Clean Sky 2 Joint Undertaking

Call Text

4th Call for Core Partner (CPW04): List and full description of Topics

- December 2016 -

History Table		
Version n°	**Issue Date**	**Comment**
R1	05/12/2016	Release for the Participant Portal of the European Commission
R2	06/12/2016	Order of LPA topics corrected

<u>Important notice on Q&As</u>

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

In case of questions on the Call (either administrative or technical), applicants are invited to contact the JU using the dedicated Call functional mailbox: Info-Call-CPW-2016-01@cleansky.eu

Note that questions received up until 12th January 2017, 17:00 (Brussels Time) will be answered after analysis and published in Q&A when appropriate. In total, two publications of Q/As are foreseen: 20th December 2016 and 24th January 2017 (estimated dates).

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

Index

Overview of number of topics and total funding value per SPD

Area	No. of topics	Indicative topic Funding (M€)
IADP Large Passenger Aircraft	3	23.65
IADP Regional Aircraft	0	0
IADP Fast Rotorcraft	1	11
ITD Airframe	0	0
ITD Engines	0	0
ITD Systems	3	19
Small Air Transport (SAT) Transverse Area	0	0
ECO Transverse Area	0	0
Technology Evaluator 2	0	0
TOTAL	**7**	**53.65**

List of Topics for Core Partners Wave 04 (CPW04)
Type of Actions: Innovative Action (IA)

Identification Code	Title	Ind. Value (Funding in M€)	Topic Leader
JTI-CS2-2016-CPW04-LPA-01-11	Design of a wing with HLFC (Hybrid Laminar Flow Control) technology	10,00	Airbus
JTI-CS2-2016-CPW04-LPA-01-12	High density energy conversion system for an APU	3,65	Safran
JTI-CS2-2016-CPW04-LPA-02-03	Development and manufacturing of multifunctional and integrated thermoplastic fuselage shell, passenger floor and cargo floor including the main system, cabin and cargo elements	10,00	Airbus
JTI-CS2-2016-CPW04-FRC-01-02	Design, manufacture and deliver a high performance, low cost, low weight wing for Next Generation TiltRotor (NGCTR)	11,00	Leonardo Helicopters
JTI-CS2-2016-CPW04-SYS-01-01	Networking solutions for future cockpit communications	6,00	Thales
JTI-CS2-2016-CPW04-SYS-01-02	System solutions for Cabin & Cargo operations, communication and power management	8,00	Thales
JTI-CS2-2016-CPW04-SYS-02-09	Next generation of energy storage solutions for more electrical aircrafts	5,00	Thales

1. Clean Sky 2 – Large Passenger Aircraft IAPD

I. Design of a wing with Hybrid Laminar Flow Control [HLFC] Technology

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP V5) Ref.	WP 1.4.4		
Topic Leader(s)	Airbus		
Indicative Funding Topic Value (in k€)	10 000		
Duration of the action (in Months)	72	**Indicative Start Date**[1]	Q4 2017

Identification	**Title**
JTI-CS2-2016-CPW04-LPA-01-11	**Design of a wing with Hybrid Laminar Flow Control [HLFC] Technology**
Short description (3 lines)	
Design and construction of a wing with HLFC (Hybrid Laminar Flow Control) technology and corresponding manufacturing process, proven by means of a large-scale ground-based demonstrator.	

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

1. Background

Preface

The purpose of this Strategic Topic description is to find a Core Partner who contributes from integrator and architecture perspective with its capabilities, skills and resources performing highly integrated and multi-disciplinary design for a wing equipped with HLFC (Hybrid Laminar Flow Technology) technology.

The major target of this topic is to demonstrate a fully integrated HLFC wing by means of a large-scale demonstrator (plus supporting small-scale demonstrators) including all essential systems, sub-structures and sub-technologies to achieve a TRL4 on integrated major component level. This includes proving the complete functionality of the integrated HLFC system in an operational envelope limited to ground-based test conditions. The according design and manufacturing process has to comply with the standards and procedures of the Topic Leader. Also, all systems and technologies and its underlying manufacturing processes which are going to be developed in the course of the project shall be qualified on component level up to such a TRL level which justifies at the end the acknowledgement of TRL4 of the integrated HLFC wing.

The whole activity will be performed in close interaction with the Topic Leader, working in a multi-disciplinary environment of various design organizations/teams, either remotely or in a collocated manner. In particular at the beginning of the proposal runtime, so-called “plateau” phases of collocated teams of the Topic Leader and the Core Partner are seen as a strong enabler to jointly and efficiently develop the HLFC wing configuration concept as well as the preliminary integrated HLFC wing design concept.

In any case the 1st level design responsibility is on Topic Leader side.

The principle of operation requires a high experience in working in a multidisciplinary and integrated design environment. The expected high number of contributing parties coming from all over Europe and the complexity of the development work require also from the Core Partner personnel to become an essential management element in the organisation of the project management plan. This implies also the readiness to take responsibility in the technical lead of action, through leading work packages or sub work packages, and the definition and issuing of Call for Proposal Partners.

It is expected that the Core Partner’s commitment to this LPA Strategic Topic includes the distinct readiness along the program lifetime to be ready to follow possible necessary technical program changes/adaptions within the given technical scope.

The applicant shall clearly define which tasks, deliverables, milestones are performed within the scope of his/her proposal and which activities require additionally the support by Call-for-Proposal (CfP) Partners and/or Subcontractors (SC).

Background

The activities of this Strategic Topic covers the aerodynamic design work for the advanced HLFC wing linked to the WP1.4 “Hybrid Laminar Flow Control Large Scale Demonstration” in IADP-LPA, Platform 1, s. Figure 1. The scope, described work content, objectives and the mentioned work packages (incl. nomenclature) fully refer to the Joint Technical Proposal (JTP), version 5, as the baseline document.

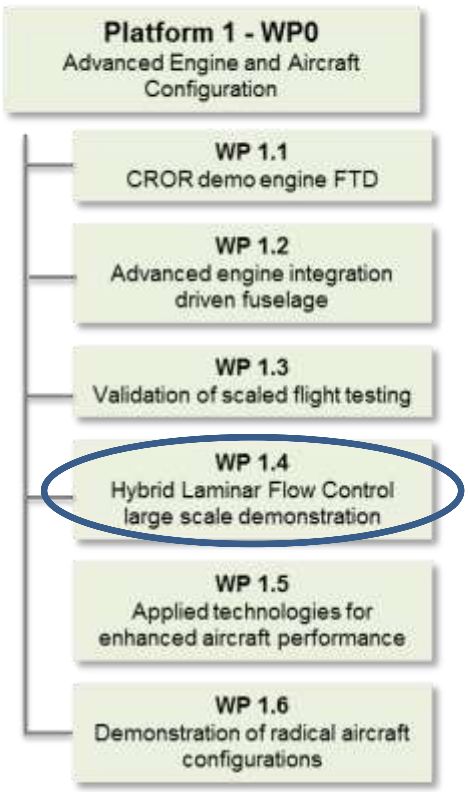


Figure 1 - Work Breakdown Structure

The significant drag reduction potential of the HLFC technology was addressed in a number of large R&T programmes in the US and in Europe for more than two decades ago. In 2011 Boeing revealed flight test pictures with a HLFC system applied on the fin of the B787-8 and is also advertising this HLFC system as aerodynamic enhancement package for the B787 evolution. Despite this pre-serial example by Boeing and even though the physics and the technical principles are well understood, no “industrial” technology solution could be developed so far to materialize the aerodynamic potential, while keeping the complexity and weight of the required systems low.

Furthermore, the effort and cost to manufacture, operate and maintain these systems need to be brought down to an acceptable level. Boosted by the recent progress to mature the NLF technology for short range large transport aircraft, there is a significant transfer of knowledge and technologies applicable for the HLFC technology. In addition, a set of new technologies in virtually all areas of material processing, manufacturing and automation in combination with new materials open the door to develop industrially viable solutions for the HLFC technology applied on airframe.

The overarching objective of this topic is to develop a HLFC wing based on a passive suction concept (fall-back solution is minimum active suction support), and to qualify it by means of a feasibility demonstration, targeting a TRL4 at integrated major component level. The applied design process, the integrated technologies and the manufacturing process shall comply with the standards and procedures of the Topic Leader so that the further way of the HLFC wing (beyond CS2) towards pre-serial design and manufacturing standard is guaranteed. Moreover the chosen design and manufacturing process shall target highest ecological standards ("ECO" design), such as recycling capability of materials, predicted energy consumption of future pre-serial or serial manufacturing process.

Overall Objectives

- Development of a wing with HLFC technology comprising of and integrating all sub-structure elements (ribs, spar connections, any supporting structures, etc.), technologies and systems required to demonstrate on ground the principle functionality of the whole HFLC technology on wing in an operational envelope limited to ground-based test conditions. The following items are of major importance and have to be demonstrated and proved:
- Support the determination of the operational envelope of aircraft equipped with HLFC technology on wing.
- Aerodynamic shape design and determination of the aerodynamic performance incl. boundary layer characterisation by means of stability calculations. This shall include the consideration of surface imperfections and suction conditions on the extension of the laminar flow. The numerical results shall be validated by experimental results obtained by means of representative Wind Tunnel model tests.
- Surface quality requirements are met, i.e. microscopic surface quality of the micro-perforated leading edge cover (hole size and shape, burrs, joints, steps, gaps, etc.), macroscopic shape tolerances (contour fidelity such as waviness, absolute airfoil dimensions) following wing technical design directive of the Topic Leader.
- A functioning ice protection system in the leading edge of the HLFC wing.
- A functioning passive suction system (fall-back solution is minimum active suction support). The suction system has to demonstrate the specified full setting range and accuracy for the whole operational flight envelope.
- Capability that all other required systems (such as high-lift devices, actuators, pipes, harness, etc.) can be integrated into the HLFC wing (mountable, space allocation, freedom of motion of kinematics, failure cases, etc.) and can operate according to their specified range of use. Early consideration of in-service/maintenance aspects such as easy interchangeability and interface design concepts between components.
- Development of the test plan and definition of required tests for proof of structure concept and system integrity.
- Proof of structure and system integrity in case of damage or heavy environmental conditions using virtual simulation capabilities in connection with small to mid-scale demonstrators for testing of bird strike, hail strike, operation under ice conditions, etc.

- In close interaction with the Topic Leader development of the complete manufacturing process (procedures, instructions, jigs and tools, potential Call-for-Proposal Partner, subcontractors, etc.) suitable to pave the way for pre-serial production of the HLFC wing demonstrator, which will be realized following this proposal.

  The manufacturing process shall also target for a later HLFC wing production at high-rate and low cost, similar to rates of common Large Passenger Aircraft wing production. The determination and the monitoring of the evolution of the Non-Recurring Costs (NRC) and Recurring Costs (RC) along the proposal phase are of high importance.
- Development of repair solutions for the chosen structure and manufacturing concept.
- All systems and technologies and its underlying manufacturing processes which are going to be developed in the course of the project have to be qualified on component level up to such a TRL level which justifies at the end the acknowledgement of TRL4 of the integrated HLFC wing.
- Development of all necessary tests, reports, means of compliance to qualify the HLFC wing including all integrated structural elements, technologies and systems to a TRL status at integrated major component level, which will enable the realization of an industrial demonstrator following this proposal. At the same time support the design of the long-term route to later qualification/certification for the wing equipped with HLFC technology.
- Assessment of the detailed design concept for the HLFC wing on overall aircraft level so that finally a precise determination of the net benefit level is possible.

2. Scope of work

There are three major research pilars representing state-of-the-art HLFC design experience in Europe on which the present topic is based on:

1. The running FP7 L2 Project ”AFLoNext” (runtime until mid 2018) is showing very promising results in developing a simplified HLFC technology applied on fin of a Large Passenger Aircaft and target to gather first operational experience with this technology in a flight test campaign in 2017.

   Also, AFloNext is developing a HLFC wing demonstrator (mid scale) with the major objectives to investigate into advanded manufacturing concepts for the micro-perforated leading edge skin of the wing and the demonstrating the principle physical intergation of all essential systems, structure and technologies.
2. The 2nd pillar is provided through the recently finished German funded project “HIGHER-LE”, in which an advanced HLFC design and manufacturing concept for the fin of a Large Passenger Aircaft could be demonstrated be means of a large-scale Wind-Tunnel Test (WTT). In addition, HIGHER-LE has resulted in the imrovement of new- or refinement of existing methods and tools to assess the performance of the HLFC technology (e.g. measuring the quality of micro-perforated sheets, etc.). These achievements are used as desing standards in AFLoNext, s. point 1, as well as in CS2, Large Passenger Aircraft (LPA), Platform 1, WP1.4.1, which is decribed under point 3.
3. The third pillar is given by CS2 itself, since in LPA, Platform 1, WP1.4.1 the development of the

HLFC technology applied on Horizontal Tail Plane (HTP) of a Large Passenger Aircraft is operational and running since almost 1,5 years. Here is the target to further improve the HLFC technology (reducing weight and costs, RC and NRC) and extend it towards application on a HTP (non-symmetric shape compared to fin, different flow conditions and planform parameters, etc.)

The aim and the nature of this topic builds on a continuous development of the HLFC technology for airframe application, based on the research achievements made in Europe over the last two decades and the 3 pillars of recent project results as shown before. It is important that the applicant demonstrates that he has access to all the necessary IPs required to perform the work. This includes also IP protected results or items. The scope encompass the demonstration of a fully integrated HLFC wing by means of a large-scale demonstrator (plus supporting small-scale demonstrators) including all essential systems, sub-structures and sub-technologies to achieve a TRL4 on integrated major component level.

The capabilities and design expertise which are required by the successful applicant to fulfil the objectives within the given scope are matching with a typical Large Passenger Aircraft design process between Milestones M2 (configuration definition) to M6 (first hardware design).

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.4.4-1	Project design finalized, configuration and overall aircraft assessment of HLFC wing done.	R/RM	Q1/2018
D1.4.4-2	Preliminary integrated wing design with selected structure and system concept available	R/RM	Q3/2018
D1.4.4-3	Test plan available and required tests defined (for proof of concept)	R/RM	Q2/2019
D1.4.4-4	Fully multidisciplinary design loop for baseline design and concept definition available	R/RM	Q2/2020
D1.4.4-5	Wind Tunnel (WT) model designed and ready for test	RM/R/D	Q2/2021
D1.4.4-6	Wind-Tunnel Test (WTT) performed and analysed	R	Q1/2022
D1.4.4-7	Large-scale ground-based demonstrator ready to test	D	Q4/2022
D1.4.4-8	Final aerolines and HLFC wing concept frozen	RM/R	Q3/2022
D1.4.4-9	Data from test with large-scale ground-based demonstrator analysed, validated and reported	RM/R	Q2/2023
D1.4.4-10	Detailed design concept for HLFC wing available	RM/R	Q3/2023

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

Note 1: *All deliverables might be subject to change based on the to-be defined detailed project schedule during the first phase of proposal execution.*

Note 2: *Further deliverables will be defined during negotiation phase and during the first phase of project execution. Such deliverables will evolve from the definition of small-to mid-scale demonstrators (installation and integration trails, bird strike test, etc.) supporting the design of the* *large-scale integrated HLFC wing.*

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1.4.4-1	TRL3: concept freeze	RM	Q3/2020
M1.4.4-2	Feasibility demonstration towards TRL4	RM	Q2/2023

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

Note 3: *All milestones might be subject to change based on the to-be defined detailed project schedule during the first phase of proposal execution.*

Note 4: *Further milestones will be defined during negotiation phase and during the first phase of project execution. Such deliverables will evolve from the definition of small-to mid-scale demonstrators (installation and integration trails, bird strike test, etc.) supporting the design of the large-scale integrated HLFC wing.*

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

- It is expected that the applicant has a world-class background and experience in overall aircraft design, in particular in the field of flight physics, structure- and system design compliant to FAR 25/EASA CS-25 rules and regulations and all respective ATA chapters.
- The applicant's organization shall have a Design Organization Approval (DOA) for commercial aircraft design and build and has either signature authority or delegated authority (by the customer) for the airframe and related sub-structure within the perimeter of this proposal.
- The applicant shall have outstanding skills and capabilities in manufacturing and assembly of major airframe components, either in metallic and/or composite, for Large Passenger Aircrafts or other certified aircrafts in commercial aviation.
- Proven and widely recognized expertise, methods and tools for virtual and physical testing, design and execution of experiments. All proposed laboratories and test rigs by the applicant shall have a qualification/accreditation level, which smoothly allows after the proposal runtime continuing the development of the HLFC wing design and manufacturing concept towards pre-serial and later on serial standard.
- The applicant shall demonstrate experience in-depth project management in time, cost and quality together with evidence of past experience in large project participation.
- It is intended that the applicant takes also responsibility for work package lead (incl. co-developing the project management plan and closely monitoring the project progress), which in detail has to be defined in the negotiation phase.

Furthermore, the applicant shall have the following special skills in aircraft design and production:

- For the shape- and component design as well as structural analysis it is a big advantage if the applicant performs this with the tool set which is commonly used by the Topic Leader, such as CATIA v5, NASTRAN.
- Installation, assembly and space allocation studies having Digital Mock-Up (DMU) capability.
- High-fidelity numerical (CFD) and experimental skills for aerodynamic design, modelling and analysis.
- Proven and widely recognized expertise in HLFC design capability using a validated tool chain, incl. stability calculations, suction and surface requirements, etc.

