectors, protection devices and integrated electronics, with a peak power in excess of 500 W/kg for 2 minutes and more than 200 Wh/kg at 1C. The pack shall be divided in an even number of battery units, forming two sets of approximately equal mass;
- capability to connect the pack directly to a three-phase 115V variable frequency aircraft network, using a mass and volume optimised approach, for charging the battery or supplying AC power, alone or in parallel with a typical aerospace 115V AC alternator;
- capability to connect the pack directly and simultaneously to two suitable three-phase electric motors or AC networks, and to exchange a minimum total of 20 kW of power in both directions with the motors or AC networks (when motors are used, position sensors will be assumed);
- a high power battery charger which allows charging at a minimum rate of 60W/kg from both 115V AC/400 Hz airport ground power carts, and three-phase 240V-380V AC/50 Hz euro grid power.

Each battery unit will be designed with evolution capabilities in mind, using battery modules with clearly defined interfaces and the ultimate goal of reaching the performance objectives of WP 5.1.
The height of each battery unit will be a maximum of 110 mm, the width a maximum of 200 mm and the length is a maximum of 1500 mm.
Battery units shall be designed such as to allow handling by operators who have pilot or aircraft mechanic licences with type specific training, but do not have specific battery qualifications. This implies that each connector must either prevent accidental contact with people and objects, or be safe to touch (recessed power pins, no risk of electric shock).
Unintended occurrence of short circuits in high power batteries may cause a fire and explosion hazard, with harmful levels of UV light and a strong blast effect. The maximum instantaneous power output of such a battery could be high enough to vaporize an electrical conductor of significant size, or set fire to the insulation

of much larger wires, or even set fire to internal components of the battery itself. Specific features must be designed to ensure that unintended shorting of power leads is effectively prevented, and that intentional shorting of the power leads is difficult without specialised tooling. The effects of a short circuit must be in line with applicable regulations. Possible solutions include an internal mechanical or electronic (SSPC) disconnect or protective flaps sealing the main contacts to IP2X level or better.
By definition, a battery module has integration, interconnection and optionally voltage balancing functions that are independent from the integration, interconnection and voltage balancing functions of all the other modules. Integration may still depend on features of the common housing, but not on any other module, so that each module can be easily accessed and replaced. A battery module shall also contain information or software functions that are specific to the chemistry of the module.
The thermal control of each module shall be as independent as possible from the thermal control of other modules, in order to minimise the risk of thermally induced runaway in neighbouring modules. The minimum level of independence required, is the level ensuring that even if a modules goes into thermal runaway, the neighbouring modules remain stable. The key temperature requirement is to prevent a chain reaction where modules go into thermal runaway one after the other.
Finally, a battery unit also contains:

- Battery Management System (BMS) module(s), sufficiently miniaturised, and designed with a control architecture that complies with the criticality of the BMS functions;
- External Connectivity module(s) (usually one) providing externally accessible connectors for power and data;
- Power Conditioning module(s), which adapts the voltage of modules to each other or to the battery output voltage;
- Thermal Control module(s), which removes heat from the battery unit housing.

All the modules are grouped in a housing that provides structural strength and thermal insulation.
The battery unit composed of housing and modules shall be designed to survive without damage exposure to ambient temperatures between -15°C and 40°C under cover, 40°C corresponding to peak hot day temperature. The duration of the exposure is limited by day / night cycles. Indoors storage and charging shall not require specifically equipped rooms. Any area suitable for electric car charging shall be useable.
The initial charge of a cold soaked battery may take up to 30 minutes more time but shall not require special procedures.
Applicants shall describe clearly how they intend to combine and develop technologies in order to fulfil those requirements.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Project Management	*Permanent*
T2	Preliminary Design : at the end of this phase, the architecture and schematics will be reviewed with the Topic Manager, and must be validated to proceed with T3.	*M2 + 1 month*
T3	Detailed Design : at the beginning and the end of this phase, the Topic Manager will verify and validate the design process to ensure compliance with Aerospace Recommended Practices for safety critical on-board systems.	*M3 + 1 month*

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T4	Tests	*M4 + 1 month*
T5	Technical Synthesis and detailed modelling	*M5*
T6	Support integration in TM electrical test rig	*M5 to end*

Key components and technologies used in the final assembly shall be fully documented. The corresponding report shall detail all items that cannot be replaced easily by alternate solutions having identical interfaces (e.g specialised integrated circuits, battery cells, patented technologies, simulation tools, and any unconventional manufacturing process).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	High Voltage Battery Innovation Roadmap	R	M1
D2	Preliminary FMEA / FMES	R	M2
D3	Report on Key Components and Technologies	R	M2
D4	Validation Test Reports	R	M4
D5	Cost model, including cost reduction plan if needed	R	M5
D6	Validated 3D and physical digital models of off-the-shelf components	SW	M3
D7	Validated physical and CAD models of TRL 4 battery pack	SW	M4
D8	Embedded software including programmable devices	SW	M4
D9	Hardware (one battery pack, cables and supporting user documentation)	HW	M5

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Project kick-off meeting	Review	T0+1 month
M2	Preliminary Design Review	Review	Applicant choice
M3	Critical Design Review	Review	Applicant choice
M4	Validation Review (after internal tests)	Review	Applicant choice
M5	Hardware delivery	HW	T0+15 months

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

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

- The multidisciplinary context of the activity, requires competences and skills in laboratory research combined with industrial experience in design and prototyping of aerospace lithium batteries.
- Experience in aerospace lithium battery design, prototyping and manufacturing
- Design capabilities in mechanical systems, thermal control systems, electronics, software and batteries.
- Model Based Design capabilities covering electrical, chemistry aging, mechanical (strength, structural compatibility) and thermal aspects of the battery pack.
- Model exchange capability (e.g. FMI, Modelica, C,C++ or Fortran libraries, Matlab/Simulink)

5. Abbreviations

BMS	Battery Management System
SSPC	Solid State Power Controller

IX. Development of low insertion/extraction force electrical connecting device

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.2		
Indicative Funding Topic Value (in k€)	600		
Topic Leader	SAFRAN ELECTRICAL & POWER	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[64]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-40	**Development of low insertion/extraction force electrical connecting device**
Short description	
In the context of More Electrical Aircraft, the purpose of this topic is to develop a mechanical device or assembly that allows electrical multipoint electrical connections, aiming insertion/extraction force as close to zero as possible.	

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

1. Background

The move towards a more electric aircraft enatails replacing hydraulic and pneumatic systems with electrical systems.
This gives electrical power a prevailing role and implies an increased need for communication between equipments, thus more electrical harnesses and more electrical interconnections between harnesses and equipments. Electrical systems and harnesses installation time will become critical in the aircraft final assembly lines (FAL).

One way to reduce this installation time and master manufacturing high ramp-up in FAL for serial programs is to increase the amount of electrical pin/socket contacts connected per connector mating. Emerging concepts such as large integrated modules are being developped, where structural and functional building blocks are previously assembled, wired and tested outside the aircraft. Ideally, with such a modular appoach, the electrical connection between two aicraft sections could be done in one single operation.
However, each pin and socket mating is caracterised by a mating and unmating force. The higher is the number of contacts to be connected, the higher the mating force needs to be. This may lead to a mating force that is unaffordable for human operators and require the development of specific tools to assist the connection. On the other hand, mating two connectors with high amount of contacts requires carefully designed mechanical tolerances to avoid any risk of damaging the contacts while ensuring a full electrical connection for all the pins in the socket . Issues such as system reliability and development and integration of specific mating tools needs to be addressed
The development of a technology to perform a reliable and effective electrical connection for multi pin subassemblies is a critical step to achieve amodern and more efficient aircraft assembly method.

Many solutions already exist to reduce the insertion/extraction force required for connection. Here below is a non-exhaustive list of existing contacts :

- ZIF : The Zero Insertion Force is using a lever to push all spring contacts and to allow the insertion/extraction with a very little force. This technology is used for low currents.
- ARINC 600 contacts : Using Low Insertion Force connectors and contacts, the maximum number of contact is 800 of size AWG #22 contacts, and the mating force shall not exceed 467N. Considering that the bigger is the number of contacts, the higher is the insertion force, this technology does not yet show large potential for increasing the number of connections performed at once.
- Spring contacts : This technology has the benefits to avoid locating and contact damages issues. The important insertion force needed could be managed with a specific tool. However, the high cost of this technology is not compensated by a corresponding reduction of the installation lead-time.

  However, these solutions have limited potential for further imrobvements and a new approach is sought to achieve a step change.

The objective of this topic is then to totally rethink current contacts and connectors solutions with a target of insertion/extraction force as close to zero as possible.

2. Scope of work

The applicant shall propose a connecting device compliant with the technical specification which will be developped and validated in the frame of the collaboration between applicants and TM.
The first step to reach the goal of thousands contacts connection in one operation without specific tool is the design of a new electrical contact principle, able to withstand up to 50 Amps, not only for low currents. Innovative designs are sought that should address geometry, material and surface treatment to improve the current state of the art.
The second step is the integration of this contact within a connector (plug and receptacle), which shall be able to implement a new mating/unmating concept. This entails the development of a newly designed connector able to insure the electrical contact and to satisfy the specific constraints.
A non-exhaustive list of general requirements is :

- The contact insertion/extraction force as close to zero as possible , whatever the contact size is
- High contact density
- The contact shall be removable The barrel of contact shall be designed to accepts the range of permissible conductors according to ISO 8843, EN 2083 and EN4434
- The contact family includes contacts from size AWG 08 to size 24
- Contact and connector operating temperature range between -65°C and +200°C
- The environmental and climatics conditions in accordance with DO160 specifications
- Protective coating on the entire contact surface
- Electrical contact resistance less than 5 mΩ
- Compliance to REACH and RoHS environnemental requirements. Connector testing according to EN2591 standards
- A key requirement is the maintainability of the installation

Based on requirements provided by the TM resulting from airframes constraints analysis, the project will be carried out in three phases: state of current technolgies analysis, products (contact and connector) definition and specification, and components development from conceptual design phase to detailed design, protoypes manufacturing and testing.
The activities will be split into 7 major tasks:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	**Specification and definition of development orientations** - Technical requirements elicitation, analysis and refinement - Based on requirements, perform analysis of current technologies (aerospace or other domains) and evaluate the reached performances and difficulties/ limitations (technical, cost, certification) - Formalize and validate technical specification - Conduct a series of workshop to agree on a way forward and strategy / axis of work	T0+6

