Clean Sky 2 Joint Undertaking

Call Text

3rd Call for Core Partner (CPW03): List and full description of Topics

- October 2015 -

Revision History Table		
Version n°	**Issue Date**	**Reason for change**
V1	21/10/2015	First Release for publication (adoption by GB on 24th September 2015)

Important notice on Q&As

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

In case of questions on the Call (either administrative or technical), applicants are invited to contact the JU using the **dedicated Call functional mailbox:** Info-Call-CPW-2015-02@cleansky.eu

Note that questions received up until 16th December 2016 will be analysed.
In total, three publications of Q/As are foreseen: 25th November, 10th December 2015 and 7th January 2016 (estimated dates).

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

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Summary List of Topics for Core Partners Wave 03 (CPW03)
Type of Actions: Innovative Action (IA)

Identification Code	Topic #	Title	Value (Funding in M€)
JTI-CS2-2015-CPW03-LPA-01-08	1	Engine Mounting System for the CROR Flight Test Demo	3
JTI-CS2-2015-CPW03-LPA-01-09	2	Aircraft Configuration Studies and Demonstration (Scaled Flight testing, Instrumentation)	4
JTI-CS2-2015-CPW03-LPA-01-10	3	Aircraft and Hybrid Propulsion System Architecture, Integration and Verification	5
∑ JTI-CS2-2015-CPW03-LPA	**3**		**12**
JTI-CS2-2015-CPW03-FRC-01-01	1	Design, development, testing and flight qualification of smart fly-by-wire actuators for primary flight control of a civil tiltrotor	3,5
JTI-CS2-2015-CPW03-FRC-02-03	2	New generation landing gear for a compound fast rotorcraft	3,5
JTI-CS2-2015-CPW03-FRC-02-04	3	LifeRCraft Main Gear Box	12
JTI-CS2-2015-CPW03-FRC-02-05	4	Electrical Wiring Interconnection System for a compound fast rotorcraft	3,5
JTI-CS2-2015-CPW03-FRC-02-06	5	Innovative actuators for compound rotorcraft flight control	2,5
∑ JTI-CS2-2015-CFP02-FRC	**5**		25
JTI-CS2-2015-CPW03-AIR-01-04	1	Next generation movables for high speed aircrafts	5
JTI-CS2-2015-CPW03-AIR-02-09	2	Design, manufacture and deliver Technology Demonstrator of high visibility, crashworthy, low-drag integrated cockpit section for next generation civil tiltrotor (NGCTR)	3,5
JTI-CS2-2015-CPW03-AIR-02-10	3	Design, manufacture and deliver Technology Demonstrator of high visibility, crashworthy, low-drag integrated cabin section for next generation civil tiltrotor (NGCTR)	3,5
JTI-CS2-2015-CPW03-AIR-02-11	4	Design, manufacture and deliver Technology Demonstrator of high visibility, crashworthy, low-drag integrated Rear Fuselage and Tail sections for next generation civil tiltrotor (NGCTR)	3,5
JTI-CS2-2015-CFP02-AIR	4		**15,5**
JTI-CS2-2015-CPW03-ENG-01-08	1	HP Core module and its associated control laws and equipment for the UHPE demonstrator	5,5
JTI-CS2-2015-CPW03-ENG-03-03	2	VHBR Engine - HP Turbine Technology	4,5

Identification Code	Topic #	Title	Value (Funding in M€)
JTI-CS2-2015-CPW03-ENG-03-04	3	Demonstration of CFD capability in the simulation of air-oil flow in complex aero-engine bearing chambers - a systematic approach	3,5
JTI-CS2-2015-CPW03-ENG-03-05	4	"Development of large volume, mass optimised, integrated oil storage systems for large VHBR engines	3
JTI-CS2-2015-CPW03-ENG	4		**16,5**
JTI-CS2-2015-CPW03-SYS-02-03	1	Short TAT braking system - Optimized tyre design for improved brake cooling	3,2
JTI-CS2-2015-CPW03-SYS-02-04	2	High efficient compact electro-mechanical brake for small aircraft and helicopters with advanced brake disc material	4,5
JTI-CS2-2015-CPW03-SYS-02-05	3	High efficient structural landing gear parts based on advanced carbon fiber material systems and highly automated production technologies for helicopter and aircrafts	4
JTI-CS2-2015-CPW03-SYS-02-06	4	HVDC Power Center and Functions	6,5
JTI-CS2-2015-CPW03-SYS-02-07	5	Detection and Characterization of Icing Conditions Contributing to Ice Protection Optimization	3,7
JTI-CS2-2015-CPW03-SYS-02-08	6	Electro-Thermal Wing Ice Protection System For Large Aircraft	5
JTI-CS2-2015-CFP02-SYS	**6**		**26,9**

TOTAL	**22**		**95,9**

1. Clean Sky 2 – Large Passenger Aircraft IAPD

I. Engine Mounting System for the CROR Flight Test Demo

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP1.1.3 – Open Rotor Demo Engine (CROR)		
Topic Leader	SAFRAN		
Indicative Funding Topic Value (in k€)	3000 k€		
Duration of the action (in Months)	60 months	**Indicative Start Date**[1]	Q4 2016

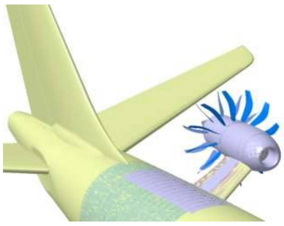
Identification	Title
JTI-CS2-2015-CPW03-LPA-01-08	**Engine Mounting System for the CROR Flight Test Demo**
Short description (3 lines)	
Design, manufacture, assembly and instrumentation of an Engine Mounting System for CROR Flight Test Demo Engine; EMS Set for characterization and validation through Partials tests: manufacture, assembly and instrumentation, mechanical tests.	

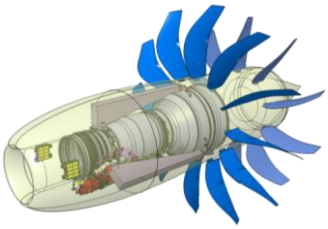
[1] The start date corresponds to actual start date with all legal documents in place.

1. Background

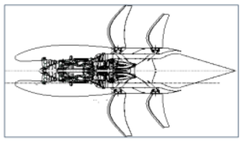
This Strategic Topic refers to the Joint Technical Proposal (JTP), addressing two Systems and Platforms Demonstrators (SPD):

- **IADP_LPA: Platform 1 - Advanced Engine and Aircraft Configuration, WP1.1.3.**
  This Platform will provide the environment to explore and validate the integration of the most fuel efficient propulsion concept for next generation short and medium range aircraft: the CROR engine. The large scale demonstration will include extensive flight testing with a full size demo engine (see below) mounted on the Airbus A340-600 test aircraft.





- **ITD Engine – WP1 Open Rotor Flight Test, 2014-2021.**
  A second version of a Geared Open Rotor demonstrator carrying on Clean Sky SAGE 2 achievements with the aim to validate TRL 6 will be tested on ground and then on the Airbus A340 flying test bed (see IADP LPA Program). From the initial SAGE 2 ground test demonstrator, some engine modifications introducing various improvements, control system update, and engine/aircraft integration activities will be necessary in order to obtain a flightworthy demonstrator (Flight Test Demo-FTD) and particularly :
  - a demonstrator having compatible interfaces with the Airbus A340 flying test bed and its systems
  - a demonstrator whose parts are flightworthy parts



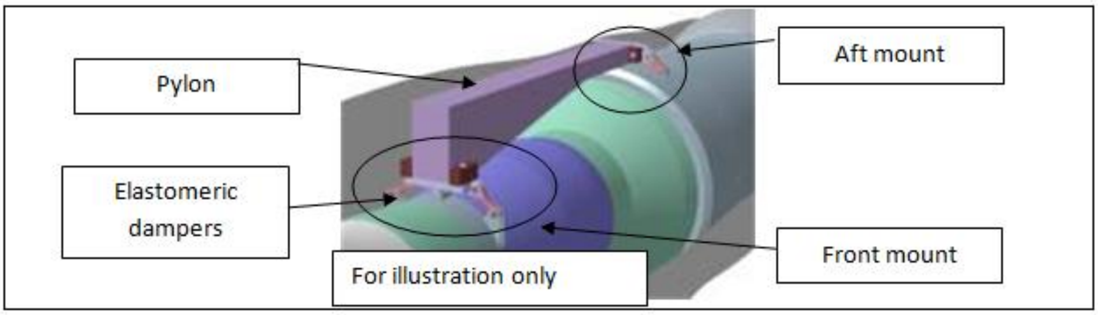
- **On the Engine Side,** the objectives are to mature the following technologies, up to TRL6 through Flight Testing of the FTD CROR Engine on the Airbus A340 flying test bed:
  - New composite open rotor blades concepts optimized for aerodynamic and acoustics
  - Pitch control full system for counter rotating blades
  - Counter rotating structures supporting the blades
  - High Power Gear Box with counter rotating outputs (PGB)
  - High efficiency PoWer Turbine (PWT)
  - Engine integration and installation in rear fuselage area

- **On the Aircraft/Engine Side,** the objectives are to evaluate and demonstrate CROR performance noise and vibration behavior through Flight Testing of the FTD CROR Engine on the Airbus A340 flying test bed.

In the frame of this Call for Core Partner, the Applicant will be responsible for the tasks linked to **the Engine Mount System (EMS) module:**

- **Engine Mount System** for Flight Test CROR Demo Engine (FTD)
  - Design adaptation of the Engine Mount System for the pass-off test and the FTD CROR Engine
  - Taking into account airworthiness studies conclusions and available test data of the GTD and the lessons learned from the GTD Mount System. The Engine Mount System may need a design adaptation and partial tests to check the ability to fly
  - Manufacturing of new parts of demo EMS module for pass-off test and FTD CROR Engine
  - Assembly / instrumentation of this demo EMS module for pass-off test and FTD CROR Engine

- **EMS Module** for Scale 1 Component Tests
  - Testing for Scale 1 Component Tests - Note that the Rig and required adaptations parts will be of the Applicant's responsibility
  - Manufacturing of one EMS Module and of test rig adaptations for Scale 1 Component Tests
  - Assembly and instrumentation of the EMS module/parts and rig for Scale 1 Component Tests
  - Scale 1 Component Tests: These tests are mechanical test with dynamic loads



The associated tasks are part of WP1.1.3.1, WP1.1.3.2, WP1.1.3.4 and WP1.1.3.5 as described in the Work Breakdown Structure (WBS) hereafter:

WP1.1.3 Open Rotor Demo Engine
- WP1.1.3.0 Engineering
- WP1.1.3.1 Propulsion System Integration
- WP1.1.3.2 Modules Adaptations or Modifications
- WP1.1.3.3 Systems and Controls Development
- WP1.1.3.4 Component Maturation Plan
- WP1.1.3.5 Preparation and Participation to Demo Flight Test

2. Scope of work

The scope of work of this CfCP is covering the perimeter of the Engine Mounts System for the Flight Test Demo engine (FTD) and the applicant's tasks are mainly located in WP 1.1.3.2 and WP 1.1.3.4. . In the first phase, the applicant is required for checking the feasibility, freezing the architecture and interfaces, and for identifying the validation plan in order to comply with the EMS specifications that will be provided by the Engine Manufacturer and the Airframer in WP 1.1.3.1.

In the second phase, the applicant will perform preliminary design, detailed design, manufacture of three sets of EMS :

- Pass-off test demonstrator EMS
- CROR FTD demonstrator EMS
- Component Test EMS

As well as :

- instrumentation and partial tests of Component Test EMS,
- instrumentation and support for pass-off test of CROR FTD demonstrator EMS
- instrumentation and support for flight test of CROR FTD demonstrator EMS

Tasks associated with the activities "Instrumentation and support of Component Test EMS " will be located in WP 1.1.3.4. Tasks associated with the activities "Instrumentation and support for pass-off and flight test of CROR FTD demonstrator EMS " will be located in WP 1.1.3.5.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1	*Mount systems development plan* Including detailed risk analysis and mitigation proposal and a preliminary test pyramid	R	T0 + 1 month
D2	*Mount system preliminary design substantiation document for Preliminary design review* To check the feasibility and to freeze the architecture and interfaces, to identify the validation plan	R and RM	T0+10 months
D3	*Design progress reports for mount systems* To check the feasibility and to freeze the architecture and interfaces, to identify the validation plan.	R and RM	T0+16 months

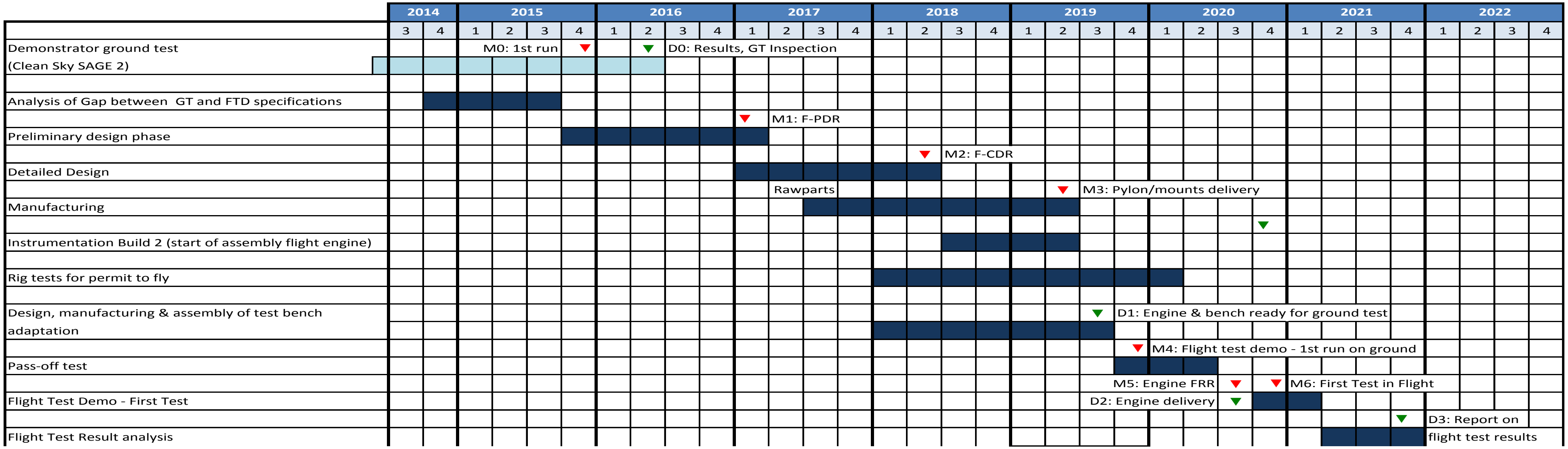
Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D4	*Mount system detailed design substantiation document for the critical design review* To approve design before hardware manufacturing engagement. Including Test pyramid, structural FEM model adapted for integration to global Aircraft FEM (GFEM) & local thermal model	R and RM	T0+18 months
D5	*Mount systems Components Tests benches readiness review* To verify test benches capability to meet validation plan requirements	R and RM	T0+27 months
D6	*Mount system hardware delivery for component test* Hardware for component test	D	T0+27 months
D7	*Mount systems Components Tests completed – hardware inspection review* To substantiate mount systems design & permit to fly	R and RM	T0+39 months
D8	*Mount system hardware delivery for demo pass-off test* Engine assembly	D	T0+32 months
D9	*Mount system hardware delivery for flight demo* Hardware for flight demo	R	T0+ 41 months
D10	*Component Tests reports for mount systems* To contribute to engine test readiness review	R and RM	T0+ 41 months
D11	*Engine readiness review documentation:* ○ Delivered Hardware status compared ○ Instrumentation ○ Test plan requirements To contribute to engine test readiness review	R and RM	T0+ 41 months
D12	*Engine pass-off test report for mount systems* To contribute to engine after-test review	R	T0+ 48 months
D13	*Engine Flight Test report for mount systems* To contribute to engine after-test review	R	T0+ 60 months

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
MS 1	*Mount systems development plan review*	RM	T0 + 4 months
MS 2	*FTD demo Mounts System : Preliminary Design Review*	RM	T0 + 10 months
MS 3	*FTD demo Mounts System :Critical Design Review*	RM	T0 + 18 months
MS4	*Mount system hardware delivery for Component Test*	D	T0+27 months

MS5	*Mount system hardware delivery for flight demo*	D	T0 + 41 months
MS 6	*Engine Flight Test report for mount systems*	R	T0+ 60 months

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

Overall CROR SNECMA Schedule



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

Expertise and skills

- Experience in design, manufacturing, instrumentation , testing and certification of aircraft engine mounts is mandatory
- Experience in elastomeric dampers is mandatory
- Experience in dynamic and vibration engine complex environnement analysis is mandatory
- Experience in test bench design and modification is mandatory
- Experience in endurance tests or other relevant tests contributing to risks abatment is mandatory
- Availability of test benches to support component test campaign is mandatory
- English langage is mandatory
- 3D modeling and 3D CFD
- Inspection means and expertise for quality assessment of produced part
- Material characterization especially for fatigue characteristics (HCF, LCF)
- 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 EMS able to be integrated on an actual scale 1 Flying Test Bed

Capabilities and track record

- Company qualified as an Aeronautic Supplier for Product Commercial Engine Parts
- Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSE, Part 21, Part 145)

Competences to deal with risks associated to the action:

- At SPD level :
  - Background in Research and Technology for aeronautics especially on EMS parts.
  - Background in delivery of instrumented part(s) or module(s) for scale 1 engine demonstrators, experience in design ,manufacturing and testing of EMS for SMR aircraft applications
- At applicant level:
  - Background in Research and Technology for aeronautics
  - Project Management capability for 10 M€ project
  - Quality Management capability for 10M€ project
  - Exchange of Technical Information through network: 3D models of parts, Interface Control Documents
  - 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

- Snecma will own the specification, while the Core Partner will own the technical solutions that he will implement into the corresponding subsystems.
- Snecma 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 Snecma. 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 Snecma 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.

5. Glossary

CfCP	Call for Core Partners
CROR	Counter Rotating Open Rotor
CS2	Clean Sky 2
CS2 JU	Clean Sky 2 Joint Undertaking
EC	European Commission
EMS	Engine Mount System
FTD	Flight Test Demonstrator
GTD	Ground Test Demonstrator
IADP	Innovative Aircraft Development platform
ITD	Integrated Technology Demonstrator
SPD	Strategic Platform Demonstrator
STD	Strategic Topic Description
TRL	Technology Readiness Level
WP	Work Package

II. Aircraft Configuration Studies and Demonstration (Scaled Flight testing, Instrumentation)

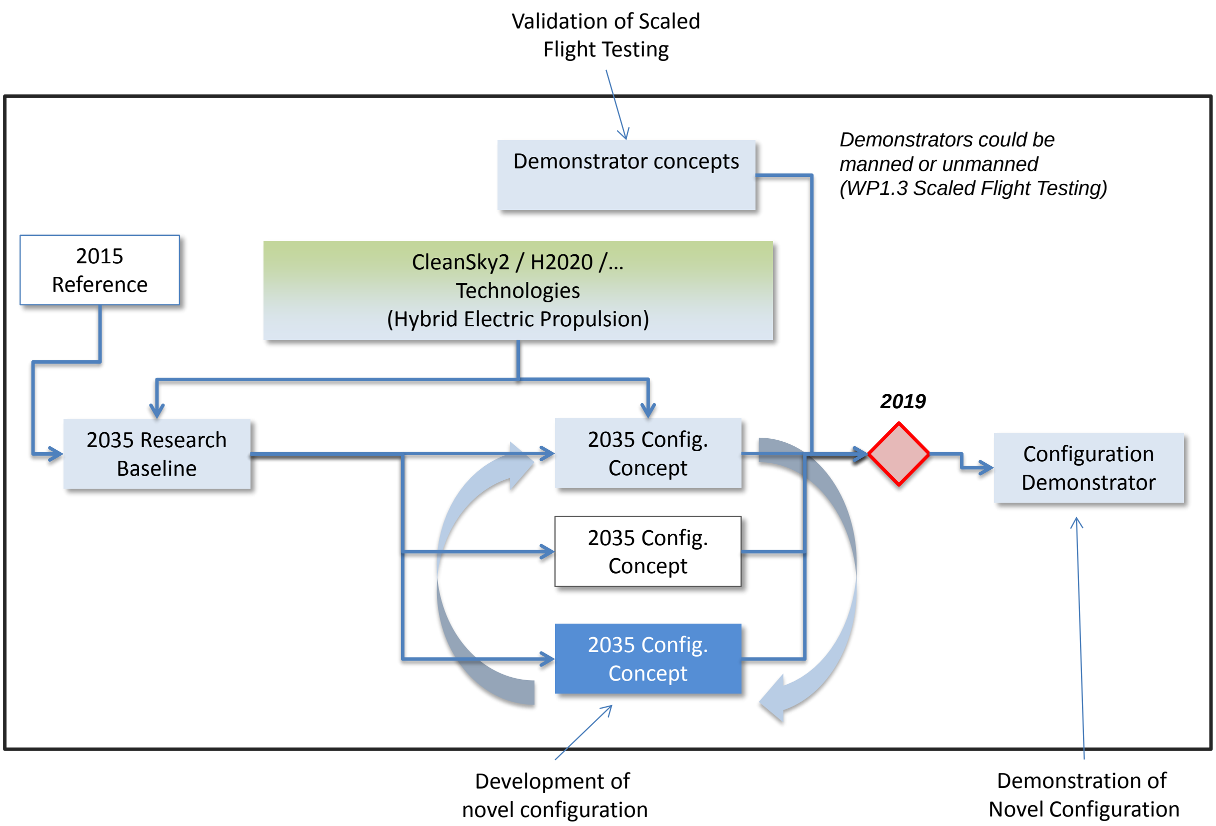
Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP 1.6 – Demonstration of Radical Aircraft Configuration WP 1.3 – Validation of Scaled Flight Testing		
Topic Leader	AIRBUS		
Indicative Funding Topic Value (in k€)	4000 k€		
Duration of the action (in Months)	72 months	**Indicative Start Date**[2]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-LPA-01-09	**Aircraft Configuration Studies and Demonstration (Scaled Flight testing, Instrumentation)**
Short description (3 lines)	
Under this task, Aircraft configuration studies (focus on Hybrid Electric Propulsion) are to be performed. For the demonstration of new configurations Scaled Flight Testing is to be validated (with focus on Instrumentation). The major part of activity relates to the design of the Alternative Energy Propulsion Architecture & Components (i.e Divergent Aircraft Configuration) and the demonstration of resulting configurations.	

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

1. Background

Under this topic, in WP 1.3 and 1.6, the applicant should develop radical novel aircraft configurations (with focus on Hybrid Electric Propulsion), participate in the development of demonstration means (Scaled Flight Testing) and in the demonstration of novel configurations.