5. Glossary

CS2	Clean Sky 2
CSJU	Clean Sky Joint Undertaking
HLFC	Hybrid-Laminar Flow Control
CfP	Call-for-Proposal
SC	Subcontractor
TRL	Technology Readiness Level
WT	Wind Tunnel
WTT	Wind-Tunnel Test
ECO	Ecological
LPA	Large Passenger Aircraft
HTP	Horizontal Tail Plane
NRC	Non-Recurring Costs
RC	Recurring Costs
CFD	Computational Fluid Dynamics
DMU	Digital Mock-Up
FAR	Federal Aviation Administration
EASA	European Aviation Safety Agency
ATA	Air Transport Association
DOA	Design Organization Approval

II. High Density Energy Conversion System for an APU

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP V5) Ref.	WP 1.1.10		
Indicative Funding Topic Value (in k€)	3 650		
Topic Leader(s)	Safran		
Duration of the action (in Months)	54	**Indicative Start Date**[2]	Q4 2017

Identification	Title
JTI-CS2-2016-CPW04-LPA-01-12	**High Density Energy Conversion System for an APU**
Short description (3 lines)	
The current proposal is dedicated to candidates to partnership in the “High density energy conversion system for an APU” topic. This topic is aimed at the development of mechanical to electrical energy conversion system, including the gearbox, the high speed electrical machines, electrical actuators, power electronics, in order to be able to supply the electrical network of an aircraft through an innovative Non Propulsive Energy generation system.	

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

1. Background

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

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

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

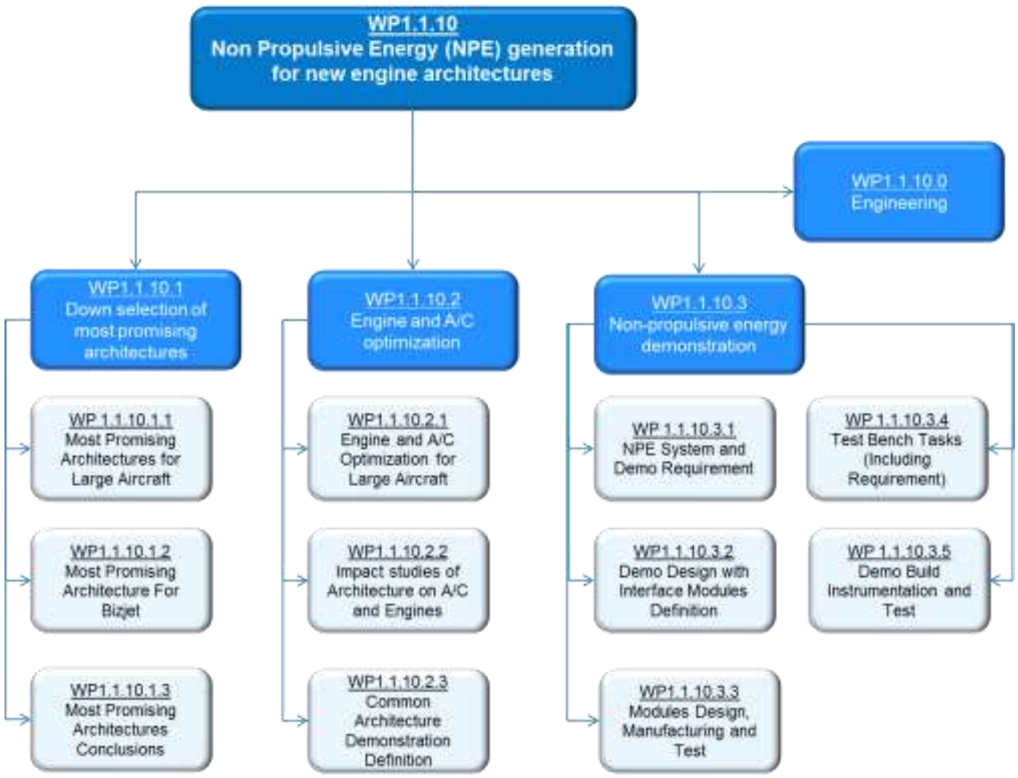


Figure 1 - Work Breakdown Structure of WP1.1.10

The studies carried out since the beginning of the project in WP1.1.10.1 & WP1.1.10.2 have shown that in some situations, the power sharing between the main engines and the APU can be of interest.

One of the main purposes of the WP1.1.10.3 Non Propulsive Energy Demonstration is to demonstrate that the APU can withstand the new level of requirements needed (in that frame, APU will not be considered as an auxiliary power source anymore but as an essential one) in such systems in terms, for example, of reliability, availability, restart capability, etc. It will also demonstrate a first set of power management/dispatch rules taking into account the aircraft needs of Non Propulsive Energy.

The innovative Non Propulsive Energy generation system under study in this work package will be made of the APU sub-system, the generators mounted on the main engines and a power management unit. The study is then focused on a new use of the APU sub-system that should bring benefits at aircraft level for new aircraft architectures (More or All Electrical).

In that frame, and as described in Figure 1, the Topic Leader will be responsible for the design and manufacturing of a gas turbine producing mechanical power on a shaft. The candidate will be responsible for the design and the manufacturing of the conversion system from the mechanical power to an electrical power compatible with aircraft network requirements. The interfaces between the gas turbine and the conversion system will be specified by the Topic Leader as will be the interface between the conversion system and the test bench located at the Leader’s facility.

From a mechanical point of view, the candidate will have the responsibility of the torsional and modal analysis of the gearbox with the support and inputs of the Topic Leader. The Leader will have the responsibility of the dynamic mechanical behavior of the gas turbine. A strong cooperation will be needed to cover the mechanical behavior of the whole demonstrator.

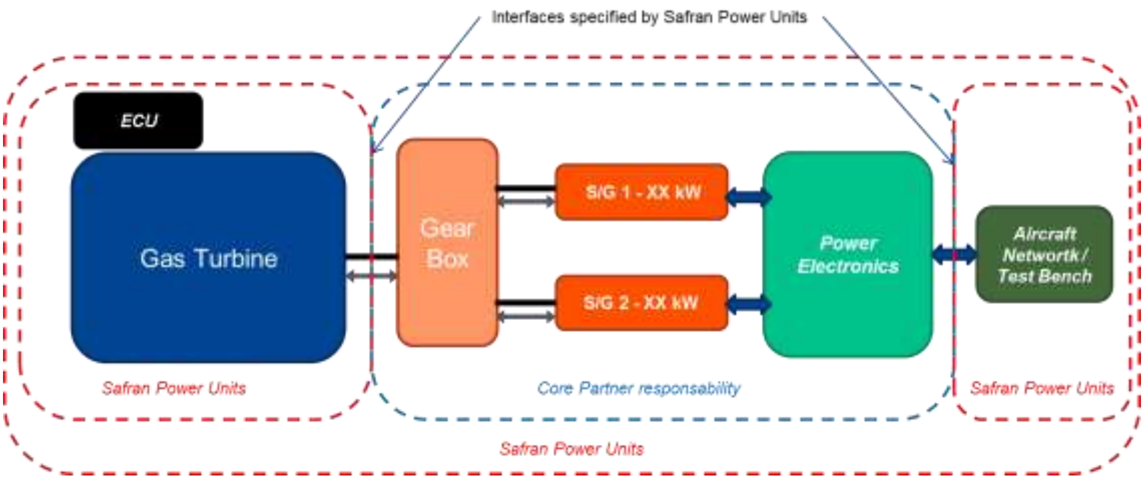


Figure 1 – Schematic of the responsibility share for NPE demonstrator

To be more precise, following the specifications (NPE system and demo requirements) the candidate will be responsible of the design/manufacturing/support of a sub-system composed of:

- A gearbox and its hydraulic and electric equipments
- Electrical machines (2 starter/generator)
- Power electronics with the capability to start the APU and to convert the energy produced by the electrical machines with the good level of quality with respect to the requirements of the aircraft electrical network.
- Electrical or pneumatic bleed control valve
- Electrical or pneumatic inlet guide vane actuator

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

In the frame of the demonstration program of WP1.1.10, the Topic Leader will focus its efforts on the gas turbine technology (Power range around 200kW – Mechanical power on shaft on the gas turbine). The candidate will be responsible for the system in charge to convert mechanical power into electrical power. Usually this conversion system needs 3 main subsystems:

1. Gearbox
2. Electrical machines and actuators
3. Power electronics.

Weight is one of the challenges of the demonstration (specifically for the gearbox and the electrical machines). Any solutions that will increase the power density of the system are welcome. For example high speed and high density machines, innovative integration of these machines in the gearbox should be proposed for review and selection in partnership with the Topic Leader.

Power density objectives for each major sub-systems are presented hereafter.

- Gearbox: 6kW/kg (casing, gears, bearing, pipes, …)
- Electrical machines: from 2 to 3 kVA/kg depending on cooling system
- Power Electronics: 1,25 kw/kg

For the purpose of the demonstration the power range (around 200kW – mechanical power on shaft of the gas turbine) makes the system under study compatible with business jets applications but the technological bricks, the power management rules and their implementation might be extrapolated to Short&Medium Range aircrafts.

The scope of work is organised around the 3 subsystems previously described. As part of WP 1.1.10.3, the candidate in partnership with WP1.1.10 members will first analyse the high level specifications issued in WP1.1.10 and perform feasibility study. The best technical solution will be selected. Thanks to this work, detailed specifications of the 3 subsystems will be proposed by the candidate, discussed and agreed with the partners.

For each subsystem, the candidate will present the following items:

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

The candidate will be then in charge of the manufacturing of the prototypes (quantity tbd) and acceptance tests at subsystem level.

The candidate will then be in charge to support demonstration activities from the assembly and debugging of the demonstrator to the end of the demonstration program and the final test report.

Strong cooperation with the Topic Leader team will be needed especially for the design of the oil system as the objective is to have only one oil system that covers the lubrication/cooling of the gas turbine, the gearbox and the cooling of starter/generators (fitted on the APU) if needed.

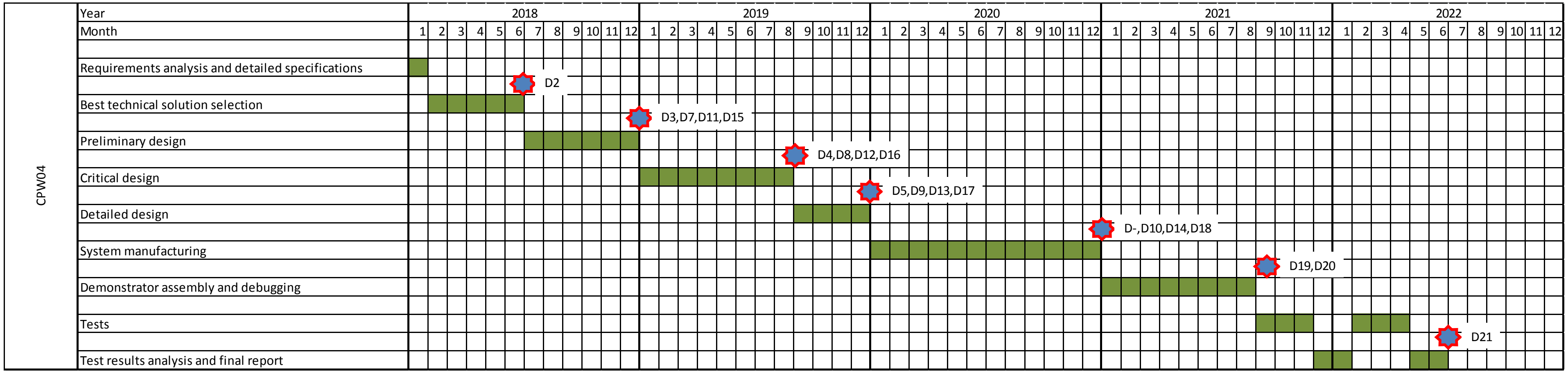
3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D1	Analysis of High Level Specifications	R	T0+1
D2	Selection of technical solution	R	T0+6
D3	Gearbox Preliminary Design Review	RM	T0+12
D4	Gearbox Critical Design Review	RM	T0+20
D5	Gearbox Detailed Design Review	RM	T0+24
D6	Hardware delivery	D	T0+36

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D7	Starter/Generator 1 Preliminary Design Review	RM	T0+12
D8	Starter/Generator 1 Critical Design Review	RM	T0+20
D9	Starter/Generator 1 Detailed Design Review	RM	T0+24
D10	Hardware delivery	D	T0+36
D11	Starter/Generator 2 Preliminary Design Review	RM	T0+12
D12	Starter/Generator 2 Critical Design Review	RM	T0+20
D13	Starter/Generator 2 Design Review	RM	T0+24
D14	Hardware delivery	D	T0+36
D15	Power Electronics Preliminary Design Review	RM	T0+12
D16	Power Electronics Critical Design Review	RM	T0+20
D17	Power Electronics Detailed Design Review	RM	T0+24
D18	Hardware delivery	D	T0+36
D19	Contribution to demonstrator assembly	D	T0+38
D20	Contribution to demonstrator debugging	R	T0+44
D21	Contribution to test campaign & final report	R	T0+54

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

Table 1 - Overall Planning



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

Expertise and skills

- Design of aeronautic commercial engine high density geared systems: lubrication, thermal mechanics, vibrations
- Design of electrical architectures: Electrical machines, power electronics, aircraft electrical network.
- 3D modelling, 3D CFD and 1D fluid circuit modeling
- Thermal modelling
- Manufacturing of aeronautic commercial engine structural and rotating parts or modules including gears
- Inspection means and expertise for quality assessment of produced part
- Instrumentation and mechanical component test capability
- Quality manual to ensure quality of design, materials, manufacturing, instrumentation, test, conditioning and shipping of hardware
- Risk Analysis, Failure Mode and Effect Analysis
- Demonstrated capability to deliver

Capabilities and Track Record

- Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSAPU, Part 21, Part 145)
- Competences to deal with risks associated to the action:
- Background in Research and Technology for aeronautics especially on gearboxes, electrical machines such as starter/generator and power electronics
- Background in delivery of instrumented part(s) or module(s) or system(s) for scale 1 demonstrators
- Project Management capability for large and complex projects with subcontractors in the range 5-10 M€ project
- Quality Management capability for large and complex projects with subcontractors in the range 5-10 M€ project
- Digital Mock-Up
- 3D models available at CATIA format

Expertise

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

Intellectual property and confidentiality

- The Topic Leader will own the specification, while the Core Partner will own the technical solutions that he will implement into the corresponding subsystems.
- The Topic Leader information related to this programme must remain within the Core Partner; in

particular, no divulgation of this strategic topic to Core Partner affiliates will be granted.

Ownership and use of the demonstrators

- The Core Partner will deliver demonstrator parts to the Topic Leader. Each part integrated or added in the demonstrator will remain the property of the party who has provided the part.
- Notwithstanding any other provision, during the project and for five (5) years from the end of the project, each party agrees to grant to The Topic Leader a free of charge right of use of the relevant demonstrator and its parts.
- After the end of the period, each party may request the return of the parts of the demonstrator(s) that it provided. If the concerned parts are returned, no warranty shall be given or assumed (expressed or implied) of any kind in relation to such part whether in regard to the physical condition, serviceability, or otherwise.

III. Development and manufacturing of multifunctional and integrated thermoplastic fuselage shell, passenger floor and cargo floor including the main system, cabin and cargo elements

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 2		
Joint Technical Programme (JTP V5) Ref.	WP 2.1		
Topic Leader(s)	Airbus		
Indicative Funding Topic Value (in k€)	10 000		
Duration of the action (in Months)	72	**Indicative Start Date**[3]	Q4 2017

Identification	**Title**
JTI-CS2-2016-CPW04-LPA-02-03	Development and manufacturing of multifunctional and integrated thermoplastic fuselage shell, passenger floor and cargo floor including the main system, cabin and cargo elements
Short description	
The aim of this strategic topic is to develop, manufacture and deliver an innovative and integrative large passenger aircraft fuselage 180° shell from thermoplastic composite material together with a passenger and a cargo floor including their main system and cabin/cargo elements. These components shall be delivered to the involved launching partners for subsequent assembly with a complementary shell provided by Airbus.	

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

1. Background

Preface

The purpose of this Topic description is to find a core partner in LPA Platform 2, who will contribute at a strategic architecture & integration level to a wide scope of research activities for large passenger aircraft. It is expected that the core partner provides all necessary capabilities, skills and resources to perform technology development at a high Technology Readiness Level in a large European research platform.

The LPA Platform 2 Multifunctional Fuselage Demonstrator started during the summer 2014 with a concept phase together with DLR and Fraunhofer, both Members of LPA, and will continue with this call.

The principle of operation requires the partner to work routinely in a multidisciplinary and integrated design environment, being part of an integrated supply chain. The expected high number of contributing parties coming from all over Europe and the complexity of the development work required (by the core partner personnel) is an essential management element in the organisation of the project management plan.

The strategic role in this topic is explicitly founded on a number of fundamental and long term contributions to demonstrators and technologies in LPA Platform 2. For the sake of clarity, these specific hot spots of work will be explained in the following description of the Topic.

The Core partner to be selected for this topic shall take a strategic role in the management of the overall activity. Even though the detailed technical description of the work is given for the first three years, the activity will last until the end of Clean Sky 2. The applicant will have to accommodate with the planning that will be commonly defined with Airbus for the last three years of activities. The commitment of the proposing candidate shall firmly include the ability to follow possible necessary technical program changes, which means the candidate has to commit to an engagement for the full program lifetime.

It is expected that for this Strategic Topic the applicant to the core partner role will take responsibility for the technical leadership and work in close cooperation with the Airbus WP Leaders and both DLR and Fraunhofer.