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T2	**Conceptual design phase** Identify technologies to improve the electrical mating performance (e.g.: innovative geometry, design, surface treatment, new material...); perform trade-off analysis and identify technology risks	T0+12
T3	**Preliminary design phase** Realize preliminary designs of concepts to, check compliance with specification and validate design.	T0+18
T5	**Validate design by simulation or lab test on components. Detailed design and definition of prototyping process**	T0+24
T6	**Prototypes Manufacturing** Manufacture the prototypes for the test phase. The amount of prototypes will be defined depending on the technical risks identified and tests to be performed.	T0+30
T7	**Prototypes tests** Perform tests in partially representative environment	T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1	Process and component Specification	Document	T0+6
D2	Preliminary design	Document	T0+18
D3	Detailed design	Report	T0+24
D4	Prototypes	Prototype	T0+30
D5	Test reports	Report	T0+36

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M1	Kick-off meeting	R	T0
M2	Technical Specification Review	R	T0+6
M3	Conceptual design presentation	R	T0+12
M4	Preliminary design presentation	R	T0+18
M5	Detailed design presentation	R	T0+24
M6	Prototype Inspection Review	HW	T0+30
M7	Tests results Review	R	T0+36

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

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

- expertise in mechanical and electrical engineering, capacity to perform thermal analysis
- good knowledge of electrical connecting technologies
- experienced in components manufacturing
- Knowledge of aeronautics requirements (DO160)
- Ability to realize prototypes and perform normalized tests according to EN2591

5. Abbreviations

AWG	American Wire Gauge
EN	European Standard
ISO	International Organization for Standardization
REACH	Registration, Evaluation and Authorisation of Chemicals
ROHS	Restriction Of Hazardous Substances

X. Development of methodology and tools based on advanced statistics applied to Electro Magnetic Compatibility analysis of cable harnesses in aeronautics

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.2		
Indicative Funding Topic Value (in k€)	700		
Topic Leader	Safran Electrical & Power	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[65]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-41	**Development of methodology and tools based on advanced statistics applied to Electro Magnetic Compatibility analysis of cable harnesses in aeronautics**
Short description	
In the context of the increasing complexity of electrical wiring systems and the corresponding large variability of input design parameters, the EMC of cable harnesses has become a major research subject. This topic aims at developing and validating a methodology and tools based on advanced statistics that allow exploring the design parameters domain, performing sensitivity analysis and identifying "very high confidence" regions in which the EMC system requirements are met.	

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

1. Background

In the last decade, the aeronautical sector faced a paradigm shift in the design of electrical systems. The introduction of composite materials in the aircraft structures and the transition to a More Electrical Aircraft entail an increase of the number of electrical loads onboard and the introduction of new types of supplies. The evolution of the FAR 25 / CS 25 regulations made safety analysis mandatory for the EWIS (Electrical Wiring Interconnection System), meaning that it becomes necessary to estimate the probabilities of failure of the wiring system.

In this complex context, the large density of cables transporting various signals increases the complexity of the design from an EMC point of view, because the space available for cabling is in general a critical design constraint. The system design must ensure that all the chosen criteria (currents, voltages, powers) are above or below the prescribed threshold values. New EMC design rules must be developed in order to ensure a low or zero rate of failure for EWIS. These rules will also help reducing as much as possible the design margins available and the disturbances in these complex systems.

The assessment of electromagnetic interference in complex systems has evolved from deterministic modeling to probabilistic approaches. A number of probabilistic approaches have been evaluated in the studies of the propagation of uncertainties of input variables to the system response. However, as far as EMC is concerned, the challenge is to examine the extreme value distribution of the responses and to assess the reliability of the system. The knowledge of the extreme values distribution, together with its associated sensitivity analysis, provides the most relevant information about the vulnerability of the system under investigation and the segregation distances to be set in order to comply with the system requirements (emission included).

This approach is meant to determine the regions in the design parameters domain that ensure the highest confidence needed to meet the EMC system requirements. The knowledge of the design margins, today neither evaluated nor known, is also essential in the design of electrical systems as it allows optimizing the harnesses design and handling all those borderline cases where the designer has no other option than to derogate from some of the design rules and change the layout of the cables. This may be long and expensive, requiring the intervention of EMC experts to validate the change.

The design of EWIS – Electrical Wiring Interconnection System is extremely complex in terms of number of cables (up to 40000 cables), number of functional electrical links (up to 10000 electrical links), routing possibilities, types of signals, flight phases, types of systems connected and loads' vulnerabilities, etc. The routing of all the cables cannot be done directly by taking into account all the parameters at once. Methods like the Monte Carlo analysis could allow determining regions of very high confidence in the design parameters domain, but require prohibitive computing time and power given the size of the problems to be dealt with. The main challenges for solving this problem are:

- To reduce the order of the models;
- To determine the propagation of variables uncertainties in the system response in order to determine the regions of highest confidence
- to perform reliable sensitivity analysis.

The topic focus will be on the identification and development of the most relevant and efficient tools to evaluate the system response and to identify the very high confidence design parameters regions with regard to the EMC compliance criteria applied to aeronautical cabling systems. The applicant shall develop a methodology (a set of methods) and the associated tools to perform the EMC analysis.

2. Scope of work

The main objective of this project is to identify and further develop state of the art statistical techniques for the specific context of EM compatibility analysis of cable harnesses in aeronautics. The challenge consists in adapting the methods or methodologies to the specific case of cable harnesses, given the nature and the number of uncertainties that describe their routing, and then to provide a robust implementation in view of estimating extreme responses. The work should provide an indication of the reasonable margins with regard to the standard thresholds (DO160, crosstalk evaluation) to justify the EWIS installation and identify routing optimization possibilities.

The EWIS EM (ElectroMagnetical) constraints computation and tests cases will be provided to the applicant to develop the statistical algorithms (methods) and is necessary combine them in a final "statistical methodology". The applicant should be able to interface with the data generated by a TLM (Transmission Line Method) based computation code which provides frequency dependant Voltage, Current and Power data over the cable network (the format will be discussed between the partner and the topic manager at the beginning of the project).

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Specification of requirements and test cases	Start: T0 End: T0 + 4 months Duration = 4 months
T2	Develop roadmap for improvement of state-of-the-art methods towards future statistical methods and tools	Start: T0 + 1 month End: T0 + 6 months Duration = 5 months
T3	Develop statistical methodology and associated tool	Start: T0 + 5 months End: T0 + 19 months Duration = 14 months
T4	Assessment of statistical methodology efficiency, e.g. with numerical and experimental validation	Start: T0 + 12 months End: T0 + 24 months Duration = 12 months

T1 – Specification of requirements and test cases
The objective of this task is the review of the data sets available and the different test cases (canonical test cases and representative test cases including a generic route definition), but also to assess the system thresholds (current, voltage susceptibilities available) and the different parameters variability: distances between cables, distances between harnesses, distances between harnesses and their respective electrical references, coupling lengths, etc.
The applicants will also review the transmission line models of the different test cases and the exchange data formats.

T2 – Develop roadmap for improvement of State-of-the-art statistical methods and tools
The objective is to review state of the art methods and associated tools for the statistical/probabilistic approach of the electro-magnetic compatibility analysis of cable harnesses in aeronautics and develop a new strategy for improvement of the state of the art towards new techniques (methodologies) to be used for the future with regard to the generic test cases established in T1.

T3 – Develop statistical methodology and associated tool
The aim of this task is to develop a methodology and an associated tool based on the methods established in Task 2. The Topic Manager highly recommends planning intermediate verification and validation steps within Task 3. For this purpose experimental or beta versions of software tools for reviews may be appropriate. During this Task a jointly selection of methods, algorithms and interfaces may occur wherever different or competing solution are available. All the algorithms chosen and/or developed, together with their right sequencing (the methodology), shall be integrated in a tool.

T4 – Assessement of statistical methodology efficiency – Numerical and Experimental Validation on canonical tests
The objective of this task is to assess the efficiency of the methodology developed in Tasks 3 – possibly by means of numerical simulations on canonical test cases and then on the representative test cases from Task 1. The aim is to test the tool, obtain a feedback and then fine-tune and adapt the statistical methods developed in tasks 3. A final numerical and experimental validation of the tool and its associated methods will be then performed with the test cases established and validated in Task 1.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Specification of requirements and preliminary canonical test cases	R	T0+2months
D2	Definition of representative test cases	R	T0+5 months
D3	State–of-the-art statistical methods, methodologies and tools for the EM and strategy for improvements	R	T0+7 months
D4	Statistical methodology and associated tool for final verification	SW	T0+19 months
D5	Methodology assessment, Results analysis and User Guide	R	T0+23 months

*Types: R=Report, SW=Hoftware

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Review of methodology/tool implementation status and readiness for assessment	R/SW	T0+12 months
M2	Final review of test report and results analysis	R	T0+24 months

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

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

- EMC applied to cabling systems (preferrabily in aeronautics)
- Proven skills on Statistical methods development and implementation
- Software design and development capabilities

XI. Development of low rating and high power HVDC optimized fuses

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.3.1		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Zodiac Aero Electric	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[66]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-42	**Development of low rating and high power HVDC optimized fuses**
Short description	
The purpose is to design and develop two types of HVDC optimized fuse prototypes: a low rating fuse for printed circuit board (up to 30A) applications, and high power fuse (up to 300A). The HVDC fuses will be designed, their performance simulated and the prototypes will be tested up to TRL6 within demonstrators. The targeted application is a further integration in Large Aircraft HVDC Power management centre.	

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

1. Background

Aeronautic power distribution systems use mostly electromechanical or semi-conductor components as protection devices for cables and electrical power distribution. For semi-conductor component, a failsafe solution is required to prevent failures such as the component not opening/cutting the electric circuits, an event that could generate fire inside the aircraft. The failsafe solution has to fulfil different requirements, for which a fuse would be a potentially good solution. However, HVDC network (540VDC) fuses currently available on the market were developed for the energy industry and are not optimized in terms of volume, weight and packaging for aircraft electrical distribution applications. The objective of this topic is to develop two new optimized fuses solutions to be integrated in aircraft distribution/protection components.