The figure sketches out the planned development process for novel configurations and the areas were a participation of the applicant is seen.

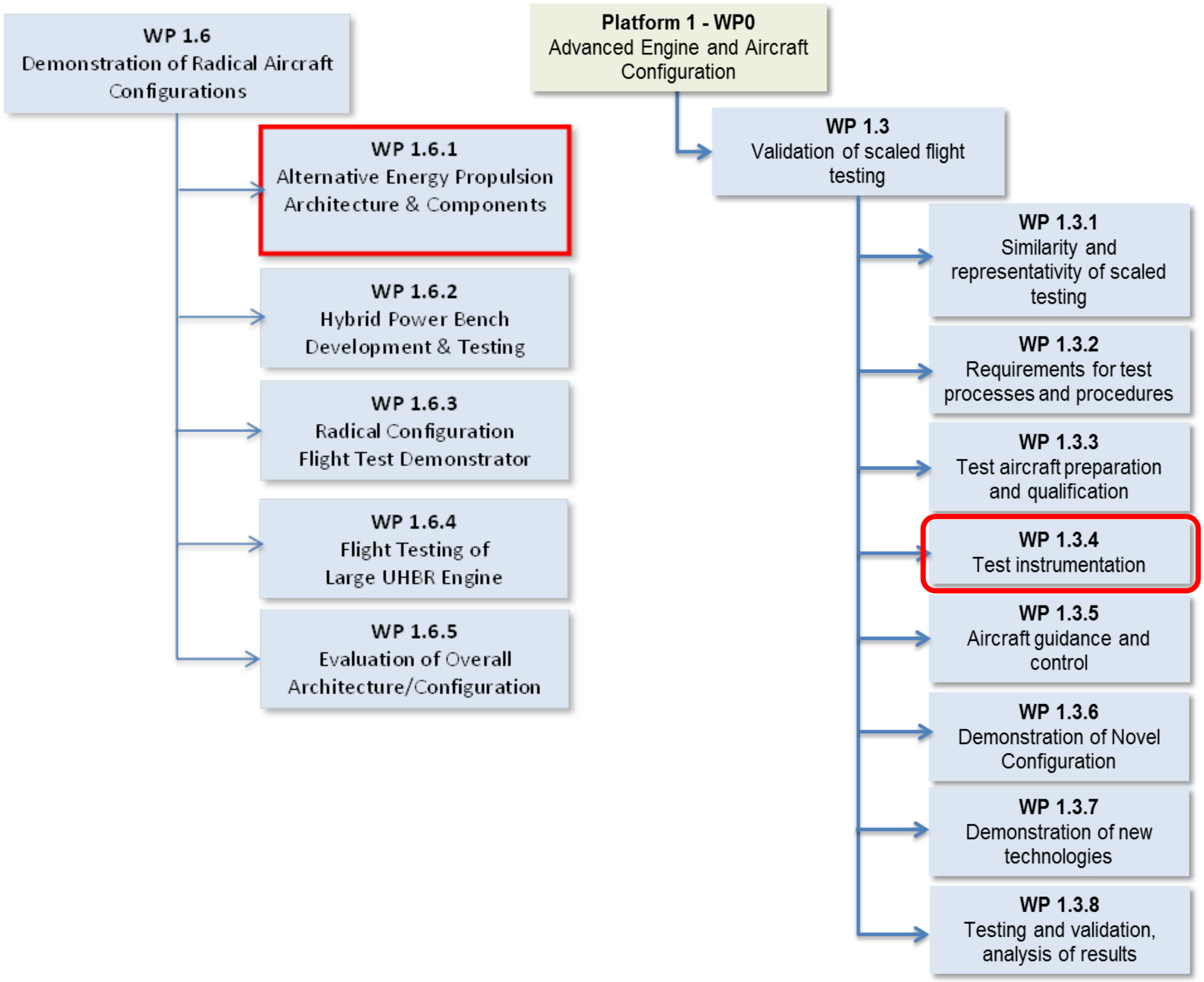
The applicant should participate in the divergent design phase for radical configurations up to a decision gate in 2019. This design phase will be fed with technology bricks from the Hybrid Propulsion demonstration (WP1.6.2) as well as from other parts of CleanSky2.

In parallel, as a new demonstration mean for configurations, *Scaled Flight Testing* is to be validated up to 2019 in WP1.3. The overall intention of work package 1.3 is the systematic proof of scaled flight testing as viable means to mature and validate new aircraft technologies and aircraft configurations to high levels of technology readiness and the representativeness of the results for full-scale vehicles. This includes the evaluation of the reliability and quality of this mean, including the definition of a principle set of standard rules and procedures for all contributing elements, for this topic especially the quality of the measurement instrumentation.

It is assumed that from flight testing some additional modifications to the instrumentation will result, which should be implemented.

The applicant could become part of the later evaluation of the Flight Test results against the predicted design performance.

The following diagrams indicate the location of the main work to be performed in the WBS of WP1.3 and WP1.6.



2. Scope of work

Scaled Flight Testing – Test Aircraft Instrumentation (WP1.3.4)

Development and build of the Flight Test Instrumentation (FTI) and matching ground equipment (ground station) for the validation of Scaled Flight Testing.

The focus in WP1.3 is on dynamically scaled flight testing of Large Passenger Aircraft configurations. From the identification of flight dynamics of a scaled model the dynamics of a real-scale aircraft, featuring a novel configuration, is to be projected. The validation of this technology is one of the objectives of WP1.3.

A matching flight test instrumentation (FTI), to capture the flight dynamics of a scaled model, is to be developed and build in WP1.3.4 by the successful partner. This includes the design of the FTI, the building, integration and test of the FTI.

The FTI should transmit data real time in flight. It is to be investigated if some integrated solution for both the data transmission and the vehicle guidance (WP1.3.5) can be found.

The duration of this task will be around 36 month from the start of this topic.

Alternative Energy Propulsion Architecture & Components – Divergent Aircraft Configuration (WP1.6.1)

Under this WP a conceptual aircraft configuration exercise will be performed, sketching up different aircraft concepts from the Large Passenger Aircraft sector.

Under this topic a successful partner will contribute to a conceptual aircraft design exercise. He will go through several design loops, using technology input from other parts of WP1.6 as well as from CleanSky2 as a whole. In these design loops the aircraft concepts are to be optimized, using multi-disciplinary optimization strategies as appropriate. Key areas of interest in WP1.6 are the Hybrid Electric Propulsion concepts and how from the integration additional overall benefit can be derived. The aircraft design work will be supported by several transversal support activities, which will be available to all design teams. A general information exchange between the design teams is welcomed.

The final down-selection of concepts (M1.6-6) to be continued will be done with input from industry side. This task will continue for 36-48 month.

A specific activity for this topic is the support to the demonstration of radical configurations beyond the down-selection of concepts. Depending on final down-selection of concepts and the outcome of the activities in WP1.3 'Scaled Flight Testing', the demonstration of a radical configuration will be continued in WP1.6. The demonstration means will then be decided, they could include Scaled Flight Testing, wind tunnel testing or full-scale flight testing. The successful partner is requested to contribute to these follow-on demonstration activities, which are planned to continue up to 72 months from contract start.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D-1.3.4-1	Matured Test Instrumentation (based on IEP)	D	T0+6
D-1.3.4-2	Test Instrumentation Review & Report	RM	T0+15
D-1.3.4-3	Modified Test Instrumentation (based on FT)	D	T0+18
D-1.3.4-4	Modified Test Instrumentation Review & Report	RM	T0+30
D 1.6.1.5-04	Concepts proposal	RM	T0+12
D 1.6.1.5-07	Concepts from 1st loop	RM	T0+24
D 1.6.1.5-10	Concepts, 2nd loop	RM	T0+36
D 1.6.1.6-01	(contribution to) Validation & Verification Plan for Demonstrator	R	T0+48
D 1.6.1.6-02	(contribution to) Conceptual Engineering Review (CER)	RM	T0+54
D 1.6.1.6-03	(contribution to) Preliminary Design Review (PDR)	RM	T0+60
D 1.6.1.6-04	(contribution to) Critical Design Review (CDR)	RM	T0+66
D 1.6.1.6-04	(contribution to) Components available	D	T0+72

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M-1.3-1	Freeze of principle flight test procedures	RM	T0+12
M-1.3-2	Test A/C ready	D	T0+15
M-1.3-3	First Flight	D	T0+18
M-1.3-4	1st flight test campaign completed	RM	T0+28
M-1.3-5	2nd flight test campaign completed	RM	T0+36
M-1.6-1	Technologies selected	RM	T0+36
M-1.6-6	G2 Architecture converged	RM	T0+48
M-1.6-7	CER (Radical Configuration emonstration vehicle)	RM	T0+54
M-1.6-8	PDR (Radical Configuration demonstration vehicle)	RM	T0+60
M-1.6-9	CDR (Radical Configuration demonstration vehicle)	RM	T0+66
M-1.6-10	Demo Vehicle complete	D	T0+72

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

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

The ideal partner is expected to have proven track record of participation in European funded programmes with industrial participation and either have established research programmes or have a strong commitment to further develop research groups capable of actively supporting the industrial partners. The partner will have demonstrable capabilities within the aerospace sector and will have access either directly or through their supply chain to address all the areas required as part of this call.

The successful partner is required to have experience in the following fields:

- instrumentation for remotely controlled vehicles for dynamically scaled Flight testing / Radical Aircraft Configurations
- test instrumentation for various flight physics related parameters, including the identification of flight dynamics
- experience in conceptual aircraft design studies for Large Passenger Aircraft, including multi-disciplinary optimisation

5. Glossary

A/C	Aircraft
FTI	Flight Test Instrumentation

III. Aircraft and Hybrid Propulsion System Architecture, Integration and Verification

Type of action (RIA or IA)	IA		
Programme Area	LPA Platform 1		
Joint Technical Programme (JTP) Ref.	WP 1.6 – Demonstration of Radical Aircraft Configuration WP 1.3 – Validation of Scaled Flight Testing		
Topic Leader	AIRBUS		
Indicative Funding Topic Value (in k€)	5000 k€		
Duration of the action (in Months)	48 months	**Indicative Start Date**[3]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-LPA-01-10	**Aircraft and Hybrid Propulsion System Architecture, Integration and Verification**
Short description (3 lines)	
The current proposal is aimed at development of tools and methods for design, optimisation and verification of various hybrid propulsion systems and their integration into a new radical aircraft configuration that will be developed and demonstrated in WP1.6 of LPA IADP.	

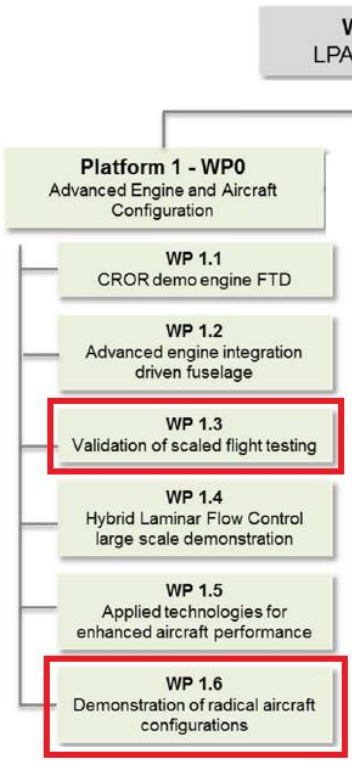
[3] The start date corresponds to actual start date with all legal documents in place.

1. Background

In order to meet Flightpath 2050 targets, optimizations of engines and aircraft in isolation are unlikely to yield required levels of improvements and more integrated designs will be required. The most optimum solutions are likely to benefit from distributed propulsion concepts that will not only increase propulsive efficiencies, but will also improve aircraft's aerodynamic characteristics by providing propulsive force when and where required. The key enabler for distributed propulsion is the hybrid power transmission, which will efficiently distribute the power to a number of remote propulsors.

Ability to decouple the direct link between the thrust and power production also opens up the space for a novel engine designs and installations that are not limited by the current constraints. In addition, a more intelligent power management on the aircraft level and elimination of the most challenging sizing cases for the power system that have to complied with today. In order to open up this new design space, a number of challenges have to be first understood and then overcome, and because of that the Work Area Leader (WAL) is looking for collaborative research partner(s) capable of supporting a joint research project on the radical new aircraft configuration for entry into service after year 2030.

This strategic theme covers two work packages within Large Passenger Aircraft – Platform 1: WP1.3 – Validation of scaled flight testing and WP1.6 – Demonstration of radical aircraft configurations as shown below.



In WP1.3 a scaled test vehicle will be developed including a complete flight test environment (vehicle, ground equipment, data process and data link), principle rules and processes for operation and operators, to ensure an absolutely robust, reliable and safe research tool on industrial standard. The configuration should be derived taking into account recent findings from other WPs of Clean Sky 2, to prepare for any flight demonstration as a part of WP1.6. The assessment includes designing and building new parts, flight-testing them and evaluating the results.

In WP1.6 the overall aircraft architecture will be a result of the opened design space, which will be populated with different aircraft and propulsion system concepts. An approach with different teams, competing in parallel activities, is envisaged. A successful Core Partner is expected to lead or participate in one of such teams using the building blocks provided by industrial partners. The building blocks may for example include different types of propulsors or gas turbine generators.

Furthermore, development of tools and methods for design, analysis and optimisation of propulsors utilizing hybrid drive systems will take place as well as their integration into a new radical aircraft configuration that will be developed and demonstrated in WP1.6 of LPA IADP. The primary areas of expertise are in the following research areas: fan/propeller design, aeroacoustics, electrical power systems, thermal management systems and aircraft design and integration. The activities in this work package will lead up to the end of 2019 decision gate and will involve the demonstration of novel propulsion concepts.

2. Scope of work

This strategic theme can be divided into 3 work streams that are closely linked together and will eventually merge in the flight test phase of WP1.6.

In the first work stream a scaled test vehicle is to be developed in WP1.3 bearing in mind that the same vehicle may be re-used in the flight demonstration within WP1.6. The core partner is expected to contribute to preparation and execution of the flight demonstration in both work packages in particular focusing on Development and Implementation of a guidance system for Validation of Scaled Flight Testing.
The requirement and architecture of the flight test vehicle guidance system will be based on input from the initial work within WP1.3.. This is seen as an area for improvement in relation former approaches, relying on line-of-sight radio control guidance of the vehicle. A better approach could involve a ground station with forward vision. With forward-vision a higher data rate is required, so a different data transmission may be useful. Also a higher integration with measurement data transmission has to be explored.
Different guidance and control concepts have to be explored and a viable solution has to be selected and implemented in the vehicle. This has to be performed in close collaboration with other sub packages of WP1.3. It is assumed that from flight testing some additional modifications to the guidance system will result, which should be implemented accordingly.

This work is expected to take up to 48 months and result in Deliverables 1.1 through 1.4.

In the second work stream, a successful Core Partner is expected to perform a conceptual design of novel aircraft configurations in order to populate design space with different aircraft and propulsion system concepts. The design exercise will use the building blocks provided by industrial partners. The building blocks may for example include different types of propulsors or gas turbines generators with specific scaling rules.
Assessment of the proposed configurations will be performed using agreed methodology and will have to meet requirements set by the industrial partners. The ultimate evaluation will be performed jointly by the industrial partners. The down-selected concepts will be further developed in the follow up activities and may also be demonstrated within WP1.6.
This work is expected to last at least until the decision gate in 2019.

The third work stream is related to design of novel propulsors utilizing hybrid drive. This hybrid drive and attached propulsors will be then demonstrated on the WP1.3/WP1.6 test vehicle. The successful core partner is expected to contribute to development of propulsor units based on the work area leader requirements and also any requirements that are flowed down from the conceptual aircraft design in the workstream 2. A number of tasks are needed to successfully execute this novel propulsor design and its successful integration into the aircraft configuration. A succssful partnr is also expected to issue and manage additional calls for proposals in support of these or any other arising tasks if needed. A number of different technologies need to come together in order to develop the novel propulsors. This is illustrated in Figures 1 and 2.

For example, the embedded fans that are expected to see high levels of inlet flow distortion and need to be designed bearing in mind their effectiveness on the more radical aircraft configuration. Novel installations are likely to expose these fans to the inlet flow with large areas of separated flow. Ability to control the flow to ensure safe and reliable operation of these fans is of high importance. Interaction between these inlet distortions and fans as well as their installation on a more radical aircraft configuration is going to affect their noise signatures. Finally, to achieve the optimum performance all the attributes in terms of overall efficiency, weight and reliability, the hybrid drive have to be designed and optimised in an integrated manner as shown in Figure 2.

Any work done on a more integrated propulsor installations is expected to be also applicable to novel engine installations where engines may be partially or fully embedded into the more radical aircraft configurations. A more detailed breakdown of required work is provided in the remainder of this section.

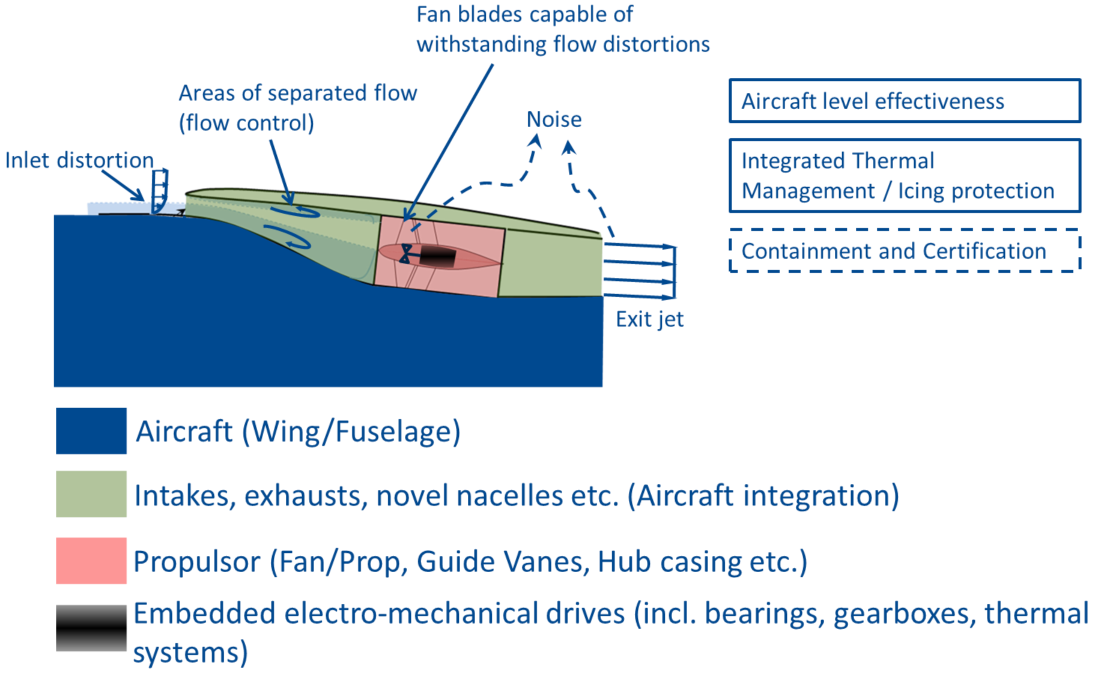


Figure 1: Design and Integration of Novel Propulsors

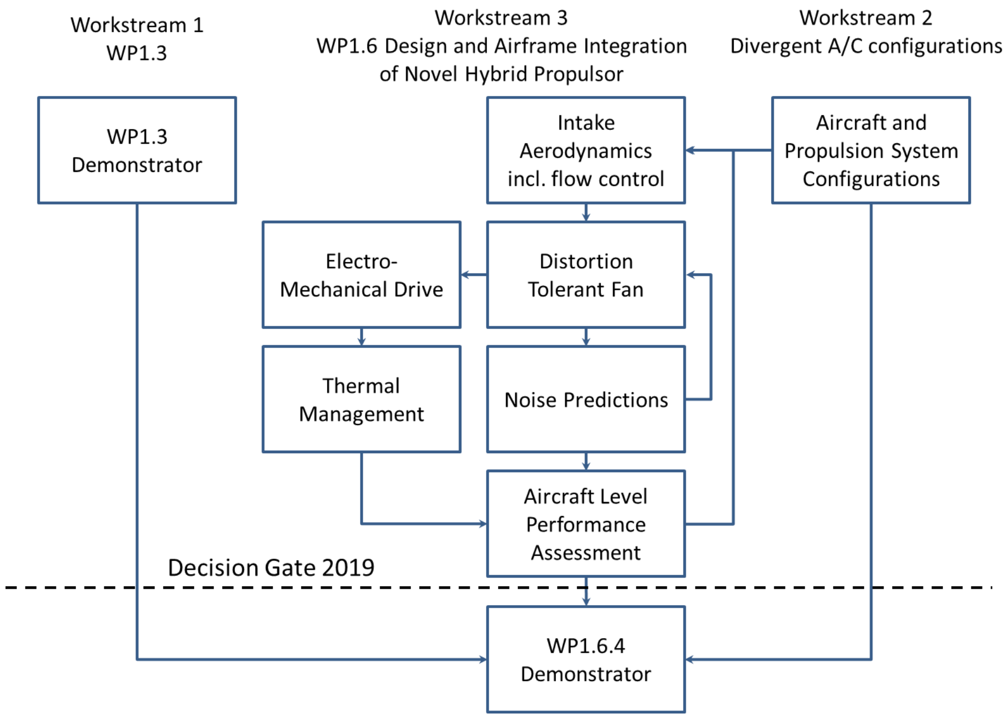


Figure 2: Interaction between different workstreams and tasks

Design and validation of fans exposed to high levels of inlet flow distortions

In a highly integrated aircraft configuration the propulsors are interacting significantly with the airframe surfaces and therefore the fans may run continuously with severe inlet distortion. This leads to challenges in maintaining the fan system efficiency, operability and life. This task will provide aeromechanical design and optimisations of various propulsor solutions. Detailed requirements will be agreed with the topic leader after the project starts. While the majority of the work may be based on computational methods, a capability and demonstrated experience of experimentally validating the methods is of key importance to the programme success.

Key areas of interest include:

- Development of Fan rotor design tool to allow for non-uniform stagnation pressure inlet profiles including aerodynamic and forcing effects mitigation strategy.
- Validation of designs proposed through analytical and experimental investigation in order to validate predicted flowfield and fan efficiencies.
- Contributions to broader understanding of boundary layer ingesting (BLI) propulsion system configurations and how the overall propulsive energy changes depending on amount of massflow, boundary layer and momentum deficit ingested.