Background

The overall objectives, linked closely to the CS2 objectives are:

- Enable a high production rate of minimum 60 aircrafts per month
- Weight reduction: -1t
- Competitive improvements (reduction of recurring costs): -1M€

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

The approach of the Innovative Physical Integration Cabin-System-Structure Platform 2 is to provide the frame for large-scale complex demonstration at full size for validation and testing on the ground.

The target is to validate high potential combinations of airframe structures, cabin/ cargo and system elements using advanced materials and applying innovative design principles in combination with the most advanced system architecture in combination with the next generation cabin.

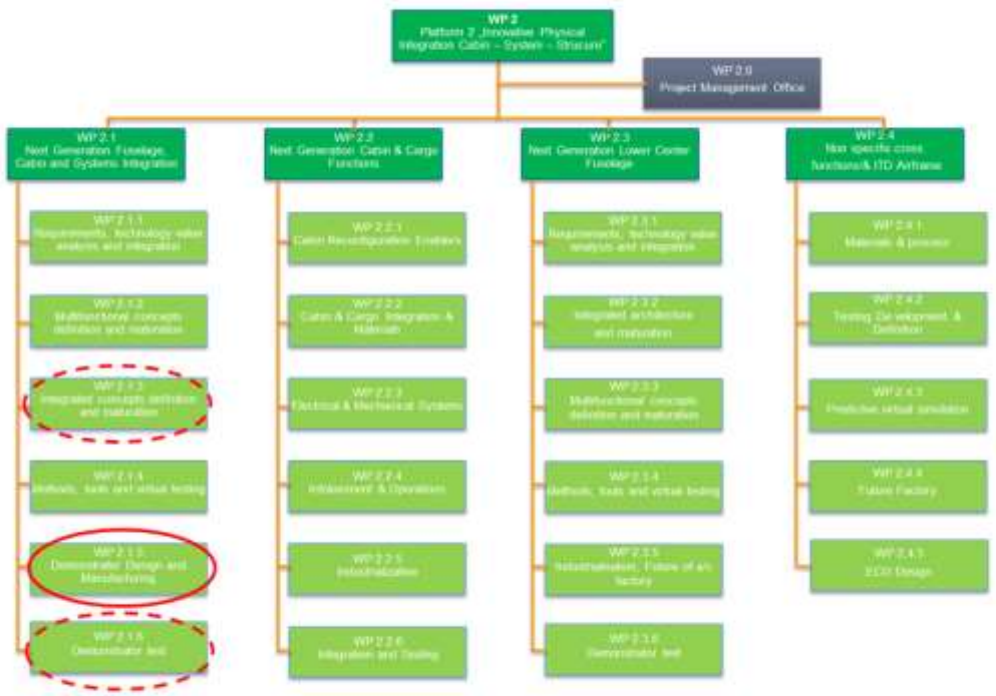
The driver of this approach is to attain a significant fuel burn reduction by substantially reducing the overall A/C energy consumption, applying low weight systems and system architecture/integration and to be able to cash in weight potentials in the structural design of the fuselage and the connected airframe structure. This must be achieved by the development and application of Industry 4.0 opportunities such as design for manufacturing & automation, automation, sensorization, data analysis and secure data exchange to demonstrate the desired manufacturing costs effects.

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

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

WP2.1 objective is the integration of cabin and systems with the primary aircraft structure to reduce weight and manufacturing cost and to enhance space for passengers and cargo by

- Removing artificial separation of functions already at the aircraft pre-design stage.
  - ⇒ *Significant weight and hence environmental improvements expected*
- consideration of the aircraft manufacturing, assembly and installation in high rate processes right from start
  - ⇒ *Aircraft cost reductions*.



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

2. Scope of work

The focus within this call lies on development and manufacturing of a thermoplastic fuselage shell for large passenger aircraft with cabin and system elements to be integrated prior to Major Component Assembly (MCA) and Final Assembly.

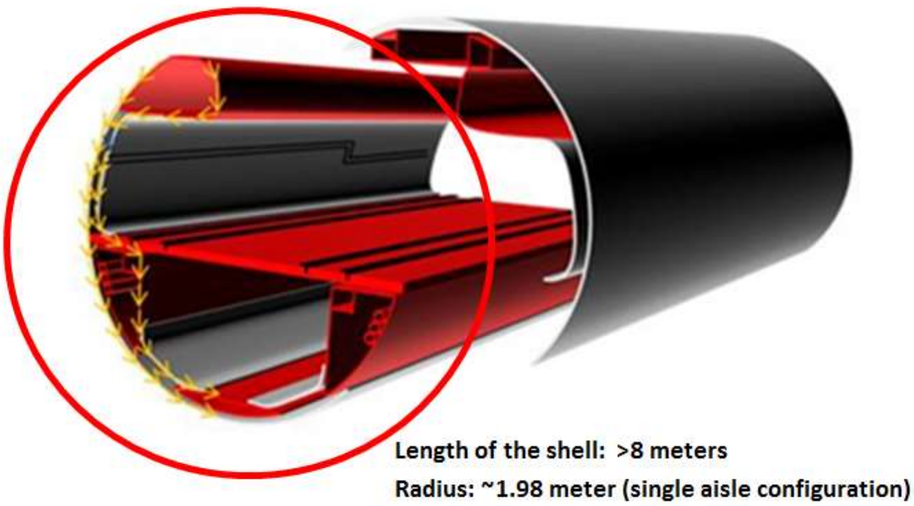
The multifunctional integration of cabin and system elements into a large passenger aircraft fuselage structure is the key to achieve further weight and cost reductions in manufacturing and assembly. Thermoplastic composites offer a high potential for a new way of dustless joining to enable pre-assembly of systems and assembling pre-equipped aircraft structures. In the frame of the multifunctional demonstration it has to be shown that the expectations in the integrative approach for an industrial readiness demonstration can be fulfilled.

The focus is not an optimisation of a single ATA chapter, but in the multidisciplinary overall optimization across all relevant ATA chapters.

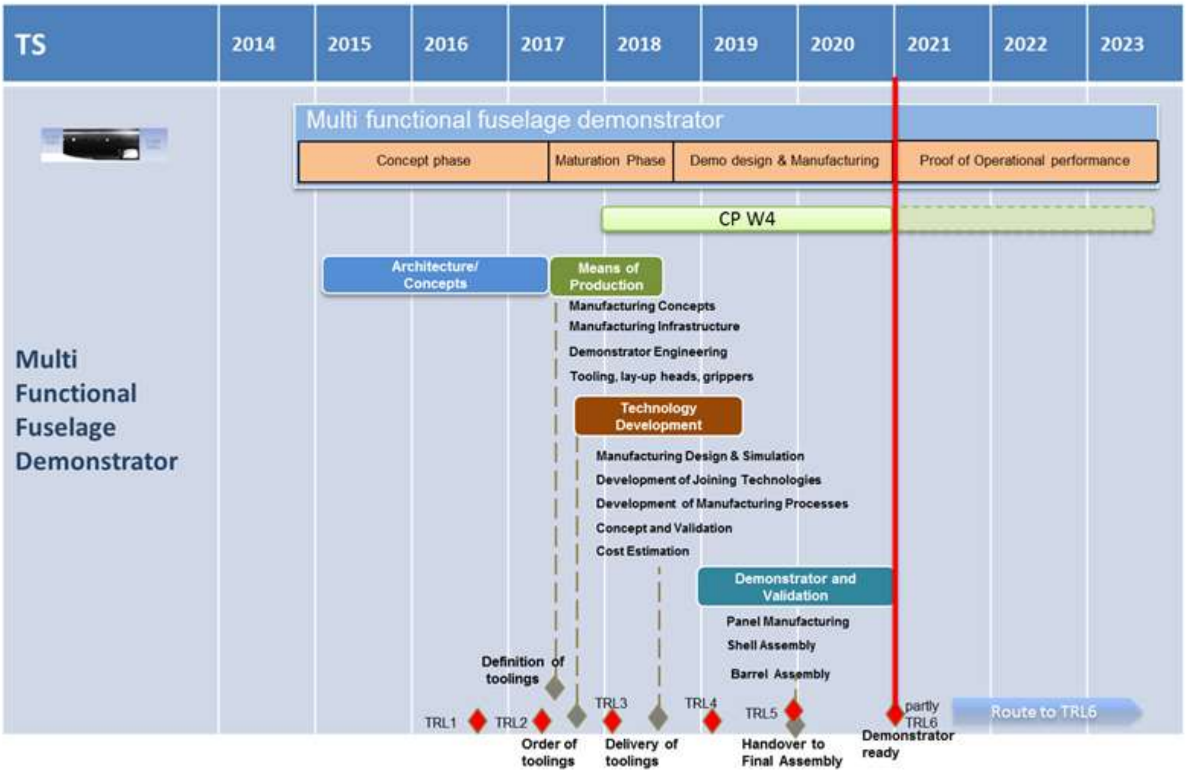
In this framework the Core partner is responsible for the maturation of selected technologies and for the design and manufacturing of a 180° half barrel fuselage shell as shown below.

The shell to be manufactured will consist of a lower right hand side shell as shown in the figure, including a cargo door cut out with a cargo door surround including the relevant interfaces. The cargo door itself is not part of this call.

The shell architecture will be a window-less stringer/ frame stiffened thermoplastic composite skin with system elements and cabin interfaces to be integrated and cabin/ cargo and system elements pre-installed as much as possible before delivery to the final assembly. This includes also the design, manufacturing and integration of the cabin floor and cargo floor in very close collaboration with Airbus already in the maturation phase.



The time frame is described in the following plan:



The objective of the core partner call is to provide part of the hardware as defined for a development, integration and demonstration of the best candidate technologies. Different technologies can be demonstrated. This will deliver the concept for the next generation of integrated fuselage structure, cabin / cargo and system integration able to the overall targets mentioned above. Inputs will be given from the concept phase which is currently running, even though the applicants must bring in their own research resources.

The work of the phase from 2020 until 2023 is not yet defined in detail, but a contribution from the applicant to a full TRL 6, based on the previous work, is expected.

The applicant will present in its proposal the schedule proposed to comply with the master plan given above. The critical path will be clearly given, together with the list of risks and the associated mitigation measures.
In case of difficulties to meet some of the milestones, a master plan will be proposed with identification of any deviations and explanations about the difficulties preventing to timely meet the different deadlines.

The applicant will have access to results and concepts, which have been selected in the concept phase. A comprehensive technical specification will be part of maturation phase and be detailed in consortium negotiation. The Core partner will be responsible for the following tasks:

- Define and work out functional & operational conditions across the different ATA chapter (e.g. ATA25, ATA53, ATA92, ATA21,…) questioning the given state of the art requirements keeping in mind the certification basis, supported and validated by Airbus.
- Develop and investigate an innovative overall fuselage airframe architecture with new integration approaches
- Selection of thermoplastic material options for fuselage structure, including integration of multi-functionalities under consideration of weldability requirements with regard to joining with a second complementary shell.
- For the integrated structure, cabin and system integration approach, the concepts for advanced manufacturing means and methods shall be defined to achieve:
    - high production rates
    - reduced total fuselage costs (structure + cabin & cargo + systems)
    - reduced and optimized installation efforts
- The development of the new integrated approach has to be in line with a lean aircraft manufacturing process.
- Figures for weight savings, reduced production costs and operational efficiency have to be reported;
- Develop a Technology Verification & Validation plan for the final concept that reflects the defined functional and operational requirements and perform virtual and physical full scale V&V tests in a close to real environment;
- Means of compliance for certification of highly integrated multifunctional concept have to be worked out;
- Integration of next generation cabin & cargo concepts
- To define the interfaces to the second shell and agree them with involved launch partners
- Provide the manufactured fuselage shell together with all integrated cabin/ cargo and system elements which are essential for the industrial readiness demonstration

- <u>Role of the core partner - Management and Coordination</u>:
    - Project progress to be reported on a regular basis
    - Manage and coordinate the progress meetings
    - Manage and coordinate project activities on related subjects.
    - Support and coordinate the reviews.
    - Manage the configuration management process.

The applicant will also be involved and contributing to the proof of operational performances in the following phase of the next generation fuselage structure, cabin, cargo and systems integrated demonstrator. As this applicant will be part of the overall evaluation of technologies and their benefits and will have full access to results and concepts selected in the concept phase.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
	180° Multifunctional Fuselage Demo Shell With integrated system and cabin elements and pax/ cargo floor module	Hardware	T0+24
	Design concept	Report	T0 + 6
	Enabler selection list (including assessment)	Report	T0 + 6
	Interface to second shell defined and agreed	Report	T0 + 6
	Life Data dossier	Report	T0 + 72
	Definition Document for associated Tests	Report	T0 + 18
	Associated Test Specimen	Hardware	T0 + 36
	Test results	Report	T0 + 60
	Final Evaluation	Report	T0 + 72

The major key deliverable of this topic is the 180° Multifunctional Fuselage Demo Shell in dimensions for a full size single aisle fuselage, approximately 8m in length, and 1.98m radius
A detailed complementary deliverable plan has to be proposed by the applicant.
Number and type of additional associated test specimen will be defined during the detailed definition of the work plan

Short description of Documents

- Design Concept: Baseline proposal for airframe & cabin architecture solution, design concepts and material specification to start detailed design.
- Enabler selection list: Trade-off studies of the candidate architectures and necessary key enabling technologies. Concept selection based on evidence provided for weight, RC and NRC savings.
- Life Data Dossier: Drawings, bill of materials, manufacturing status documented
- Definition Document for associated Tests: Test description (e.g. Number of tests, expected results)

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

General skills, capabilities

- It is expected that the applicant has a strong aerospace industry background and experience in overall aircraft design, airframe manufacturing and overall integration
- Furthermore, the applicant shall be able to demonstrate sound technical knowledge in the field of proposed contributions; he shall be able to demonstrate that this knowledge is widely recognized.

- The applicant shall demonstrate experience in-depth project management in Time, Cost and Quality together with evidence of past experience in large project participation.
- It is intended that the applicant takes also responsibility for work package co lead (incl. co-developing the project management plan and closely monitoring the project progress) which in detail has to be defined in the negotiation phase.
- The applicant shall provide evidence to be able to cope with the required high level of adequate resources in qualified personnel, required tools and equipment.

Special Skills

The applicant has:

- The capability for fuselage stress analyses and design (airframe and installation cabin or systems),
- A/c manufacturing engineering capabilities,
- Simulation capabilities for static, dynamic structural behavior as well as for acoustics and system behavior
- Capabilities and experience to manufacture large a/c thermoplastic composite structure parts,
- Engineering capabilities in water/ waste systems, ventilation systems, monuments like galleys, lavatories, stowage and partitions, electrical systems like cabin light, avionics, sensors, wireless communication
- Capabilities in integration of fuselage structure, cabin and system,
- Capabilities in material & processes to select appropriate combinations,
- Project management skills as requested in chapter 2,
- Automation specialists to optimize the concept between manufacturing and development of the new integrated approach,
- Capabilities in certification (across related ata chapters, cs-25),
- Capabilities and knowledge in requirement based engineering and lean manufacturing
- Capabilities to perform static and dynamic mechanical tests on small test elements like structural coupons, lining parts, interior parts and air ducts
- Capabilities to perform fst (fire, smoke, toxicity) tests
- Capabilities to perform acoustic tests on sa (single aisle) fuselage shells and sections
- Knowledge of and experience in the airbus supply chain
- Ability to work in an integrated supply chain

5. Glossary

CSJU: Clean Sky Joint Undertaking
LPA: Large Passenger Aircraft
IADP: Innovative Aircraft Demonstration Platform
ATA: Air Transport Association
V&V: Verification & Validation
SA: Single Aisle
A/C: Aircraft
CS-25: Certification Specifications for Large Aeroplanes Part 25
RC: Recurrent Costs
NRC: Non-Recurrent Costs
MCA: Major component assembly

2. Clean Sky 2 – Fast Rotorcraft IADP

I. Design, manufacture and deliver a high performance, low cost, low weight wing for CS2 Next Generation TiltRotor (NGCTR)

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP V5) Ref.	WP 1.4 Advanced Fuselage and Tilting Wing		
Indicative Funding Topic Value (in k€)	11 000		
Topic Leader(s)	Leonardo Helicopters		
Duration of the action (in Months)	72	**Indicative Start Date**[4]	Q4 2017

Identification	Title
JTI-CS2-2016-CPW04-FRC-01-02	**Design, manufacture and deliver a high performance, low cost, low weight wing for CS2 Next Generation TiltRotor (NGCTR)**
Short description (3 lines)	
Working from a basic architectural definition; design, manufacture and test an innovative tiltrotor wing structure for experimental flight. Work will include supporting the wing integration into an innovative Tiltrotor Technology Demonstrator for the duration of the Clean Sky 2 programme and should include innovative, lightweight materials and industrialisation technologies along with provisions for TiltRotor air vehicle and avionics systems.	

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

1. Background

The Clean Sky 2 Next Generation Civil Tiltrotor Technology Demonstrator [NGCTR TD] programme led by Leonardo Helicopter Division [LHD] aims to validate an innovative tiltrotor concept and mature technologies to the next level leveraging and building up on the existing knowledge and assets.

The CS2 NGCTR TD wing fundamentally differs from those on conventional fixed wing aircraft. On a fixed wing aircraft the engine/propeller installation is static, relatively small and inboard allowing the wing to become more slender from root to tip. The flying control surfaces occupy a relatively small percentage of the wing chord leaving ample space for the main load bearing structure. On the CS2 NGCTR TD, the mass of the engines and rotor system are at the very extremities of the wing driving up spanwise bending moments and leading to unique wing geometry.

The rotor system itself provides a unique loading environment due to the fact that it can rotate its thrust vector from parallel to perpendicular with respect to the wing. Therefore in aeroplane mode the wing generates the lift and the loading resembles that found on a conventional aircraft whereas in helicopter mode the lift is produced by the rotor only and is concentrated at the wing tips.