2. Scope of work

The objective of this task is to develop, test and deliver two types of HVDC fuses:

- One for low current calibre, suited for printed circuit board mounting (up to 30A)
- One compatible with high level of currents (up to 300A).

Both fuses will have to be optimized in terms of footprint, volume and weight in comparison with current existing products. The HVDC fuses will be tested within two equipments for a TRL6 demonstration. The work will consist in designing new packages for both HVDC fuses. Subcomponents such as fuse links and energy absorbing material will also be specifically made according to aircraft electrical distribution characteristics, ensuring an optimized volume of the solution. Finally packaging will fit new requirements for integration onto a printed circuit board or within a high power Sold State Power Controller.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Fuses prototypes definition	T0+6 Months
T2	Manufacturing and stand-alone prototypes testing according to fuse specification	T0+12 Months
T3	Update of fuses definition. Detailed design	T0+16 Months
T4	Manufacturing and final version testing according to fuse specification	T0+22 Months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Fuses prototypes definition review documentation	R	T0+6
D2	Technical synthesis and prototypes validation test report	R	T0+13
D3	Prototypes delivery	HW	T0+13
D4	Detailed design review documentation (fuses update definition)	R	T0+16

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D5	TRL6 demonstration report including technical synthesis and final fuses validation test report	R	T0+24
D6	Final fuses delivery	HW	T0+24

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Project kick-off meeting	Review	T0
M2	Fuse prototypes Preliminary Design Review	Review	T0+4
M3	Fuses prototypes Detailed Design Review	Review	T0+6
M4	Fuses prototypes Validation Review (after stand-alone tests)	Review	T0+13
M5	Fuses final version Detailed Design Review	Review	T0+16
M6	Fuses final version Validation Review (after stand-alone tests)	Review	T0+24

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

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

- Design capabilities in traditional fuses, bus bar systems, electrical connections, mechanical systems, custom packaging
- Mechanical and thermal simulation capabilities
- Testing facilities representative of aircraft electrical networks in terms of sources (constant or variable frequancies), loads, etc.

5. Abbreviations

HVDC High Voltage Direct Current

XII. Design and Development of a high temperature HVDC busbar

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.3.1		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	Zodiac Aero Electric	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[67]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-43	**Design and Development of a high temperature HVDC busbar**
Short description	
The purpose is to design and develop HVDC busbar prototype adapted to withstand high temperature. The busbar will be designed, its performance simulated and the prototypes tested up to TRL6 demonstration. The envisaged project outcome is the component integration in Large Aircraft HVDC Power management center.	

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

1. Background

Aeronautical power distribution systems use a distribution panel typically composed of electromechanical components, busbars, and harnesses. For the busbar component, temperature restrictions limits the potential for further integration and more compact designs for the distribution panel in terms of volume, weight and packaging. The evolution towards the more electric aircraft demands more and more electronics commutations and consequently, a design optimization of the distribution panel. , In this respect, key enabling technology is temperature control or the capacity to operate at high temperature. The objective of this topic is to develop a busbar capable to operate at high temperature.

2. Scope of work

The objective of this topic is to develop, test and deliver a High Temperature (at least higher than 180°C) HVDC busbar that withstands aerospace environmental constraints (vibration, altitude, partial discharge, ageing, etc.).

The High Temperature HVDC busbar will be designed and tested to demonstrate a TRL6.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	High Temperature HVDC Busbar prototypes definition	T0+6 Months
T2	Manufacturing and stand-alone prototypes testing according to specification	T0+10 Months
T3	Technical synthesis and prototypes delivery	T0+12 Months
T4	Bus bas design refinement, manufacturing and final test	T0+18 Months
T5	Technical synthesis and final High Temperature HVDC Busbar delivery	T0+24 Months

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1	High Temperature HVDC Busbar prototypes detailed definition documentation	R	T0+6 Months
D2	Prototypes validation test reports	R	T0+12 Months
D3	Prototypes delivery	HW	T0+12 Months
D4	Update of High Temperature HVDC Busbar detailed design documentation	R	T0+14 Months
D5	Final High Temperature HVDC Busbar test reports	R	T0+18 Months
D6	Final High Temperature HVDC Busbar delivery	HW	T0+24 Months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M1	Project kick-off meeting	Review	T0
M2	High Temperature HVDC Busbar prototypes Preliminary Design Review	Review	T0+3 Months
M3	High Temperature HVDC Busbar prototypes Detailed Design Review	Review	T0+6 Months
M4	High Temperature HVDC Busbar prototypes Validation Review (after stand-alone tests)	Review	T0+12 Months
M5	High Temperature HVDC Busbar final version Detailed Design Review	Review	T0+14 Months
M6	High Temperature HVDC Busbar final version Validation Review (after stand-alone tests)	Review	T0+24 Months

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

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

- Kowledge on aerospace, transport or industrial Busbar systems
- Design capabilities in traditional busbar systems
- Mechanical and thermal simulation capabilities
- Testing capabilities representative of aircraft electrical networks in terms of sources (constant or variable frequencies), loads, etc.

5. Abbreviations

HVDC High Voltage Direct Current

XIII. Cabin air quality and passenger comfort

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 6.0.2		
Indicative Funding Topic Value (in k€)	1200		
Topic Leader	United Technologies Research Centre, Ireland Ltd	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[68]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-44	**Cabin air quality and passenger comfort**
Short description	
This topic will develop a baseline for cabin air quality metrics based on assessment of passenger comfort. This will take a passenger-centric approach to investigate traditional cabin air quality and its effect on comfort, while considering other impacting factors such as temperature, pressure, and occupant density. The output of the project will inform future cabin air quality standards and technical solutions for aircraft environment control systems.	

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

1. Background

The environmental control system (ECS) on an aircraft provides cabin pressurisation, air supply, and thermal control in the aircraft cabin. Factors such as effective cabin altitude, humidity, temperature, odours, particulate and contaminants together influence the level of cabin air quality (CAQ) and passenger comfort. While some studies have shown air quality in aircraft to be good, and on a par or better than that of other transportation modes, few active measurements of cabin air quality have been undertaken, and the additional impact of boundary conditions, like reduced pressure environment on passenger comfort, is not well understood.

The provision of an environment for human habitation at modern jet aircraft cruising altitudes comes at a cost: the ECS is one of the largest non-propulsive energy consumers on board a passenger aircraft. In order to reduce the Specific Fuel Consumption (SFC) impact of the ECS, an Adaptive Environmental Control System (AECS) is being developed in the Clean Sky 2 Systems ITD WP 6.0.2 (see Figure 1). The AECS includes, among others, an air quality control system that will enable an increased level of cabin air re-circulation so that less air is brought into the cabin from the outside. The decrease of energy demand to heat external cool air up to air cabin temperature, will reduce the aircraft fuel burn. A key target of WP 6.0.2 is to maintain 'traditional' cabin air quality with decreased outside air flowrate.

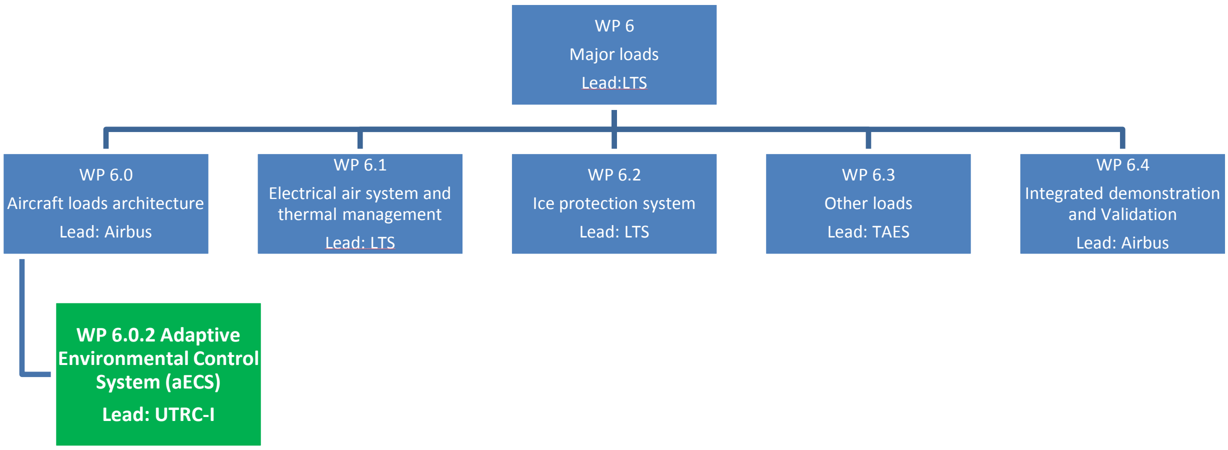


Figure1 : WP 6.0.2 in the context of WP6 Major Loads

In order to correctly parameterise the AECS system and to quantify its SFC benefit, it is required to undertake a study to determine a baseline for traditional cabin air quality in a Large Passenger Aircraft (LPA), such as single aisle aircraft, and understand how it is affected by an increased recirculation flow rate and potential accumulation of bio-effluents.

This topic calls for a passenger-centric approach to investigate the cabin air quality, and its effect on passenger comfort considering existing and new (AECS) recirculation regimes. Different factors affecting the cabin air quality need to be taken into account as detailed below.

2. Scope of work

Objective

The scope of this topic is to study how passenger comfort perception (including short term effects such as fatigue, impact on concentration, headache etc.) is affected by cabin air quality and environmental conditions in a LPA. This shall be performed in a realistic operational environment that simulates a typical ground and flight scenario. The applicant shall propose a representative test case that considers a wide variety of factors influencing comfort of aircraft passengers such as temperature, cabin pressure, relative humidity, odours, air velocity, noise, lighting and proximity to other passengers. Additionally, the applicant shall provide the means to measure and account for factors influencing passenger comfort during various experimental scenarios, particularly air quality indicators such as CO_2, CO, O_2, particles (in particular, ultrafine particles) and selected volatile organic compounds (VOCs). The test cases for this study shall be performed under various cabin air recirculation regimes. The applicant will propose a suitable experimental scenario by also considering individual sensitivity to particular comfort factors, such as age, anxieties, and acclimatisation.