The results from this study will also feed into noise assessment and installations effects related to inlet duct and integration of nozzles with the airframe. The study should also to identify new risks and opportunities that may require further high detail investigation in the future.
This work is expected to take up to 42 months and result in Deliverables 2.1 through 2.3.

Assessment of noise signatures for novel propulsor installations

This work is expected to provide the assessment of noise signatures for different configurations. In the initial phase the focus will be on the interaction of inlet distortions and propulsor (i.e. fan), engine noise signatures and to identify any potential operational limitations of boundary layer ingesting fans especially related to take-off and approach phases of flight. This will be performed using the output of high-fidelity CFD results to be supplied by either the work area leader or as a part of fan design discussed previously.
Furthermore, for a more radical configuration novel installations of main engines and propulsors are likely to provide advantages with respect to perceived noise levels on the ground in vicinity of airport. This task should generate an analytical toolset for quick assessment of novel engine/propulsor installations to reduce the noise levels and enable tradeoff between aerodynamic benefits and noise for a range of configurations assessed in this work package.
Based on evolving project requirements this task may be expanded to develop specific noise prediction capability at aircraft platform level including the hybrid propulsion system.
This work is expected to start after preliminary fan design is complete and is expected to take up to 24 months and deliver assessment in a report (deliverable 3.1).

Development of advanced analytical tool for effectiveness of propulsors integrated into radical aircraft configurations

Radical aircraft configurations may benefit from unconventional propulsor installations aimed at reducing or increasing drag on aircraft depending on flight phase or and also increasing the lift during both takeoff and landing. In order to optimise the the type, number and positions of these propulsor and their impact on aircraft characteristics, an analytical tool will be required in the early conceptual design phase of a novel propulsion system.

This task will develop a tool capable of quickly estimating aircraft level benefits based on limited number of inputs such as the size, shape and flight condition. Detailed requirements will be agreed with the topic leader after the project starts.

As a part of this task a more detailed computational studies may be required to calibrate the tool against particular design solutions in particular related to performance of inlets and exhausts from propulsors or any embedded engines. Access to either existing facilities or previous results which can be used to validate these simulations is essential. No major experimental work is expected under this task although in follow on call for partners or revision of the existing one may be needed. This will be decided by the topic leader at a later point. It is also envisaged that the work will provide the inlet boundary conditions for propulsors and engines and thus enable a more detailed fan design performed and also aircraft level performance assessments helping to understand where the benefits are coming from.

This work is expected is expected to take up to 42 months and to produce deliverables D4.1 and D4.2.

Development, validation and demonstration of electrical power systems for hybrid propulsion

Hybrid-electric aerospace propulsion will require a step change in electrical transmission systems in the aerospace sector. The Core Partner is required to support the work area leader and the rest of the consortium in studying the potential implications to the electrical solution is to be undertaken. This task will focus on electrical machines with their associated conversion equipment and architectural interfaces (i.e. mechanical, electrical, thermal and control). In order to develop later to validate and demonstrate the new hybrid propulsion system, the work will consist of the following three subtasks:

- Support the industrial partners and consortium in aircraft electrical integration and ongoing optimisation, specifically in regard to the propulsion and power generation system with the specific focus on implications of higher voltage solutions. It is highly desirable that the study conclusions are validated/ demonstrated on laboratory based rigs.
- Perform 2035 electrical machine and, if applicable, associated power converter detailed design studies against different requirements to be defined by the industrial partners. It is anticipated there will be 4/5 different studies undertaken.
- Develop control concepts for propulsion motor and gas turbine power generation systems.

- Validate and demonstrate these concepts through laboratory based rigs including assessment of the impacts on the electrical, thermal and mechanical systems.

This work is expected is expected to take up to 48 months and to produce deliverables D5.1 through D5.6. Any EMC issues and health & safety implications on maintenance and operational activities should be identified as a part of activities for the future follow up work.

Novel intake or nacelle aerodynamics and demonstration of separation suppression in adverse pressure gradient regions

This task will undertake experimental and computational analysis on pressure gradient driven separations on advanced intake configurations or external surfaces of embedded propulsors. Detailed requirements will be agreed with the topic leader after the project starts, but it is envisaged that first proposed configurations will be analysed and redesigned without resorting to any form of passive or active flow control.

System solutions to alleviate any operational limitations will be explored as a part of this project. These solutions may include different forms of flow control, but their effectiveness in reducing the pressure losses and flow non-uniformity should be traded against the weight and complexity of those solutions against the overall system performance.

The analysis should emulate the presence of a downstream fan and a realistic inlet flow profiles that should take into account presence of the boundary layer and any distortions during different flight phases (e.g. takeoff rotation). This programme of work should aim to quantify the level of flow control required to demonstrate the novel intakes/diffusers or on the novel nacelle. In addition CFD studies should be conducted to investigate simulation of the experimental results to provide design guidelines.

This work is expected is expected to take up to 48 months and to produce deliverables D6.1 through D6.3.

Development of integrated thermal management systems

Radical aircraft configurations may require the transmission of power to unconventional propulsor installations. Inefficiencies in the power transmission will add to the heat load that must be dissipated from the aircraft. This task should undertake initial studies aimed to identify the system solutions required to yield an integrated aircraft thermal management system. The system solutions should be able to deal with the existing thermal management challenges of providing environmental control for passengers, heat dissipation from on-board electrical loads as well as new heat loads from transmission of high power loads and the heat requirements associated with engine, nacelle and aircraft anti-ice systems.

This task should aim to identify system solutions and subsequent activities to validate and verify the system designs within the first 24 months (Deliverables 7.1 and 7.2). Based on these initial recommendations follow up activities will be agreed.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1.1	A/C Guidance and Control System Design (first loop)	H/S	T0 + 12 months
D1.2	A/C Guidance and Control System Review & Report (first loop)	R	T0 + 18 months
D1.3	A/C Guidance and Control Design (based on flight test)	H/S	T0 + 30 months
D1.4	Matured A/C Guidance and Control System Review & Report	R	T0 + 42 months
D2.1	Literature review reported and baseline fan design agreed.	RM	T0 + 6 months
D2.2	Preliminary results for noise and performance assessment.	R	T0 + 18 months
D2.3	Flow distortion compliant fan rotor aeromechanical design validated and methodology reported.	R; H/S	T0 + 42 months
D3.1	Noise assessment completed and reported for implementation in the tool developed under Task 4. Recommendations for further research identified.	Report	T0 + 42 months
D4.1	Preliminary toolset and progress report	RM; H/S	T0 + 9 months
D4.2	Validated tool reported and available for use	R; H/S	T0 + 42 months
D5.1	Progress report on assessment of higher voltage solutions, EMC issues and health & safety implications on maintenance and operational activities.	R	T0 + 24 months
D5.2	Final report on assessment of higher voltage solutions, EMC issues and health & safety implications on maintenance and operational activities. Risk reduction actions recommended.	R	T0 + 42 months
D5.3	Progress report on 2035 electrical machine and associated power converter detailed design studies. Proposal for lab demonstration presented.	R	T0 + 24 months
D5.4	Final report on 2035 electrical machine and associated power converter detailed design studies.	R	T0 + 42 months
D5.5	Propose initial baseline concept for a control system for propulsion motor and gas turbine power generation systems	R	T0 + 24 months
D5.6	Report on validation and demonstration of integrated control system solutions through laboratory based rigs including assessment of the impacts on the electrical, thermal and mechanical systems.	R	T0 + 42 months
D6.1	Assessment of baseline configurations	R	T0 + 12 months
D6.2	Assessment of selected configurations benefiting from advanced system solutions or flow control	R	T0 + 24 months

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D6.3	Applicability of flow control method on novel nacelles reported.	R	T0 + 42 months
D7.1	Proposal identifying the opportunities for a more detailed conceptual design presented.	RM	T0 + 12 months
D7.2	System solutions and subsequent activities to validate and verify the system designs are reported.	R	T0 + 24 months

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M1	Management structure in place. *Requirements, deliverables, and level of spend and dissemination agreed.*	RM	T0 + 6 months
M2	Progress review to be held.	RM	T0 + 24 months
M3	Final review.	RM	T0 + 48 months

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

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

The ideal partner is expected to have proven track record of participation in the European funded programmes with industrial participation and either have established research programmes or have a strong commitment to further develop research groups capable of actively supporting the industrial partners. The partner will have demonstrable capabilities within the aerospace sector and will have access either directly or through their supply chain to address all the areas required as part of this call.

It is imperative that a successful partner demonstrates their willingness and ability to meet evolving requirements set by the industrial partners due to the dynamic nature of the project.

The following is the list of special skills and capabilities expected from the successful partner:

- Demonstrated experience in conceptual aircraft design
- Capability in computational modelling and experimental testing of various propulsor solutions (ducted and unducted fans with or without inlet distortions).
- Experience in aeromechanical design and optimisations of such fans.
- Experience in assessing noise propulsor/engine noise signatures and potential operational limitations especially related to takeoff and approach phases of flight.
- Experience in analytical, computational and experimental assessments of various aircraft-

propulsor-engine configurations and method. Access to or plans to develop tools to allow novel design optimisations.

- Experience in electrical power systems to provide electrical power system architecture and specifications as well as both steady state and transient modelling capability. It is essential that the partners have existing methods to validate higher voltage implications and overall integrated aerospace power and propulsion test rigs to validate control strategies. It is desirable that partners have other subscale rigs and demonstrators to support the programme.
- Experience in guidance systems for scaled vehicles for Dynamically Scaled Flight Testing / Radical Aircraft Configurations.

5. Glossary

BLI	Boundary Layer Ingestion
EMC	Electro Magnetic Compatibility

2. Clean Sky 2 – Regional Aircraft IADP

No topic launched in this Call.

3. Clean Sky 2 – Fast Rotorcraft IADP

I. Design, Development, Testing and Flight Qualification of Smart Fly-By-Wire Actuators for Primary Flight Control of a Civil Tiltrotor

Type of action (RIA or IA)	IA		
Programme Area	FRC (Tilt-Rotor)		
Joint Technical Programme (JTP) Ref.	WP Level 1 [WP 1.1, WP1.2, WP1.6]		
Topic Leader	AGUSTAWESTLAND		
Indicative Funding Topic Value (in k€)	3500 k€		
Duration of the action (in Months)	68 months	**Indicative Start Date**[4]	Q4 2016

Identification	Title
JTI-CS2-2015-CPW03-FRC-01-01	**Design, Development, Testing and Flight Qualification of Smart Fly-By-Wire Actuators for Primary Flight Control of a Civil Tiltrotor**
Short description (3 lines)	
Design, development, manufacture and qualification of smart fly-by-wire actuators for swashplate, control surface and tilting wing / large flap actuation. Focus shall be initially put on trade-off analysis between existing actuation technologies (mainly EHSV, EHA and EMA) and on system redundancy complemented by either functional or technological dissimilarity or a suitable mix of both. The final units will be integrated in the tiltrotor demonstrator.	

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

1. Background

In the framework of Clean Sky 2 FRC IADP, the present Call requires Partner(s) (company or consortium) to provide innovative engineering solutions for the Tiltrotor NextGen CTR demonstrator primary actuation systems. The present document describes also the general requirements that JU shall consider for the selection of the appropriate Partner(s) for this novel actuation system development.

Fly-by-wire is nowadays a mature technology for both civil fixed and rotary wing applications and it is considered mandatory to achieve the most efficient control and management of such a high number of actuation devices. Nevertheless, in order to meet the general objectives of the IAPD in terms of ease of operability and maintenance cost reduction, minimization of the environmental impact of the aircraft operation and maintenance through bigger use of electrical systems with a concurrent minimization of traditional hydraulic systems (particularly the traditional centralized hydraulic lines), a further technological breakthrough is deemed necessary. Hence innovative engineering concepts must be embedded in the design of this novel actuation system:

- Use of "more electric" actuation: the chosen actuator technology shall dispense with traditional hydraulic power distribution concepts relying upon centralized power modules. The hydraulic oil volume used onboard shall be minimized, and the use of environmental friendly hydraulic fluids (non-petroleum based) shall be considered.
- Use of "smart" actuation concept: the actuator electronics, developed concurrently with the actuator HW, shall be either integrated in the servo-actuator or anyway placed in close proximity of the flight control surface. This actuator electronic unit will be in charge of closing the position control loop of the servo-actuator (including also force and/or electrical equalization loops depending on actuator architecture), performing BIT (Built-In-Test) for fault detection and isolation, and various maintenance support functions. The servo-electronics will be interfaced with the aircraft Flight Control Computers through reliable high speed digital data-buses such as Can-Bus (ARINC 825 aerospace standard). The data-bus will be used to exchange positional command, operating modes, and actuation system status between the FCCs and the ACUs (Actuator Control Units). The "smart" actuation concept will significantly improve the Flight Control System flexibility, its failure detection capability and it will ease the system maintenance tasks.

2. Scope of work

The main objective of this technology line is to design, develop, and manufacture the primary fly-by-wire actuators for the NGCTR flying demonstrator. The activity shall therefore culminate with the integration of the actuation system into the NGCTR vehicle and the achievement of SOF (Safety of Flight) qualification of the equipments in order to allow the demonstrator flying activities.

The NGCTR flight control actuation system is anticipated to be composed by a number of independent, local systems managing specific functions.
In this view, the subject actuators shall be designed in such a way that the main system functionalities are guaranteed (swash-plate, tail control surfaces, wing actuation, landing gear extension / retraction / uplock / breaking) throughout the whole flight envelope whilst ensuring adequate safety levels.

The Tiltrotor NextGen CTR primary actuation system will comprise the following items:

Actuator	Actuator class (power, thrust, stroke, small amplitude bandwidth)	Foreseen possible technologies & architectures
Prop-rotor swash-plate actuators (collective, longitudinal cyclic and lateral cyclic)	≈5 kW, ≈64kN, 200÷400mm, ≈8 Hz	Electro-hydraulic (e.g. EHSV, DDV, EBHA) – hydraulic pump on transmission 2x3 dual-triplex tandem (i.e. hydraulically duplex, electrically triplex) plus switching valve, triplex-triplex parallel, etc.
Roll control actuators / Wing conversion actuator	≈3 kW, ≈24kN, 100÷200mm, ≈5 Hz	Electro-hydraulic (e.g. EHSV, DDV, EBHA) - hydraulic pump on transmission or Electro-mechanical (EMA) 2x3 simplex-simplex parallel, 2x two simplex-simplex and one simplex EMA in parallel, etc.
Nacelle conversion actuators	≈6 kW, ≈160kN, 800÷1000mm, ≈3 ÷ 5 Hz	Ball-screw Electro-hydraulic (e.g. EHSV, DDV, EBHA) - hydraulic pump on transmission or Electro-mechanical (EMA) 2x dual-triplex, 2x triplex EMA, 2x simplex-duplex + backup, etc.
Elevator actuators / Rudder actuators	≈3 kW, ≈32kN, 40÷120mm, ≈5 ÷ 8 Hz	Electro-hydrostatic (EHA) or Electro-mechanical (EMA) Three simplex-simplex EHA parallel, two simplex-simplex EHA and one simplex EMA in parallel, etc.

At the beginning of the present research and development activity, the Applicant/s will be required to evaluate the state-of-art in both electro-mechanical (EMA) and electro-hydraulic actuators (including but not limited to EHSV, DDV, EHA and EBHA) and perform a trade-off analysis between the various existing and emerging actuation technologies by taking into account the specific NGCTR high-level system and safety requirements, and Key Performance Parameters (KPP). Having in mind the constraints dictated by system safety / reliability and required performances, a particular emphasis will be put on maximization of power efficiency and minimization of actuator size.

The applicant will also emphasize the design modularity between the different state-of-art solutions, focusing on, but not limiting to:

- Integration of different state-of-art solutions into one modular 'expandable-on-demand' design.
- Interchangeability and commonality of the modular hardware between different functionalities (hydraulic, mechanical, electronic) and applications (rotor controls, surfaces control) based on a 'plug-and-play' philosophy.

Starting from this preliminary exploration task the Applicant/s will be requested to interact closely with WAL specialists to choose the most suitable actuation system configuration and to harmonize the electrical and hydraulic interfaces.

The physical redundancies and the safety provisions of actuation system (by-pass valves, anti-jamming mechanisms, etc.) shall be commensurate with the hazard classification for overall flight control system loss event (i.e. CAT, 10^{-9}/FH failure rate), namely each actuator shall provide a two-fail operating capability. In order to improve the overall system reliability and safety, it is highly recommended to enforce dissimilarity at the maximum extent in the design. This goal can be achieved with a twofold approach, i.e.:

- At system level and thanks to inherent Tiltrotor's over-actuated configuration, by introducing and exploiting functional dissimilarity where possible, in order to complement the physical redundancies (i.e. flight controls can be reconfigured), and
- At sub-system level (flight control actuator) by sharing the design and development task between two or more Partners, each of them specialized in a specific technology. For instance, should a triplex arrangement be considered necessary by the safety case for aileron actuator, a dissimilar implementation may consist in a duplex electro-hydraulic actuator complemented by a simplex EMA. The coordination between the Partner(s), their sub-Suppliers, and the WAL should be ideally carried out according to SAE-ARP-5007A guidelines.

A system modeling and simulation tool shall also be developed for integration in a full-aircraft avionic test bench.

Low maintenance effort and easy accessibility for inspections shall also be considered.

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

Tasks		
Ref. No.	***Title - Description***	***Due Date*** [T0+mm]
T1	Trade-off analysis across existing and emerging actuator technologies, concept exploration starting from high-level system requirements; definition of system configuration and detailed system requirements in support of Actuation System Requirement Review.	T0+2
T2	Development of selected system configuration and support of actuation system Preliminary Design Review. Preliminary digital mock-up models (DMU) and simulation models are prepared in support of PDR.	T0+6
T3	Definition and development of detailed HW (actuators and ACUs) and SW design (ACUs embedded SW), support to actuation system Critical Design Review; the simulation models undergo a significant review and refinement process, the level of complexity is agreed between WAL and the Partner/s.	T0+18
T4	Implementation of HW/SW design consolidated at CDR. The HW is manufactured (mock-ups / A models), the SW coded and tested, and the system is experimentally validated at Partner's premises. The simulation models are validated against the experimental data.	T0+30
T5	Fully representative rig units (B1 models – EFA candidates) are manufactured, incorporating feedbacks from A models into B1 design standard. Support to WAL for actuation system integration into Flight Control System rig and into TDH (Tied Down Helicopter), at WAL's facility.	T0+38
T6	Agreement of qualification test procedures and support to actuation system Test Readiness Review for EFA qualification.	T0+48
T7	EFA qualification testing (environmental and functional qualification of HW, formal SW testing and qualification), post-processing of qualification data and Vehicle Ground Testing results. Manufacturing of EFA flight-worthy units (B2 models) for WAL, incorporating possible feedbacks coming from qualification activities into B1 design standard. Preparation of Qualification Test Reports and Declaration of Design and Performances (DDP) to allow start-up of experimental flight trials.	T0+56
T8	Support to IADP flight activities and continued airworthiness (PRs closure and support to flight data analysis); conclusion	T0+68

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D1	Trade-off analysis / Concept Exploration & Definition	R	T0+2
D2	Configuration development and Preliminary Design Review deliverables	R / D	T0+6
D3	Detailed HW and SW design, Critical Design Review deliverables	R / D	T0+18

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date*** [T0+mm]
D4	Validation Reports	R	T0+30
D5	Validated Simulation Models	D	T0+30
D6	Fully representative rig units (EFA candidates, B1 models), provided with a Preliminary DDP	D	T0+38
D7	Technical documentation supporting TRR, Qualification Test Plan and Procedures	R	T0+48
D8	Qualification Test Reports, EFA DDP	R	T0+56
D9	EFA shipset (B2 models) and spare units	D	T0+56
D10	Amended design documents according to flight trials results	R	T0+68

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date*** [T0+mm]
M1	System Requirement Review	RM	T0+2
M2	Preliminary Design Review	RM	T0+6
M3	Critical Design Review	RM	T0+18
M4	Test Readiness Review	RM	T0+48
M5	Experimental Flight Approval	R / D	T0+56

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

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

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

- Compliance to SAE AS9100.
- Experience of aeronautic rules, certification processes and quality requirements.
- Experience in design, validation, manufacturing and environmental/functional qualification of airborne equipments, either actuation systems, avionic systems (embedding complex HW and DAL-A SW) or both, according to RTCA-DO-160, RTCA-DO-178 and RTCA-DO-254 (or other civil or military equivalent standards) for safety critical equipments.
- Familiarity with EMI compatibility issues: capacity to design complex electronic HW in compliance with EMC guidelines, and experience in performing EMC justification analyses and experimental assessments according to RTCA-D0-160, EUROCAE ED-107/ARP-5583, ED-81/ARP-5413 and ED-84/ARP-5412 or equivalent civil or military standards (TBC).
- Experience in research, development and manufacturing in the following technology fields:
    - Conventional FBW actuators with electro-hydraulic servovalves (EHSV or DDV),

- Self-contained, electrically powered, FBW electro-hydrostatic actuators (EHA and EBHA),
  - High-performance brushless or variable reluctance electrical motors, direct-drive ball-screw, or hinge-line EMA,
  - Smart actuation and actuator control electronics.
- Well proven engineering and quality procedures capable to produce the necessary documentation and means of compliance to achieve the “Safety of Flight” with the applicable Airworthiness Authorities (FAA, EASA, etc.).
- Design Organization Approval (DOA) desirable.
- Experience in Safety assessment process according to SAE-ARP-4754 and SAE-ARP-4761 standards, willingness to interact closely with WAL safety specialists in order to produce the necessary outputs (safety and reliability reports and fault trees/analyses).
- Shape, component design and structural analysis using CATIA v5 and NASTRAN.
- Capacity to optimize the HW and SW design, to model mathematically/numerically complex mechatronic systems with suitable simulation tools (Matlab/Simulink, Dymola/Modelica, etc.) and to analyze both simulation and experimental results to ensure that the various required performance goals are met.
- Capacity to repair “in-shop” equipment due to manufacturing deviations.