Dynamic stability requirements dictate that one of the key design drivers is stiffness in torsion and bending to counteract “whirl flutter” instability modes. Furthermore, the large rotors induce “helicopter style” high cycle fatigue loading on the wing structure which must be accounted for when designing for fatigue.

Accomplishing an efficient integration of these diverse requirements dictates the necessity of conceiving a structural and aerodynamic solution quite unlike anything developed so far, where architectural and technological innovations will come together to form an optimal design.

The aim of this call is to develop a suitable wing structure which meets the above requirements for integration onto the CS2 NGCTR TD and to investigate the scalability of the architecture.

2. Scope of work

a) Functional Requirements

The CS2 NGCTR TD wing is developed jointly (by Leonardo Helicopter Division and the Core Partner) to meet the following functional requirements:

- Interface with a main cabin section (note that this is a high wing configuration)
- Produce the required lift to allow the aircraft to achieve its defined flight envelope
- Have the minimum practical profile drag
- Be capable of withstanding leading edge birdstrike in accordance with the relevant basis of certification
- Have sufficient structural integrity to withstand ultimate loading throughout the defined flight envelope
- Provide sufficient life to allow completion of the technology demonstrator flight test programme.
- Be of sufficient stiffness to prevent flutter and other aeroelastic coupling effects between the wing and rotor system through all phases of flight including abnormal attitudes within the controllable envelope of the aircraft.
- Provide a mechanism to reduce as much as practical the area of impingement between wing and rotor downwash when the vehicle is transitioning to/from or is in the hover which must be compatible with the wing flexibility.
- Provide the level of HIRF protection to meet required aircraft safety levels
- Provide space and attachment provisions for the following systems:
  - Fuel tanks and potential wet fuel cells in the wing and spar structure
  - Flap and aileron control surfaces
  - Fuel pumps, pipes and drains
  - Fuel dumping system
  - Actuators and control cables for control surfaces
  - AFCS and other avionics boxes
  - Provisions and separation for electrical looms
  - Protected space for interconnect drive shaft
  - Mid wing gearbox
  - Fire suppression systems
- Provide a wing tip interface with the nacelles which house the engine, rotor system, tilting mechanism and associated gearboxes and ancillaries.
- Provide sufficient access such that all of the above systems can be maintained
- Although not applicable for the CS2 NGCTR TD, consideration for future embodiment should be given to the following requirements:
- Operation in known icing conditions
- To operate throughout the specified temperature ranges given in the basis of certification
- Embody direct lightning, indirect lightning and full HIRF protection as necessary

b) CS2 NGCTR TD Wing

The preliminary concept architecture for the wing is shown in figure 1 below. It is required to mature this design to a level ready for manufacture and to then produce, test and deliver a wing for incorporation into the topic leader's flight test demonstrator.

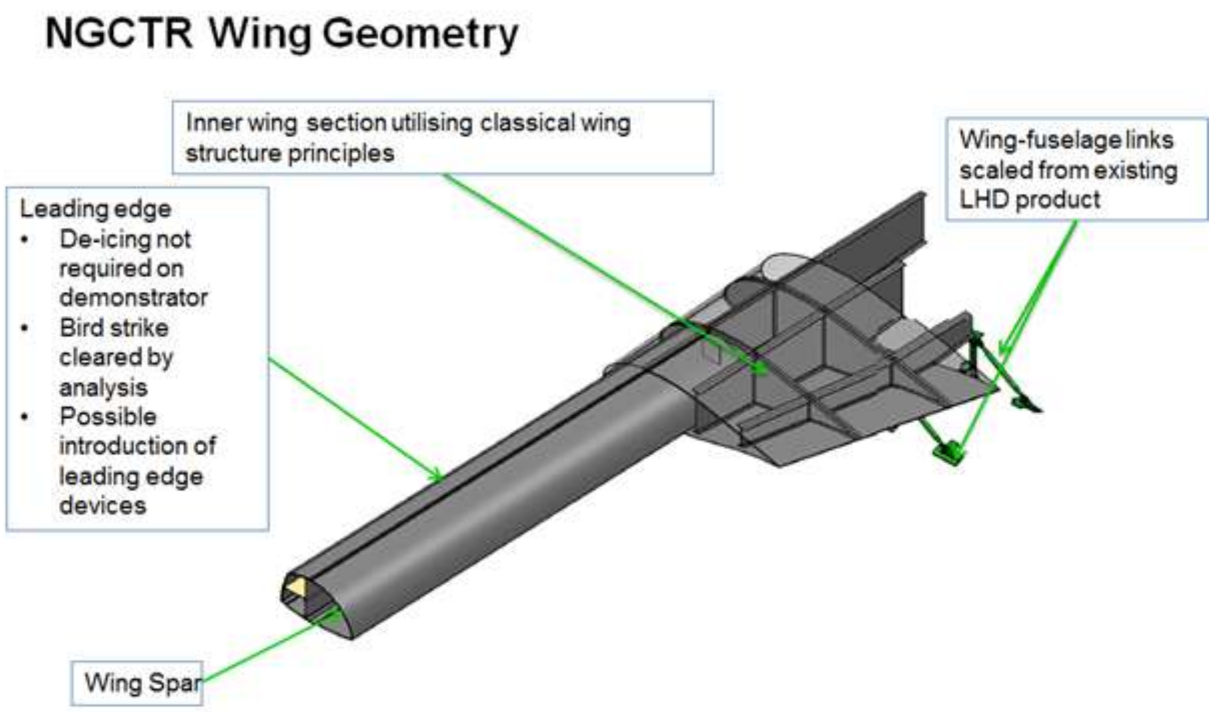


Figure 1. CS2 NGCTR TD Wing Preliminary Architecture

The wing has the following approximate dimensions:
Span ≈ 12m
Chord ≈ 1.6m
Thickness/Chord ≈ 23%

The fixed central wing is expected to use conventional architecture and comprise spars, including the main front spar, ribs and upper and lower skins. This area may need to accommodate any of the following: fuel; interconnect drive shafts; a transfer gearbox as well as other avionic systems. This area also provides the interface with the fuselage.

The outboard wing section contains the wing flap and associated guides to alleviate rotor wake impingement in the hover and roll control devices. There may also be a requirement to provide lift augmentation at slow airspeeds or for take-off and landing in Short Take-Off and Landing (STOL) mode. Due to the requirement for a large area to be moveable this part of the wing will be of unconventional design with the only structural component being the main spar. This area must provide space for the flight control surface actuators, the interconnect shaft and electrical wiring. The outboard wing section also provides the main structural interface with the nacelles carrying the engines and rotor systems. This area may carry fuel and associated systems in the spar.

The main front spar runs from one wing tip where it interfaces to the nacelle to the other. It may need to be broken in the centre of the aircraft to allow fitment of the mid wing gearbox but structurally this is a non-preferred option with a single piece spar being more efficient. The spar has a complex, multi-cellular shape unique to this wing due to the requirements for the large flap system which means it also must carry the interconnect shaft, the avionic systems, ice protection system provision considerations and potentially fuel. It must also carry provisions for the flap actuators and guides and the leading edge. The spar also integrates into the structure of the centre fixed wing section. The design of the flap guides and mechanism must be such that the flap can achieve its desired setting angles at all necessary wing deflections. The flap itself and the aileron do not form part of this Call.

The nacelle interface provides the connection between the wing and the nacelle. This interface consists of three components. There is the structural interface which must be designed to carry the static loads transferred from nacelle to wing and to satisfy the required fatigue and damage tolerance policies. There is the system interface which must provide access into the nacelle for the inter-connect drive shaft and other relevant systems carried in the wing. Finally there is the sealing interface between the wing and nacelle. This is likely to perform two functions: to provide an environmental barrier; to provide an aerodynamically smooth surface when the aircraft is in aeroplane mode.

The leading edge interfaces with the main spar and contains provision considerations for the wing ice protection system. The leading edge must also provide birdstrike protection for the main spar.

c) **Technology and Architecture Scalability**

A further objective of the CS2 NGCTR programme is to exploit the technology and develop an aircraft that is scalable. The preliminary architectural layout as per section 2.2 is to be analysed and a final concept chosen based on the potential for scalability.

d) **Partner Workshare & Statement of Work**

Figure 2 shows in graphical form the Core Partner Work Breakdown Structure.

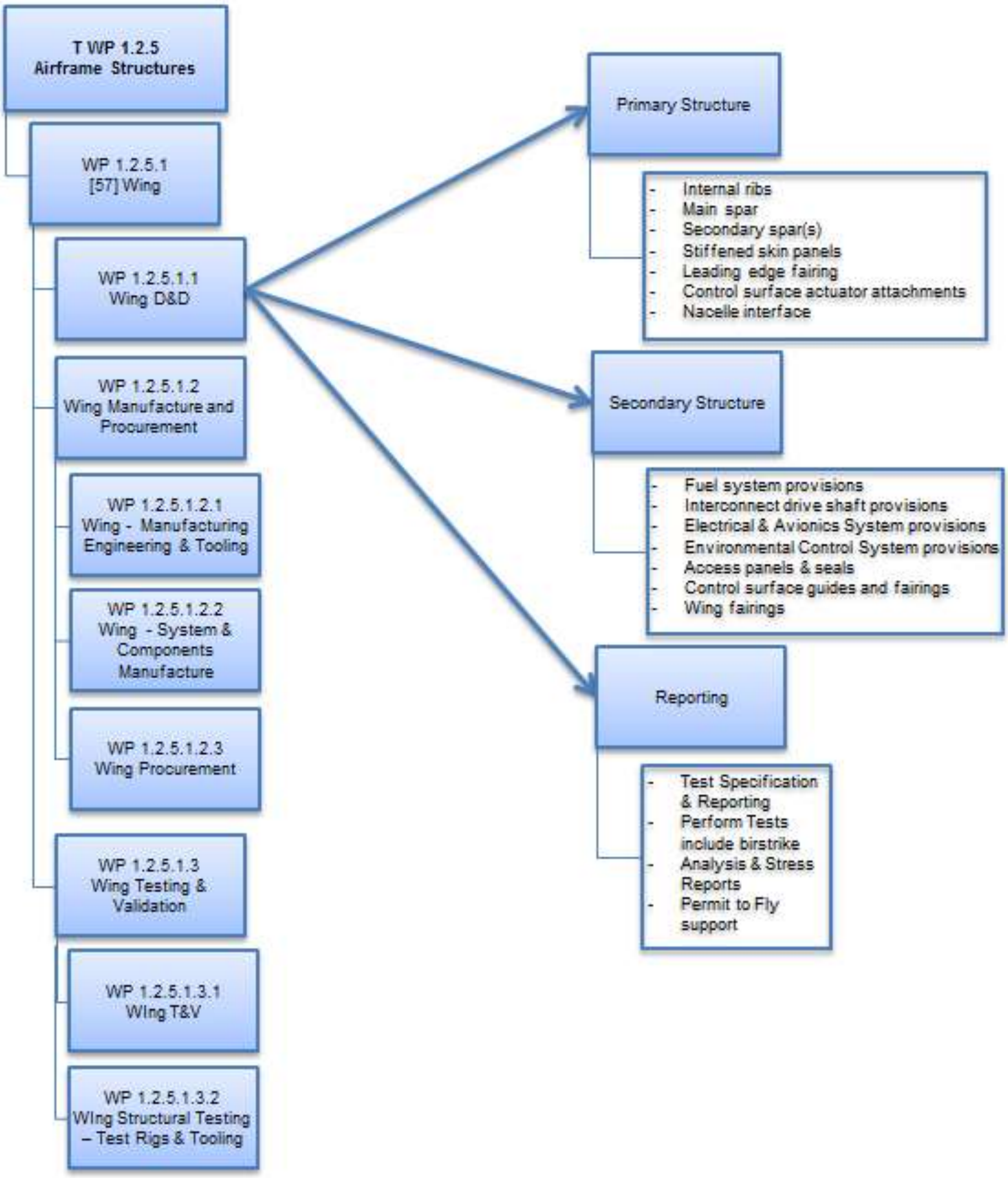


Figure 2. Core Partner Work Breakdown Structure

- **<u>Design and Development</u>**

  The Core Partner shall work with the Topic Leader to develop the CS2 NGCTR TD Wing as defined in figure 2 to a level where they can be manufactured and installed on the CS2 NGCTR TD for flight test. In this the Core Partner shall be responsible for:

- Developing along with the Topic Leader a suitable low weight wing with stiffness tailoring provide acceptable aeroelastic characteristics
- Preliminary and Detailed design of the CS2 NGCTR TD Wing

- Work with the topic leader to create, support and maintain a single digital mock-up (DMU) of the structure using CATIA V5.
- Production of a compliance plan to the agreed basis of certification for the relevant configuration in support of the achievement of the complete aircraft for “Permit to Fly”
- Assisting the topic leader with the basis of certification in areas pertinent to the wing
- Performing the detailed stress analysis of the wing
- Achieving the agreed weight targets
- Selection of materials and manufacturing processes in association with the Topic Leader
- Production of any test plan and analysis of test results necessary to achieve permit to fly clearance for the wing
- Definition of any inspections required
- Provide a study which reviews the structural implications of scaling the technology demonstrator wing solution.
- Production of flight test instrumentation requirements and telemetry monitor limits
- Provide the required level of airworthiness evidence to allow LHD to achieve a “Permit to Fly” fly for CS2 NGCTR TD
- Support to flight test programme ensuring wing integrity permits flight test programme execution

  It must be noted that the wing spar in the given architecture is a single load path whose failure would be catastrophic making it a critical part.

- **<u>Testing</u>**

  The Core Partner shall design and build all test specimens (including instrumentation), test rigs and perform all the testing of the wing which is necessary to obtain a permit to fly for the CS2 NGCTR TD.
  The following tests and test articles are envisioned:

- Full scale fatigue test to achieve sufficient hours for the flight demonstrator programme
- Residual static strength testing up to ultimate load values post fatigue testing using the fatigue test specimen
- Coupon testing to develop any material properties necessary for the inclusion of new or novel construction materials
- Component sub assembly tests to develop and prove any novel construction or manufacturing processes
- Experimental Bird Strike clearance shall consider development of innovative advanced simulation and high accuracy models to mitigate the need for physical testing.

❖ Instrumentation: The instrumentation requirements shall be jointly agreed to ensure the compatibility with the data acquisition systems (Ground and Flight).

❖ Manufacture: The Core Partner shall work with the Topic Leader to mutually agree the industrialisation and material selection strategies to ensure maximum synergy with the long term goals of the Core Partner and Topic Leader. In particular, there shall be a focus on light weight low cost, rapid manufacturing techniques.

The Core Partner shall be responsible for:

- Manufacture a conforming instrumented test specimen
- Manufacture and deliver to the Topic Leader an experimental flight worthy wing instrumented with the requisite sensors to verify Core Partner design requirements
- Design and procure all the required manufacturing tooling
- Sourcing of all raw materials
- Sourcing of all bought out components (if any)
- Provide all quality documentation for the delivered structural elements
- Provide quality methods substantiation documentation and a quality plan
- Provide a description of applied manufacturing processes and associated quality documentation

Manufacturing Innovation shall consider development and maturation of new techniques and processes embodying a virtual factory concept aimed at improving cost, process and quality control, such as:

- Composite curing and assembly process simulation to optimise the tool design and curing process
- Use of low cost / low batch tooling
- Out-of-autoclave techniques
- Automation for manufacturing and inspection
- Robust quality control

As a risk mitigation measure, conventional manufacturing processes and materials may be considered where it can be demonstrated that there is a time or cost benefit without any adverse effect on the scope and validity of the flight test programme.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Minutes of CS2 NGCTR TD Wing System Requirement Review (SRR)	R	Q2 2018
2	Minutes of CS2 NGCTR TD Wing Preliminary Design Review (PDR)	R	Q3 2018
3	Minutes of CS2 NGCTR Wing TD Critical Design Review (CDR)	R	Q2 2019
4	CS2 NGCTR TD Wing Design Data Set and Interface Definition Documents	R	Q3 2019
5	Minutes of CS2 NGCTR TD Test Readiness Review (TRR)	R	Q3 2019
6	First Article Inspection Report	R	Q1 2020
7	CS2 NGCTR TD Wing Qualification Reports	R	Q4 2020
8	Wing Static and Fatigue Test Report	R	Q2 2021
9	Wing Stress Report	R	Q2 2021

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	System Requirements Review	RM	Q2 2018
2	Preliminary Design Review	RM	Q3 2018
3	Critical Design Review	RM	Q2 2019
4	First Article Inspection	RM	Q1 2020
5	Test Readiness Review	RM	Q3 2019
6	Delivery of CS2 NGCTR TD Wing	D	Q4 2020

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

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

Skills and Capabilities

Suitable Core Partner(s) across the proposed team shall:

- Have as a minimum a proven track record of the construction of significant aircraft structural modules or components
- Be experienced in the design and manufacturing of structures in non-conventional and conventional composite materials (thermoset and thermoplastic plus high temperature systems) and innovative and conventional metallic components
- Have the capability to manufacture and assemble composite and metallic parts