The applicants will define which are the key chemical species and particle sizes to qualify the cabin air quality. The applicant will also define the detectable concentration levels of such species, measurement system to be used, measurement locations etc. as well as cabin air recirculation regimes and flight mission profiles. These will be further defined with the topic manager. Moreover, the applicant will propose an advanced and flexible measurement methodology to measure a wide range of potential contaminants that can be identified as indicators of cabin air quality along the test campain.The cabin air quality measurement shall be cross referenced to ASHRAE Standards 62.1-2013 and 161-2013, and other related aircraft air quality standards and studies. The study will modulate cabin air quality only within known safe limits for human exposure. The outcome of the study will establish a baseline of key markers of cabin air quality.

Applications should foresee performing the following activities:

1. *Definition of parameters and experimental scenarios that affect cabin comfort*

   The applicants shall define which are the key chemical species and particle sizes to qualify the cabin air quality. The applicant shall work with the Topic Manager to define those species that will be modulated during an experimental scenario and that are representatative of the cabin air quality in a LPA at selected recirculation regimes. Such parameters should be based on, but not limited to, existing literature, standards and available published reports / studies on cabin air quality. These paramaters could include:

   - temperature, humidity, pressure;
   - CO_2, CO, O_3, BTEX (Benzene, Toluene,Ethylbenzene and Xylene), VOC (incl. odour thresholds) and particles;
   - age, anxieties, acclimatisation, proximity to other passengers and flight duration.

   Additionally, the applicant should consider air composition and other parameters under normal operating conditions only.

2. *Cabin air quality measurement methodology definition*

   The applicant shall outline an appropriate methodology for the integration of cabin comfort indicators across a range of operational scenarios. This will result in measurable data that could be later incorporated into a closed loop control system for the AECS. Since cabin comfort can be considered subjective, factors influencing comfort perception should be taken into account in the methodology (this could, for example, include short term effects such as fatigue, impact on concentration, headache, itchy eyes etc.). The measurement methodology should be advanced to measure a wide range of potential contaminants that may be identified as indicators of cabin air quality along the test campain. Other means of gathering participant feedback such as the use of wearable personal devices and phone applications should be considered.

Furthermore, the applicant shall perform a preliminary test and measurement campaign to validate the methodology and test set-up according to appropriate international standard methods.

3. *Definition of experimental methodology, risk assessment, and experimental plan*

   The applicant shall prepare a comprehensive plan outlining the experimental methodology, tasks and risks for the study of human subjects. Additionally, if required, the applicant should obtain the appropriate permits to undertake such testing. The applicant should propose appropriate experimental scenarios to sufficiently examine cabin air quality perception.

4. *Human test campaign on cabin comfort perception and results analysis*

   The applicant will perform a test campaign on cabin comfort under different cabin environmental conditions considering existing and new (AECS) recirculation regimes that will determine different concentrations of selected contaminants. The entire variability range of each cabin parameter will be tested to provide a comprehensive understanding on how it affects passenger comfort at different testing conditions. The test campaign will be performed during two phases. During Phase 1 a traditional cabin air flow regime will be considered. Non traditional cabin air flow scenario will be taken into account during Phase 2.

   The applicant will analyse and aggregate the data collected during the test campaign to assess the level of cabin comfort and will provide a report of the effect of cabin environmental conditions on passenger comfort. Additionally, the applicant shall provide recommendations for future cabin air quality standards and for aircraft adaptive environmental control systems and propose air quality metrics.

Tasks		
Ref. No.	***Title***	***Due Date***
T1	Definition of parameters and experimental scenarios that affect cabin comfort	T0 + 3M
T2	Cabin air quality measurement methodology definition	T0 + 6M
T3	Definition of experimental methodology, risk assessment, and experimental plan	T0 + 8M
T4	Human test campaign on cabin comfort perception and results analysis	T0 + 24M

3. Major deliverables/ Milestones and schedule (estimate)

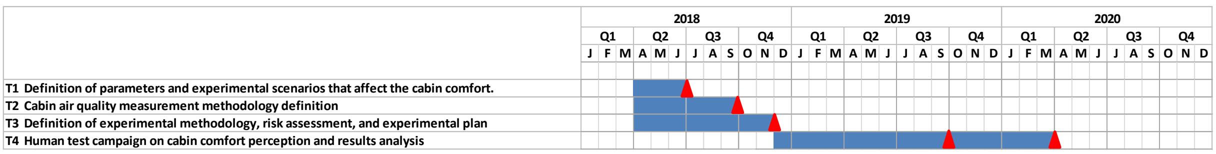
Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Report outlining definition of cabin comfort parameters, including chemical species of interest, concentration levels, selected cabin air regimes	R	M3
D2	Report on measurement methodology and measurement equipment	R	M6
D3	Detailed human subject study plan (including participant feedback methodology and all applicable permits for human subject)	R	M8
D4	Report on the effects of cabin environmental conditions under traditional cabin air regime on passengers comfort, including proposed cabin air quality indicators and recommendations	R	M18
D5	Report on the effects of cabin environmental conditions under non traditional cabin air regimes on passengers comfort, including proposed cabin air quality indicators/metrics and recommendations. The report will include comprehensive results from the analysis of data collected in Phase 1 and 2.	R	M24

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Project kick off meeting	M	T0
M2	Detailed test plan finalised and approved (including review of methodology, human subject testing plan and permits)	M	T0 + 8
M3	Presentation of passenger comfort campaign results under traditional cabin air regime	M	T0 + 16
M4	Presentation of passenger comfort final campaign results and proposed air quality metrics	M	T0 + 24

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

Suggested schedule is outlined below.



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

- Experience in undertaking similar measurement/assessment campaigns using a representative ground test rig/chamber. The test environment shall be adjustable within a realistic range of temperature, pressure, relative humidity, air velocity, etc. The test environment shall have the ability to modulate the recirculated air volume and measure air quality to concentration levels relevant for human exposure. The environment shall also enable the introduction of known concentrations of chemical species (VOCs, CO_2 etc.) and particles.
- Access to representative flight parameters to perform a representative simulation of time-based operational scenario, including flight phase information (cabin pressure, time on ground, cruise duration, food/drinks service, etc.) would be advantageous.
- Knoweldge and experience in epidemiological/physiological studies/surveys involving human subjects, specifically in the area of air quality assessment.
- Capability to undertake the defined human subject testing campaign and to independently obtain all necessary certification and permits to perform such work in its country of origin in a timely fashion. Additionally, the applicant should be familiar with the necessary leglislation regarding acquiring and storage of personal information, and complete the Ethics Assessment during the proposal stage.

5. Abbreviations

AECS	Adaptive Environmental Control System
BTEX	Benzene, Toluene,Ethylbenzene and Xylene
CAQ	Cabin Air Quality
ECS	Environmental Control System
LPA	Large Passenger Aircraft
SFC	Specific Fuel Consumption
WP	Work Package
VOC	Volatile Organic Compounds

XIV. Development of a Foreign Object Debris (FOD) protection device applied to an electrical ECS fresh air inlet

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 6		
Indicative Funding Topic Value (in k€)	1500		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[69]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-02-45	**Development of a Foreign Object Debris (FOD) protection device applied to an electrical ECS fresh air inlet**
Short description	
Electrical Environment Control System (eECS) takes external fresh air from an inlet. Depending on aircraft altitude and type of inlet, debris and contaminants may be ingested and cause premature degradation of pack performances, affect the cabin air quality and reduce eECS components life time. The topic aims at developing protective solutions to prevent eECS performance degradation due to FOD.	

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

1. Background

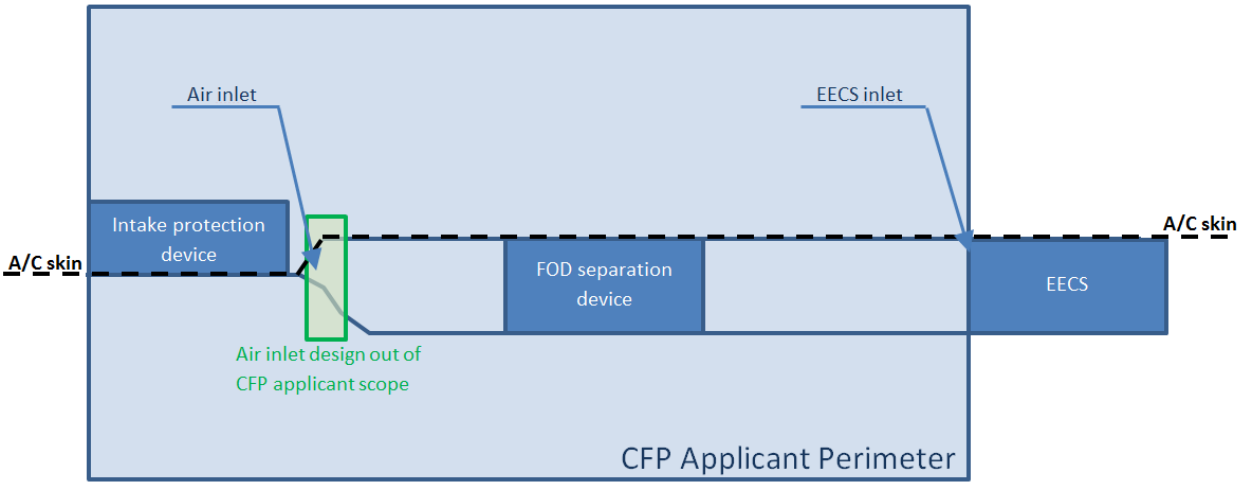
In the frame of Clean Sky 2 - Systems ITD, several technological bricks are developed to address needs for a future Electrical ECS which allows significant benefits compared to conventional pneumatic solutions:

- Fuel consumption reduction through more efficient use of A/C energies
- Improvement of A/C availability by increasing systems reconfiguration capabilities

In this approach, an air intake located on the belly fairing of the aircraft collects external fresh air and injects it directly into the e-ECS compressor. This working mechanism is radically different in bleed packs, where air is bled out from the engine.