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

5. Glossary

ACU	Actuator Control Unit
BIT	Built In Test
CAN	Controller Area Network
CDR	Critical Design Review
CS2	Clean Sky 2
DAL	Design Assurance Level
DDP	Declaration of Design and Performance
DDV	Direct Drive Valve
DMU	Digital Mock Up
DOA	Design Organization Approval
EBHA	Electrical Backup Hydraulic Actuator
EFA	Experimental Flight Approval
EHA	Electro-Hydrostatic Actuator
EHSV	Electro-Hydraulic Servo-Valve
EMA	Electro Mechanical Actuator
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference

FBW	Fly By Wire
FRC	Fast RotorCraft
IADP	Innovative Aircraft Demonstrator Platform
ITD	Integrated Technology Demonstrator
JU	Joint Undertaking
FPP	Key Performance Parameters
NDA	Non Disclosure Agreement
NGCTR	Next Generation Civil TiltRotor
PDR	Preliminary Design Review
PR	Problem Report
SOF	Safety of Flight
SRR	System Requirement Review
TBC	To Be Confirmed
TBD	To Be Defined
TRR	Test Readiness Review
WAL	Work Area Leader

II. New Generation Landing Gear for a Compound Fast Rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.3 – Landing System		
Topic Leader	AIRBUS HELICOPTERS		
Indicative Funding Topic Value (in k€)	3500 k€		
Duration of the action (in Months)	51 months	**Indicative Start Date**[5]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-FRC-02-03	**New Generation Landing Gear for a Compound Fast Rotorcraft**
Short description (3 lines)	
The aim of this Strategic Topic is to design, develop, manufacture, test and qualify up to permit to fly (TRL6) a Landing Gear System (1 NLG, including the centre lock mechanism, 2 MLGs and their tires, rims, brakes and retraction system) intended to be installed on the LifeRCraft Flying Demonstrator.	

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

1. Background

The **LifeRCraft project (FRC-IADP WP2)** aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies, as from the current Clean Sky Programme, opens up to new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a sustainable way, for both the operators and the industry.
The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

The activities of the work package FRC2.3 cover the Landing Gear System which includes:
- The nose landing gear with retraction actuator and center lock mechanism (including cockpit control TBC)
- 2 main landing gears with retraction actuators
- Tires, rims
- 1 brake on each main landing gear (brake control out of the scope)
- Landing gear compartment doors and associated mechanism to open/close them
- Control box (valid for electrical retraction)

In the following, one shipset includes the above mentionned equipment.

In addition to the technical requirements presented in this document, the following should be taken into account by the Core Partner:

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

Recurring cost estimation:

The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.

For the PDR, the Core Partner will provide an estimation of the recurring cost of the component on the basis of the assumptions given by the WAL. An up-date will be provided for CDR and at the end of the demonstration phase.

The possibility to have a maximum of common parts between LH MLG and RH MLG will be studied.

Data management:

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

- CATIA V5 R21
- VPM
- Windchill

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

Eco-design

The Core Partner should have the capacity to perform Life Cycle Analysis (LCA) to define environmental impact (energy, VOC, waste …) of technologies.

This approach will be integrated during design & manufacturing phases. The WAL will be able to support LCA approach (Methodologies training or pilot cases).

The Core Partner should have the capacity to monitor and decrease the use of hazardous substances regarding REACh regulation.

2. Scope of work

The aim of this document is to detail the activities required for designing and developing up to TRL6 the above mentionned landing gear system to be integrated into the compound helicopter.

All the design activities (stuctural analysis, metal protection schemes (corrosion, wear,…), sealing technology…) should be done as if developping a landing gear system for a serie H/C. However, all the substantations (e.g. test, analysis) and documentations herafeter described are supporting a permit to fly for a demonstrator.

Detailed & Informative System Overview

- **Applicable documents**

Acronym	Name	Reference
[NF_EN_1005]	Sécurité des machines – Performance physique humaine – Partie 2 : manutention manuelle de machines et d'éléments de machines	NF EN 1005-2
[CS29]	Certification Specifications for Large H/C (Amdt3 dated 11/12/2012)	CS29
[AC29]	AC29-2C Certification of Transport Category Rotorcraft	AC29-2C
[FAR29]	Airworthiness standards: Transport category rotorcraft	FAR29 Amdt52 dated 05/04/2010
[JAR-OPS3]	Commercial Air Transportation (Helicopters), Amendment 5	JAR-OPS 3
[ARP5381]	Minimum Performance Recommendations for Part 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel and Brake Assemblies	ARP5381
[ARP4761]	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems	ARP4761
[ANC2]	Ground loads	ANC2
[TSO_C26d]	Technical Standard Order Aircraft Wheels, Brakes and Wheel/Brake Assemblies for Parts 23, 27 and 29 Aircraft	TSO-C26d

- **System functions**

Main functions ensured by the Landing Gear system are:

- To support H/C on ground
- To absorb energy coming from ground during H/C landing
- To retract and to extend LG (normal mode)
- To open and close the landing gear doors during extension /retraction phase of LG
- To extend LG in emergency mode (free fall under gravity load is preferred)
- To allow controlled maneuvering on ground
  - To provide MLG differential braking
  - To provide MLG parking brake capability including on slope
  - To provide free swiveling capability for nose LG including NLG locking capability
- To provide LG statuses
  - MLG extended (for each MLG) and locked
  - MLG retracted (for each MLG) and locked
  - NLG extended and locked

- NLG retracted and locked
  - NLG wheels aligned
  - MLG S/A extended (weight off wheel, for each MLG)
  - NLG S/A extended (weight off wheel)
  - Parking Brake Status (Locked, Unlocked)
  - NLG status (wheel axle swiveling Locked/Unlocked), also visible from outside aircraft on ground
- To provide towing capabilities
- To provide mooring interface
- To provide weight on wheel measurement (option)

Notes:

- the MTOW range of the fast rotorcraft will be between 6000 kg and 8000 kg.
- the certification basis of the landing gear system is the CS29.

- **System Overview**

Landing Gear system will be composed of following systems/equipment:

- Two Main Landing Gears
  - Each Main Landing Gear should have capability to install a leg fairing (door)
- One Nose Landing Gear
  - The Nose Landing Gear should have capability to install a leg fairing (door)
- A retraction system for each Landing Gear (an electrical actuator is preferred (1))
- A hydraulic brake for each Main Landing Gear
- A Wheel (rim and tire) for each Main Landing Gear
  - Selected tyre size is 17.5x5.75-8 (TBC)
- 2 Wheels (rims and tires) for the Nose Landing Gear
  - Selected tyre size is 5.00-4 PR14 (TBC)
- Landing gear compartment doors for each main landing gear and for the nose landing gear
  - Include the mechanism driven by the landing gear to open / close them

(1) An electrical actuator to perform the function extension/retraction for each Landing Gear is considered as acceptable as long as it is not in the ground load path when the Landing Gear is extended.

Note: landing gear wheel positions and landing gear bay volumes are presented in Section 0 hereafter.

Description of Work

Hereafter is presented the overall descripton of work:

Ref. No.	Title - Description	Due Date
TS 1	**Kick-off meeting (KOM):** The objective of this meeting is to: ***Formally review the project phase.*** ***Review the technical documentation.*** ***Identification of main technical risks and related activities to address them.*** ***Review the detailed development time schedule.*** ***Define frequency of intermediate engineering reviews.***	T_0 (Oct 2016)
TS 2	**Progress report (PR):** During the entire project Phase, the Core Partner shall provide every two months a Progress Report.	Every 2 month from T_0
TS 3	**Specification review:** The main objectives of this task are: ***to review the Landing Gear system requirement specification.*** ***describe the product to be designed, manufactured, qualified and provided to the WAL for testing.*** ➔ This activity will be closed by a review: Requirement Specification review.	T_0 to T_0+ 4
TS 4	**Preliminary design:** The main objective of this activity is to validate the Landing Gear system specification and check that its design is consistent with the requirement specification: architecture concept according to performance and safety requirements, sizing, interfaces definition, substantiation of design choice, means of compliance, material and protection plan, qualification test program… ➔ This activity will be closed by a review: Preliminary Design Review (PDR).	T_0 to T_0+ 6
TS 5	**Critical design:** The main objective of this activity is to realize the detailed design (mechanical, electrical, hydraulic, …), realise drawings, finalize safety analysis, define qualification test procedure for demonstrator landing gear system, prior to launch equipment manufacturing (except long cycle items such as forging which should be launch prior to CDR). ➔ This activity will be closed by a review: Critical Design Review (CDR).	T_0+ 7 to T_0+ 16

Ref. No.	Title - Description	Due Date
TS 6	**B1 model manufacturing:** Development model identical in form, fit and function with the specified equipment, it might contain non-qualified components, hence is not flight cleared (B1 model). The B1 model is manufactured according to design file validated in last CDR. It is primarily used on system test and integration rigs, covering the full range of operations. ➔ This activity will be closed by a First Article Inspection (FAI in development)	T_0+ 17 to T_0+ 23
TS 7	**B1 model qualification tests at Core Partner's bench to validate TRL5 (functional, performance and endurance)** The Core Partner will realize the necessary bench tests with B1 models to demonstrate the TRL5 (environment and lab tests). B1 model will be used to perform the qualification drop tests (required), extension/retraction tests (required), endurance tests (required, number of cycles TBD to support Permit to Fly), environmental tests (required, tests to be performed TBD to support Permit to Fly), partial static/fatigue tests (TBC if required) Above tests will be performed on Core Partner's bench tests. ➔ This validation will be closed by a TRL5 review and validation.	T_0+ 23 to T_0+ 29
TS 8	**B2 model manufacturing (1 shipset):** The applicant will have to manufacture B2 model according to design file validated in last Critical Design Review. Prototypes will be used for: - validation of the installation in the Helicopter, including provisions and harness routing (used as a M-Model) - TRL6 (Flight Test) validation on Core Partner's benches. ➔ This activity will be closed by a First Article Inspection and delivery of one shipset to the WAL.	T_0+ 20 to T_0+ 26
TS 9	**Spare parts** Identification of the spare parts or spare L/Gs to be delivered to be defined depending on: - Time to get complex parts - Time to get a spare L/G ➔ This activity will be closed by delivery of agreed spares (parts or L/Gs) to the WAL.	T_0+ 25 to T_0+ 31
TS 10	**Flight test campaign:** The Core Partner will support the WAL during flight test campaign (engineering support and logistic support). ➔ This activity together with TS 2.3-10 will be closed by a TRL6 review validation.	T_0+ 33 to T_0+ 50

Ref. No.	Title - Description	Due Date
TS 11	**TRL6 demonstration:** The Core Partner will provide the complementary evidence for TRL6 validation. ➔ This validation will be closed by a TRL6 review and validation.	T_0+ 47
TS 12	**Final synthesis report** The Core Partner will analyse results of tests done on benches, on flight demonstrator in order to identify the action plan and design changes necessary to define serial product. ➔ This activity will be closed by a final report	T_0+ 49

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Program management documents (progress reports):			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 1.1	Development Plan	information	15 working days before KOM
D 1.3a	Progress Report Development including: weight, conformity to requirements, status of the actions (reviews, meetings, coordination memos…)	information	Every 2 months
D 1.4	Configuration Management Plan	Approval	PDR
D 1.8	Technology Readiness Level (TRL) Documentation	Review	At KOM, and updated 25 working days (TBC) before PDR, CDR, QR
D 1.9	Risk and/or Opportunity analysis with association mitigation and/or implementation plans	Review	At KOM, and updated 25 working days (TBC) before PDR, CDR, QR
D 1.10	List of Problems	information	On WAL request
D 1.11	Corrective action plan	Review	On WAL request
D 1.12.3	Weight Report	Approval	15 working days before KOM and 25 working days before PDR,CDR and delivery if any update necessary

Deliverables			
Engineering documents (progress reports):			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 2.2	Product Specification and Compliance matrix to WAL specification	Approval	25 working days (TBC) before PDR, CDR, QR
D 2.3	Interface Control Document (ICD). Note: Data Bus ICD shall be provided also, but in a separate document	Approval	25 working days (TBC) before PDR, CDR
D 2.4	Design File and Design description Detailed Documentation (architecture choices, substantiation files including stress calculation, analyse results, 2D drawings, compliance matrix,…)	Review	25 working days (TBC) before PDR, CDRs
D 2.19	Material Plan	Approval	25 working days (TBC) before PDR, update if necessary.
D 2.20	Structural Analysis Handbook (methods)	Approval	25 working days (TBC) before PDR, update if necessary.
D 2.21	Design Handbook (methods)	Approval	25 working days (TBC) before PDR, update if necessary.
D 2.22	Qualification Review (QR) TRL5 substantiations + TRL5 Form	Document	T_0+ 31
D 2.23	TRL6 substantiations + TRL6 Form	Document	T_0+ 47
D 2.24	Final Synthesis Report	Document	T_0+ 49

Deliverables			
Quality Assurance documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 3.2	Acceptance Test Procedures (ATP)	Approval	25 working days before Development FAI; Reviewed 25 working days before FAI.
D 3.3	Acceptance Test Report (ATR)	Information	With each delivery
D 3.4	Certificate of Conformity and Delivery Note	Information	With each delivery
D 3.5	Log Card	Information	With each delivery

Deliverables			
Quality Assurance documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 3.6	Concessions / Production Permit	Approval	With each delivery
D 3.7	Review report	Approval	15 working days at the latest following the review (KOM, PDR, CDR, FAI, QR)
D 3.8	FAI Report	Approval	Report of development FAI before qualification tests° /flight tests start, at the latest 15 days following the review.
D 3.9	Storage and conditioning sheet	Approval	Before first equipment delivery
D 3.11	Critical parts file	Approval	First version 25 working days before PDR Last version 25 working days before CDR

Deliverables			
Qualification documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 4.1	Verification Plan	Approval	15 working days before KOM Updated 25 working days before PDR and 25 working days before CDR
D 4.2	Test Procedure	Approval	40 working days before the start of the test
D 4.4	Verification Test Reports	Approval	15 working days after the end of the tests
D 4.5	Theoretical verifications	Approval	25 working days before QR
D 4.6	Similarity Substantiation documents	Approval	25 working days before QR
D 4.7	Verification coverage Analysis Report	Approval	25 working days before QR
D 4.8	Component Repair Manual (CRM) qualification file.	Approval	25 working days before PDR Updated 25 working days before CDR and QR if necessary
D 4.9	Declaration of Design and Performance (DDP)	Approval	25 working days before QR

Deliverables			
Qualification documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 4.10	Model Description and Compliance Matrix	Approval	With each delivery of model

Deliverables			
Safety / Reliability documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 5.1	[Safety/Reliability Plan]	Review	25 working days month before PDR
D 5.2	[Reliability assessment]	Review	Preliminary 25 working days before PDR, Updated 25 working days before CDR, Final 25 working days before QR
D 5.3	[Safety Assessment]	Review	Preliminary 25 working days before PDR, Updated 25 working days before CDR, Final 25 working days before QR
D 5.4	[Common Cause Analysis]	Review	Preliminary 25 working days before PDR, Updated 25 working days before CDR, Final 25 working days before QR
D 5.5	[CPL-FMECA-Failure Catalogue] including the FMES Note: Report and Excel file provided by the WAL	Review	Preliminary 25 working days before PDR, Updated 25 working days before CDR, Final 25 working days before QR
D 5.6	Computer Data files related to the demonstration of Safety-Reliability probabilities Note: Fault Trees in electronic format.	Review	On WAL request
D 5.9	Safety /Reliability Compliance Matrix	Review	Preliminary 25 working days before PDR, Updated 25 working days before CDR, Final 25 working days before QR

Deliverables			
Safety / Reliability documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 5.10	FRACAS Procedure (TBC before T0)	Information	Final 25 working days before PDR
D 5.11	FRACAS Report	Information	On WAL request

Deliverables			
Environment Rules Documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 10.1	Material and Safety Data Sheet (MSDS) (TBC before T0) **Note: Concerns only preparation**	Approval	Preliminary 25 working days before PDR Update 25 working days before CDR Update 25 working days before QR
D 10.2	Material Declaration form (TBC before T0) **Note: Provide also excel form**	Approval	Preliminary 25 working days before PDR Update 25 working days before CDR Update 25 working days before QR

Deliverables			
ILS Documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 5.27.20.03	Ground Service Equipment	Approval	First issue 25 working days before PDR, Final 25 working days before CDR, updated 25 working days before QR
D 5.27.21	Troubleshooting	Approval	First issue 25 working days before PDR, Final 25 working days before CDR, updated 25 working days before QR
D 5.27.30	TechPub (Level TBC before T0)	Approval	First issue 25 working days before PDR, Final 25 working days before CDR, updated 25 working days before QR

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
M 1	Kick-Off Meeting	Review	T_0 (Oct 2016)
M 2	Specification Review	Review	T_0+ 4
M 3	Preliminary Design Review	Review	T_0+ 6
M 4	Critical Design Review	Review	T_0+ 16
M 5	B1-Model Delivery: First Article Inspection 1	FAI inspection	T_0+ 23
M 6	B2-Model Delivery: First Article Inspection 2	FAI inspection	T_0+ 26
M 7	Declaration of Design and Performance	Delivery	T_0+ 30
M 8	Qualification Review / TRL5 Review	Review	T_0+ 31
M 9	Spare Delivery	Delivery	T_0+ 31
M 10	TRL6 Review	Review	T_0+ 47
M 11	Final Synthesis Report	Review	T_0+ 49

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

The Core Partner must have design, testing and manufacturing capability in the relevant Field (mechanical, electrical, hydraulic).
The Core Partner shall demonstrate ability to design, qualify and manufacture aeronautic equipment, if possible in a DO/PO organization (PART21).
The Core Partner must show prior experience in the design and manufacturing of aircraft landing systems, such experience being particularly appreciated for rotorcraft landing system.

Minimum qualification required: ISO9001, EN9100.
Preferable qualification: PART21, PART145

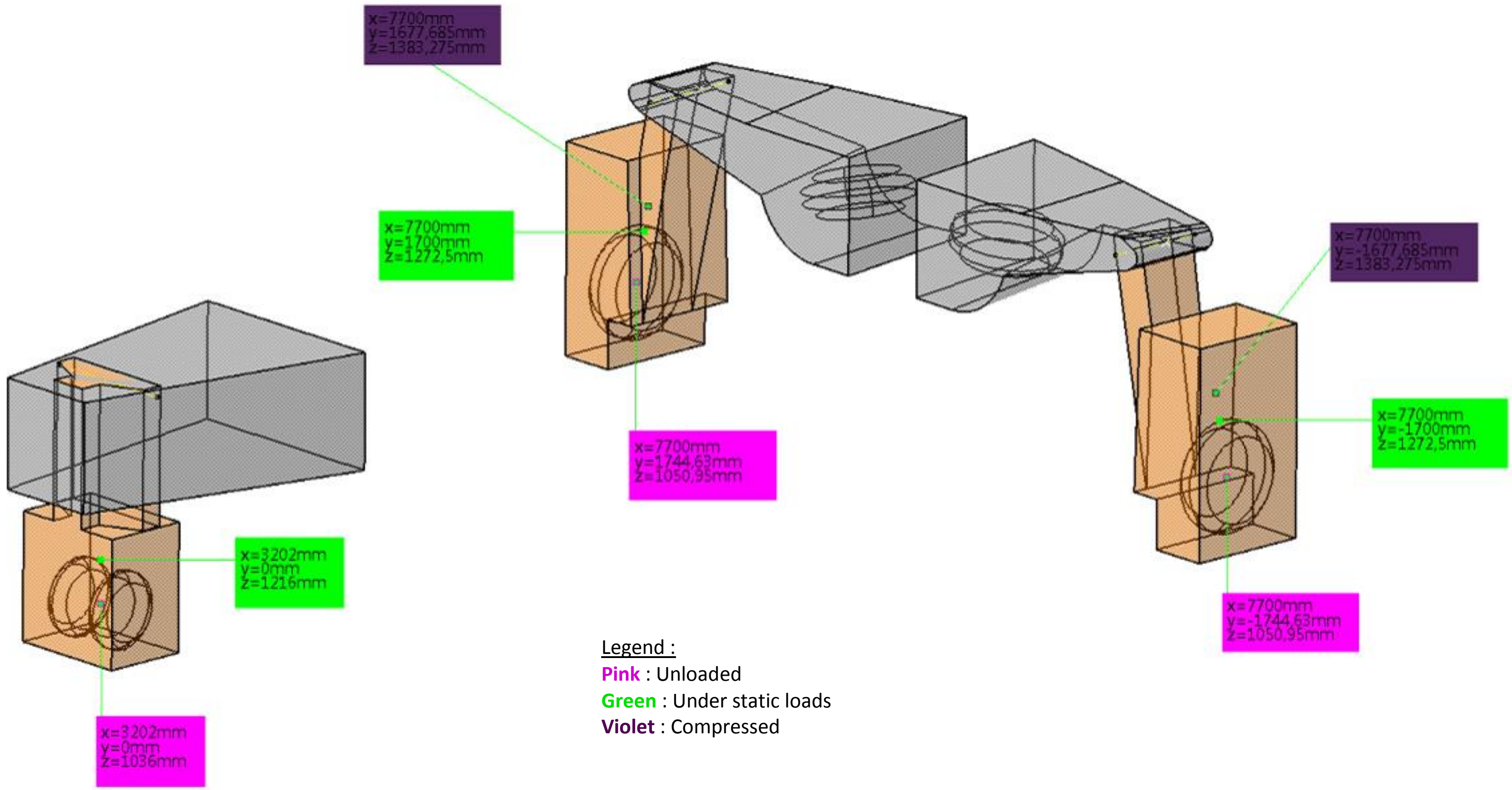
In its CfP answer, the Core Partner shall describe how it will answer to the technical requirement described in this CfP description and shall provide project plan (project logic, schedule, organization).

Further information on the landing gear wheel positions and bay volumes are made available in the following pages.

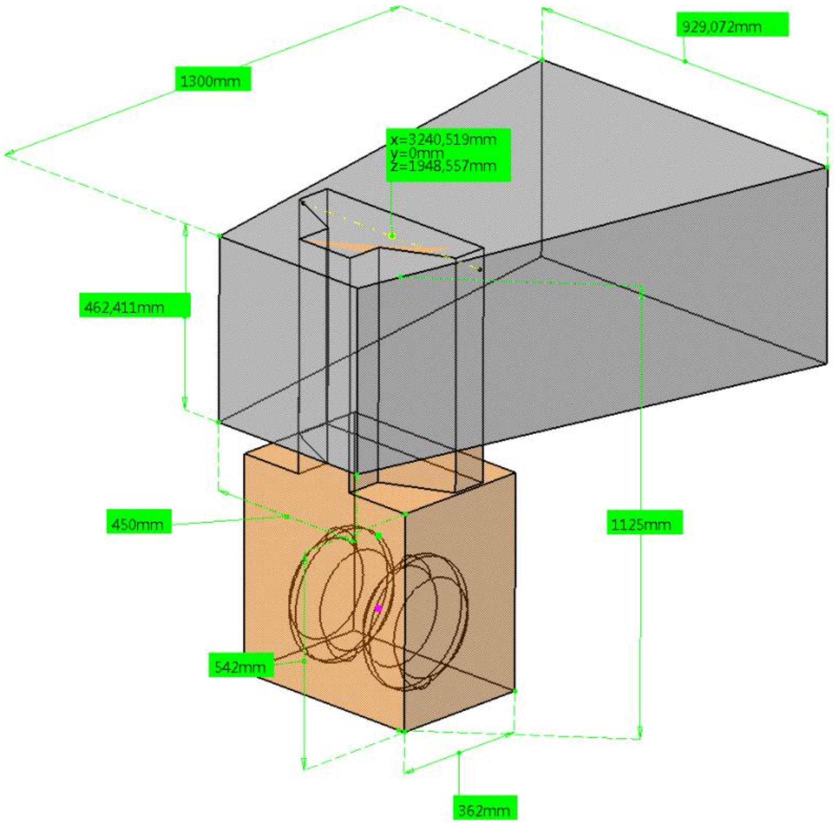
Specification of landing gear wheel positions and bay volumes

Note: The data given below are order of magnitude given for information, update figures will be provided at T0 and may change until PDR.