- Use the design, analysis and configuration management tools of the aeronautical industry (eg: CATIA V5 R22, VPM, DMU, Hypermesh, MSC Nastran, Abaqus, NASGRO, Fluent)
- Have a proven track record in the management of complex projects of research and manufacturing technologies
- Experience with TRL Reviews or equivalent technology readiness assessment techniques in research and manufacturing projects in the aeronautical industry
- Proven experience of collaboration with other aeronautical companies in industrial air vehicle developments
- Have the capacity to support the production of documentation and means of compliance to achieve experimental prototype “Permit to Fly” with the appropriate Airworthiness Authorities
- Be capable of specifying and conducting material and structural tests including full scale
- Be capable of designing and incorporating repairs resulting from manufacturing deviations
- Be capable of evaluating design solutions and results IAW Eco-design rules and requirements
- Have qualification competences: design organization approval (DOA) is desirable but not mandatory
- Be capable to produce CS2 NGCTR components according to environmental Quality System international standards
- Be capable to manufacture, test, checks CS2 NGCTR components to assure the required production quality
- Have access to the qualification process to obtain the “Permit to Fly” of the CS2 NGCTR
- Be capable of designing and manufacturing/procuring all tooling and assembly jigs as required

Suitable Core Partner(s) should:

- Have experience of collaborating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturers) within international R&T projects
- Have a Quality System approved to international standards (i.e. EN 9100:2009/ ISO 9001:2008/ ISO 14001:2004)
- Be capable of supporting the overall aircraft configuration management
- Be capable of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA) of materials and structures

Management & Coordination Activities

Core Partner shall:

- Work within the common terms of the Grant Agreement for Members (GAM)
- Manage & coordinate directly all the work packages for which they have full responsibility
- Follow the Configuration Management process throughout the duration of the entire programme
- Work within the terms of the Consortium Agreement and sign a Core Partner agreement to comply with the Topic Leader’s processes, standards and quality requirements

5. Glossary

AFCS	Automatic Flight Control System
ATP	Acceptance Test Procedure
CDR	Critical Design Review
CPW	Core Partner Wave
CS2	Clean Sky 2
CSJU	Clean Sky Joint Undertaking
DMU	Digital Mock Up
DOA	Design Organization Authority
EMC	Electro-Magnetic Compatibility
EN	European Normalization
HIRF	High Intensity Radiated Fields
IADP	Systems and Platforms Demonstrator
IAW	In Accordance With
ISO	International Organization for Standardization
ITD	Integrated Technology Demonstrator
LCA	Life Cycle Analysis
LCCA	Life Cycle Cost Analysis
LHD	Leonardo Helicopter Division
NGCTR TD	Next Generation Civil Tiltrotor Technology Demonstrator
NRC	Not Recurring Cost
OEM	Original Equipment Manufacturer
PDR	Preliminary Design Review
QTP	Qualification Test Proposal
QTR	Qualification Test Report
REACH	Register, Evaluation & Authorization of Chemical products
R&T	Research and Technology
SAR	Search and Rescue
STOL	Short Take-Off and Landing
SPD	Systems and Platforms Demonstrator
TD	Technology Demonstrator
TRL	Technology Readiness Level
TRR	Test Readiness Review
WBS	Work Break Down Structure
WP	Work Package

3. Clean Sky 2 – Systems ITD

I. Network solutions for future cockpit communications

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP V5) Ref.	WP 1.4		
Indicative Funding Topic Value (in k€)	6 000		
Topic Leader(s)	Thales		
Duration of the action (in Months)	54	**Indicative Start Date**[5]	Q4 2017

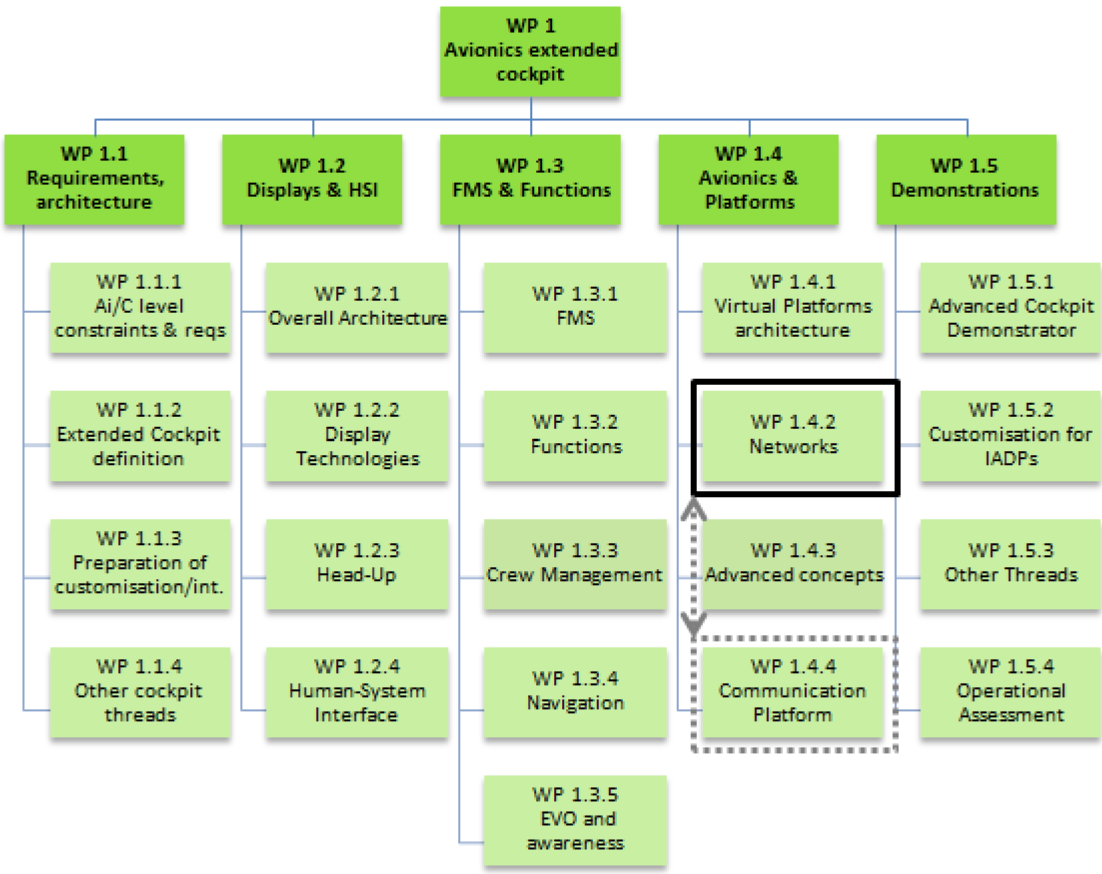
Identification	**Title**
JTI-CS2-2016-CPW04-SYS-01-01	**Network solutions for future cockpit communications**
Short description (3 lines)	
The strategic topic aims at studying and developing key communication network elements that will support future Air Traffic Services and Airlines Operations. The activities include analysis of the multi-link and network management concepts, study and integration of new routing capabilities in the cockpit, as well as the development of a ground infrastructure enabling end-to-end testing.	

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

1. Background

Organisation

This Strategic Topic is part of the ITD Systems WP1, which is addressing the main functions and candidate technologies for the Avionics Extended Cockpit. The associated work breakdown structure is presented in the following figure.



Within this work package, the Strategic Topic will be integrated in WP1.4.2, working in close collaboration with WP1.4.4. The latter aims at developing the ITD Systems (SYS) Communication Platform, which will demonstrate key capabilities for the next generation cockpit architectures.

Context

The modernisation of Air Traffic Management (ATM) and the continuous need for more data communications will require a significant evolution of the cockpit radio and network architectures in the following decade and beyond.

The FAA and Eurocontrol have defined a new set of radio technologies, called Future Communication Infrastructure (FCI), which is intended to be deployed globally to support the operational concepts that are being developed in SESAR and NextGen programmes. The candidate solutions are:

- AeroMACS: Airport surface data-link based on the WIMAX technology,
- LDACS: L-band air-to-ground system, being proposed to supplement VDL Mode 2,
- Satcom Class A: New generation of satellite communication system such as Iris in Europe.

However, the introduction of those new capabilities in the so-called federated architectures (i.e. based on dedicated LRU installed in the avionics bay) implies penalties for the airlines including additional weight, power consumption and volume. Due to the ever increasing number of data-link functions, the legacy architectures are no longer adequate and should be replaced in the future by more distributed architectures based on Software Defined Radios.

At the network level, the multi-link concept has been identified in SESAR as a key enabler for supporting new safety critical services. The objective is to provide robust and highly available data-link connectivity taking advantages of the availability of multiple communication means. This specific functionality builds upon the selection of the most appropriate data-link and associated vertical handovers, as well as the notion of concurrently using multiple sub-networks to support the time-critical exchanges in the context of the future concept of operations.

In addition, the Aviation Industry is moving to adopt Internet Protocols (IP) for almost all off-board communication networks. While today IP is the basic technology for the non-safety networks in the AISD and PIESD domains, Airframers are now looking to include Internet Protocol Suite (IPS) routers as a line-fit solution in the cockpit (ACD domain). The AEEC committee has started standardisation activities for this new technology in 2015 with a first phase dedicated to the definition of the roadmap and analysis of the architecture.

The SYS Communication Platform will tackle those challenges and demonstrate the feasibility and benefit of new radio and network architectures for the cockpit. The underlying concepts seek to achieve:

- Significant savings in Size Weight and Power (SWAP) by moving away from the existing federated architecture towards an integrated, modular approach.
- Efficient management of the routing and radio resources, enabling the support of new Air Traffic Management services.

Those systems will help to reduce the environmental impact of the aircraft, as well as removing capacity constraints and improving operational efficiency with introduction of new capabilities which underpin Air Traffic Management modernisation as part of the NextGen and SESAR programmes.

In WP1.4.2, the Strategic Topic will play a key role in this activity by addressing the main issues related to the network sub-system. While WP1.4.4 is studying the overall system design, including both networks and sub-networks, the radio sub-system, the communication management implementation, it is also in charge of the integration and validation of the platform.

Objectives

This Strategic Topic will study the future network architectures and associated algorithms/protocols that will allow increasing the efficiency and availability of the cockpit communication means. Those solutions will be a key enabler for supporting the future Safety Services and Trajectory Based Operations.

The specific objectives of the strategic topic are listed hereafter:

- Analysis of the multi-link and information-centric networking concepts and identification of the impact on the network elements,
- Definition of novel link management algorithms taking advantage of the future radio bearers,
- Introduction of Software Defined Network (SDN) concepts in the network architecture,
- Study of the key routing functions for the new Internet Protocol Suite (IPS) systems,
- Development of a first generation of IPS router for integration in the SYS Communication Platform,
- Definition of a cockpit communication manager and adaptation of the related applications,
- Development of a ground test solution enabling assessment of the end-to-end communication system in a multi-link environment.

It is expected that this strategic topic will work in close collaboration with the WP1.4.4 (Communication Platform). In particular, it will base the studies and developments on the solution requirements and system design that will be generated in WP1.4.4. Moreover the building blocks developed in the Strategic Topic will be integrated in the SYS Communication Platform and assessed jointly with this other work package.

The expected maturity level at the end of the activity is TRL6. For each component, the applicant will describe the lag between the delivered system and a prototype that could fly. The applicant will give its current maturity level for each component of the call and the planning of maturity within the project.

2. Scope of work

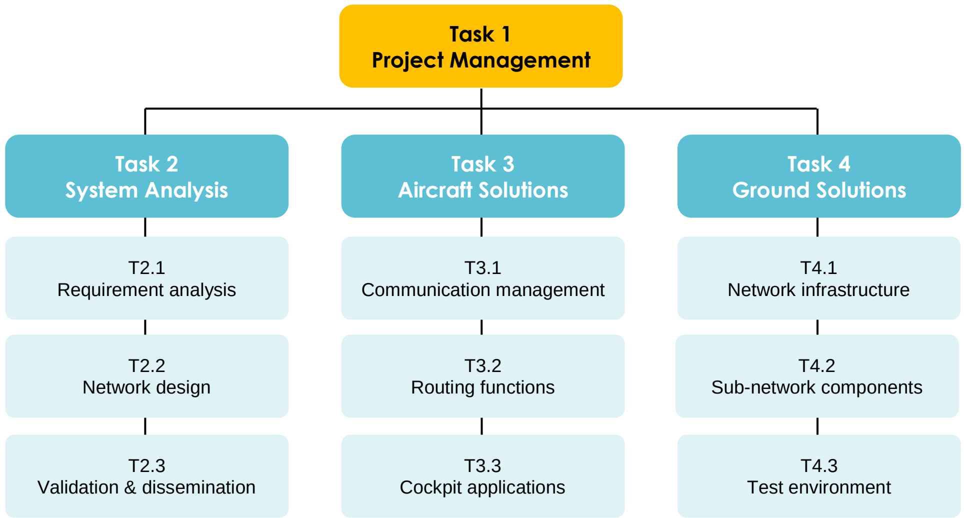
The activities of this CP call will take place within the WP1.4.2 “Networks” of the Clean Sky 2 ITD Systems. This Strategic Topic shall include four high-level tasks, as described hereafter:

- **Task 1 (Project Management)** is in charge of the project monitoring, administration, reporting and ensures the technical consistency and convergence towards project high level objectives.
- **Task 2 (System Analysis)** aims at analysing the network design for the future cockpit communication systems, taking into account the progressive introduction of the Internet Protocols and the need to maintain a high level of safety and security. This task will also support the analysis of the tests performed on the SYS Communication Platform and the dissemination activities.
- **Task 3 (Aircraft Solutions)** will analyse the aircraft solutions required to support future Safety

Services, including communication management, airborne routing functions and applications.

- **Task 4 (Ground Solutions)** will develop the test environment for the SYS Communication Platform. It will provide all system elements required to performed end-to-end cockpit communications, emulating a comprehensive ground network infrastructure.

Topic work breakdown structure:



The detailed description of the activities that have to be carried out are listed hereafter:

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	**Project Management** In this task, the CP will have to interface with the Work Area Leader, provide reporting in the frame of the ITD Systems process and participate in regular progress meetings. This task is also devoted to internal coordination of the Topic activities, i.e. administrative and technical coordination, ensuring on-time and on-budget delivery of the project outputs.	T0+54

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T2.1	**Requirement analysis** This task aims at analysing the key requirements for the development of future cockpit networks. It consists of the following activities: Analysis of the evolution of the off-board network protocols and architectures (e.g. standardisation activities, SESAR developments). Definition of the network needs and requirements, taking into account the set of system requirements provided by WP1.4.4. Supply of a deliverable, which presents the output of this work, including the main trends and requirements for future cockpit networks.	T0+18
T2.2	**Network design** This task is a study of the end-to-end network system design, taking into account the progressive introduction of IP technologies. It consists of the following activities: Analysis of the multi-link concept in the context of future Air Traffic Services (i.e. definition of multi-link, identification and assessment of candidate solutions) and allocation of the key multi-link functions to the system elements. In particular, the potential application of network coding techniques will be assessed. Review of the information-centric networking (ICN) architecture concept in order to determine possible extensions of the Internet Protocol Suite capabilities with respect to message scheduling, prioritisation and link selection. Determination of the impacts on aircraft and ground architectures, including the security aspects.	T0+24
T2.3	**Validation & dissemination** This task is aimed at supporting the dissemination activities and final validation of the system in cooperation with WP1.4.4. It consists of the following activities: Support of the validation for the SYS Communication Platform that will be integrated and verified in the WP1.4.4. The CP will participate in the test campaigns and support the analysis of the associated results, summarising the main conclusions. Dissemination of the project output in relevant scientific literature, conferences and standardisation bodies. The selection of the topics and targeted journals, events and committees will have to be agreed with the Work Area Leader.	T0+51

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T3.1	**Aircraft communication management** This task is a study of the communication management function within the aircraft, including link and network management. It consists of the following activities: Definition of the aircraft network architecture based on the Software Defined Network concepts and taking into account existing function decompositions such as the one defined in ARINC 839 (MAGIC). Study of the link management algorithms in the context of multi-link, using input from T2.2. The objective is to define candidate link selection algorithms for the ACD domain. Analysis of the network management mechanisms, including security, fault and configuration management.	T0+36
T3.2	**Aircraft routing functions** This task will study and define innovative airborne routing functions based on the Internet Protocol Suite. It will also supply the associated protocols for integration in the SYS Communication Platform. The task consists of the following activities: Analysis of the output from the IPS standardisation groups (ICAO, ARINC, RTCA, Eurocae) and definition of the routing functions that will be needed for supporting future safety services applications. Study of the key protocols and features for future IPS routers such as multi-link support, mobility management, security, QoS, redundancy. Supply of the IPS routing protocols, compliant with the future ARINC and RTCA/Eurocae standards, for integration in the SYS Communication Platform. The related functions and interfaces will have to comply with the requirements and interface description provided by the WP1.4.4. Unit integration and verification of the routing protocols on the target platform. Support of the system integration and verification that will be performed in WP1.4.4.	T0+54

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T3.3	**Aircraft cockpit applications** This task aims at defining and implementing avionics applications that will be used to operate and test the networks. The application set needs to cover ATS (e.g. FANS 1/A, ATN B1/B2), AOC (e.g. ARINC 620, 702A) and IP testing applications. The final list of applications will be defined with the Work Area Leader, taking into account the work performed in the System Analysis activities (Task 2). The task consists of the following activities: Identification of the applications that should be used for the SYS Communication Platform based on the WP1.4.4 requirements. This includes the analysis of the possibility to use pre-ATN B3 applications. Definition of a uniform interface between the Applications and the Communication Manager. Development of the applications (or preferably use and adaptation of existing solutions) that will be employed to operate the SYS Communication Platform with the associated gateways when required. Unit integration and verification of the applications on the target platform. Support of the system integration and verification that will be performed in WP1.4.4.	T0+54
T4.1	**Ground network infrastructure** This task shall provide the network elements required to emulate a ground system aiming at communicating with the aircraft cockpit. It consists of the following activities: Identification and definition of the required network protocols. The initial list includes ACARS and IPS as well as multi-link management. This list will have to be updated in order to take into account the WP1.4.4 requirements. Development of the required protocols or preferably use of existing solutions, depending on the level of maturity of the technologies and standards. Unit integration and verification of the network protocols. Support of the system integration and verification that will be performed in WP1.4.4.	T0+54