Depending on aircraft environment and type of air intake, debris and contaminants may be mixed with the external air and ingested by the turbo-compressor. These FOD can be presented as a various sizes and natures such as: gravel, runaway debris, water (liquid, ice and hail), sand, etc. Ingestion of such particles by the compressor may result in premature wear of the blades which in turn gradually impacts the turbomachine's performances. It may also result in complete failure of the compressor if the FOD is of significant size. Other potential consequences are as follows (non-exhaustive list): blockage of compressor air inlet, clogging or degradation of the heat exchanger inner circuitry, cabin pollution, water ingestion…

In order to protect the turbo-compressor and the electrical pack against the negative impact of FOD, the air quality injected into the compressor must be properly treated. This topic aims to develop a FOD protection and separation device for the eECS to be validated up to TRL5.



CFP applicant perimeter

Main preliminary data:

- Air inlet flow rate: [700; 900] g/s
- Minimum operating temperature: -50°C in flight
- FOD separation device pressure drop shall be as low as possible. The order of magnitude is around 10 mbar.

2. Scope of work

In line with overall eECS TRL strategy of the Work package 6 in the ITD system, the purposes of this topic are to:

- design and develop a full scale FOD protection and separation device
- validate the device and the related technology at TRL 5

These two main objectives may be addressed through four major tasks:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	Identification of FOD and aerodynamic conditions at aircraft air inlet	T0 + 6 months
T02	Selection of the most appropriate separation and protection technologies and devices	T0 + 10 months
T03	Detailed design and manufacturing of the separation and protection device	T0 + 14 months
T04	Device validation and verification at full scale	T0 + 24 months

- **T01: Identification of FOD and aerodynamic conditions at aircraft air inlet**.
  The goals of this task are:
  - To identify and characterize FOD and aerodynamic conditions at aircraft air inlet depending on inlet type and position as well as aircraft environment. This activity shall be supported by the Topic Manager and the Airframer. The results of these investigations shall provide the basis of an eECS specification released by the Airframer.
  - To specify the efficiency breakdown for each item : air intake flap, FOD separation and protection device to reach the overall efficiency (done with the support of the Topic Manager)
- **T02: Trade and selection of the appropriate separation and protection device.**
  The applicant will propose a solution for separation and protection against FOD, taking into account various possible approaches and parameters such as but not limited to:
  - Aircraft air inlet type and position,
  - Actuated flap, FOD scavenge, Pipe geometry, vortex …
- **T03: Detailed design and manufacturing of separation and protection devices**
  The task focuses on:
  - The applicant will design and manufacture a prototype, taking into account the specificity of the Aircraft and eECS needs such as mechanical interfaces, air flow rate, pressure drop, etc.
- **T04: Device validation**
  This task aims at:
  - Defining the device validation test procedure
  - Manufacturing the test benches / tests required for the validation (contamination, separation efficiency measurement)
  - Performing the test campaign, analysing test data and summarizing the results in the validation report

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D01	Report on FOD and aerodynamic conditions at aircraft air inlet	Report	T0 + 6 months
D02	analysis of the most appropriate solution to protect eECS from FOD	Report	T0 + 10 months
D03.1	Detailed definition of prototype device	Report	T0 + 14 months
D03.2	Validation plan	Report	T0 + 14 months
D03.3	Prototype devices	Hardware	T0 + 18 months
D04	Validation report	Report	T0 + 24 months

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

- Engineering and knowledge of particle behaviour and/or filtration for aerospace applications.
- CFD modelling and simulation
- Experience in prototype demonstrators
- Capability for Experimental test bench for RAM air intake
- Particpation of SME is strongly encouraged, especially with capabilities for laboratory support

5. Specific confidentiality issues

Implementation Agreement will be shared between the Partner(s), the Topic Manager and the Airframer. Any Information related to this topic will not be shared outside of these parties.

XV. Electro-Mechanical Brake actuation for Small Aircraft [SAT]

Type of action (RIA or IA)	IA		
Programme Area	SYS / SAT		
Joint Technical Programme (JTP) Ref.	WP 7.2 – More Electric / Electronic technologies for small aircraft		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	Piaggio Aero	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[70]	Q2 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-SYS-03-13	**Electro-Mechanical Brake actuation for Small Aircraft**
Short description	
This topic aims at developing an electro mechanical brake actuation system that meets sizing, manufacturing, affordability and performance requirements for small aircraft. The development is expected to include prototype, subsystem integration, laboratory tests and to reach TRL5.	

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

1. Background

Over the last years, in the context of the more electric aircraft technology trend, the development of electric brake actuation systems has gained interest also for small aircraft and helicopters.
This topic aims at introducing such innovation in the small aircraft sector with a view to reduce costs and complexity of wheel brake actuation systems currently in use. There are a number of potential benefits in replacing legacy hydraulic systems with more electrical ones:

- The combination of brake-by-wire control technology and electro-mechanical brake actuation is expected to ease system integration and facilitate the implementation of advanced braking logics (possibly including antiskid function) also for small aircraft platforms.
- Electric braking is also expected to increase reliability, allow for health monitoring and reduce unscheduled maintenance costs.
- The replacement of hydraulic systems may bring weight savings and bring energy efficiency gains.
- The removal of hydraulic fluids eliminates the risk of leaks and the associated fire and safety concerns.
- As for safety requirements, typically satisfied through redundant architectures and fail-safe design criteria, electric actuation and health-monitoring / prognostic functions may bring simplification without reducing the level of safety.

The design approach may have to encompass a preliminary analysis on the testing in view of meting safety requirements; a trade-off on materials in order to better meet performance and life requirements may also be envisaged.

2. Scope of work

The project will make use of innovative design architectures and cost effective technologies to develop a reliable electric brake actuation system to be integrated with brake equipment for SAT Landing Gear application. The system should also offer health-monitoring functions to improve preventive and predictive maintenance capability. The specific application domain and requirements of the SAT sector may facilitate paving the way to improve the competitiveness of European supply chain in the field of design and production of electrically actuated braking system.

The project may be organized along the following tasks:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	*Detailed technical specification for the landing gear brake actuation system* The partner will concur with the Topic Manger in the definition of the system requirements (i.e. system components, performances, mass, envelope, reliability maintenance, testing and safety aspects, health monitoring strategy, validation tests).	T0 to T0+2

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T02	*Preliminary design of the brake actuation system and Technologies identification* The partner will provide preliminary studies supported by sketches and analyses in order to evaluate possible alternative designs. The technical specification will be frozen at the end of this phase. Presentation of the technologies to be adopted. Trade-off analysis to assess impact on weight, size and cost.	T0+3 to T0+8
T03	*Brake system integration and final design* The partner will identify, possibly based on previous experience, suitable materials/equipment for braking elements; it will ensure the brake actuation design can be integrated with a suitable brake in a prototype assembly The partner will finalize the design of the brake actuation system and all necessary equipment and define its integration in the brake assembly.	T0+9 to T0+18
T04	*Brake system manufacturing* The partner will develop and prototype the brake actuation system and ensure the construction, integration and preliminary testing of the demonstrator brake assembly. The partner shall design / identify test rig(s) suitable for testing the brake actuation system.	T0+19 to T0+26
T05	*Brake systems integration testing* The partner shall test actuation system integration into the demonstrator brake assembly.	T0+27 to T0+30
T06	*Full Brake systems testing* The partner shall perform the validation tests in suitable test rig(s), in accordance with the technical specifications.	T0+31 to T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Detailed technical specification	R	T0+3
D2	Preliminary design of the brake systems. Technologies identification	R	T0+8
D3	Brake actuation system design	R	T0+18
D4	Brake system test final report	R	T0+36

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M1	PDR	RM	T0+15
M2	CDR	RM	T0+19

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M3	Validation of manufacturing and integration	D	T0+30
M4	test report approval/validation	R	T0+36

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

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

- Previous experience in design and development of advanced electrical actuation technologies in the field of aeronautical brake system;
- Proven experience in international R&T collaborative projects 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 typical tools / methodologies of the aeronautical industry (i.e. mechanical stress by finite element method, thermal analysis capabilities in static and dynamic conditions…);
- Knowledge on electrical and mechanical component and system integration;
- Knowledge on advanced brake disc and friction materials (like ceramic and composite) and experience/background on different type of friction material (carbon/carbon or metallic/carbon);
- Test rig design/integration capability and availability of instrumentation for data acquisition, data recording. Preferably, experience with dynamic braking test rig capable to deal with high temperature.

XVI. Development of Digital Integrated Multifunction Probe for Air Data Sensing [SAT]

Type of action (RIA or IA)	IA		
Programme Area	SYS / SAT		
Joint Technical Programme (JTP) Ref.	WP 7.3 -Fly By Wire architecture for small aircraft		
Indicative Funding Topic Value (in k€)	1000		
Topic Leader	Piaggio Aero	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[71]	Q2 2018

Topic Identification Code	Topic Title
JTI-CS2-2017-CfP07-SYS-03-14	**Development of Digital Integrated Multifunction Probe for Air Data Sensing**
Short description	
To develop a digital multifunction and fully integrated air data probe, capable of providing local measurements of Static Pressure, Total Pressure, Angle-of-Attack (AOA), Angle-of-Sideslip (AOS) and Total Air Temperature (TAT), to be used as part of a redundant Flight Control System architecture	

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

1. Background

Over the last years, in the context of more electric aircraft, the request for fully integrated air data probes has rapidly increased. One of the main technical issue in the development of such probe is the capability to combine improved reliability and weight reduction.
In fact, although Fly-by-Wire (FBW) technology is well established in large aircraft, it has not yet found its way into SAT A/C, which are still mainly equipped with different sources of air data: pitot tubes, static ports, angle-of-attack vanes, etc. These devices are then pneumatically connected to a central air data computer, providing the necessary information to the pilots.
The introduction of fully-integrated, fault tolerant/health monitoring stand-alone air data probes can lead to a remarkable reduction of complexity and weight in a FBW control system for SAT A/C.