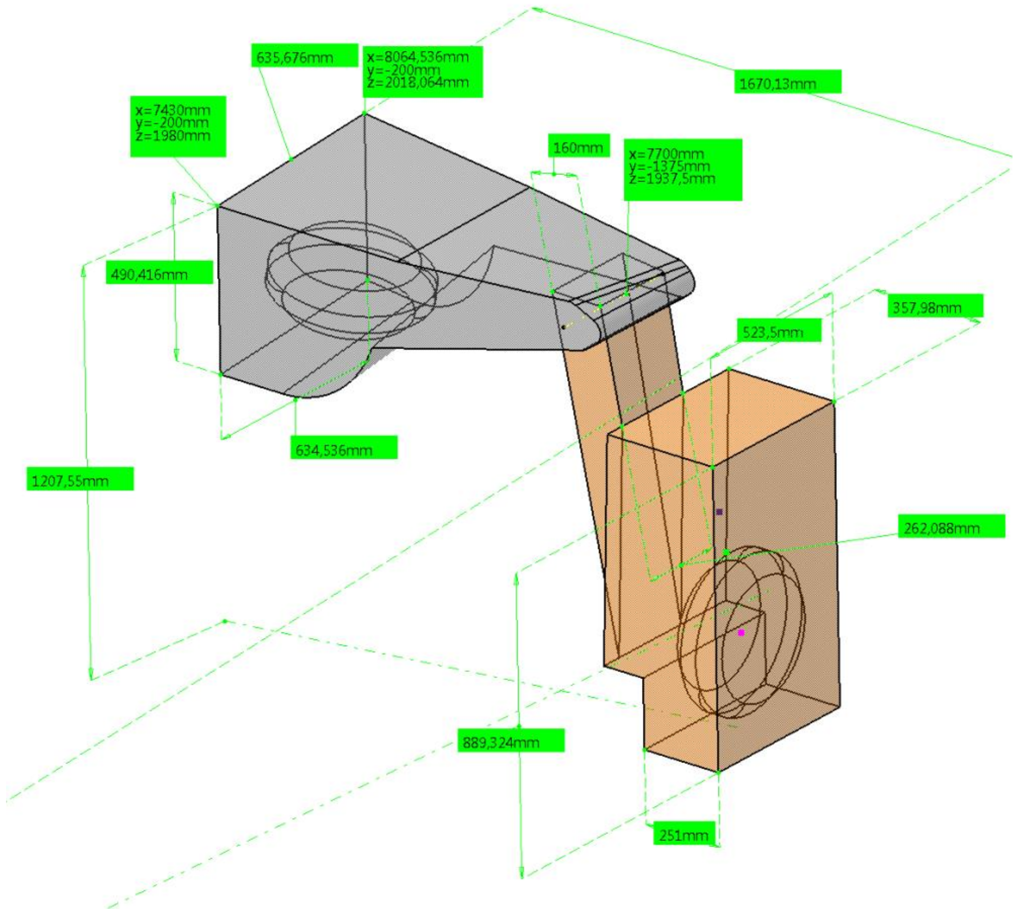
- MLG and NLG wheel center positions



- <u>NLG bay volume allocation and S/A structural attachment</u>



▪ <u>MLG bay volume allocation and S/A structural attachment (left side)</u>



5. Glossary

CDR	Critical Design Review
CfP	Call for Proposal
DDP	Declaration of Design and Performance
FAI	First Article Inspection
FMECA	Failure Mode, Effects, and Criticality Analysis
FMES	Failure Mode Effect Summary
FRACAS	Failure Reporting and Corrective Action Systems
H/C	Helicopter
L/G	Landing Gear
MLG	Main Landing Gear
MTOW	Maximum Take-Off Weight
N/A	Not Applicable
NLG	Nose Landing Gear
PDR	Preliminary Design Review
TBC	To Be Confirmed
TechPub	Technical Publication
WAL	Work Area Leader

III. LifeRCraft Main Gear Box

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.6 - Mechanical drive System		
Topic Leader	AIRBUS HELICOPTERS		
Indicative Funding Topic Value (in k€)	12000 k€		
Duration of the action (in Months)	51 months	**Indicative Start Date**[6]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-FRC-02-04	**LifeRCraft Main Gear Box**
Short description (3 lines)	
The aim of this Call for Core Partners is to Design, Manufacture, Test and Support part of Main Gear Box modules for the Compound Rotorcraft Demonstrator IADP LifeRCraft. The Main Gear Box modules should include an optimized design to meet the ecological challenges and to be sustainable for environment, customer and industry. An innovative co-development strategy will be used for main module. The Main Gear Box modules could include innovative designs, trend setting manufacturing processes, innovative materials but if the TRL of each innovation is lower than 4 in 2015 and if it is risky for the program, a conventional solution must be provided and might be implemented as a back-up.	

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

1. Background

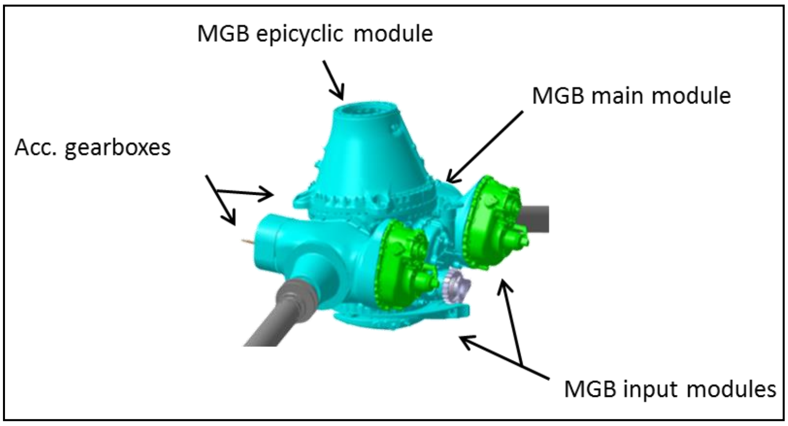
The **LifeRCraft project (FRC-IADP WP2)** aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry. The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including capability to land on unprepared surfaces nearby obstacles and to load/unload rescue personnel and victims while hovering, long range, high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.
In addition to the complex vehicle configurations, Integrated Technology Demonstrators **(ITDs)** will accommodate the main relevant technology streams for all air vehicle applications. They allow the maturing of verified and validated technologies from their basic levels to the integration of entire functional systems. They have the ability to cover quite a wide range of technology readiness levels.

This Topic belongs to the LifeRCraft project and is managed as part of the Work package 2.6 “Mechanical Drive system”.

2. Scope of work

The Main Gear Box consists of the following components:

- Two input modules (left and right)
- Main module
- Two accessory modules
- Epicyclic module
- Lubrication and cooling system



Rotorcraft Demonstrator IADP LifeRCraft Main Gear Box

The scope of the Core Partner's work covers all components **except** the following ones (colored in green in the illustration above):

- Main Gear Box Input modules
- Main Gear Box Cooling system

The Core Partner shall perform all the activities needed to design, develop, and support the LifeRCraft Demonstrator Main Gear Box Modules except the components excluded above. Therefore activities such as, technical assessments, design, manufacture and test are part of the scope of work. Additionally to these technical activities that will be described further, the Core-Partner shall also perform the corresponding management activities in liaison and in agreement with the Work Area Leader (WAL) representing Airbus Helicopters (AH).

The major design principles are focusing on:

- Light weight design
- Performances and Reliability of the Main Gear Box
- Limited Power losses
- Main Gear Box Monitoring
- Certifiable design (CS29 is the baseline)
- Limited and easy maintenance and support of drive system (Part and Assemblies installation/Removal, maintenance tasks etc...)
- Dynamic behaviour influenced by drive system rotation speed range

The Core Partner's Roles and Responsibilities (R&R) in the performance of its activities are listed hereafter.

Technical Activities

The Core-Partner R&Rs will be: Design, Development and Support Responsible.

Therefore the WPs and the tasks in which the Core Partner will work are as follows:

WP 1 - MGB Accessory Modules (Left and Right):

This WP consists of designing, developing and supporting two accessory modules of the MGB. These modules are mainly constituted of cylindrical gears, bearings, housings and part of lubrication system. The interface with environment (Main Gear Box and accessories) of the accessory modules will be defined with all others requirements in a specification supplied by AH after project start. The achievement of the WP in compliance with the specification will be done through the following tasks:

Phase 1	▪ Task : Project (global 3D view and sizing) ▪ Task :Interface drawings ▪ Task :Detailed Studies ▪ Task :Parts (or system) substantiation (calculation) ▪ Task :Global FEM (for loads share and deflexions) ▪ Task :Specifications, follow up, choice of equipment ▪ PDR (milestone review)
Phase 2	▪ Task :Drawing set ▪ CDR (milestone review)
Phase 3	▪ Task :Kit manufacturing and assembly ▪ Task :Tests requests (development, flight clearance, flight) ▪ Task :Drawing kit (development, flight clearance, flight) ▪ Task :Test Realization and Follow up (development, flight clearance, flight) ▪ Task :Conclusion to test (development, flight clearance, flight)
Phase 4	▪ Task :Modification studies following development test results ▪ Task :Drawing set modification ▪ Task: Manufacturing of modified parts and assemblies.
Phase 5	▪ Task :flight clearance complete file (certification plan, limitations, directives, FMECA, maintenance doc)
Phase 6	▪ Task : Tools and assembly procedures for module assembly and maintenance ▪ Task: Following and supporting the flight demonstrator all along its flight tests campaign: solve assembly issues, solve technical problem encountered during assembly, ground or flight tests, Solve incident in development (PPS methodology), Give and approve work done on aircraft quality folder.

<u>IMPORTANT:</u> Number of kits needed by AH for the whole system integration and demonstration is as follows:

- 2 accessory module sets for flight (LH and RH)/ 1 accessory module set (LH and RH) spare for flight
- 2 accessory module sets (LH and RH) for Main Gear Box integration tests and flight clearance

Other kits as may be necessary for development tests and fatigue tests to be performed by the Core Partner including corresponding spare parts have to be proposed by the candidate.

WP2 - MGB Epicyclic Module

This WP consists of designing, developing and supporting the epicyclic module of the MGB. This module is mainly constituted of an epicyclic gears with a conical housing supporting the servo-control fittings, monitoring system, lubrication system (sprayings etc..), equipment support etc….. The interface with environment (Main Gear Box and Rotor system) of the epicyclic module will be defined with all others requirements in a specification supplied by AH after project start. Reuse of an existing epicyclic gear set (owned by either CP or AH) could be investigated. The achievement of the WP in compliance with the specification will be done through the following tasks:

Phase 1	▪ Task : Project (global 3D view and sizing) ▪ Task :Interface drawings ▪ Task :Detailed Studies ▪ Task :Parts (or system) substantiation (calculation) ▪ Task :Global FEM (for loads share and deflexions) ▪ Task :Specifications, follow up, choice of equipment ▪ PDR (milestone review)
Phase 2	▪ Task :Drawing set ▪ CDR (milestone review)
Phase 3	▪ Task :Kit manufacturing and assembly ▪ Task :Tests requests (development, flight clearance, flight) ▪ Task :Drawing kit (development, flight clearance, flight) ▪ Task :Test Realization and Follow up (development, flight clearance, flight) ▪ Task :Conclusion to test (development, flight clearance, flight)
Phase 4	▪ Task :Modification studies following development test results ▪ Task :Drawing set modification ▪ Task: Manufacturing of modified parts and assemblies.
Phase 5	▪ Task :Flight clearance complete file (certification plan, limitations, directives, FMECA, maintenance doc)
Phase 6	▪ Task : Tools and assembly procedures for module assembly and maintenance ▪ Task: Following and supporting the flight demonstrator all along its flight tests campaign: solve assembly issues, solve technical problem encountered during assembly, ground or flight tests, Solve incident in development (PPS methodology). Give and approve work done on aircraft quality folder.

<u>IMPORTANT</u>: Number of kits needed by AH for the whole system integration and demonstration is as follows:

- 2 epicyclic modules for flight / 1 epicyclic module spare for flight
- 2 epicyclic modules for Main Gear Box integration tests and flight clearance

Other kits as may be necessary for development tests and fatigue tests to be performed by the core partner including corresponding spare parts have to be proposed by the candidate.

WP 3 - MGB Main Module

This WP consists of co-developing with AH, manufacturing and supporting the main module of the MGB. This module is mainly constituted of bevel gears, housings, lubrication system, monitoring system, equipment support, … AH will issue a specification after project start to define the detailed requirements of the main module. The achievement of the WP in compliance with the specification will be done through the following tasks:

Phase 1	▪ Task : Industrial and innovative technology implementation requirements (Mechanical features) ▪ Task :Specifications, follow up, preliminary choice of industrial scheme ▪ PDR (milestone review)
Phase 2	▪ Task :Drawing set ▪ CDR (milestone review)
Phase 3	▪ Task :Kit manufacturing and assembly ▪ Task :Drawing kit (development, flight clearance, flight) ▪ Task : Simple test realisation and development, flight clearance test support ▪ Task : Support for flight clearance documentation
Phase 4	▪ Task :Drawing set modification ▪ Task: Manufacturing of modified parts and assemblies
Phase 5	▪ *Out of Work Scope (Flight clearance complete file under AH responsibility)*
Phase 6	▪ Task : Tools and assembly procedures for module assembly and maintenance ▪ Task: Partcipate to the follow-up and the supportof the flight demonstrator all along its flight tests campaign: contribution to solve assembly issues, solve technical problem encountered during assembly, ground or flight tests, Contribution to solve incident in development (PPS methodology), Give advice on aircraft quality folder.

Following details on the table hereafter, the MGB Main Module will be co-developed jointly by AH and the Core Partner. Departing from the conventional Build-to-Spec partnership, this organization aims at maximizing the benefit of experience and innovation capabilities of both parties and sharing the aggregated IP (amalgamed Background and Results) in a fair and balanced manner as described in the table below, with co-ownership as an output of this work package:

- AH will bring its Background obtained with similar MGB main modules, including lessons learnt from flight testing of the high speed rotorcraft test bed X3;
- The Core Partner will bring its own experience of aeronautical gear boxes and will have the opportunity to propose new innovative technologies at all development phases.

Assuming technical success, such co-development scheme will create very favorable conditions for a lasting partnership for exploitation of project results to occur in the further development and serialization of fast rotorcraft products.

Phases	**Co-Development Organization**
Initial Specification	• AH only
Phase 1 : Design	• Co-development with AH leadership • IP allocated to AH
Phase 2 & 4: Design detailed activities	• Co-development with shared leadership • IP shared (co-ownership)
Phase 3 & 4 : Manufacturing processing, tooling and	• Co-development with Core Partner leadership • IP allocated to Core Partner

Phases	Co-Development Organization
Manufacturing	
Phase 3 : Development Tests	• Co-development with AH leadership
Phase 3 : Flight Clearance	• AH leadership with contribution of Partner
Phase 6: Flights support	• AH leadership with contribution of Partner

IMPORTANT: Number of kits needed by AH for the whole system integration and demonstration is as follows:

- 2 Main modules for flight / 1 main module spare for flight
- 3 Main modules for Main Gear Box integration tests and flight clearance

Other kits as may be necessary for development tests and fatigue tests to be performed by the core partner including corresponding spare parts have to be proposed by the candidate.

Managing and Coordination Activities

The core partner will:

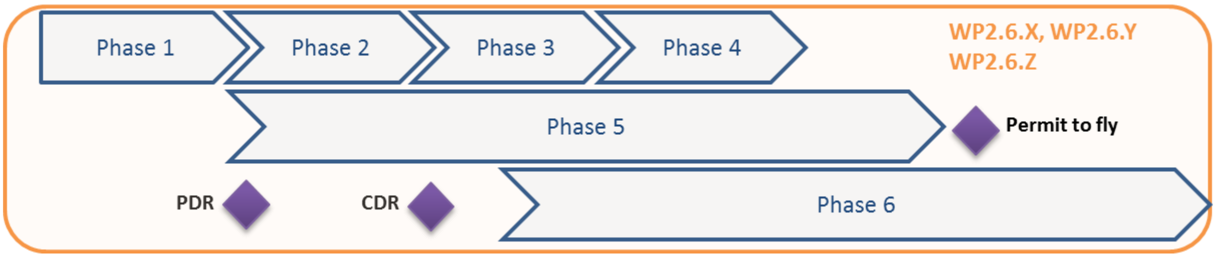
- Manage & Coordinate directly all the WPs that it will be fully responsible for ;
- Share the WPs reporting work for the follow up with AH for the overall project development
- Follow the Configuration Management process via VPM or Windchill (to be confirmed) over the entire program duration (details to be defined during project coordination phase prior start).

The work plan is structured into phases which are concluded with deliverables and milestones. Project management will follow standard practices by applying reviews as PDR, CDR, TRR etc.

Detailed description/content of project phases

The descriptions and details which will follow have been established under the assumptions that:

- The selected core partner is certified CS21 (DOA and POA) and familiar with the rules and requirements applicable in the aeronautic industry or at least the leading industrial partner within the cluster has to fulfil these requirements and take over full responsibility for airworthiness.
- The selected core partner is able to manufacture according the quality requirements which are standard in aeronautic industry (ref. Phase 3).



Should the above mentioned requirements not be satisfied, the Core Partners's certification according to CS21 has to be achieved at the latest 6 months prior the delivery of the flightworthy parts. The acquisition of data and test results and production of compliance evidence needed to obtain a Permit to Fly has to be performed under the Core Partner's own responsibility and included in its cost estimate.

Phase 1

This phase will enable to settle all data necessary to reach the specification requirements. The main challenge is to satisfy all the requirements and boundary conditions for a high speed rotorcraft by designing several essential and specific elements of its Main Gear Box. Recurring cost for a potential production have also to be addressed. The weight for Accessory Modules and Epicyclic Modules should not exceed certain target values as indicated in the general requirements further below.

The way how to achieve these targets is under the responsibility of the core partner.

At the end of Phase 1 the following items have to be addressed for the PDR:

- System specification & associated compliance matrix
- Detailed System description (functional, technological (material, protection, coating) etc...)
- Interfaces status
- Equipment status
- Documentation list and status
- Development test plan
- Performance & limitations (SLL, TBO etc..)
- Weight breakdown (see NOTE below)
- RC, DMC
- Digital Mock Up status
- Drawings baseline
- Electrical network compatibility
- Procurement and Industrial status
- Delivery to test means
- Preliminary certification basis & plan
- Preliminary safety & reliability analysis
- Preliminary supportability (including maintainability & testability) analysis
- Critical parts list
- Risk and opportunity analysis
- Updated synthetic schedule

Phase 1 comprises a set of **study drawings** and **substantiation documents** for the whole system. This includes, but is not limited to:

- performing architecture/structural layout (common design office with AH)
- performing detailed studies
- Performing static and dynamic substantiation for parts and system (by calculation)
- Performing finite element models for loads share and deflections.
- Performing a logic test plan to be done (on parts and system) before delivery (harmonized with AH)
- Performing Critical part list
- Performing Certification plan
- responsible to achieve the specification targets (SLL)
- selection of material and process (harmonized with AH)
- responsible for manufacturing-tool design
- definition of inspection- and repair methods
- etc…

An AH support to the Core Partner could be envisaged.

In order to achieve a Permit to Fly, several harmonisation tasks and agreements necessary for organization of the co-development activities have to be done prior start of phase 1. This comprises:

- Tool harmonisation (substantiation, IT, Program management, configuration management, . .)
- Quality assurance process harmonisation
- Communication management
- Dissemination of reports, technical documentation (e.g. substantiation documentation, test results, quality documentation, etc.)
- Granting mutual access rights for general documentation, information, quality reports, …
- Co-development phase set-up

Phase 2

This Phase aims at delivering the detailed drawings of the parts, the equipment, the equipped parts and assemblies of the whole system. Phase 2 comprises a complete drawing set for the system in the scope of work.

At the end of this phase the following topics have to be addressed <u>for the CDR</u>:

- System specification & associated compliance matrix update
- Detailed System description (functional, technological (material, protection, coating) etc...) update
- Interfaces status update
- Equipment status update
- Documentation list and status update
- Development test plan update
- Performance & limitations (SLL, TBO etc..) update

- Drawings set status for:
  - Parts
  - Equipped parts
  - Assemblies
  - Equipment
- Weight breakdown update
- RC, DMC update
- Digital Mock Up status update
- Electrical network compatibility update
- Procurement and Industrial status update
- Delivery to test means update
- Preliminary certification basis & plan update
- Preliminary safety & reliability analysis update
- Preliminary supportability (including maintainability & testability) analysis update
- Critical parts list update
- Risk and opportunity analysis update
- Updated synthetic schedule update

Phase 3

This phase is dedicated to tests and kits manufacturing.

All test requests have to be prepared in accordance with the development test plan. Components development tests will be performed by the Core Partner using its own test facilities. Drive system integration tests will be performed with participation of the Core Partner using AH's back-to-back MGB rig.

They should cover tests necessary for system development on bench, for flight clearance and for flight. All the necessary data have to be detailed into the test requests to define:

- The goal of the test
- The tested hardware
- The servitude hardware
- The test means
- The test program
- Successful test criteria
- The expertise and controls to be done before and after test.

Drawings kits, corresponding to dedicated test request, have to be released to be manufactured. All tests have to be followed. A report of the test has to be issued. Each test has to be answered by design office conclusion.

Phase 4

Depending on Phase 3 results, some modifications may appear mandatory: this is the aim of Phase 4.

All data from previous phases (results from design phase and from tests etc...) have to be collected and summed up. Thus, all necessary modifications can be synthetized and substantiated.

Phase 4 comprises a complete **drawing set update** for the system and a substantiation file for each modification.

Phase 5

This phase is dedicated to achieve a “Permit for Fly”. Baseline regulation is CS29.