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T4.2	**Ground sub-network components** This task shall provide the sub-network components required to emulate a ground system aiming at communicating with the aircraft cockpit. It consists of the following activities: Identification and definition of the required sub-networks. The initial objective is to support existing and future waveforms for the cockpit data communications (e.g. VDL Mode 2, Inmarsat SwiftBroaband and SB-SS, Iris, LDACS, AeroMACS). This list will have to be updated in order to take into account the WP1.4.4 requirements. Development of the required waveforms or preferably use of existing solutions, depending on the level of maturity of the technologies and standards. Unit integration and verification of the sub-networks. Support of the system integration and verification that will be performed in WP1.4.4.	T0+54
T4.3	**Ground test environment** This task shall provide the test environment for the ground system, including conventional ATS and AOC applications, as well as test applications. The task consists of the following activities: Identification and definition of the required applications. The list of applications has to be coherent and interoperable with the ones defined in T3.3 (Aircraft cockpit applications). The final list of application sets will have to be agreed with the Work Area Leader. Development of the required applications or preferably use of existing solutions. Unit integration and verification of the applications. Support of the system integration and verification that will be performed in WP1.4.4.	T0+54

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title – Description***	***Type****	***Due Date***
D1.4.2_2.1	Final network system needs and requirements	R	T0+18
D1.4.2_2.2	Network architecture study	R	T0+12
D1.4.2_2.3	Dissemination and system validation report	R	T0+51
D1.4.2_3.2a	Routing function and interface specifications	R	T0+24
D1.4.2_3.2b	Delivery of the aircraft routing protocols (associated with an Integration test report)	D	T0+36
D1.4.2_3.3a	Final application specifications	R	T0+18
D1.4.2_3.3b	Delivery of the aircraft application sets (associated with an Integration test report)	D	T0+36
D1.4.2_4.1a	Ground network infrastructure specifications	R	T0+24
D1.4.2_4.1b	Delivery of the ground network infrastructure (associated with an Integration test report)	D	T0+42
D1.4.2_4.2a	Ground sub-network components specifications	R	T0+24
D1.4.2_4.2b	Delivery of the ground sub-network components (associated with an Integration test report)	D	T0+42
D1.4.2_4.3a	Ground test environment specifications	R	T0+24
D1.4.2_4.3b	Delivery of the ground test environment (associated with an Integration test report)	D	T0+42

**Type: R: Report, D: Delivery of hardware/software/system*

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type****	***Due Date***
M1.4.2_1	Kick-off meeting	M	Q3 2017
M1.4.2_2	System analysis completed	M	T0+24
M1.4.2_3a	All aircraft solutions specified	M	T0+24
M1.4.2_3b	All aircraft solutions delivered	M	T0+42
M1.4.2_4a	All ground solutions specified	M	T0+24
M1.4.2_4b	All ground solutions delivered	M	T0+42

**Type: M: Milestone*

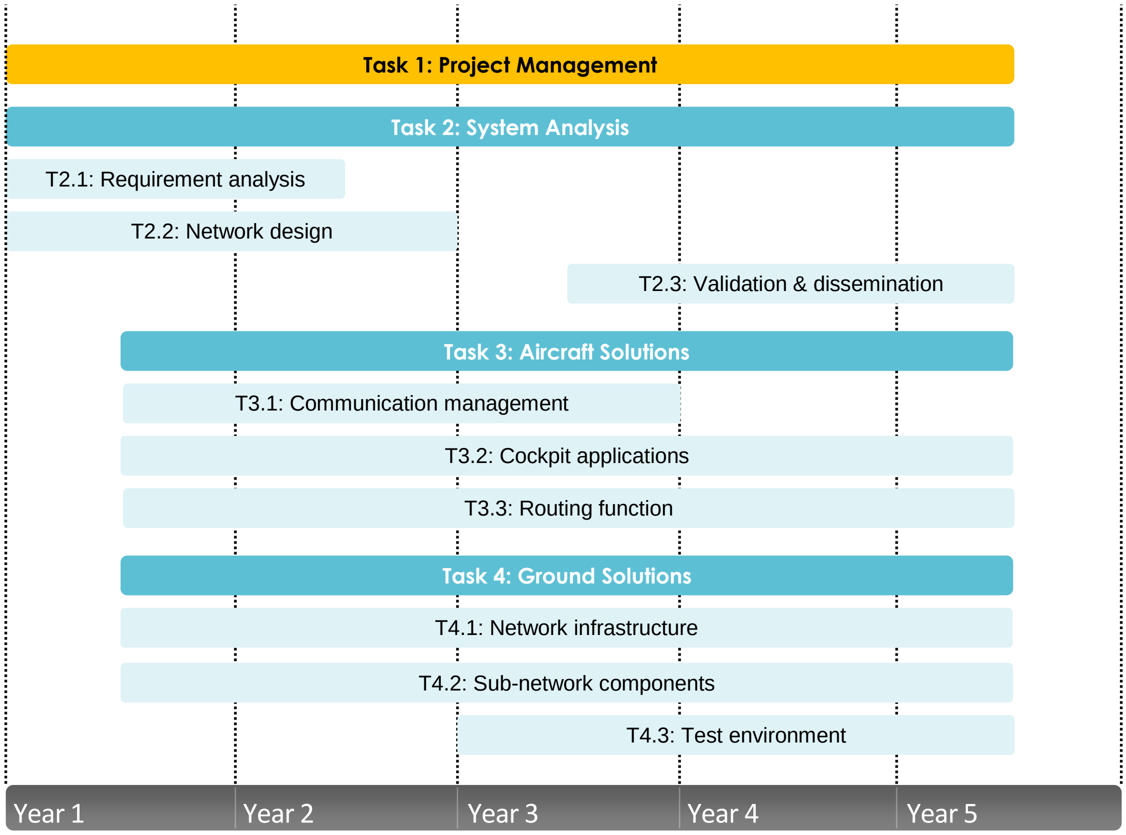
The “Outputs” listed in the following table are technical reports generated by the CP that will have to be provided as input to the WP1.4.4 in order to facilitate full and efficient integration of the CP work in the SYS GAM. These reports are not contractual deliverables; however, their technical content will be adequately included in the content-wise nearest deliverable, to allow a proper technical follow-up by the JU.

Outputs		
Ref. No.	***Title – Description***	***Due Date***
O1.4.2_2.1	Initial network system needs and requirements	T0+6
O1.4.2_2.2	Multilink analysis report	T0+24
O1.4.2_2.3	Dissemination objectives	T0+36
O1.4.2_3.1a	Network management mechanisms	T0+24
O1.4.2_3.1b	Candidate solutions for link management	T0+30
O1.4.2_3.2	IPS router analysis report	T0+18
O1.4.2_3.3	Initial application specifications	T0+12

The “Inputs” listed in the following table are documents generated by the WP1.4.4 (one of them is a Clean Sky JU deliverable) that will have to be provided as input to the CP.

Inputs		
Ref. No.	***Title – Description***	***Due Date***
O1.4.4_02	Initial definition of the communication demonstrator	T0+1
D1.4.4_02	Final requirements for IMC (system requirements for the SYS Communication Platform)	T0+1

Topic schedule



The overall duration of this strategic topic is 54 months, nevertheless the last key milestones are scheduled for T0+42. The remaining year for the topic is primarily intended to support the integration and validation of the system elements delivered to the WP1.4.4. It will also allow the CP to analyse the results of the test campaigns and to disseminate outputs.

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

The CP shall have the skills and capabilities to deliver the defined analysis reports, as well as prototypes that are fully validated and ready for integration in the SYS Communication Platform.

Skills and knowledge

- Recognised skills and knowledge in the following fields:
    - Radio-communication waveforms dedicated to cockpit systems, including VHF, VDL Mode 2, AeroMACS, Inmarsat SBB and LDACS,
    - Avionics network systems, including ACARS, ATN/OSI and IP routers,
    - Cockpit communication avionics testing,
    - Ground network infrastructure,
    - IP protocols including transport layers (UDP, TCP), routing protocols, mobility management, security and QoS functions,
    - Network coding with application to aeronautical communications,
    - Network management,
    - Software Defined Radio and Network (SDR and SDN),
    - Information-centric networking (ICN) architecture concepts.

Capabilities

- Resources in house for design, manufacturing, material, instrumentation and tests.
- Proven experience in delivering operational capabilities, including:
    - Aircraft Control Domain (ACD) airborne routers,
    - Air/ground routers,
    - Ground end systems for Air Traffic Control.
- Proven experience in designing airborne and ground test beds for the Aviation Industry (e.g. Airframers, Avionics Suppliers, Communication Service Providers) with the ability to deliver large-scale data-link simulation and test solutions.
- Proven experience in developing:
    - ATS and AOC applications (FANS1/A, ATN B1 and B2, ARINC 620 and 702), as well as test applications,
    - ACARS and ATN/OSI routers on state-of-art IMA (Integrated Modular Avionics) platforms,
    - Aeronautical waveforms including VDL Mode 2 and LDACS,
    - Avionics radio management systems.
- Proven experience in simulating:
    - Link management protocols and seamless vertical (i.e. media independent) handovers,
    - Network coding for aeronautical communications,
    - Security mechanisms including IPSec and key management.

Research & Technology (R&T)

- Demonstrated prior R&T experience in the fields of airborne routers and Software Defined Radio technologies for Air Traffic Management.

- Experience with SESAR programme is desirable in order to be able to effectively leverage from the operational concepts developed in the SESAR framework.

Standardisation and regulation

- Good understanding of the work carried out in the aviation standards bodies related to data-link systems such as AEEC DLK (Data Link) and AEEC DLUF (Data Link User Forum), and in the IPS standardisation bodies (AEEC IPS and/or RTCA SC-223).

5. Glossary

ACARS	Aircraft Communications Addressing and Reporting System
ACD	Aircraft Control Domain
AEEC	Airlines Electronic Engineering Committee
AeroMACS	Aeronautical Mobile Airport Communication System
AISD	Airline Information Services Domain
AOC	Aeronautical Operational Control
ARINC	Aeronautical Radio Incorporated
ATS	Air Traffic Services
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
CP	Core Partner
CS2	Clean Sky 2
CSJU	Clean Sky Joint Undertaking
DLK	Data Link
DLUF	Data Link User Forum
Eurocae	European organisation for Civil Aviation Equipment
FANS	Future Air Navigation System
FCI	Future Communication Infrastructure
FLX	Flight Avionics
ICAO	International Civil Aviation Organisation
ICN	Information-Centric Networking
IMA	Integrated Modular Avionics
IMC	Integrated Modular Communication
IP	Internet Protocol
IPS	Internet Protocol Suite
IPSec	Internet Protocol Security
ITD	Integrated Technology Demonstrator
LDACS	L-band Digital Aeronautical Communication System
LRU	Line Replaceable Unit
MAGIC	Manager of Air Ground Interface Communications
OSI	Open Systems Interconnection
PIESD	Passenger Information and Entertainment Services Domain
QoS	Quality of Service

RTCA	Radio Technical Commission for Aeronautics
SB-SS	SwiftBroadband Safety Services
SDN	Software Defined Network
SDR	Software Defined Radio
SYS	ITD System
SWAP	Size Weight and Power
TCP	Transmission Control Protocol
TRL	Technology Readiness Level
UDP	User Datagram Protocol
VDL	VHF Data Link
VHF	Very High Frequency
WiMAX	Worldwide Interoperability for Microwave Access
WP	Work Package

II. System solutions for Cabin & Cargo operations, communication and power management

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP V5) Ref.	WP 2		
Indicative Funding Topic Value (in k€)	8 000		
Topic Leader(s)	Thales		
Duration of the action (in Months)	60	**Indicative Start Date**[6]	Q4 2017

Identification	**Title**
JTI-CS2-2016-CPW04-SYS-01-02	System solutions for Cabin & Cargo operations, communication and power management
Short description (3 lines)	
The aim of the strategic topic is to identify the baselines for new standards and processes for Cabin operations, to evaluate new architectures for Cabin and Cargo systems (in particular for communication and power management), and to demonstrate the associated technologies up to TRL6 for selected technologies, and at TRL4 to 5 for the overall system	

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

1. Background

Current Aircraft Cabin and cargo systems have generally been developed specifically for each function, with ad-hoc communication layers between systems when exchanges between functions were identified as necessary. As a consequence, these current architectures present the following drawbacks:

- Lack of standardisation of interfaces, hence limited interoperability between systems
- Redundancy in some transverse sub functions (power management, self-testing, etc.)
- Introduction of innovative functions is complex, as it must be tailored to each specific system with different communication protocols

Tomorrow's aircraft cabin system will need to cope with a variety of challenges, and new context:

- Intense pressure to reduce the turnaround time, in order to optimize the aircraft time in flight. In this context, cabin operations are one of the high priority items that should be improved.
- Even more focus than today on key performances with impact on the environment (power consumption, weight…)
- New regulatory constraint for some systems (e.g. replacement of Halon for fire suppression)
- Connectivity and big data provides opportunities to introduce new added-value functions

Main objective of this core partnership is to develop and demonstrate a new Cabin and Cargo system platform.

This can be broken down into the following scientific and technical objectives:

- Identified and weighted new Cabin system & communication architectures.
- Propose the baseline for Cabin system & communication standardization.
- Propose solutions and contributes to standardization of smart grid power management within the cabin.
- Optimized ground operations by introducing new methods and processes (allowed by the new Cabin system & communication architectures).
- Develop up to TRL 6 Technology bricks for Cabin & Cargo equipment compliant with new cabin system & communication architectures.
- Build Cabin & Cargo demonstrators to partially validate the new Cabin system & communication architectures (up to TRL4 minimum, TRL5 is the ultimate target).

For each technical element, applicants shall indicate and justify the TRL level at the start of the topic, and the TRL roadmap within the topic life time.
The targeted demonstrations will be based on Core Partner own ground test rigs.

2. Scope of work

The activities of this CP call will take place within the Clean Sky 2 ITD Systems, within the WP2 “Cabin & cargo systems”. The Core partner will be level 1 WP leader for this part of the topic, i.e. WP2 leader.

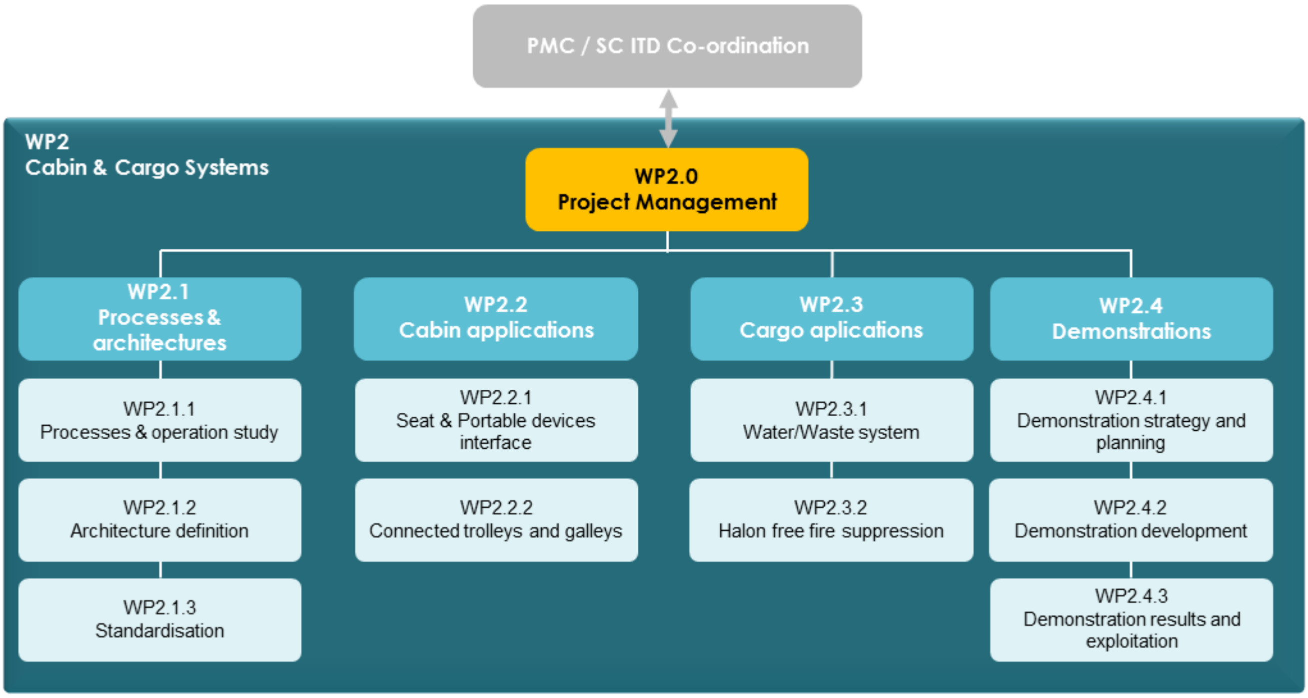
The current topic description presents a proposal of work organisation within WPs. The potential Core Partners may propose their own WP organisation if justified, whilst respecting the main objectives of the overall WP2.