2. Scope of work

Scope of this call is the development of a digital multifunction, fully integrated, fault tolerant/health monitoring, stand-alone air data probe, capable of providing local measurements of Static Pressure, Total Pressure, Angle-of-Attack (AOA), Angle-of-Sideslip (AOS) and Total Air Temperature (TAT), to be used as part of a redundat Flight Control System architecture.
The air data probe object of this call shall also provide anti-ice capability (e.g. automatic heater in order to avoid holes occlusion due to ice formation), foresee redundant power supply and digital self-test capability (power-up, initiated and continuous built-in test) for health monitoring (in order to provide an overall data validity), all based on a single Line-Replacable Unit (LRU) communicating with other FBW control system devices through a standard communication bus.
The probe design should also target at minimizing size, weight and power consumption by the use of innovative materials.
The applicant may wish to address the following tasks:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	**System Requirements Review** The SRR examines the functional requirements and performance requirements defined for the system and the preliminary program or project plan and ensures that the selected concept will satisfy the requirements.	T0+2
T02	**Conceptual Design** The conceptual design process produces a high-level design concept that may be assessed to determine the potential for the resulting design implementation to meet the requirements. This may be accomplished using such items as functional block diagrams, design and architecture descriptions, sketches, etc. Main tasks may be: - High Level Architecture design - Generation of an High-Level technical description - Identification of the main components (HW and SW) - Preliminary Interface Definition (HW and SW)	T0+6

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T03	**Detailed Design** Develop the detailed design of the Air Data Probe starting from Conceptual Design Data. Output of the detailed design phase should include: - Detailed Architecture design - Detailed Drawing of the Air Data Probe and of each components (including schematics and interconnection between components) - HW and SW Development	T0+12
T04	**Implementation** The Partner, starting from Detailed Design Data, shall produce the Air Data Probe.	T0+18
T05	**Acceptance Test and Verification** The acceptance test demonstrates that the manufactured product performs in compliance with the requirement specification.	T0+20
T06	**Environmental Requirements Verification – Flightworthy Units Delivery** The Partner shall perform a subset of environmental tests (Temperature, Vibration, Icing, EMI/EMC) on the Air Data Probe in order to verify compliance with the environmental requirements.	T0+26
T07	**Support to System Integration** The Partner shall provide technical support for the Air Data Probe integration into the Flight Control System.	T0+36

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	System Requirement	R	T0+2
D2	Air Data Probe Prototype Manufacturing	R, HW	T0+18
D3	Air Data Probe Acceptance Test Report	R	T0+20
D4	Air Data Probe Environmental Test Report	R	T0+26

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

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	System Requirement Review	R	T0+2
M2	Preliminary Design Review	R	T0+6
M3	Critical Design Review	R	T0+12
M4	Air Data Probe Delivery	HW	T0+18

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M5	Air Data Probe Acceptance Test Report	R	T0+20
M6	Air Data Probe Environmental Test Report	R	T0+26

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

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

The applicant(s) shall have:

- Experience in development and design of advanced technologies in the field of Embedded Computing.
- Proven experience in international R&D projects cooperating with industrial partners, institutions, technology centres, universities.
- Quality and risk management capabilities demonstrated through applications on international R&D projects and/or industrial environment.
- Proven experience in the use of design, analysis and configuration management tools of the aeronautical industry.
- Expertise in industrial air vehicle developments with experience in "in-flight" components and laboratory set-up for aeronautical certification.
- HW/SW Development and Integration capabilities.
- Test rig design capabilities.
- Instrumentation data acquisition, recording and monitoring capabilities.

5. Abbreviations

A/C	Aircraft
AOA	Angle of attack
AOS	Angle of sideslip
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
FBW	Fly by Wire
HW	Hardware
LRU	Line Replaceable Unit
R&D	Research and Development
SAT	Small Air Transport
SRR	System Requirements Review
SW	Software
TAT	Total air Temperature

XVII. Super hydrophobic and erosion resistant coating for turbine scroll and downstream pipe

Type of action (RIA or IA)	RIA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 100.2		
Indicative Funding Topic Value (in k€)	700		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	36	**Indicative Start Date**[72]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-03-15	**Super hydrophobic and erosion resistant coating for turbine scroll and downstream pipe**
Short description	
The aim of this topic is to develop an improved eco-friendly hydrophobic/ice-phobic solution able to resist to ice erosion in a turbine scroll and its downstream pipe. Scope of the work includes reproducing the conditions of ice formation and accretion in a turbine of an air conditioning system, screening of existing super hydrophobic solutions applicable inside the scroll and the downstream pipe.	

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

1. Background

Currently, the air cyle machine uses a heating system on the downstream pipe called de-icing ring to heat the surface of the pipe. The temperature source could be electric resistance heaters or hot air coming from the compressor stage of the air cycle machine. Those two solutions are energy consuming and the Topic Manager would like to reduce energy consumption by the development of passive energy-saving solutions.

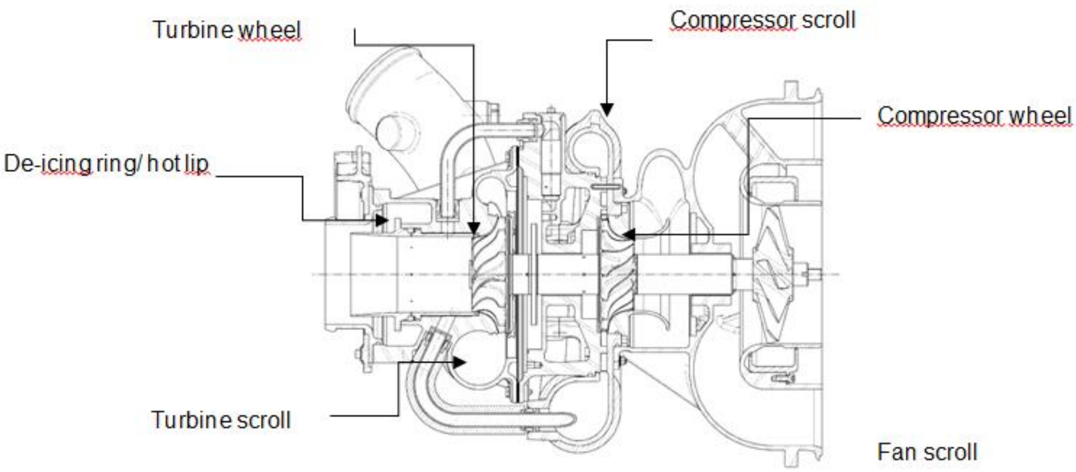


Fig. 1: Cross section of an Air Cycle Machine (ACM).

Ice-formation on a cold surface in a cold high speed flow and its prevention by superhydrophobic or ice-phobic surfaces have been extensively studied in the aerospace field, mainly for the foreseen application of the wing or nacelle leading edge (for exemple Storm EU FP7 Project). Scientists have experimented and simulated the formation of ice at the impact point in various conditions and for different contact angles. The physical behavior of ice formation and accretion are different in the turbine and in the pipe compared to wing leading edge, where supercooled water is involved. Indeed, at the wing leading edge the conditions present higher Mach (0.3 to 0.7), larger water droplets (20µm to 1 mm) and impact angles varying from 90 to 30 deg. Ice formation could occur at the impact of the water droplet or during the runoff of the water on the wing surface after the impact.

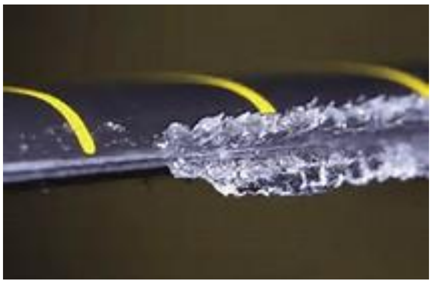


Fig 2: Ice formation on wing leading edge (Source NASA)

Therefore, in the turbine and in the pipe, ice accretion is linked to a turbulent rotating flow containing microscopic frost crystals. Typically the conditions in a turbine and in the downstream pipe are Mach 0.2, temperature around – 35°C, with water droplets of 1µm and impact angles near 0 deg.
Moreover, the lack of erosion resistance has been highlithed in many projects especially in Storm FP7 project,

with a limited lifetime of ice-phobic coatings. Current litterature in the field of identification of mecanisms of superhydrophobicity and formulation of different preparation methods of superhydrophobic surface is rich and is growing rapidly. Nevertheless, the associated problem of surface degradation induced by wear, abrasion and especially erosion, and their effects on hydrophobicity properties remain unsufficiently studied and unsolved. Thus, there is a clear need to develop high mature solutions combining ice-phobic characteristics and erosion resistance.

The purpose of this topic is to develop superhydrophobic and erosion resistant solutions to be applied on the ECS turbine scroll and inside the pipes downstream of the turbine to avoid frost/ice accretion. The first step of the project will focus on frost formation and accretion studies inside the turbine and the pipe. The selcted partner will perform a screening of existing coatings or surface texturation of aluminium or thermoplastics material as applied on the inner surfaces of turbine parts, and will develop an innovative ecofriendly solution (such as, for example solgel coating) up to TRL 4. Validation test will be performed on a demonstrator delivered by the Topic Manager. The selected partner will define, develop and perform the characterization tests of the ice-phobic or anti-frost accretion that will allow validatingit's the performance and the erosion resistance of the adopted solution.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
Task 1	Development of a test set up and definition of the requirements for the ice-phobic solution	M8
Task 2	Screening of the existing solution in term of ice-phobic performance and erosion resistance	M18
Task 3	Development of new superhydrophobic/ice-phonic solutions with erosive resistance properties	M36

Task 1 : Development of a test set up and definition of the requirements for the ice-phobic solution

The first step of the project will focus on the frost formation and accretion studies inside the turbine and the pipe. At the beginning of the project, the Topic Manager will provide the selected partner with the information concerning the air cycle machine and the characteristics of the air flow.

The selected partner shall define an experimental test set-up (incluing turbine wheel, injector and scroll provided by the Topic Manager) to reproduce, observe and measure the ice formation and accretion on the surface of the current uncoated pipe without hot lip. Depending on applicant capabilities and available tests facilities, the experimental test set-up could be the complete rig that reproduce the frost formation conditions and allow measurements, or it could be the ice-formation measurement system that will be installed in the Topic Manager facilities.