LifeRcraft will be a flying demonstrator vehicle and therefore has to meet certain requirements to achieve a Permit to Fly. AH is the responsible in front of the airworthiness agency, and it is mandatory that AH will be supported by the Core Partner. Therefore the Core Partner has to provide all documentation necessary to achieve Permit to Fly. The Core Partner main tasks are needed to support AH activities in the process to obtain a Permit to Fly by delivering the following documentation:

- System Description document
- System F.H.A. and F.M.E.C.A.
- Substantiation documentation for stress/fatigue
- System Maintenance document
- System limitations document
- Directives to be applied for the system
- Program/Reports/documentation of performed tests (entire test-pyramid)
- Manufacturing documentation
- Quality documentation for the delivered system
- Quality substantiation documentation

<u>**Note**</u>: As the Permit to Fly documentation has to be endorsed by AH CVE’s, a harmonization process with AH of the Permit to fly documentation has to be planned by the Core Partner.

This phase include the tests to be performed by the Core Partner at the level of the components (or sub-components) to contribute to Permit to Fly.

Phase 6

This phase is dedicated to solve the manufacturing and/or assembling concerns on the system itself if they happen. The goal is to answer to dedicated non conformities (manufacturing and/or assembling problems) by discarding or managing the parts (inspection reports, concessions).

<u>**Note**</u>: All concessions for non-conformities of parts/assemblies that the Core Partner intends to deliver to AH for demonstrator must be discussed with AH before delivery. Depending on the consequences of the non conformities under concession, AH reserved its right to refuse it. This has to be discussed during harmonization process for Permit to Fly.

In addition, this phase covers the flight tests conducted by AH, with the support of the Core Partner:

- To have a direct link between developer/manufacturer for quick response in case of malfunctions, defects, improvements, etc;
- To ensure quick feedback to the Core Partner from test campaigns;
- To ensure quick improvements from the Core Partner, if necessary.

The goal of this phase is to give solutions to assembly issues on flight demonstrator and to technical problems that can be encountered during ground/flight tests. In those cases, instructions and work approval on quality folder have to be done.

In case of incident in development, dedicated task force and methods (PPS for example) have to be put in place to solve the problem.

The Core-Partner has to participate and provide input to the project synthesis, particularly, taking the lessons learnt of the demonstration evaluation and support the Technical evaluation process and the necessary estimations to define the characteristics of a commercial product.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables / Outputs			
Ref. No.	***Title - Description***	***Type***	***Due Date***
	Released interface drawings	Drawings	T_0+1
	Released detail Studies	R + Drawings	T_0+2
	PDR capitalization	R	T_0+3
	CDR capitalization	R	T_0+8
	parts substantiation folders	R	T_0+20
	Released drawing set	Drawings	T_0+20
	Tests capitalization	R + Drawings	T_0+20
	Flight Clearance folder (certification plan, limitations, directives, FMECA, maintenance doc etc…)	R	T_0+20
	Flight test synthesis		T_0+51

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

Milestones			
Ref. No.	***Title – Description***	***Type***	***Due Date***
	Main Gear Box PDR		T0+3
	Main Gear Box CDR		T0+6
	Development assemblies delivery for integration tests (input modules)		T0+14
	Flight Assemblies delivery for demonstrator		T0+20
	Flight Clearance documentation		T0+24
	First Demontrator Flight		T0+33

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

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

- **Mandatory experience & capabilities**

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

- Experience in design and sizing of gearbox for rotorcraft.
- Tools for design and stress analysis in the aeronautical industry (i.e. CATIA v5 release 21, SAMCEF etc…)
- Capacity and experience in manufacturing parts for rotorcraft drive system (gears, housings, shafts etc…)
- Capacity to assess and eventually repair "in-shop" components due to manufacturing deviations.
- Experience in specifying equipment and following suppliers for rotorcraft drive system (bearings, free wheels, sensors etc…), housings, shafts etc…
- Capacity and experience to assemble rotorcraft gearboxes.
- Capacity and experience to test, to develop and to provide support to rotorcraft gearboxes tests
- Tests definition and preparation: stress and strain predictions, deflexion prediction and instrumentation definition
- Analysis of test results
- Capacity of evaluating the results versus the technical proposals from the beginning of the project till the end of it IAW Eco-design rules and requirements.
- Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.
- Competence in management of complex projects of drive system development.
- Experience with TRL Reviews in research and manufacturing projects for aeronautical industry
- Experience in integration multidisciplinary teams in concurrent engineering within reference aeronautical companies.
- Capacity of providing large aeronautical components within industrial quality standards.
- Capacity to support documentation and means of compliance to achieve prototype Permit to Fly with Airworthiness Authorities (i.e. EASA, FAA, national institutions and any others which apply).
- Experience in technological research and development in the following fields:
    - Gears and meshing behaviour
    - Bearings behaviour
    - Lubrication/cooling system
    - Innovative processes (welding, heat treatment, protections, coatings, dimensional controls, health non-destructive controls (MPI, X ray, tomography etc...))
    - Assembly procedures
- Capacity to specify material, protection and coatings tests along the design and manufacturing phases of aeronautical components, including:
    - Characterization of innovative materials
    - Panel type tests (compression, shear, combined loads)
    - Advanced instrumentation systems
    - Impact tests

- **Appreciated experience & capabilities**

- Participation in international R&T projects cooperating with industrial partners, institutions, technology centres, universities and OEMs (Original Equipment Manufacturer).
- Proven experience in collaborating with reference aeronautical companies within last decades in:
    - Research and Technology programs
    - Industrial drive system developments including flight test phase and feedback

- **Equipment**

The following list gives an overview of possible and well known manufacturing equipment but can be extended with Core Partner approved technologies.

- Facilities and machines for:
    - Gears cutting and grinding
    - Splines cutting and grinding
    - Housings machining
    - Heat treatment
    - Nitriding, Carburizing
    - Hard coating projection
- Non Destructive Inspection (NDI):
    - MPI, FPI
    - Eddy current inspection
    - ultrasonic inspection
    - X – ray
    - Tomography
    - Dimensional inspection systems
- Facilities and workshop for drive system assemblies
- Dedicated Bench test rigs (specific, functional, power etc…)

- **Certification & Quality organization:**

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

- **Data management tools:**

AH will use the following tools for drawing and data management:

- CATIA V5
- VPM
- Windchill (TBC)

The Core Partner shall provide interface drawings and 3D model for digital mock-up in CATIA V5. Co-development strategy imposes that deliverables (3D models, drawings, bill of material, data and configuration management) have to be done with the same tools used by AH.

- **General technical requirements**

Main functions

- Transfer and increase the torque from input to output of the module
- Transfer and reduce the speed from input to output of the module
- Withstand and transfer external loads
- Provide drive system monitoring
- Transfer a reverse torque on PGB only
- Enable Large pitch attitude operation range

Sub functions

To provide support and provisions for other functions:

- Hydraulics system
- Electrical system
- Health monitoring system
- Environmental conditioning System

General requirements

- Main Gear Box: Maximal input Torque [1500kW]– Nominal input speed [21 000rpm].
- Light Weight. Objectives for Accessory and Epicyclic Modules will be defined in specification.
- Space allocation for will be defined in specification.
- Operation in loss of lubricant mode for >30 minutes (*)
- CS29 certifiable (Category A)(*)
- Maximum efficiency (minimization of power losses)
- TBO of 4000 hours with rate reach of 80 % (*)
- SLL objective for parts 4500 hours (*)
- Reduced and easy maintenance
- Eco friendly materials and processes .(see NOTE below)
- Quality in accordance to a serial product

(*) These requirements are sizing requirements: it has to be shown that they have considered at PDR and CRD, but the full substantiation as required for a serial product is not part of the scope of this topic.

<u>**Note:**</u> Materials & Processes - Selection of materials and manufacturing processes will be harmonized with AH.

General Process for establishing weight and recurring cost breakdown

<u>Weight:</u>

The target is to obtain the lowest weight possible for the proposed components compliant with

technical requirements and compatible with a serial aeronautical production.
The applicant has to provide in its offer an estimated maximum weight of its proposed component. This value will be updated at the signature of the consortium agreement taking into account the design data available at this time, the difference with the weight provided in the offer will be substantiated and submitted for approval of the leader.
For the PDR, the core-partner will have to provide a detailed weight breakdown of the components in accordance with the technology and the technical requirements and interfaces agreed with the leader.
For the CDR, the core-partner will provide an update of the weight breakdown with a substantiation of the difference with the PDR version. If an update of the overall weight is necessary, it will be submitted for approval of the leader.
The components for the flying demo will be delivered with a weight record sheet, and the deviation with the maximum weight agreed during CDR will be substantiated.
At the end of the demonstration phase, the core-partner will provide a weight estimation of the component for a production part in accordance with the lessons learned during the demo phase. Differences with the CDR weight have to be explained.

Recurring cost estimation:
The target is to obtain the optimum between the level of performances of the fast rotorcraft and the cost of the potential product.
For the PDR, the core-partner will provide an estimation of the recurring cost of the component on the basis of the specifications given by the leader. Updates will be provided for the CDR and at the end of the demonstration phase.

5. Glossary

AH	Airbus Helicopters
CDR	Critical design Review
CVE	Certification Verification Engineer
DMC	Direct Maintenance Cost
DOA	Design Organization Agreement
FEM	Finite Element Model
FHA	Failure Hazard Analysis
FMECA	Failure Mode Effect and Consequence Analysis
FPI	Fluorescent Penetrant Inspection
LGB	Lateral GearBox
LH	Left Hand
MGB	Main GearBox

MPI	Magnetic Penetrant Inspection
PDR	Preliminary design Review
POA	Production Organization Agreement
PPS	Practical Problem Solving
RC	Recurring cost
RH	Right Hand
SLL	Safe Life Limit
TBO	Time Between Overhaul
TRL	Test readiness Level
WP	Work Package

IV. Electrical Wiring Interconnection System for a Compound Fast Rotorcraft

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP 2.8 Electrical System		
Topic Leader	AIRBUS HELICOPTERS		
Indicative Funding Topic Value (in k€)	3500 k€		
Duration of the action (in Months)	51 months	**Indicative Start Date**[7]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-FRC-02-05	**Electrical Wiring Interconnection System for a Compound Fast Rotorcraft**
Short description (3 lines)	
The aim of this Topic is to perform the detailed design of equipment installation, design the harnesses and their content, perform the detailed design of these harnesses installation and anemometry installation, perform the detailed design of ADU structure, manufacture harnesses and ADU structure, assemble ADU, test, deliver and ensure the FAL and Flight Line support. To be noted innovation on use of 270 V DC voltage for power supply and presence of an ESN (Electrical Structural Network).	

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

1. Background

The **LifeRCraft project (FRC-IADP WP2)** aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies, as from the current Clean Sky Programme, opens up to new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a sustainable way, for both the operators and the industry.
The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

The activity of the present topic corresponds to WP 2.8.2.2 and is a part of the EWIS for the LifeRCraft demonstrator: WP 2.8.2.

WP 2.8.2 Organization:

2.8.2	Electrical Architecture& Integration	
2.8.2.1	Architecture phase of EWIS	Airbus Helicopters Activity: Architecture (electrical system schematic view PWD and 3D space reservation for harness routing and equipments), negotiation with the selected Core-partner , Core-partner follow up, verification plan for Permit to flight - Extrapolation to serial Aircraft.
2.8.2.2	Detailed design & Manufacturing & support	Core Partner's Activities: Detailed design of ADU structure (including stress validation), harnesses and installation of equipment & harnesses & ADU on the aircraft. Manufacture ADU/ESN & harnesses to be delivered and deliver installation drawings. Support during assembly in FAL or during flight in Flight Line (including harness modification on helicopter) Documentation for Permit to Fly

The H/C will include on-board two electrical networks:

- The 270VDC H/C network compliant with MIL-STD-704-F (new technology on rotorcraft).
- The 28VDC H/C network compliant with EN2282.

As the main airframe will include significant parts in composite, it will also include an ESN (Electrical Structural Network) which will lead to study lightning effects (direct and indirect) and HIRF protection.

The aircraft should have between 10000 and 15000 electrical links.
An electrical link is meant for a connection between 2 points.

2. Scope of work

2.1. Generalities

- **Norms and standards to apply**

In case of deviation w.r.t. any of the requirements given in this paragraph “Norms and standards to apply”, the Core-partner has to identify the deviation and alert the WAL. Airbus Helicopters will then decide if this deviation is acceptable or not.

Airbus Helicopters documents

DOCUMENT REFERENCE	ISS	TITLE/CONTENT
TBD		EWIS Sub System Specification
TBD		Safety installation guideline
TBD		Selection of electrical components
TBD		Electrical harnesses installation rules
TBD		Selection of metals and semi-finished product
TBD		Rules for anemometry installation
TBD		Selection of non-metallic materials and semi-finished products
TBD		Paints
TBD		metallization
TBD		Corrosion guidelines
TBD		Antennas guidelines
TBD		Zoning temperature

These documents will be given in due time to the selected Core Partner.

Norms certification documents

DOCUMENT REFERENCE	ISS	TITLE/CONTENT
EN3197		Aerospace series Design and installation of aircraft electrical and optical interconnection systems
CS29	3	Certification specifications for large rotorcraft
CRI F09	1	Helicopter System Wiring
EN3475		Aerospace series; Cables, Electrical aircraft use. Test methods
EN2283		Testing of aircraft wiring
EN2282		Characteristics of aircraft electrical supplies
EN3371		Electrical bonding technical specification
EN2853		Current ratings for electrical cables with conductor EN2083

- **Tools to use**

– Mandatory: CATIA V5 R21 for equipment installation + module CATIA V5 sheet metal for brackets and ADU structure
– Mandatory: CATIA V5 R21 module EHI for 3D harnesses, EHF for 2D harness drawings, EHA for harness installation
– Mandatory: VPM for DMU management
– Mandatory: Windchill for configuration management
– Mandatory: SEE toolset, provided by IGE+XAO (Complete See suite)
– 3D VIA Composer tool from Dassault Systems (Recommended)

2.2. Definition

Electrical Wiring Interconnection System (EWIS) means any wire, wiring device, or combination of these, including termination devices, installed in any area of the airplane for the purpose of transmitting electrical energy, including data and signals between two or more intended termination points.

The concerned components quoted in this topic description are the following ones:

- Wires and Cables
- Bus bars
- The termination point on electrical devices, including those on relays, switches, contactors, terminal blocks, and circuit breakers and other circuit protection devices.
- Connectors, including feed-through connectors.
- Connector accessories.

- Electrical grounding and bonding devices and their associated connections
- Electrical splices (not recommended).
- Materials used to provide additional protection for wires, including wire insulation, wire sheaths and conduits that have electrical termination for the purpose of bonding.
- Shields or braids.
- Clamps and other devices used to route and support the wire bundle
- Cable tie devices
- Labels or other means of identification.
- Pressure seals.

The definition given covers EWIS components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks, including, but not limited to, circuit board back-planes, wire integration units and external wiring of equipment.

The term “wire” means bare or insulated wire used for the purpose of electrical energy transmission, grounding or bonding. This includes electrical cables, coaxial cables, ribbon cables, power feeders and data busses.

ADU is meant for any delivery which contains harnesses, structure, brackets and/or equipment and/or anemometry pipes.

The term harnesses covers all harnesses, ESN harnesses and ADU harnesses.
ESN strutural parts are covered by bracket wording in the rest of the document.

2.3. Core Partner Performance

- **Weight**

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

At the end of the contract, the Core Partner shall provide a weight estimation of the component for a production part in accordance with the lessons learned during the development.

- **Recurring cost estimation**

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

- **Data management**

Airbus Helicopters will use the following tools for drawing and data management:
- CATIA V5 R21
- VPM
- Windchill

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

- **Eco-design**

Capacity of performing Life Cycle Analysis (LCA) to define environmental impact (energy, VOC, waste …) of technologies.
This approach will be integrated during design & manufacturing phases. Airbus Helicopters will be able support LCA approach (Methodologies training or pilot cases).
Capacity to monitor and decrease the use of hazardous substances regarding REACh regulation
Capacity to monitor and decrease the use of hazardous substances regarding REACh regulation.

2.4. <u>Definition of the work packages</u>

The work package will be divided in 3 sub work packages:

- Sub WP 1: Detailed design
- Sub WP 2: Manufacturing & delivery to Airbus Helicopters
- Sub WP 3: Support to Assembly and Flight Line.

These 3 sub work packages will be described in detail in the following chapters.

In general, all the design activities have to be done taking into account optimization of weight, cost of each part to be manufactured, cost/easiness of assembly, maintainability requirements. Regular reviews with Airbus Helicopters will particularly focus on these topics.

From October 2016 to June 2018, one representative of the Core-partner design team should be located in Airbus Helicopters Facilities in France.

A plateau phase has to be foreseen from October 2016 to June 2017 in Airbus Helicopters Facilities in France.
The Core-partner will have to participate at periodic design office session at one premise of the Topic Manager or of one other Core Partner involved in the project.
In general, all the deliveries of parts/drawings have to be done to Airbus Helicopters facilities in France.
In general, the applicant will have to integrate functional modifications from September 2016 to 7 months before the harness delivery date through PWD modifications (provided by Airbus Helicopters). The applicant will also have to integrate any DMU modifications coming from DMU integration phase of all different stakeholders participating to the definition of the aircraft.

The Core-partner will have to provide a technical support in Airbus Helicopters Facilities in France from T0 + 20 m. until T0 + 28 m.

2.5. Sub WP 1 - Detailed design

- **Technical description**

The Core-partner will be responsible to perform the detailed design of harnesses, installation of harnesses, equipment installation and ADU/ESN structure definition.
He will also be in charge to install Anemometry system (Pitot arms + pipes) in the aircraft.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T 2.8.2.2-1	Realize the complete definition of harnesses with IGE XAO Tools	See §6
T 2.8.2.2-2	Perform the design of harnesses in the DMU	See §6
T 2.8.2.2-3	Perform the design of harness installation in the DMU and with 3D VIA tool	See §6
T 2.8.2.2-4	Perform the equipment installation	See §6
T 2.8.2.2-5	Perform the design of ADU's/ESN structure & installation	See §6
T 2.8.2.2-6	Perform the anemometry installation drawings	See §6
T 2.8.2.2-7	Configuration management	See §6

- **Detailed description of each task of Sub WP 1**

T 2.8.2.2 – 1: Realize the complete definition of harnesses with IGE XAO Tools

Input Data:

- Master 3D indicating the localization of each equipment in the aricraft
- EED database (reverse of equipment connectors)
- PWD (Principle Wiring Diagram)

- ESR (Electrical Space Reservation)
- Technical note to deliver all the additional requirements
- List of all PWD to take into account (aircraft configuration)
- IDD or IP

Work to do:

- Harness concept : make the concept of all harnesses in the aircraft taking into account the cut off connectors indicated in the PWD and propose others possible cut offs if it eases the assembly of harnesses or the maintenance.
- Harness topology defined, harness has a unique number, harness respects route segregation, sheaths defined, maximum or minimum wire length for antennas
- Detailed electrical definition of each harness :
    - Type of each wire
    - Wire reference
    - Numbering of each wire
    - Connectors and backshells reference
    - End fitting rules
    - Reference of additional modules as ground modules, lugs, interconnection module, switch, rotator …
- Calculate voltage drops for all power supply wire, making sure that such drops do not exceed the maximum allowed/specified values.
- Optimize gauges of wires
- Calculate the weight of all harnesses

The deliverables will be SEE EDB database completely filled and ready to transfer to work preparation.

At the end of the project, the content of SEE EDB database will be delivered to Airbus Helicopters.

T 2.8.2.2 – 2: Perform the design of harnesses in the DMU

Input Data:

- Methodological guides for EHI use
- Master 3D indicating the localization of each equipment in the aircraft
- Harness concept for all harnesses
- Technical note to deliver all the additional requirements.
- DMU
- Space allocation for routing
- IP/IDD

Work to do:

For each harness, the harness has to be designed in 3D in the DMU taking into account all the rules of routing and the DMU environment. Therefore, the 3D harness will define:

- Choice of the backshell : straight or elbowed
- Key coding of the backshell for elbowed ones
- Connectors and backshells have to be seen in the 3D using a representative model.

- Diameters of harnesses have to be calculated and designed in DMU
- Sheaths have to be designed
- Additional parts as pass through, labels, tie-raps and flags to help to install harness have to be defined as well.

Then, a drawing in 2D (flatten 3D drawing of each harness) has to be performed including the following elements:

- Manufacturing details for each connector
- Bill of material of all parts defined in the 2D drawings.

T 2.8.2.2 – 3: Perform the design of harness installation in the DMU and with 3D VIA tool

Input Data:

- Master 3D indicating the localization of each equipment in the aricraft
- Harness 3D
- Technical note to deliver all the additional requirements
- DMU
- List of standard brackets

Work to do:

- Define all the brackets necessary to maintain harnesses (3D + 2D drawings if 3D manufacturing not possible)
- Interface drawings in 3D to inform Airframe/Mechanics Core-partners and partners where they have to foresee in their parts fixation points for these brackets and metallization code.
- 2D drawings to install screwed brackets on structure including installation of the electrical item label.
- 2D Drawings for stuck & riveted brackets on the structure
- Installation drawings in 3D in 3D VIA tool enriched with electrical item for each connector, screws, nuts, spacers, ty-raps …

In addition, the Core-partner will first select standardized brackets and only if not possible will design new brackets.

T 2.8.2.2 – 4: **Perform the equipment installation**

Input Data:

- Master 3D
- DMU
- IDD/IP
- Space allocation

Work to do:

- Design 3D interface drawings by equipment to inform Airframe Core-partners and Partners where they have to foresee in their parts fixation points + metallization code + bonding/grounding + antenna ground plan.
- Design the bracket if needed : 3D or/and 2D drawings with their bill of material
- Installation drawing of the brackets/rack/equipment on the structure in 3D or/and 2D with

bill of material associated for each equipment and add the label of the electrical item on each equipment.

T 2.8.2.2 – 5: Perform the design of electrical ADU's Structure & installation

Input Data:

- Master 3D
- DMU
- IP/IDD
- Space allocation with the external envelop to respect strictly.

Work to do:

- Design the structure respecting the stress constraints, sizing constraints
- Brackets to maintain harnesses inside will be defined and riveted.
- Robustness and reproducibility of the ADU's structure have to be ensured.
- Tolerancing has to be robust.
- Stress calculation (static & dynamic) has to be made by the Core-partner and delivered to Airbus Helicopters.
- Weight and Cost impact of the choice of material or technology has to be assessed and delivered to Airbus Helicopters.
- Deliver 3D and 2D drawings of each structural part
- Deliver 3D and 2D drawings for ADU assembly.

T 2.8.2.2 – 6: Perform the anemometry installation drawings

Input Data:

- DMU
- Space allocation
- Material to use
- Rules to route anemometry pipes

Work to do:

- Perform the installation drawings in 3D and in 2D of anemometry pipes
- Deliver the drawings with the bill of material.
- Pitot arm definition and installation drawings.