The work to be carried out by the applicant is proposed to be structured in 5 sub-work packages: 4 technical work packages and one management work package, each of them containing several tasks:

- **WP2.0: WP management** is in charge of the topic implementation monitoring, administration, dissemination and reporting and ensures the technical consistency and convergence towards topic high level objectives. It implements the TRL process and monitors the quantitative and qualitative gains from the new systems towards CS2 objectives.
- **WP2.1 C&C Processes and architecture** studies the optimisation of cabin & cargo operations, in particular during Turn-Around-Time, but not limited to it. It analyses the candidate new generation architecture, focusing in particular on Power management and connectivity of various functions. It also analyses the applicable standard and synchronises actions towards proposal of future standard evolutions, to be prepared within the topic lifetime work.
- **WP2.2 Cabin Application:** specifies and develops solutions for the cabin domain. Functions expected to be covered include connected trolleys and galleys, integration of portable devices, seat management… For each functions, a review of existing and desirable standards will feed WP2.1. The technology bricks developed in this WP will be inputs for the demonstrations in WP2.4
- **WP2.3 Cargo Applications**: specifies and develops solutions for the cargo domain. Functions expected to be covered include water waste, increasing re-use of water, halon-free fire suppression and link with inert gas generation system. For each functions, a review of existing and desirable standards will feed WP2.1. The technology bricks developed in this WP will be inputs for the demonstrations in WP2.4
- **WP2.3 C&C demonstrations** : puts in place the demonstration strategy for WP2, develops or adapts the required test rigs, implements the demonstration scenario and exploits the results of test to feed the TRL evaluations.

It is expected that this strategic topic will work in close collaboration with IADP Large Passenger Aircraft (LPA) Platform 2. In particular, synchronization meetings will be organized by the WP2 leader with the LPA PTF2 management team in order to ensure the coherence of the approaches followed for the future cabin concepts, to avoid any duplication of work and to foster synergies where possible (as part of WP2.0).

Topic work breakdown structure:



Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP2.1.1	**Processes & operations study** This work package maps operations of the cabin crew and cabin supply activities on the ground and during flight. Based on the results of this evaluation optimized processes relying on more automation are defined. The focus will be on catering supply, cabin safety equipment, and seats. Typical enablers will be automatic inventory management and an automated ordering process a seat state and safety equipment monitoring process	Q4-2018
WP2.1.2	**Architecture definition** In liaison with WP2.1.2, this WP defines the overall cabin and cargo system architecture providing enhanced support to crews. A first version will provide inputs to WP2.2 systems definition, and later iterations will take into account feedback from the developments. One focus area will be power management, where opportunities of sharing power electronics resources and providing more flexibility (including power arbitration algorithms) will be leveraged. Another focus area will be on data communication architecture, to ensure efficient interfaces between systems, and with the maintenance operation (via CMS). Focus will be on reliability, configurability and scalability of the solution, to address several A/C platforms and ensure extendable capabilities during aircraft lifetime.	Q2-2019

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP2.1.3	**Standardisation** This WP will take inputs from both architecture definition (WP2.1.2) and developments in WP2.2 and WP2.3 to support various standard analysis, and proposal for evolution or new standards. In particular, focus will be on evolutions of A812 for more efficient galley power management, interface with CMS, interface for portable devices.	Q2-2022
WP2.2.1	**Seat & Portable devices interfaces** Development and test up to TRL5 of sensor-fitted seat, able to provide crew with automatic detection of seat state (to support take-off readiness evaluation, maintenance status evaluation, etc.), and analysis of required interfaces with cabin central monitoring. PEDs are becoming more widely used in A/C industry including for communication between passenger and cabin crew. This work package shall evaluate the existing and future functionalities as a preparation for a common standard. As a support activity, this WP will include the design and the validation up to TRL5 of a modular and optimized power converter for multiple applications in the Cabin areas (which will also support WP2.2.2 and 2.2.3)	Q3-2020
WP2.2.2	**Connected trolleys and galleys** In this work package an automatic inventory reading for trolleys shall be evaluated. This would allow the content of the trolley to be transferred via an on-board connectivity system in a timely manner. The WP will explore, specify, design and develop key functionalities of a future (wirelessly) connected trolley. Evolution of galleys will be developed, with objective to support automatic detection of galley module content (galley reconfiguration). Both sub tasks will support TRL5 demonstration in WP2.4	Q4-2020
WP2.3.1	**Water/Waste System** In an innovative approach and for application in future passenger aircraft, a new modular and highly flexible system Water/Waste system based on the reuse of the grey water for toilet flushing shall be defined and demonstrated. The definition of this new system concept shall be supported by application of specialized simulation tools in order to identify and validate solutions to avoid critical system states. The weight savings, (refuelled potable water and part of the drainage system), shall be evaluated and justified against the weight penalty of some additional equipment necessary for the provision of the grey water at the toilet. Standards for the internal system interfaces between different function blocks shall be defined.	Q3-2021

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP2.3.2	**Halon free fire suppression** The objective is to mature up to TRL5, new technologies based on water mist and oxygen depleted air for a new system able to replace the current Halon-based systems. The target system, combining water mist and nitrogen injection, has already been assessed TRL3, proof of concept. For a system demonstration at TRL5, further investigations on system and equipment level are required, showing feasibility for a wide range of A/C applications and in the full range of environmental conditions. The interface to existing inert gas generation systems shall be defined. The definition of adapted means of certification will also be studied.	Q3-2021
WP2.4.1	**Demonstration strategy and planning** In the WP the overall strategy for Cabin and cargo system demonstration will be setup. In particular, the large ground test means to be used for major demonstration shall be selected and the required modifications defined. It is expected that demonstrations of different system will be as much as possible integrated, but standalone demonstrations can be included where required. The potential link with cabin demonstrations in LPA/PTF2 shall be studied.	Q1 2019
WP2.4.2	**Demonstration development** In this WP, the modification to test rig infrastructure are implemented. Prototypes from WP2.2 and WP2.3 are integrated and demonstration scenarios are put in place.	Q4-2021
WP2.4.3	**Demonstration results and exploitation** This WP hosts the main demonstration sessions themselves, as well as the recording of data, and analysis that will support the TRL maturity evaluation in WP2.0.	Q2-2022

3. Major deliverables/ Milestones and schedule (estimate)

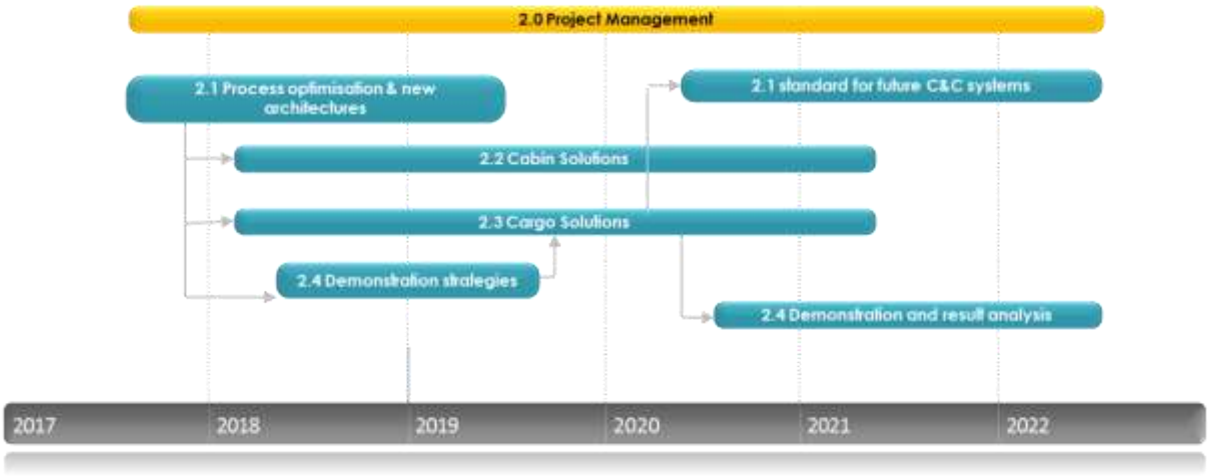
The deliverables listed in the following table are required for an effective integration of the Core Partner work in the SYS GAM. Applicants are set free to define additional deliverables, in line with the development plan they propose, with a view to ensure monitoring of technical progress and a full coverage of activities in the reporting.

In general, about 5 to 6 deliverables per year are expected for the full WP2 scope.

In line with the Clean Sky 2 reporting requirements, the Core Partners shall contribute to the yearly progress report by timely delivering progress reports on their activity to the SYS GAM coordinator. The Core Partners progress reports are not deliverables of the SYS GAM and are used to feed the SYS GAM periodic reporting towards the CSJU.

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D_2.1.1_1	Cabin process and operations and architecture state of the art	R	Q2-2018
D_2.1.1_2	Future optimized Cabin process and operations	R	Q3-2018
D_2.1.2_1	Future cabin and cargo architecture definition – initial version	R	Q2-2018
D_2.1.2_1	Future cabin and cargo architecture definition – updated version	R	Q3-2021
D_2.1.3_1	Standardisation report for cabin & cargo applications	R	Q1-2022
D_2.2.1_1	Connected seat specification	R	Q4-2018
D_2.2.1_2	Connected seat development report	R	Q3-2020
D_2.2.1_3	Portable electronic device interface report	R	Q3-2019
D_2.2.1_4	Common power electronics specification	R	Q4-2018
D_2.2.1_5	Common power electronics development report	R	Q3-2019
D_2.2.2_1	Connected trolleys & galleys specification	R	Q3-2018
D_2.2.2_2	Connected trolleys & galleys development report	R	Q3-2020
D_2.3.1_1	Water waste system architecture trade off studies	R	Q2-2018
D_2.3.1_2	Water waste system development report	R	Q2-2021
D_2.3.2_1	Halon free fire suppression systems architecture description (including interface to OBIGGS)	R	Q2-2018
D_2.3.2_2	Halon free fire suppression systems development report	R	Q2-2021
D_2.4.1_1	WP2 demonstration strategy	R	Q4-2018
D_2.0_1	WP2 TRL plan (including criteria and expected means for each function/TRL level)	R	Q2-2018
D_2.4.3_1	WP2 demonstration results and analysis	R	Q1-2022

**Type: R: Report, RM: Review Meeting, D: Delivery of hardware/software (note that deliveries are expected to take place between WP 2 partners of the Core partnership, if needed)*



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

The CP shall have the skills and capabilities to deliver the defined analysis reports, as well as prototypes that are fully validated and integrated into relevant tests platform.

Capabilities

- Resources in house for design, manufacturing, material, instrumentation and tests, including access to large demonstration platform at cabin system level.
- Proven experience in design and implementation of relevant cabin and cargo systems
  - Passenger seat and service
  - Trolleys
  - Galleys
  - Water and waste systems
  - Fire extinction systems
- Facility of access to entities qualified as an Aeronautical Supplier for cabin and cargo systems

Research & Technology (R&T)

- Demonstrated experience in collaborative R&D of cabin and cargo systems, and in collaboration with other system suppliers and airframers.
- Proven experience of TRL maturity evaluation

Standardisation and regulation

- Capacity to contribute to international standardisation committees in the field of cabin & cargo systems; proven recognised contribution to relevant standards is an asset.

Intellectual property and use of the demonstrator

- The CP partner will provide the demonstrations means for all developed technologies.
- Potentially, the CP may deliver demonstrator parts to other CS2 members, in particular if synergies with LPA/PTF2 are identified and achievable in the programme. In this case, each part

integrated or added in a separate demonstrator will remain the property of the party who has provided the part.

5. Glossary

CP	Core Partner
CS2	Clean Sky 2
CSJU	Clean Sky Joint Undertaking
CMS	Centralized Maintenance System
ITD	Integrated Technology Demonstrator
LPA	Large Passenger Aircraft
OBIGGS	On Board Inert Gas Generation System
PTF2	Platform 2 (part of LPA project dealing with aircraft cabin evolutions)
TAT	TurnAround Time
TRL	Technology Readiness Level

III. Next generation of energy storage solutions for more electrical aircrafts

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP V5) Ref.	WP 5.1		
Estimated Topic Value (funding in k€)	5 000		
Topic Leader(s)	Thales		
Duration of the action (in Months)	48	**Indicative Start Date**[7]	Q4 2017

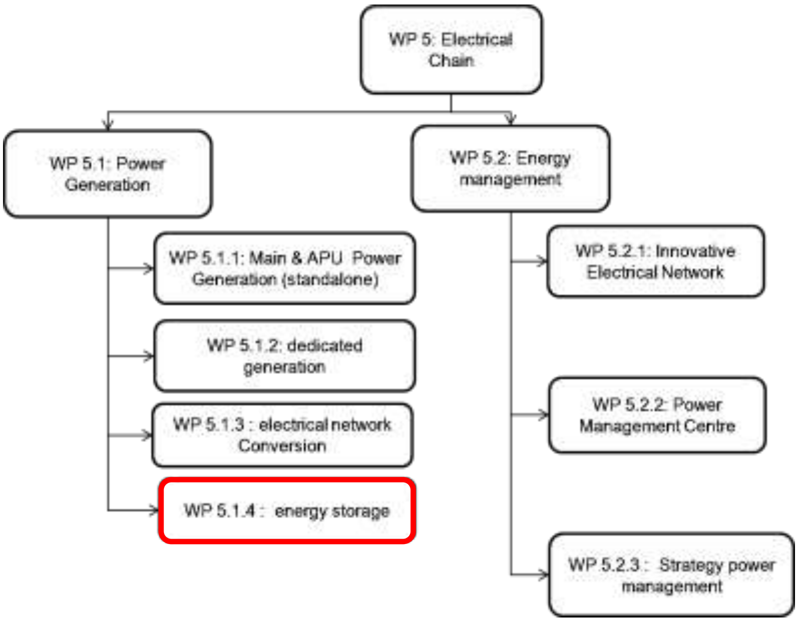
Identification	**Title**
JTI-CS2-2016-CPW04-SYS-02-09	**Next generation of energy storage solutions for more electrical aircrafts**
Short description (3 lines)	
Development of innovative energy storage solutions for aircraft LVDC and HVDC electrical networks, connected components and applications. Safety, robustness, availability, lifecycles, power density, weight and compactness are the main criteria driving the design of the requested solutions.	

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

1. Background

The major objective of the "Power generation" work package (WP5.1) is to actively prepare the ATA24 System for the future generation of aircraft power network, which includes the development of innovative conversion and generation equipment for aircraft applications. The proposed topic focuses on energy storage activities, is planned as part of sub-work package WP5.1.4 (ref. picture "WP5 electrical chain" below) and is a key contributor of WP5.1.

The call aims at developing the next generation battery module equipped with its dedicated accessories (BMS and charger) for both LVDC and HVDC electrical networks, in the context of aircraft applications.



WP5 electrical chain WBS

In the recent years, the use of advanced materials for the electrodes [1, 2] has paved the way for a technology evolution of lithium-ion batteries, which has allowed achieving a remarkable increase of energy and power density. The performance improvement in terms of energy and power density makes lithium-ion batteries technology particularly attractive for aircraft applications, where increased on-board energy and power demands must be combined with weight reduction and efficient power management.

Furthermore, the next generation aircraft will implement the "more electrical aircraft" design approach, which will increase the demand for such a key performances.

This calls for a focused research effort with a view to adapt this battery technology such as to fulfil the specific requirements of the aeronautic sector, and to validate the suitability of such innovation to the next aircraft generation.

In the following paragraphs, the main applications and some key performance parameters are listed. Applicants are expected to address the technology development challenges, providing application cases and proposed solutions, including measures to minimize critical drawbacks such as vent gas, heat, fire, etc.

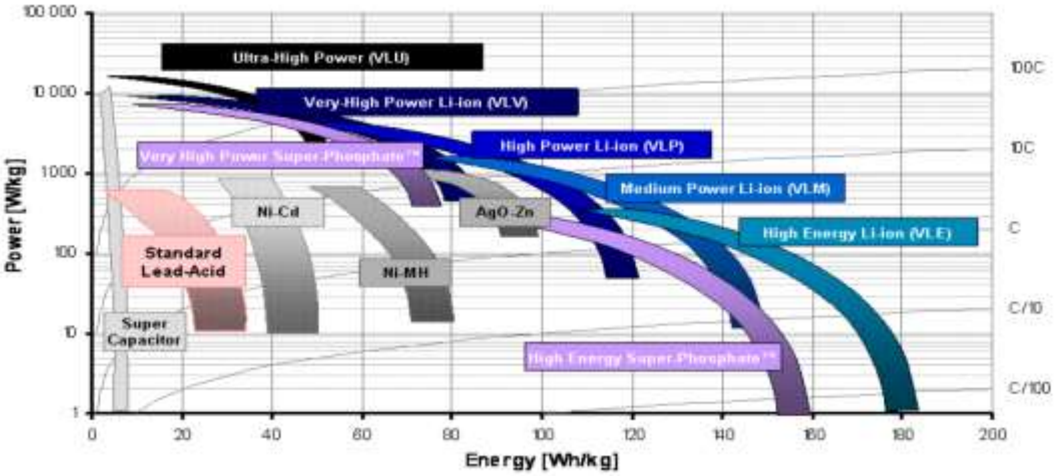


Figure 1: Ragone diagram showing the capability of the existing li-ion battery technologies.

[1]: Subrahmanyam Goriparti and all. "Review on recent progress of nanostructured anode materials for Li-ion batteries". Journal of power sources. 2014.
[2]: YiDi Zhang, Yi Li and all. "High-energy cathode materials for Li-ion batteries: A review of recent developments". Sept. 2015

It is envisaged that the progress of the lithium-ion battery in term of density, will allow:

- To withstand with the existing and new demand to supply LVDC, and HVDC power in emergency case,
- To start high power engines,
- To supply electrical break system,
- To hybridize a high speed Ram air Turbine (RAT),
- To extend the application on others functions on the DC generation network to simplify the electrical architecture of more electrical aircraft,

for which the applicant is requested to propose its innovative solutions.