Applicants may propose to reproduce only the air flow with static parts including a supersonic nozzle with a fixed swirl. The topic manager will provide the geometry of the convergents. The characteristics of the air flow are the following ones:

- pressure delta is 4 bars,
- outlet pressure is ambiant pressure,
- inlet temperature is comprised between 30°C and 80°C

- humidity is betwwen 10 gramms and 20 gramms of water per kilogram of dried air.
- dust polution of the air flow is determined by 10^9 to 10^{11} nuclei per m^3 .

Based on the experimental measurements, the characteristics of the air flow and droplets or frost crystals impacts on the surface will be determined and used to identify the requirements for the superhydrophobic/icephobic solutions.

Task 2 : screening of the existing solutions applicable to an inner surface

The aim of this task is to study the solutions already available: the applicant shall screen the existing coatings or surface texturation available on aluminium or thermoplastics material applicable on the inner surfaces of parts.

These coatings will be applied on technological samples (piping : 4' in diameter, 4' length) and characterized on the experimental set-up developed in Task 1.

A ranking will be established according to their superhydrophobic/icephobic performance but also to their erosion resistance to frost crystals impact at low impact angles.

Task 3: development of new superhydrophobic/ice-phonic solutions with erosive resistance properties

Solution for aluminium alloys, thermoplastics and their characterization shall be proposed

The aim of this task is to study and develop an innovative eco-friendly solution (for example solgel coating) up to TRL 4 on AA2024 and on cast AS7G06.

The applicant shall also consider thermoplastic as a substrate, hence study and develop an innovative eco-friendly solution up to TRL 4 for reinforced (short carbon fibers) thermoplastic (e.g. PEEK) obtained by injection process.

The coated samples will be characterized in details on flat samples by the applicant : SEM-EDX, FIB, contact angles measurements, contact angle hysteresis, hardness…

The coatings developed will be applied on technological samples (piping : 4' in diameter, 4' length). The superhydrophobic/ice-phobic performances and erosion resistance of these coatings will be assessed with the experimental test set-up developed in Task 1.

Characteristics of the erosion test will also be calibrated with the current surface solution (anodic acid oxidation) in order not to develop a too agresive erosion test.

Tests will be performed at the applicant facilities or at the Topic Manager test center depending of the location of the test set-up.

A comparison with the performances of coatings studied in Task 2 will be done.

The final tests will be performed at the Topic Manager facilities on a complete Turbomachine

The applicant shall also perform an economic and ecological analysis (for both existing and new caotings)

The Topic Manager will provide all the samples required for the study.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Definition of the requirements (based on TM input)	R	M0
D2	Test set-up able to create and measure frost formation and accretion,	R+H	M10
D3	Updated Specification of super hydrophobic/ice-phobic characteristics based on ice accretion measurements	R	M12
D4	Report on Screening of existing solutions	R	M18
D5	Development of coatings on Aluminium and thermoplastics	R	M24, M30
D6	Manufacturing of demonstrators : coatings on aluminium and thermoplastics	HW	M 30
D7	Tests of technological samples	R	M33
D8	Economic and ecological analysis	R	M36

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

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

- Strong experience in ice-formation studies and experiments
- Strong experience on surface technologies, especially on chrome free surface treatments, in particular on the following alloys : cast AS7G06, AA2024,
- Experience and knowledge on the surface treatments of reinforced (short fibers) thermoplastics (e.g. PEEK)
- Experience on erosion wear
- Capabilities required to performed the study :
    - Confinated flow and water droplets / ice crystals measurements,
    - SEM-EDX, FIB, XRD, contact angles measurement
    - Erosion tests and wear measurment

XVIII. Aircraft mission modelling: ground and flight operations

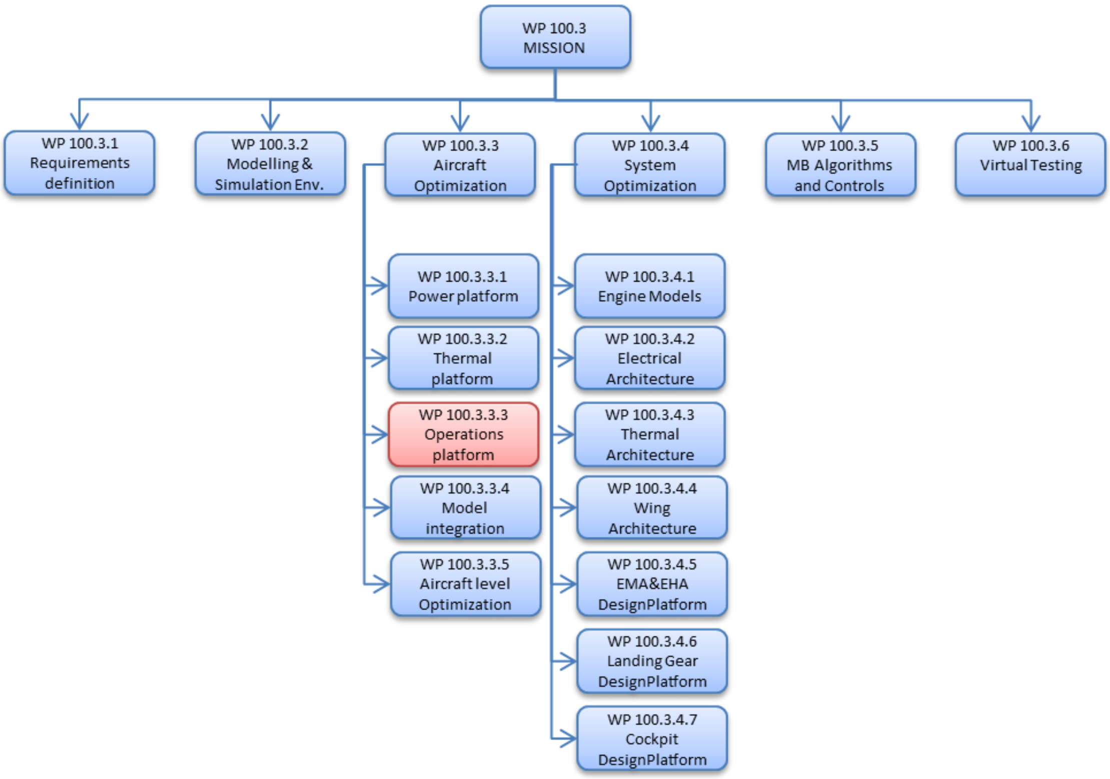
Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP100.3		
Indicative Funding Topic Value (in k€)	500		
Topic Leader	United Technologies Research Centre, Ireland	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	24	**Indicative Start Date**[73]	Q2 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-SYS-03-16	**Aircraft mission modelling: ground and flight operations**
Short description	
The goal of this call is to develop parametrizable models of in-flight and on-ground aircraft operations covering all mission profiles across multiple aircraft platforms. The models have to be developed in the form of a Modelica library and integrated within the MISSION aircraft and system trade-off platforms; in addition, the operation library has to interface with available detailed models of airport environment and ATC platforms.	

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

1. Background

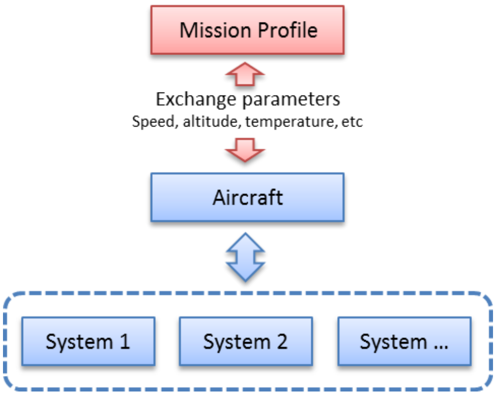
Market drivers such as operational considerations, societal concerns and increased consumer expectations are resulting in aircraft manufacturers designing a new generation of highly efficient aircraft characterised by new levels of comfort, system integration, and optimised aerodynamics. A new generation of software tools is required for time effective, cost effective, and reliable system design and performance prediction. The high level of system integration that is characteristic of new aircraft designs is dramatically increasing the complexity of both design and verification. Simultaneously, the multi-physics interactions between structural, electrical, thermal, and hydraulic components have become more significant as the systems become increasingly interconnected (e.g. the interaction between thermal load due to increased cabin electrical power usage, an electrically-powered environmental control system, and electrically powered flight control actuation). New methodologies and tools are therefore required to enable better coordination between different design disciplines, so that appropriate requirements are specified at different design phases, and design trades and potential problems are identified before physical prototypes are built and tested through expensive test campaigns.



The aim of WP 100.3 (MISSION – Modelling and Simulation Tools for System Integration on Aircraft) is to develop and demonstrate an integrated modelling, simulation, design and optimization framework based on MBSE and oriented to the aerospace industry. This framework will holistically support the entire design, development and validation process of an aircraft, starting from conceptual aircraft-level design, toward capture of key requirements, system design, integration, validation and verification. This CfP is proposed in WP 100.3.3, which is dedicated to the development of the aircraft level optimization platform. In particular, the call focuses on the development of a simulation platform to evaluate in-flight and on-ground aircraft operations (WP 100.3.3.3). The key objective of this activity is to develop appropriate models of aircraft operations covering all relevant mission profiles across multiple aircraft platforms, including existing, present and future operations.

2. Scope of work

The goal of this activity is to develop parametrizable models of in-flight and on-ground aircraft operations covering all mission profiles across multiple aircraft platforms. The models have to be developed in the form of a Modelica library and integrated within the MISSION aircraft and system trade-off platforms; in addition, the operation library has to interface with available detailed models of airport environment and ATC platforms.