T 2.8.2.2 – 7: Configuration management

Input Data:

- Rules for configuration management

Work to do:

- ECP to perform
- ECR to perform in case of modifications
- Release of drawings in the configuration tool including center of gravity and weight for each part.

- **Sub WP 2 – Manufacturing and delivery to Airbus Helicopters**

The Core-partner will be in charge to manufacture the harnesses, the structure of ADU and the assembly of harnesses/anemometry in the structure of each ADU.
All the manufactured parts have to be delivered in Airbus Helicopters facilities in France or Core Partner facilities in Europe.

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T 2.8.2.2-8	Work preparation of harnesses, electrical boxes or ADU	See §3
T 2.8.2.2-9	Manufacturing & testing	See §3
T 2.8.2.2-10	Assembly of ADU	See §3

T 2.8.2.2 – 8: Work preparation of harnesses, electrical boxes or ADU
To do so, the Core-partner will have to do the work preparation of harnesses, electrical boxes and airframe parts and ADU Assembly (including pitot arms).
The calculation of the recurring cost of each harness has to be done and a report presenting for each harness the cost of Bill of material and the cost of manpower have to be delivered to Airbus Helicopters.

T 2.8.2.2 – 9: Manufacturing & testing
Concerning harnesses manufacturing, the Core-partner will have to use the instruction sheet given by Airbus Helicopters explaining all the manufacturing rules to apply. These documents will be given as an input to the Core-partner.
All the harnesses shall be delivered to Airbus Helicopters completely tested, checked and validated.
A document will be given to the Core-partner to define the testing requirements.
Tests shall be performed in the following conditions:

- Temperature: (20+/- 5)°C
- Atmospheric pressure 86kPa to 106kPa (860 mbar to 1060 mbar)
- Relative moisture: 45% to 75%

The following acceptance tests must be performed without any equipment’s connected on harness:

- Insulation tests
- Continuity tests
- Voltage strength tests.

Each harness & each electrical boxes have to be weighed before delivery.
Each ADU airframe (except small electrical boxes) has to be weighed before assembly.
A weight report has to be sent to Airbus Helicopters.

T 2.8.2.2 – 10: Assembly of ADU
A particular attention has to be made regarding chafing issues when installing harnesses and/or anemometry pipes and/or equipments/boxes within the structure of the ADU.

A detailed inspection has to be made prior to delivery to Airbus Helicopters and a report has to be given to Airbus Helicopters.
A technical note describing all the part number installed in the ADU has to be delivered also.
Each ADU after assembly has to be weighed before delivery.
A weight report has to be sent to Airbus Helicopters.

- **Sub WP 3 – Support to Assembly Line and Flight Line**

The Core-partner must support the assembly of the aircraft located in Airbus Helicopters facilities in France and during its flights from T0 +20 to end T0+51.

In case of assembly problem and/or modification of electrical inputs (PWD) or delivery of some additional inputs (PWD), the Core-partner has to provide solution and modify the drawings to reflect the new solution.
Electrical workers able to modify harnesses delivered and/or ADU delivered have to be able to work in Airbus Helicopters facilities in Marignane, France.
The Core Partner should also be able to deliver new harnesses if modification cannot be implemented on already manufactured harnesses or in case of new installation harnesses.

The Core Partner will analyse results of tests done on flight demonstrator in order to identify the action plan and design changes necessary to define serial product.
This activity will be closed by a final report.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 01	ADU structural parts drawing + stress analysis	3D, 2D if needed	T0 + 16
D 02	Harness installation Interface drawings	3D	T0 + 16
D 03	Equipment Interface drawings	3D	T0 + 16
D 04	Harness installation Brackets drawings	3D, 2D if needed	T0 + 16,5
D 05	Brackets for equipment installation drawings	3D, 2D if needed	T0 + 16,5
D 06	ADU assembly drawings	3D VIA or 2D if needed	T0 + 20
D 07	Stuck & riveted brackets installation drawings	2D	T0 + 16
D 08	Anemometry installation drawings (pipes + pitot arm)	3DVIA or 2D	T0 + 20
D 09	Voltage Drop calculation note		T0 + 21
D 10	Weight assessment note		T0 + 21
D 11	2D harness drawings		T0 + 21

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D 12	Screwed brackets installation drawings	3D or 2D	T0 + 18,5
D 13	Harness installation drawings	3D VIA	T0 + 18,5
D 14	Equipment installation drawings	3D VIA or 2D if needed	T0 + 18,5
D 15	Harness Recurring cost calculation note		T0 + 23
D 16	SEE EDB database : 2 deliveries to be confirmed		T0 + 32 T0 + 51
D 17	Harnesses & ADU delivery to Airbus Helicopters		T0 + 17
D 18	Technical note describing the configuration of all the parts assembled in each ADU		T0 + 17
D 19	Weighed Weight report of all manufactured parts		T0 + 21
D 20	Documentation for Permit to Fly		T0 + 32

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
RM1	Kick off Meeting	Review	T0
R2	Progress Report	Report	Every month from T0 to T0 + 51
RM3	DMU Reviews	Review	Every week from T0 to T0 +17
RM4	Intermediate Design Review	Review	T0 + 6
RM5	Critical Design Review	Review	T0 + 14
RM6	Delivery review	Review	T0 + 20
RM7	Final Synthesis report	Report	T0 + 51

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

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

The applicant must demonstrate the following capabilities:

- design and manufacturing capabilities in electrical harnesses Field.
- ability to design and manufacture aeronautic harnesses.
- master design with selected tools defined in the present section.

Minimum qualification required: ISO9001, EN9100.
Preferable qualification: CS PART21, PART 145.

In its application, the applicant shall describe how it will answer to the technical requirements described in this topic description and shall provide project plan (projects logic, schedule, organization, interfaces with Airbus Helicopters, complete toolset used).

5. Glossary

ADU	Assembly Delivery Unit
DMU	Digital Mock Up
ESN	Electrical Structural Network
EWIS	Electrical Wiring Interconnection System
CR	Change Request
ECP	Engineering Change Proposal
FWD	Functional Wiring Diagram
IDD/IP	Interface Design Description / Interface Principle
ISS	issue
PWD	Principle Wiring Diagram
TBD	To be defined
WP	Work Package

V. Innovative Actuators for Compound Rotorcraft Flight Control

Type of action (RIA or IA)	IA		
Programme Area	FRC		
Joint Technical Programme (JTP) Ref.	WP2.9 Actuation System		
Topic Leader	AIRBUS HELICOPTERS		
Indicative Funding Topic Value (in k€)	2500 k€		
Duration of the action (in Months)	51 months (until end of LifeRCraft demo flights)	**Indicative Start Date**[8]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-FRC-02-06	**Innovative Actuators for Compound Rotorcraft Flight Control**
Short description (3 lines)	
The aim of this topic is to design, develop, manufacture, test, qualify up to flight clearance and to support during flights (until TRL6) actuators to control compound rotorcraft lateral rotors and secondary control surfaces. The purpose of these actuators is to interface between the Automatic Flight Control Computers and the control surfaces. It should include innovative solutions offering improvement in term of weight, safety level, cost and use of materials having a low impact on environment.	

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

1. Background

The **LifeRCraft (IADP)** project aims at demonstrating that the compound rotorcraft configuration implementing and combining cutting-edge technologies as from the current Clean Sky Programme opens up new mobility roles that neither conventional helicopters nor fixed wing aircraft can currently cover in a way sustainable for both the operators and the industry. The project will ultimately substantiate the possibility to combine in an advanced rotorcraft the following capabilities: payload capacity, agility in vertical flight including capability to land on unprepared surfaces nearby obstacles and to load/unload rescue personnel and victims while hovering, long range, high cruise speed, low fuel consumption and gas emission, low community noise impact, and productivity for operators. A large scale flightworthy demonstrator embodying the new European compound rotorcraft architecture will be designed, integrated and flight tested.

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

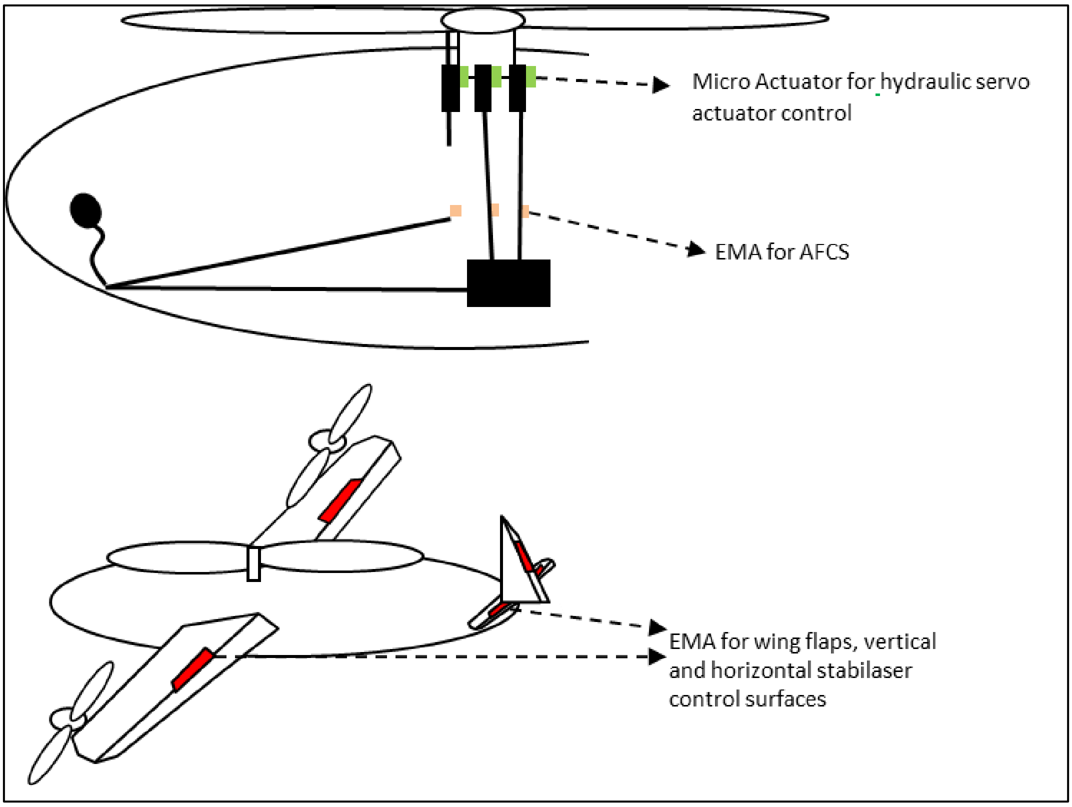
2. Scope of work

The aim of the present topic is to design, manufacture, test and support part of Flight Control System for the Compound Rotorcraft Demonstrator IADP LifeRCraft.

This Flight Control system should include an innovative technology as well as an optimized design (weight and cost), to meet the ecological challenges and to be sustainable for environment, customer and industry.

The Flight Control system could include innovative designs, trend setting manufacturing processes, innovative materials but if the TRL of each innovation is lower than 4 in 2016 and if it is risky for the program, a conventional solution must be provided and might be implemented as a back-up only.
The Flight Control system consists of:

- Control sticks (cyclic, collective and yaw)
- A set of levers and rods
- A set of hydro-mechanical-actuators
- A set of electro-mechanical-actuators (EMA)
- An Automatic Flight Control System (AFCS)
- Secondary control surfaces



Rotorcraft Demonstrator IADP Flight Control system synoptic

IMPORTANT: The following items are <u>out of the scope</u> of the Core Partner's work:

- Control sticks (cyclic, collective and yaw)
- Control levers and rods
- Hydro-mechanical-actuator
- Automatic Flight Control Computers
- Secondary control surfaces

The major design principles are focusing on:

- Light weight design
- Low dimension for easy integration
- Performances (stroke, load capacity, frequency, etc…)
- Internal monitoring
- Certifiable design (CS29 is the baseline)
- Limited and easy maintenance and support of EMA (Part and Assemblies installation/Removal, maintenance tasks, etc...)
- Reliability of the EMA
- Optimum aircraft life cycle cost
- Ecological design principles (material, manufacturing processes)

The subject of topic relates to all the activities needed to design, develop, and support the LifeRCraft Demonstrator actuation system as described above. Therefore activities such as, technical assessments, design, manufacture and test will be necessary to perform into the scope of this call. Additionally to these Technical activities that will be described further it also described the managing activities that as Core Partner should be performed by it - always in accordance with the Work Area Leader (WAL) representing Airbus Helicopters.

Following are listed the subjects in which the Core Partner(s) will perform its activities, under the following Roles and Responsibilities:

<u>Technical Activities</u>

The Core Partner(s) roles and responsibilities will be: Design, Development and Support Responsible for the Work Package 2.9.8 entitled Actuators. Therefore the WPs and the tasks in which the Core Partner(s) will work are:

<u>WP 2.9.8-1: EMA for AFCS</u>

This WP consists in designing, developing, testing and manufacturing a EMA for primary flight control system. The interface with environment of the EMA will be fixed with all others requirements in a specification supplied by AH after project start.

This EMA is a piloting series actuator for helicopter:

- This actuator includes its motor drive electronics.
- Integrated in the flight control mechanical links of the helicopter on at least one of the four axes (pitch/roll/collective/yaw).
- Interfaced to an Automatic Flight Control System through digital, discrete and analog links.
- The actuator converts AFCS orders into mechanical linear motion.

The achievement of the WP in compliance with the specification will be done through the management plan.

<u>WP 2.9.8-2: EMA for horizontal and vertical stabiliser and wing flaps</u>

This WP consists in designing, developing, testing and manufacturing a control surface actuator for horizontal and vertical stabiliser and wing flaps. The interface with environment of the EMA will be fixed with all others requirements in a specification supplied by AH after project start.

This EMA is a piloting series actuator for helicopter:

- This actuator includes its motor drive electronics.
- Integrated in the flight control mechanical links of surfaces of the helicopter.
- Interfaced to an Automatic Flight Control System through digital, discrete and analog links.
- The actuator converts AFCS orders into mechanical motion (linear or rotative motion).

The achievement of the WP in compliance with the specification will be done through the management plan.

<u>WP 2.9.8-3: Micro Actuator for hydraulic servo actuator control</u>

This WP consists in designing, developing, testing and manufacturing a micro actuator for primary flight control system. The interface with environment of the micro actuator will be fixed with all

others requirements in a specification supplied by AH after project start.
This micro actuator is a piloting parallel actuator for helicopter:

- This actuator includes its motor drive electronics.
- Integrated in the hydraulic servo actuator of the helicopter in parallel of mechanical pilot input.
- Interfaced to an Automatic Flight Control System through digital, discrete and analog links.
- The actuator converts the AFCS orders into mechanical motion (linear or rotative motion) in order to move a control valve into the hydraulic servo actuator.

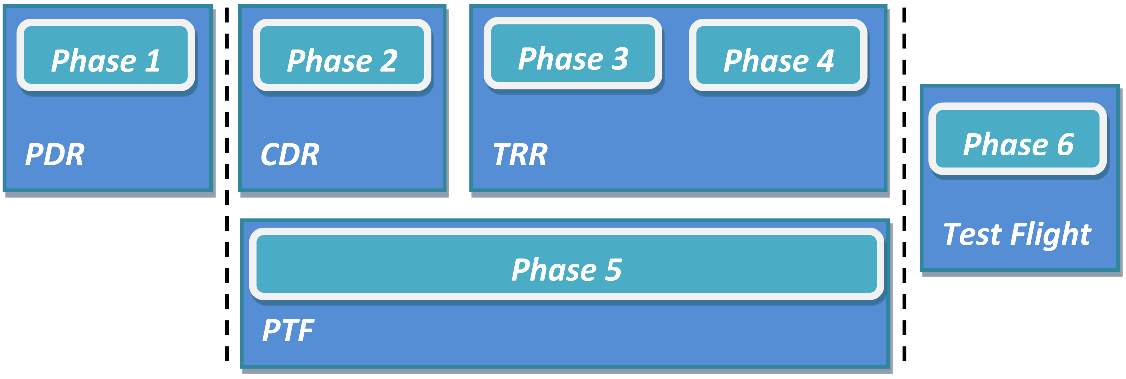
The achievement of the WP in compliance with the specification will be done through the plan management.

Managing and Coordination Activities

The Core Partner(s):

- is (are) responsible as member(s) of the consortium according to the Grant Agreement documentation
- manage & Coordinate directly all the WPS for which he has full responsibility
- follow the Configuration Management process over entire program duration (details to be fixed during GAM-Phase)
- share the WPs reporting work for the follow up with AH for the overall project development.

The work plan is structured into phases which are concluded with deliverables and milestones.
Project management will follow standard practices by applying reviews as PDR, CDR, TRR etc.



Detailed description/content of the phases

The descriptions and details which will follow have been established under the assumptions that:

- The selected Core Partner(s) is (are) certified CS21 (DOA and POA) and familiar with the rules and requirements applicable in the aeronautic industry or at least the leading industrial partner within the cluster has to fulfil these requirements and take over full responsibility for airworthiness in the front of the WAL.

- The selected Core Partner(s) is (are) able to manufacture according the quality requirements which are standard in aeronautic industry and to demonstrate to the WAL that provided actuators are flightworthy.
- If the above mentioned requirements are not satisfied, the certification of the Core Partner according to CS21 has to be achieved at the latest 6 months prior the delivery of the flyable parts. The acquisition of data and test results and production of compliance evidence needed to obtain a Permit to Fly has to be performed under the Core Partner(s)' own responsibility and included in its cost estimate.

Details phases are same for three subjects (2.9.8-1, 2.9.8-2 and 2.9.8-3)

Phase 1

This phase will enable to settle all data necessary to reach the specification requirements. The main challenge is to satisfy all the requirements and boundary conditions for a high speed rotorcraft by designing specific elements. Recurring cost for a potential production have also to be addressed. The weight for the system should be as low as possible.

The way how to achieve these targets is under the responsibility of the Core-Partner(s).

Phase 1 comprises a set of study drawings and substantiation documents for the whole system. This includes, but is not limited to:

- Performing architecture/structural layout
- Performing detailed design (limited common design office at AH facility)
  - Responsibility of reaching the weight targets
  - Selection of material and process (harmonized with AH)
  - Responsibility of the manufacturing tools design
  - Responsibility of achieving recurring cost estimations
  - Achieving and documenting data for life cycle assessment
  - Definition of test components
  - Definition of inspection and repair methods (to be approved by AH)

Several additional information sets (interface definition, external loads documentation, general requirement specification…) prepared by AH will enable the Core Partner to perform the task. A permanent support is envisaged.

In order to achieve a Permit to Fly, several harmonization tasks and agreements have to be defined prior the start of phase 1. This comprises:

  - Engineering-Tool harmonisation (substantiation-tools defined by AH, IT, Programme management, configuration management)
  - Quality assurance process harmonisation
  - Communication management
  - Dissemination of reports, technical documentation (e.g. substantiation documentation, test results, quality documentation, etc.)
  - Modus vivendi of access rights for general documentation, information, quality reports, …
  - Co-development phase

The end of Phase 1 will be concluded by the PDR (the output documentation for PDR will be detailed in the future specification at T0).

Phase 2

Based upon the outputs of Phase 1, this Phase will achieve the detailed drawings of the parts (hardware and software), the equipment, the equipped parts and assemblies of the whole system.
At the end of this phase the following topics have to be addressed for the CDR:

- System specification & associated compliance matrix update
- Detailed System description (functional, technological (material, protection, coating) etc...) update
- Interfaces status update
- Equipment status update
- Documentation list and status update
- Development test plan update
- Drawings set status (Parts, Equipped parts, Assemblies, Equipment)
- Weight breakdown update
- Electrical network compatibility update
- RC, DMC update

Phase 3

This phase is dedicated to tests and kits manufacturing.
All test requests have to be prepared in accordance with the development test plan. They should cover tests necessary for system development on bench, for flight clearance and for flight. All the necessary data have to be detailed into the test requests to define:

- The goal of the test
- The tested hardware
- The servitude hardware
- The test means
- The test program
- Successful test criteria
- The expertise and controls to be done before and after test.

Drawings kits, corresponding to dedicated test request, have to be released to be manufactured.
All tests have to be monitored by the design responsible. A report of the test has to be issued.

Phase 4

Following the phase 3, this phase is dedicated to analyse results after tests. This is the aim of phase 4. All data from previous phases (results from design phase and from tests etc...) have to be collected and summed up. Thus, all necessary modifications will be synthesized and substantiated. AH will validate these modifications in meeting planned for this purpose. In particular some modification necessary to obtain Permit to Fly will be implemented and substantiated by new tests.

Phase 4 includes a complete drawing set update for the system and a substantiation file for each modification.

Phase 5

This phase is dedicated to achieve a "Permit to Fly". Baseline regulation is CS29.

LifeRcraft will be a flying demonstrator vehicle and therefore has to fulfil several requirements to achieve a Permit to Fly. AH is the responsible in front of the airworthiness agency, and it is mandatory that AH will be supported by the Core Partner(s). Therefore the Core Partner(s) has to provide all documentation necessary to achieve Permit to Fly.

In the frame of Permit to Fly the main deliverables are:

- Documentation in the process to achieve Permit to Fly
- System Description document
- Substantiation documentation for stress/fatigue
- System Maintenance document
- System limitations document
- Directives to be applied for the system
- Program/Reports/documentation of performed tests (entire test-pyramid)
- Manufacturing documentation
- Quality documentation for the delivered system
- Quality substantiation documentation

Note: As the Permit to Fly documentation has to be endorsed by AH CVE's, a harmonization process with AH of the Permit to Fly documentation has to be forecasted

This phase include the tests to be performed by the Core-Partner at the level of the components (or sub-components) to contribute to Permit to Fly.

Phase 6

Flight test-phases conducted by AH need the support of the Core-Partner:

- To have a direct link between developer/manufacturer for quick response in case of malfunctions, defects, improvements etc.
- To ensure quick feedback to the Core Partner(s) from test campaigns
- To ensure quick improvements from Core Partner(s), if necessary

The goal of this phase is to give solutions to assembly issues on flight demonstrator and to technical problems that can be encountered during ground/flight tests. In those cases, instructions and work approval on quality folder have to be done.

In case of incident in development, dedicated task force and methods (PPS for example) have to be put in place to solve the problem.

Project synthesis

The Core Partner(s) has (have) to participate and provide input to the project synthesis. It particularly regards the lessons learned from the demonstration evaluation, supporting the technical evaluation process (including Eco-design aspects) and participating in the evaluation of characteristics for a commercial product.