Applications should also address the drawbacks of existing high dense Lithium-ion battery chemistry such as LCO and NCA. One is namely, the side effect of thermal runaway event, which induces critical and unwanted effects such as abrupt increase of heat and/or generation of large amount of vent gas. These effects, particularly undesirable in aeronautics applications, require designing a heavier container with an ad-hoc exhaust system to discharge vent-gas outside the aircraft. This in turn requires adding multiple redundant levels of protection, which may dramatically reduce the expected benefit of the final solution.

Recent advances in electrodes, such as mixed active material composed with Nickel Manganese Cobalt (NMC), variety of LFP chemistries, and lithium sulphur allow obtaining excellent thermal stability and safe operation, as well as high energy and power density and good cycle life.

Applicants should elaborate on and propose the most suitable recent lithium battery chemistries which are compatible with following targets and challenges:

- Lithium battery category dedicated for high power demand with power density up to 8kW/kg with low energy density up to 100 Wh/kg,
- Lithium battery category dedicated for high energy demand with high specific energy density up to 400Wh/kg and energy density of about 1015 Wh/L,
- Suitability for safety requirements as specified in applicable aeronautical standards such as D0-311,
- Withstanding environmental conditions as specified in DO-160 RTCA standard,

The following others subassembly of the battery system shall be also studied:

- Evaluation of different recent approaches for the design of BMS estimation functions such as electrochemical model and electrochemical impedance spectroscopy (EIS) in order to satisfy the state of charge (SOC) real time estimation with an error not greater than 2%,
- The diagnostic/prognostic functions,
- Associated protection functions and features of selected chemistries,
- Associated DC/DC reversible charger converter topologies suitable for LVDC, HVDC networks specification and for the selected chemistries for charging algorithms. The targeted efficiency performance of the requested charger is 94% over the whole operating voltage range. In addition, the technologies used shall allow reaching a power density up to 2kW/kg,
- The housing of the battery system shall withstands environmental constrains specified in D0-160 and thermo-mechanical constrains generated by unlimited overcharge of the incorporated battery chemistry (refer to D0-311 requirements). The weight and volume should be made as light as possible using adequate material.

A multi physics simulation model of the battery system including a characterization of the selected chemistries is also required as part of this activity.

Demonstrators of lithium pack modules units and demonstrators of LVDC and HVDC integrated battery systems are expected as deliverables; tests reports on electrical performances and safety issues are to be delivered.

For the demonstrators, the following approach based on 2 runs may be adopted; however, applicants are set free to propose their own approach:

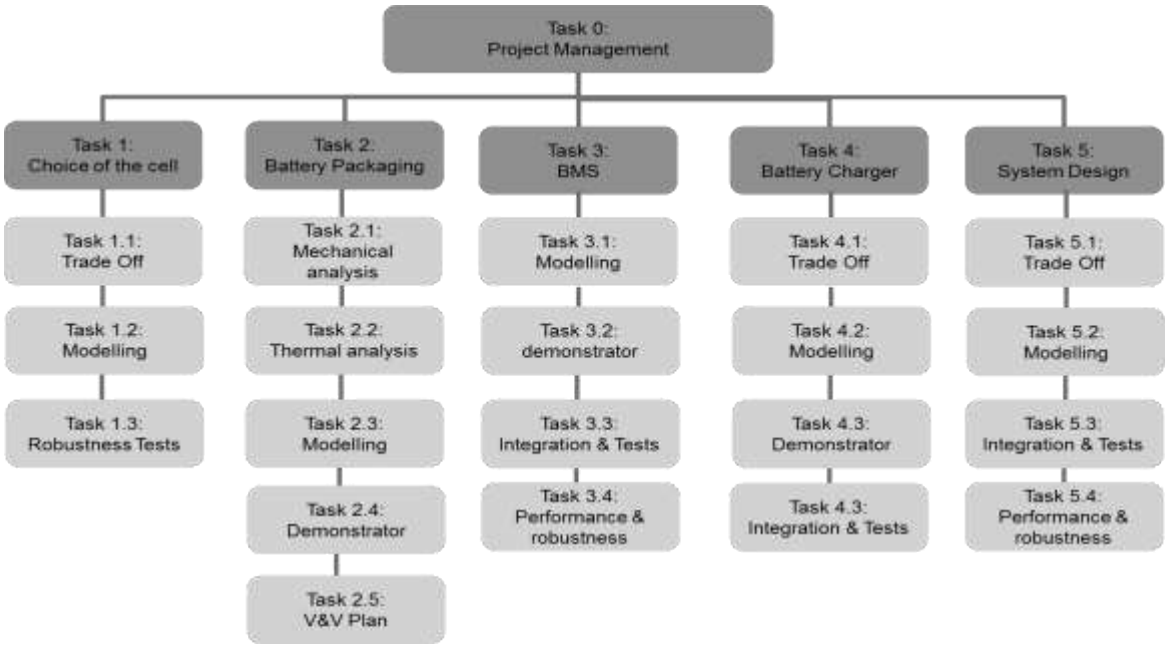
- Two major deliverables are identified, which may suggest implementing the work in two phases. In a first phase the work will focus on the selection of adequate cells chemistries (choice of cell phase) and on for the development of a battery pack module; in a second phase the work will focus on the development of battery System for LVDC and HVDC network applications. The battery System shall be developed by combining several battery pack modules. Combinations in series and/or in parallel will be proposed to satisfy the LVDC and HVDC network applications. The technology Readiness Level expected on each phase is 5.

- A proposed approach is depicted in the figure on the next page:
  - Feasibility study for the two categories of battery (high power density battery and high energy density battery) will be performed at RUN 1,
  - Development of prototypes (pack, LVDC and HVDC battery system) only for the high energy density battery in RUN2.

2. Scope of work

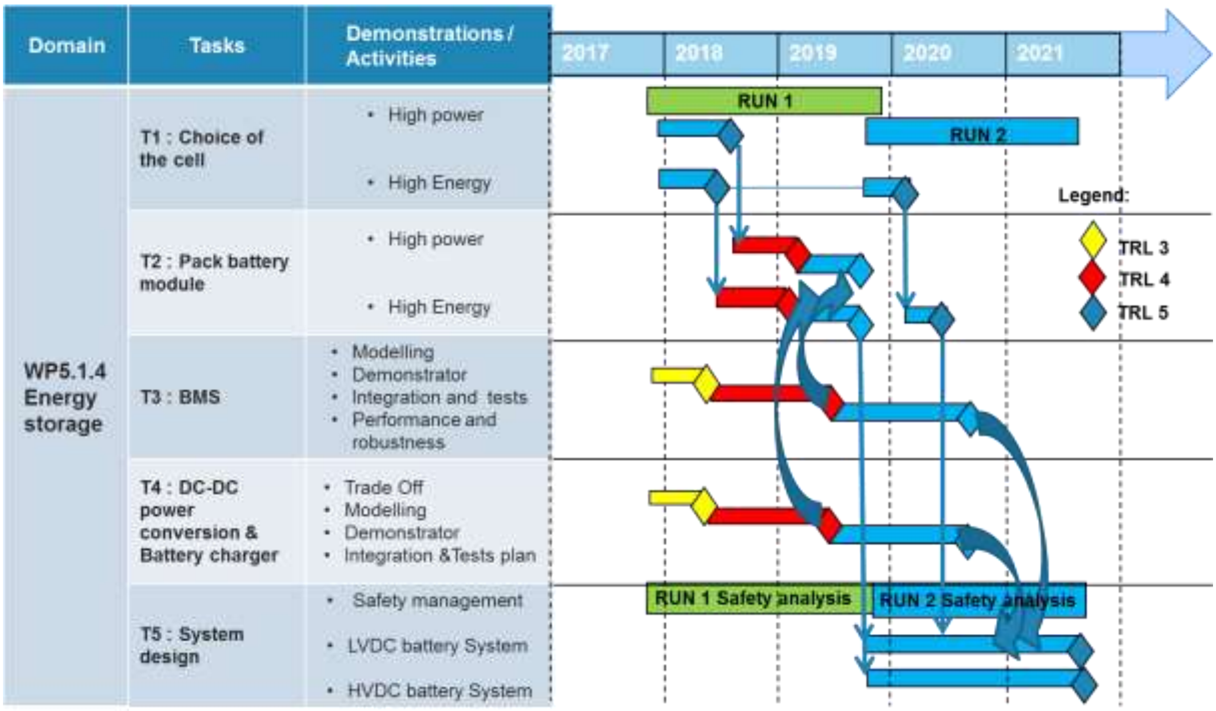
The proposed work encompasses five main chapters, described hereafter:

- Choice of the cell (chemistry, design and process manufacturing),
- Battery Packaging,
- Battery Management System,
- Battery Charger,
- System design



Topic work breakdown structure

The proposed work lasts four (4) years with two development phases, as described in the suggested schedule below:



<u>Task 1: Choice of the cell for high energy and for high power applications for each category of battery (chemistry, design and performances)</u>

<u>Task 1.1: Trade off</u>

The following objective shall be pursued:

- Identify Lithium-Ion cell manufacturers and gather between 8 and 10 lithium-Ion cells composed with various anode, cathode and electrolyte chemistries, various cell casing format (cylindrical or prismatic or pouch cell), and capacity compatible with the application needs defined by the Work Area Leader.
- The applicant shall have the possibility to supply various cells from different manufacturers and shall be autonomous to collect the technical information on the cells and also on the manufacturing process of the cells.
- Classify by order of interest the list of identified Lithium-Ion cells. Criteria to classify this list of cells will be defined with the Work Areas Leader; however, energy density, properties of raw material used for electrodes and electrolyte, cell voltage, safety, thermal runaway risks, and cost criteria are to be considered in the trade-off study,
- Robustness and abusive tests such as overcharge, external short, and Arc tests to evaluate performances and safety behaviour for the selected cells shall be executed to complete and/or to validate the characterization and the dynamic behaviour over time of the cell,
- Two Lithium chemistries shall be selected as the most suitable

Task 1.2: Modelling

For the selected cells, the applicant will develop detailed electrical and electrochemical models of each category of cell using simulations tools (compatibility with SABER and ANSYS tools are required, use of C language code may be envisaged as a way to exchange scripts).

These models shall be validated and updated through the various characterization and robustness tests to be foreseen in the implementation plan.

Modelling the cell shall help model the battery pack for Low Voltage DC and High Voltage DC applications.

Task 1.3: Robustness Tests

Tests plan shall be proposed to evaluate and to characterize the selected cells. This tests plan could be updated at least for the second phase of cells selection in order to take into account the evolution of standards and the results of first prototype.

The results obtained on various cells shall be gathered in a data base, which will be the object of a deliverable.

Task 2: Pack battery module

This task has three main objectives described hereafter:

Task 2.1: Design phase

The safety shall be the key design driver during the design phase and the applicant shall follow the design rules recommended in the safety standard for lithium-ion batteries (RTCA DO-311).

Task 2.2: Modelling

The applicant will develop a detailed model of the battery pack module both for the Low Voltage and the High Voltage DC/DC battery system solutions. These battery pack models shall be validated and updated through the various characterization and robustness tests to be foreseen in the work plan.

Task 2.3: Robustness Tests

The applicant shall propose a tests plan to evaluate the battery pack module and also the battery system taking into account:

- The aircraft environment provided by the Work Area Leader
- The Lithium-ion battery standards (D0-311, D0-347, …)

Task 3: Battery Management System (BMS)

The applicant shall be able to design and to develop adequate BMS for selected Li-ion chemistries. The BMS architecture shall be modular to be compatible with low Voltage DC and High Voltage DC network applications and several technologies solutions for the chemistry. TRL5 is expected at the end of the activity for this function.

- The BMS contributes to the safety management, the applicant shall provide solutions to
    - Validate measurements from sensors,
    - detect faults or hidden failure,
    - Monitor and activate protective measures ,
    - give feedback of the battery,
    - satisfy the state of charge (SOC) real time estimation with an error not greater than 2%,
- The BMS shall include the following functionalities:
    - it is reprogrammable to comply with several Lithium chemistries,
    - it embeds software driven functions such as SoC, SoH, life duration, battery voltage. Adequate selection and sizing of hardware component must be performed, in particular with respect to memory size and communication functions such as to cope with software complexity and run-time requirements,
    - Communication interface to communicate with the battery charger and also with a dedicated laptop shall be compatible with serial bus (such as CAN Bus, or ARINC 429 Bus or Ethernet)
- A model of the BMS shall be provided by the applicant for both the LVDC and HVDC battery solutions
- For safety analysis, information on the hardware and the software used shall be provided for system studies.

Task 4: Battery charger

The applicant shall provide batteries chargers compatible with the following electrical networks:

- DC electrical network for both the LVDC and HVDC battery solutions applications;
    - For the low Voltage DC network the level is 28V and the DO160 standard shall be applicable, with the latest approved version of this standard
    - For the High Voltage DC network the level is 540V or 270V. For this new aircraft network, an applicable standard is not yet identified. However, applicants are encouraged to refer to relevant standards for HVDC electrical power network, also from other sectors such as the automotive. The Work Area Leader and the applicant will discuss and define a dedicated specification for this HVDC network application, at the early stage of the project.

- The battery charger function shall be implemented in a DC-DC converter. The applicant shall develop this DC-DC converter with at least the functionalities mentioned hereafter; this list will be completed by the Work Area Leader with a specification document, which will be part of the SYS GAM deliverables:

- Programmable converter embedded current and voltage loop
- Interface communication compatible with the battery
- Reversibility function, the DC-DC converter shall operate in buck or boost modes, and shall integrate galvanic insulation.

- For this development, a trade off analysis on the DC-DC converter architecture is to be envisaged with the Work Area Leader to select and freeze the adopted solution. The expected output power is around 10kW.

Task 5: System design

This main sub-task shall gather all information coming from the previous sub-tasks and ensure compliance with the needs provided by the Work area Leader.

The safety management plan shall detail requirements for the following components

- Cell hardware,
- electronic hardware of the pack battery
- electrical hardware
- mechanical hardware at the pack battery module and at battery system
- software architecture

One prototype with dedicated BMS and battery charger is expected for each power network applications (LVDC and HVDC power networks); the envisaged Technology Readiness Level for these prototypes is 5. The applicant shall perform the robustness test defined in the task 2.3, for which it will manufacture additional prototypes.

The following table identifies the input and output deliveries between the applicant and the Work Area Leader; the list is not exhaustive and may be complemented in the application and / or during the project implementation:

INPUT – OUTPUT expected between the applicant and the topic leader			
Ref. No.	***Title - Description***	***Type***	***Due Date***
In-T5-n°1	Specification for RUN 1	R	Q4 2017
In-T5-n°2	Specification for RUN 2	R	Q4 2019
In-T4-n°1	battery charger Specification	R	Q4 2017
Out-T1-n°1	Cell technologies selection reports for RUN1 and RUN2	R	Q4 2019 Q2 2020

INPUT – OUTPUT expected between the applicant and the topic leader			
Ref. No.	***Title - Description***	***Type***	***Due Date***
Out-T1-n°2	Cell models and optimized versions	D	Q3 2018 Q1 2020
Out-T2-n°1	High Power pack battery module with charger battery, BMS and dedicated software	D	Q42019
Out-T2-n°2	High Energy pack battery module with charger battery, BMS and dedicated software	D	Q42019
Out-T2-n°3	High Power pack battery module model	D	Q42019
Out-T2-n°4	High Energy pack battery module model	D	Q42019
Out-T3-n°1	BMS models for TRL4 and TRL5 versions	D	Q3 2019 Q4 2020
Out-T4-n°1	Battery charger models for TRL4 and TRL5 versions	D	Q3 2019 Q4 2020
Out-T5-n°1	RUN 1 safety analysis	R	Q1 2018
Out-T5-n°2	LVDC battery System with charger battery, BMS and dedicated software	D	Q42021
Out-T5-n°3	LVDC battery System tests report	R	Q42021
Out-T5-n°4	RUN 2 safety analysis	R	Q1 2020
Out-T5-n°5	HVDC battery System with charger battery, BMS and dedicated software	D	Q42021
Out-T5-n°6	HVDC battery System tests report	R	Q42021

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

3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D5.1.4-a	Pack battery module tests report	R	Q4 2019
D5.1.4-b	Battery System tests report	R	Q4 2021

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M5.1.4-a	Kick-Off Meeting	RM	Q4 2017
M5.1.4-b	RUN1 – battery pack modules validated and delivered	RM	Q4 2019
M5.1.4-c	RUN2 – battery system validated and delivered	RM	Q4 2021

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

4. Special skills, Capabilities, Certification expected from the Applicant

Strong knowledge on and proven experience with Li-ion battery system, including safety design and electro-chemistry performances optimizations.

The partner shall have test, integration and simulation means for the development and the integration of the overall system.

- Proven experiences in industrial applications of Li-Ion battery module development;
- Experiences in the automotive industry is well appreciated, however, the applicant shall have the capacity to carry out research and development under aircraft environmental testing standards such as DO-160;
- Experience with high power density technology and isolated tension constraints for the DC-DC converter development;
- Capability to address requirements deriving from various existing standards in the battery pack development and evaluation (RTCA DO 311, DO 160)

5. Glossary

BMS	Battery Management System
DC	Direct Current
LVDC	Low Voltage DC network
HVDC	High Voltage DC network
MHI	Machine Human Interface
Pin	Power Input
Pout	Power Output
SoC	State Of Charge
SoF	State Of Function
SoH	State Of Health
TRL	Technology Readiness Level