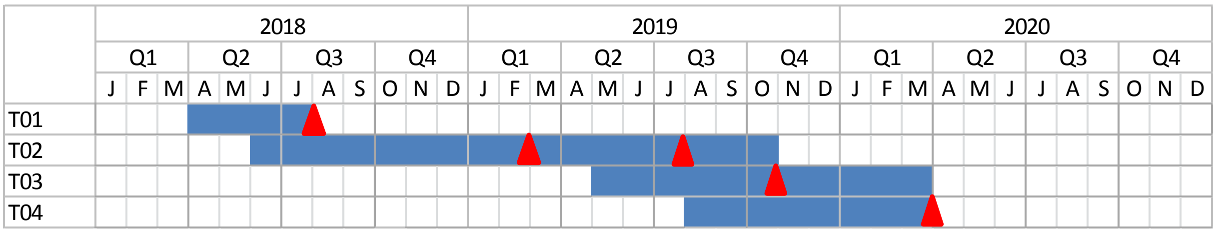
The flight operations model library must provide functionalities for parametrization of all relevant in-flight and on-ground variables, such as jettisonable loads, on-ground towing/pushback scenarios (including eTaxi), runway-length, air-speed, height profile and weather conditions. The final package should contain functionalities for automatic generation and update of mission models from databases (e.g. BADA). The library will be combined with the MISSION aircraft level models in the following use cases (among others):

- Comparison and detailed quantification of benefits of alternative operations scenarios
- Comparison of benefits of different aircraft configurations
- Calculation of aircraft weight and balance during normal and abnormal operation

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T01	Definition of requirements and specifications	T0+4M
T02	Development of a Modelica-based library of models for aircraft operations	T0+18M
T03	Integration of the operations library within the optimization platforms at aircraft and system level	T0+24M
T04	Validation of the operations library within MISSION framework	T0+24M

3. Major deliverables/ Milestones and schedule (estimate)

Tentative Gantt chart



Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D01.a	State of the art and interoperability review	Report	T0+2
D01.b	Model requirements, interface specification, and validation and verification requirements	Spec	T0+4M
D02.a	Aircraft operations: model library and documentation	Data + Models	T0+11M
D02.b	Aircraft operations: model library demonstration	Demo	T0+16M
D03.a	Aircraft level platform integrating operations	Demo	T0+19M
D04.a	Model library validation within MISSION framework	R	T0+24M

*Types
: R=Report, D-Data, HW=Hardware, Spec = Specifications, Demo = Demonstration

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

- Thorough understanding of existing and envisaged aircraft operations scenarios developed through linkages to airlines, airframers, and/or airport operations.
- Expertise in development of Modelica-based model libraries for the design, analysis and simulation of the dynamic behaviour of complex systems.
- Expertise in modelling, evaluation and demonstration of aircraft in-flight and on-ground operations through relevant projects, including participation in national and EU-funded efforts.
- Expertise in MBSE methodologies to manage system requirements and support design, analysis, verification and validation activities.
- Knowledge of simulation tools used in the ATM domain
- Experience and competence in management of multidisciplinary research projects within national and EU-funded programs
- Experience in collaborating with aeronautical companies, industrial partners, and research centers on national and international joint efforts in research and development programs.
- Ensure efficient management of study and development phases.

5. Abbreviations

ATC	Air Traffic Control
BADA	Base of Aircraft Data
MBSE	Model-Based Systems Engineering
MISSION	Modelling and Simulation Tools for System Integration on Aircraft

10.Clean Sky 2 – Technology Evaluator (Transverse Area)

I. TE Technology diffusion model

Type of action (RIA or IA)	RIA		
Programme Area	TE2		
Joint Technical Programme (JTP) Ref.	WP3 – TE Integration at Mission Level		
Indicative Funding Topic Value (in k€)	200		
Topic Leader	DLR	**Type of Agreement**	Implementation Agreement
Duration of the action (in Months)	18	**Indicative Start Date**[74]	Q4 2018

Topic Identification Code	**Topic Title**
JTI-CS2-2017-CfP07-TE2-01-06	**TE Technology diffusion model**
Short description	
This topic focuses on the development of a technology diffusion modelling capability, which enables TE to estimate the rates of propagation of technologies of individual concept vehicles into the other seat classes of the global fleet.	

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

1. Specific challenge

Cross-positioned within the Clean Sky 2 Programme, the Technology Evaluator (TE) is a dedicated evaluation platform. Its main function is to assess the environmental impact of the technologies developed in Clean Sky 2. In relation to well-defined environmental (noise, CO_2, NO_x) and societal benefits and targets the contribution of these new technologies is additionally estimated addressing their overall impact.

The corresponding technologies are developed within Innovative Aircraft Demonstrator Platforms (IADPs) and Integrated Technology Demonstrators (ITDs) and they are clustered in coherent and mutually compatible solution sets, defining concept aircraft models. In-depth assessments of these concept aircraft models will be conducted on three levels:

- Mission level
  A Clean Sky 2 concept aircraft and its reference aircraft model[75] is compared along the same trajectory in order to determine the environmental benefit of the Clean Sky 2 technologies, namely noise on ground and emissions (CO_2 and NO_X).
- Airport level
  Clean Sky 2 concept aircraft models replace their reference technology counterpart at different time scales (2015/2020/2035/2050) in terms of airport traffic scenarios. The purpose of this replacement approach is to evaluate the full potential of environmental benefits of Clean Sky 2 technologies on airport level by concentrating on noise on the ground and the population affected by certain noise levels and emissions (CO_2 and NO_x).
- Air Transport System (ATS) level
  Similar to the airport level, Clean Sky 2 concept aircraft models replace their reference technology counterpart at different time scales (2015/2020/2035/2050) in terms of complete traffic scenarios. In this respect, the resulting impact is measured on a global scale.

This call addresses the extension of TE assessment capabilities through the development of a technology diffusion prediction model. The purpose of this model is to interlink vehicle-related technologies of individual concept vehicles, which are provided by the respective IADPs, ITDs or the TA SAT to the TE with the fleet-related deployment models for ATS level assessment by diffusing these technologies into other vehicles and seat classes in the global fleet. Such a diffusion modelling capability is expected to provide a more realistic future technology penetration scenario in comparison to a global fleet composed of only Clean Sky 2 concept models and non-Clean Sky 2 technology vehicles.

[75] The reference aircraft model refers to an aircraft having entered into the market in the year 2014.

2. Scope of work

Against this background, the TE is seeking solutions to the following challenges with respect to technology diffusion modelling:

- What are the decision drivers that motivate the introduction of new technologies into air vehicle programmes?
- How do technological advances introduced to a certain vehicle class propagate to other vehicle classes?
- Which are the main drivers and parameters that govern such technology diffusion into other vehicle classes?

Based on these findings, a model is to be developed that allows for a time-discrete prediction of diffusion of technologies in air vehicles.
For this purpose, the Topic Manager will provide a detailed overview of Clean Sky 2 technologies and their respective concept vehicles.
The developed methodology is then to be applied for the provided world fleet scenario within the ATS assessment level, providing a detailed analysis of which Clean Sky 2 technologies diffuse at which point in time from concept vehicles into the remaining vehicle/seat classes. Additionally, an estimation of the impact of this diffusion on vehicle level is foreseen to be given.

In summary, the work will cover:
1) Development of a technology diffusion model for aircraft and rotorcraft
2) Analysis of technology diffusion within the Clean Sky 2 global fleet on ATS level
3) Determination of composition of the global fleet due to the forecasted technology diffusion and quantification of the fleet's vehicle performance as result of the diffusion

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D 1	Overview of relevant CS2 technologies and their estimated impact on initial CS2 concept vehicle class.	Report	T0+6;
D 2	Theory of diffusion of technology bricks from initial CS2 concept vehicle classes to other vehicle classes. Description of mechanisms which govern the rate of diffusion to other vehicle classes, depending on the type of technology.	Report	T0+12; T0+18
D 3	Technology diffusion model, which provides forecast of global fleet composition and estimated vehicle performance. User manual and report on verification of results.	Model+ Report	T0+18
D 4	Final Report of the analysis of the composition of the global fleet in a given timeframe due to the forecasted technology diffusion and of the quantification of the fleet's vehicle performance as result of the diffusion.	Report	T0+18

<u>Please find below the indicative schedule:</u>

- Month 1 – Kick-off meeting (1 day) in Brussels. The meeting will be organised by the Topic Manager.
- Month 12 – Intermediate meeting in Brussels. The meeting will be organised by the Topic Manager.
- Month 18 – Final meeting in Brussels. The meeting will be organised by the Topic Manager.

3. Impact

This work strengthens the TE ATS level assessment by providing a technology diffusion modeling capability, which will allow the TE to devise more realistic fleet compositions for a given global fleet scenario. In the ATS level assessment this fleet is currently composed of Clean Sky 2 concept vehicle models, which represent a limited fraction of vehicle seat classes with additional TE concept aircraft models filling the gaps between these vehicle classes. The diffusion model enables the TE to improve the fleet composition through estimating the point in time of introduction of Clean Sky 2 technologies and their impact on the remaining vehicle classes in the fleet.

4. Special skills and capabilities expected from the applicants

Applicants should have the following skills and expertise:

- Profound expertise in technology assessment and technology diffusion analysis
- Expertise in conceptual and preliminary design level of air vehicle design
- Profound knowledge of derivation of simplified models of complex technical and economic interrelations
- Ability to deliver clear and concise reports in English

5. Topic specific condition(s) for participation applicable to topics related to the TE

In the light of the statutory tasks of the Technology Evaluator and the specific nature of the TE actions and in order to ensure a full independence of work, to prevent any conflict of interest and to ensure a competitive, transparent and fair process, the following "additional conditions" in accordance with Article 9.5 of the H2020 Rules for Participation apply:

- The **16 Leaders of JU listed in Annex II to Regulation n° (EU) No 558/2014 and their affiliates**[76] may not apply to the topics related to the TE.

All applicants will be requested in the application submission forms to:

- officially state whether they are an affiliate[77] to a private Member of the JU;
- issue a declaration of absence of conflicts of interest[78] that will determine its admissibility.

The above criteria and the declarations will be checked by the JU which will determine the admissibility of the applicants. The JU reserves its right to request any supporting document and additional information at any stage of the process.

[76] See the definition under Article 2.1 of H2020 Rules for Participation

[77] Applicants shall check the definition based on Article 2.1 of H2020 Rules for Participation

[78] As part of the declaration, the legally authorized representative of the applicants entities will be requested to declare any interest which may bias the integrity and independence of its work under the topic, whether the representative(s) of the entity participate to the IADP/ITD steering committees or TE Coordination Committee and whether it was involved in the preparation, definition and approval of the topics of the calls or had any privileged access information related to that.