3. Major deliverables/ Milestones and schedule (estimate)

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-M-1	Kick-Off Meeting	Review	T_0 (Oct. 2016)
2.9.8-M-2	Specification Review	Review	T_0+ 4
2.9.8-M-3	Preliminary Design Review	Review	T_0+6
2.9.8-M-4	Critical Design Review	Review	T_0+12
2.9.8-M-5	Model for AH FCS test bench (not for flight) + First Article Inspection	Delivery + FAI	T_0+18
2.9.8-M-6	Model for proto assembly	Delivery	T_0+25
2.9.8-M-7	Model for spare part	Delivery	T_0+30
2.9.8-M-9	Declaration of Design and Performance	Delivery	T_0+30
2.9.8-M-10	Qualification Review / TRL5 Review	Review	T_0+31
2.9.8-M-11	TRL6 Review	Review	T_0+48
2.9.8-M-12	Final Synthesis Report	Review	T_0+50

Quantity model delivery: EMA for AFCS			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-QM-1	Model for AH FCS test bench (not for flight): -Qty=1 (TBC)	Delivery	T_0+18
2.9.8-QM-2	Model for proto assembly (for flight): -Qty=13 (TBC)	Delivery	T_0+25
2.9.8-QM-3	Model for flight spare part: -Qty=3 (TBC)	Delivery	T_0+30

Quantity model delivery: EMA for horizontal and vertical stabiliser and wing flaps			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-QM-4	Model for AH FCS test bench (not for flight): -Qty=1 (TBC)	Delivery	T_0+18
2.9.8-QM-5	Model for proto assembly (for flight): -Qty=8 (TBC)	Delivery	T_0+25
2.9.8-QM-6	Model for flight spare part: -Qty=2 (TBC)	Delivery	T_0+30

Quantity model delivery: Micro Actuator for hydraulic servo actuator control			
Ref. No.	***Title - Description***	***Type***	***Due Date***

Quantity model delivery: Micro Actuator for hydraulic servo actuator control			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-QM-7	Model for AH FCS test bench (not for flight): -Qty=2 (TBC)	Delivery	T_0+18
2.9.8-QM-8	Model for proto assembly (for flight): -Qty=6 (TBC)	Delivery	T_0+25
2.9.8-QM-9	Model for flight spare part: -Qty=2 (TBC)	Delivery	T_0+30

Deliverables			
Program management documents (progress reports):			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-PM-1	Development Plan	information	15 working days before KOM
2.9.8-PM-2	Progress Report Development including: weight, conformity to requirements, status of the actions (reviews, meetings, coordination memos…)	information	Every 2 months
2.9.8-PM-3	Configuration Management Plan	Approval	PDR
2.9.8-PM-4	Technology Readiness Level (TRL) Documentation	Review	At KOM, and updated 15 working days (TBC) before PDR, CDR, QR
2.9.8-PM-5	Risk and/or Opportunity analysis with association mitigation and/or implementation plans	Review	At KOM, and updated 15 working days (TBC) before PDR, CDR, QR
2.9.8-PM-6	List of Problems	information	On WAL request
2.9.8-PM-7	Corrective action plan	Review	On WAL request
2.9.8-PM-8	Weight Report	Approval	15 working days before KOM and 15 working days before PDR,CDRand delivery if Update necessary

Engineering documents (progress reports):			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-ED-1	Product Specification and Compliance matrix to WAL specification	Approval	15 working days (TBC) before PDR, CDR, QR
2.9.8-ED-2	Interface Control Document (ICD).	Approval	15 working days (TBC) before PDR, CDR

Engineering documents (progress reports):			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-ED-3	Design File and Design description Detailed Documentation (architecture choices, substantiation files including stress calculation, analyse results, 2D drawings, compliance matrix, etc)	Review	15 working days (TBC) before PDR, CDRs
2.9.8-ED-4	Material Plan	Approval	15 working days (TBC) before PDR, update if necessary.
2.9.8-ED-5	Qualification Review TRL5 substantiations + TRL5 Form	Document	T_0+31
2.9.8-ED-6	TRL6 substantiations + TRL6 Form	Document	T_0+48
2.9.8-ED-7	Final Synthesis Report	Document	T_0+50

Quality Assurance documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-QA-1	Acceptance Test Procedures (ATP)	Approval	15 working days before Development FAI; Reviewed 15 working days before FAI.
2.9.8-QA-2	Acceptance Test Report (ATR)	Information	With each delivery
2.9.8-QA-3	Certificate of Conformity and Delivery Note	Information	With each delivery
2.9.8-QA-4	Concessions / Production Permit	Approval	With each delivery
2.9.8-QA-5	Review report	Approval	15 working days at the latest following the review (KOM, PDR, CDR, FAI, QR)
2.9.8-QA-6	FAI Report	Approval	Report of development FAI before qualification tests° /flight tests start, at the latest 15 days following the review.
2.9.8-QA-7	Storage and conditioning sheet	Approval	Before first equipment delivery
2.9.8-QA-8	Critical parts file	Approval	First version 15 working days before PDR Last version 15 working days before CDR

Qualification documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-QD-1	Verification Plan	Approval	15 working days before KOM Updated 15 working days before PDR and 15 working days before CDR

Qualification documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-QD-2	Test Procedure	Approval	15 working days before the start of the test
2.9.8-QD-3	Verification Test Reports	Approval	25 working days after the end of the tests
2.9.8-QD-4	Theoretical verifications	Approval	15 working days before QR
2.9.8-QD-5	Verification coverage Analysis Report	Approval	15 working days before QR
2.9.8-QD-6	Component Repair Manual (CRM) qualification file.	Approval	15 working days before PDR Updated 15 working days before CDR and QR if necessary
2.9.8-QD-7	Declaration of Design and Performance (DDP)	Approval	15 working days before QR
2.9.8-QD-8	Model Description and Compliance Matrix	Approval	With each delivery of model

Safety / Reliability documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-SR-1	[Safety/Reliability Plan]	Review	15 working days month before PDR
2.9.8-SR-2	[Reliability assessment]	Review	Preliminary 15 working days before PDR, Updated 15 working days before CDR, Final 15 working days before QR
2.9.8-SR-3	[Safety Assessment]	Review	Preliminary 15 working days before PDR, Updated 15 working days before CDR, Final 15 working days before QR
2.9.8-SR-4	[Common Cause Analysis]	Review	Preliminary 15 working days before PDR, Updated 15 working days before CDR, Final 15 working days before QR
2.9.8-SR-5	[CPL-FMECA-Failure Catalogue] including the FMES Note: Report and Excel file provided by the WAL	Review	Preliminary 15 working days before PDR, Updated 15 working days before CDR, Final 25 working days before QR
2.9.8-SR-6	Computer Data files related to the demonstration of Safety-Reliability probabilities Note: Fault Trees in electronic format.	Review	On WAL request

Safety / Reliability documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-SR-7	Safety /Reliability Compliance Matrix	Review	Preliminary 15 working days before PDR, Updated 25 working days before CDR, Final 15 working days before QR

Environment Rules Documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-ER-1	Material and Safety Data Sheet (MSDS) (TBC before T_0) **Note: Concerns only preparation**	Approval	Preliminary 15 working days before PDR Update 15 working days before CDR Update 15 working days before QR
2.9.8-ER-2	Fulfilled form F085 002 Material Declaration form (TBC before T_0) **Note: Provide also excel form**	Approval	Preliminary 15 working days before PDR Update 15 working days before CDR Update 15 working days before QR

ILS Documents			
Ref. No.	***Title - Description***	***Type***	***Due Date***
2.9.8-IL-1	Ground Service Equipment	Approval	First issue 15 working days before PDR, Final 15 working days before CDR, updated 15 working days before QR
2.9.8-IL-2	Troubleshooting	Approval	First issue 15 working days before PDR, Final 15 working days before CDR, updated 15 working days before QR
2.9.8-IL-3	TechPub (Level TBC before T0)	Approval	First issue 15 working days before PDR, Final 15 working days before CDR, updated 15 working days before QR

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

- **Requirements needed to achieve a Permit to Fly**

  - Provide material data which are required to achieve a Permit to Fly
  - Use material, processes, tools, and calculation tools etc. which are commonly accepted in the aeronautic industry and certification authorities.
  - Harmonize (AH-Core Partner(s)) calculation processes/tools
  - Interact with AH at any stage of the work
  - Access to the production sites
  - Core Partner (s) is (are) expected to initiate a plan in order to reach the target of TRL 6 at the end of demonstration
  - Perform updates of documentation in case of content not accepted by authorities.

- **Special Skills**

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

- Experience in design and sizing of EMA flight control system for aircraft.
- Practise of tools for design and stress analysis in the aeronautical industry (i.e. CATIA v5 release 21, SAMCEF etc…)
- Capacity and experience in manufacturing EMA parts
- Capacity to assess and eventually repair "in-shop" components due to manufacturing deviations.
- Tests definition and preparation: stress and strain predictions, deflexion prediction and instrumentation definition
- Analysis of test results
- Capacity of evaluating the results versus the technical proposals from the beginning of the project till the end of it IAW Eco-design rules and requirements.
- Capacity of evaluating results in accordance to Horizon 2020 environmental and productivity goals following Clean Sky 2 Technology Evaluator rules and procedures.
- Competence in management of complex projects of EMA FCS system development.
- Experience with TRL Reviews in research and manufacturing projects for aeronautical industry
- Capacity of providing complex aeronautical components within industrial quality standards.
- Capacity to support documentation and means of compliance to achieve prototype "Permit to Fly" with Airworthiness Authorities (e.g. EASA, FAA, national institutions and any others which apply).
- Capacity of performing Life Cycle Analysis (LCA) and Life Cycle Cost Analysis (LCCA).
- Capacity of evaluating design solutions and results with respect to IAW Eco-design rules and requirements all along the project.
- Design Organization Approval (DOA).
- Product Organization Approvals (POA).
- Capacity to specify material, protection and coatings tests along the design and manufacturing phases of aeronautical components, including:
    - Characterization of innovative materials and processes
    - Environment conditions
    - Resistance
- Capacity to insure quality monitoring of manufactured parts

- **Technology maturity**

In order to reach the main goals of the project, the two major aspects of maturity and safety have to be considered for materials and processes.
Because of the ambitious plan to develop a flying prototype in a short time frame, the technology used by the Core Partner(s) must be at a high maturity level (TRL4) to safely reach the required technology readiness for the flying demonstrator.
To secure this condition, the Core Partner(s) will have to demonstrate the technology readiness for his proposed technology with a TRL review, to be held together with the WAL.

Core Partner (s) is (are) expected to show that the proposed technology are at TRL4 in 2016.
The TRL review must be held within one year after the beginning of the project and must confirm a maturity of TRL5 (or at least TRL4 if a solid action plan to reach TRL5 within the scope of one further year is validated and accepted by AH).
Furthermore, the schedule of the project and the budget framework do not allow for larger unanticipated changes after the middle of the project. Therefore, it is required that, at the start of the activities, the Core Partner(s) demonstrates his capability to develop and manufacture the required items with a baseline technology as a back-up solution in case the new technology proposed is not reaching on time the TRL level required above.
This back-up plan, which is made to secure the accomplishment of the project goals shall be agreed between AH and the Core Partner(s) within half a year after the start of the activities.
Furthermore the M&P activities in the IADP and Airframe ITD shall support the safe inclusion of the Core Partner(s) technology into the complete H/C.

- **Certification**

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

- **Data management**

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

- CATIA V5 R21
- VPM & Windchill compatible
- SAP compatible

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

General Process for establishing weight and recurring cost breakdown

<u>Weight:</u>
The target is to obtain the lowest weight possible for the proposed component compliant with the technical requirements and compatible with a serial aeronautical production.
In its offer, the applicant has to provide an estimated maximum weight of its proposed component. This value will be updated for the signature of the consortium agreement regarding the design data available at this time. The difference with the weight provided with the offer will be substantiated and the new weight figure will have to be agreed with the WAL.
For the PDR, the core-Partner will have to provide a detailed weight breakdown of the component in

accordance with the technology, the technical requirement and the interfaces agreed with the WAL. The difference with the weight agreed in the consortium agreement will be substantiated and submitted to the approval of the WAL.
For the CDR, the Core-Partner will provide an update of the weight breakdown with a substantiation of the difference with the PDR version. If an update of the overall weight is necessary, it will be submitted to the approval of the WAL.
The components for the flying demo will be delivered with a weight record sheet and deviations from the target agreed during CDR will be substantiated.
At the end of the demonstration phase, the Core Partner will provide a weight estimation of the component for serial production accordance with the lessons learned during the demo phase. Differences from CDR weight have to be explained.

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

- **General technical requirements**

Subject 2.8-1: EMA for AFCS

Main function
- Convert an electrical input into mechanical linear motion
- Internal monitoring and internal failure detection

Family concept
- A mechanical part wich supports: the motor, the output shaft and the position pick-offs
- An electronic part wich supports: two electronic boards and the connector of the equipment

Technical requirement
- Stroke: from +/-2.5 to +/-20mm
- Operational load: full performances for at least 25daN
- Input frequency: up to 10Hz
- Bandwith: >10Hz
- Speed: from 20 to 25mm/s
- Physical dimensions about:
    - Length: target 160mm maxi
    - Width: target 43mm maxi
    - Height: target 75mm maxi
- Design according to CS29 requirements
- ARINC 429 command input
- EMC and lightning protection

- Remain irreversible with a limit load of about 600daN
- End play in normal operation 0.1mm
- Light weight (target < 750g)
- Vibration level: 7g in all direction
- ECO friendly materials and process
- Quality in accordance to a serial certified aeroanautical product
- Temperature envelope: target for a serial definition: -40°C to 85°C
- Resistance to environment (DO160)
- Minimum flight time for demonstrator:200h FH + ground operation
- Altitude range: 15000 Ft

Subject 2.8-2: EMA for horizontal and vertical stabiliser and wing flaps

Main function
- Convert an electrical input into mechanical power (linear or ortative motion)
- Internal monitoring and internal failure detection

Family concept
- A mechanical part wich supports: the motor, the output shaft and the position pick-offs
- An electronic part wich supports: two electronic boards and the connector of the equipment

Technical requirement
- Stroke: from 20 to 40mm for linear motion or from +/-5° to +/-15° for rotative motion
- Load: from 500N+/-250N to 1500N+/-500N for linear motion or from 120Nm+/-60Nm to 300Nm+/-150Nm for rotative motion
- Speed: from 0.5mm/s to 3mm/s for linear motion or from 0.5°/s to 1.5°/s for rotative motion
- Physical dimensions about:
    - Length: target 180mm maxi
    - Width: target 40mm maxi
    - Height: target 150mm maxi
- CS29 certifiable
- ARINC 429 command input
- ENC and lightning protection
- Remain irreversible in case of lose of electrical power
- End play in normal operation 0.1mm for linear motion or 0.05° for rotative motion
- Light weight (target 1000g maxi)
- Vibration level: 7g in all direction
- ECO friendly materials and process
- Quality in accordance to a serial product
- Temperature envelope: target for a serial definition: -40°C to 100°C (TBC)
- Resistance to environment (DO160)
- Minimum flight time for demonstrator:200h FH + ground operation
- Altitude range: 15000 Ft

Subject 2.8-3: Micro Actuator for hydraulic servo actuator control

Main function

- Convert an electrical power into mechanical power (linear or rotative motion)
- The output shaft has linear movement or rotatif movement
- Internal monitoring and internal failure detection

Technical requirement

- Stroke: about +/-2mm for linear motion or +/-3° for rotative motion
- Load: at less 10N
- Frequency on full stroke up to 250Hz
- Physical dimensions about:
    - Length: target 120mm maxi
    - Width: target 50mm maxi
    - Height: target 50mm maxi
- CS29 certifiable
- New technology for hight frequencies application with hight reliability must be privileged
- ARINC 429 command input
- EMC and lightning protection
- Return in neutral position
- End play in normal operation 0.02mm for linear motion or 0.03° for rotative motion
- Light weight (target 300g maxi)
- ECO friendly materials and process
- Quality in accordance to a serial product
- Temperature envelope: target for a serial definition: -40°C to 130°C
- Resistance to environment (DO160)
- Minimum flight time for demonstrator:200h FH + ground operation
- Altitude range: 15000 Ft

5. Glossary

AH	Airbus Helicopter
AP	Autopilot
CDR	Critical Design Review
CFD	Computational Fluid Dynamics
CRD	Component Requirements Document
CVE	Certification Verification Engineer
DMC	Direct Maintenance Cost
EMA	Electro Mechanical Actuator
FAI	First Article Inspection
FCS	Flight Control System

IP	Intermediate-Pressure
ITD	Integrated Technology Demonstrator
KOM	Kick Of Meeting
PDR	Preliminary Design Review
PPS	Practical Problem Solving
PTF	Permit To Flight
QR	Quality Review
RC	Recurring Cost
SEMA	Series Electro Mechanical Actuator
STD	Standard
TBD	To Be Defined
TCL	Trust Collective Level
TRL	Technology Readiness Level
TRR	Test Readiness Review
WAL	Work Area Leader
WP	Work Package

4. Clean Sky 2 – Airframe ITD

I. Next Generation Movables for High Speed Aircraft

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	A-4.1		
Topic Leader	AIRBUS / DASSAULT / SAAB		
Indicative Funding Topic Value (in k€)	5000 k€		
Duration of the action (in Months)	84 months	Indicative Start Date[9]	Q4 2016

Identification	Title
JTI-CS2-2015-CPW03-AIR-01-04	Next Generation Movables for High Speed Aircraft
Short description (3 lines)	
To design and demonstrate multifunctional control surfaces for next generation aircrafts, and also associated design, manufacturing, testing and certification processes. New control surfaces will have the objective of - adapting the geometry to the flight point (morphing) - reducing loads (more efficient loads alleviation) - reducing weight though optimized structures - reducing noise - reducing manufacturing costs (thermoplastics, 3D printing, ...). Improvements of validation and certification methods will address the integration of simulation as an accepted contribution to the means of compliance.	

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

1. Background

The overall objective of the Airframe ITD is to progress on the efficiency of Airframes in terms of aerodynamics (drag reduction for lower CO2 emissions), in terms of structures (weight reduction for lower CO2 emissions), in terms of noise and vibration generation and control (reduction of community noise, improvement of cabin comfort, weight reduction), and in terms of costs.
WP A4.1 of Airframe ITD, titled "Novel control", addresses in particular the improvement of control strategies in support of the objectives above. Novel control addresses all physically movable parts of the aircrafts which have the objective of adapting (controlling) the airflow, as well as the sensors, actuators and control laws which will control the physical movements.
Progress on movables has several objectives:

- Improving low speed / high lift performances, with options compatible with laminar flow
- Improving basic aircraft six degrees of freedom control, in particular at high speed where strong aeroelastic effects reduce and sometimes cancel the efficiencies of the control surfaces (ailerons in particular).
- Adaptation of aero shape to flight point ("morphing"): aircraft must be designed for more than one flight point for optimal efficiency
- Load control, both manoeuvre and gust induced
- Adaptation of airflow captured for ventilations, through adaptive inlets, in order to limit the induced drag to the minimum.

Techniques and technology supporting movables are rapidly progressing, both in terms of morphing solutions (quite notable is the output of the SARISTU FP7 project) and in terms of actuation techniques, electrically powered or not. By focusing on the aerodynamic surfaces design, skin material and manufacturing as well as the required new, advanced design methodologies, it is now considered possible to develop and integrate industrially feasible morphing applications with respect to flap and winglet trailing edges, air inlets and vortex generators. While trailing edge devices integrated in an aircraft flap are capable of tailoring the wing lift to the exact flight conditions and as such bring cumulative benefits over the aircrafts mission, winglet adaptation has significant load control capabilities, offering either weight or fuel consumption reduction opportunities. Air inlets on the other hand offer shorter term benefits to be reaped by, for example, direct system weight reduction while deployable vortex generators have very important local benefits.
Integration of movables at aircraft level is a difficult topic for several reasons including the reduced volumes available in high speed wings, the very high loads of high speed aircrafts, and also the limited heat transfer in composite wings. Innovative movables have then to be designed from the start with a specific integration strategy.
Movables have also negative impacts as they generate parasitic drag due both to fairings made necessary by the volume of the devices and due to flow leakage, and generate also noise due to vortices and generated turbulence. Design and integration of movables must be done with the objective of minimizing such impacts.
Last but not least, movables are a large cost item in particular because of the cost of the actuation

system, and integration solutions leading either to simpler actuators or to a reduced number of actuators would be quite beneficial.

2. Scope of work

Main steps and logic

Progress on movables can be pursued in a "top down" process, elaborating technical solutions for already identified movable concepts, and also in a "bottom up" process starting from innovative actuation / morphing technologies and elaborating new movable concepts which could bring progress at aircraft level. Consequently the present call is proposed combining both "top down" and "bottom up" approaches.

Activities to be performed are as follows:

1. Explore one or more innovative movable solutions for each of the nine main target applications
   - Multifunctional slat for a laminar wing, for which outer surface-quality and deformation-allowables will be particularly important;
   - Multifunctional slat for a turbulent wing, for which non-recurring cost and kinematics interface will be particularly important;
   - Adaptive winglet: active winglet trailing edge for large winglet concepts, active winglet leading edge, ...;
   - Multifunctional control surface concepts like roll control support by HTP (elevator);
   - Flight control re-configuration in terms of failure exploration of multifunctional control surfaces for safe flight home flight envelop limitation;
   - Ailerons with augmented functions (new control surfaces and actuation, one example can be embedded flap track fairings) and low cost;
   - Adaptable (morphing) inlets and outlets for secondary airflow capture (ventilations);
   - Smart vortex generators (VGs), able to be deployed and retracted depending on the flight conditions;
   - Concept for integration of an advanced flow control system.

   Other applications in which innovative movables can improve the performances of the airframe can be proposed by applicants.

   Concepts should be explored first at a generic level, making use of the existing state of the art, for applicability both to Large Passenger Aircraft and to Business Jets.

2. Assess feasibility and impact on aircraft performances of the proposed solutions, in cooperation with Airbus, Saab and Dassault. The assessment shall include as a minimum:
   - A preliminary load assessment and mechanical and functional definition, leading to a weight estimate
   - An estimation of the expected benefit in terms of drag, noise, load control, etc. based on simulations and/or on lower end testing

- A preliminary analysis of integration solutions and of the impact of system failures, supporting assessment of certificability
- A roadmap for deployment including ROM costs

3. Based on the assessment above, select a limited set of the proposed target applications and associated solutions for development to TRL= 4 to 5, in concertation with leaders and other core partners. Within the available budgets, selection will take into account the Airframe ITD global objectives and priorities, supporting both next generation Bizjets and Large Passenger Aircrafts, and the applicant's own priorities: selected solutions shall have clear added value at aircraft level and also have a clear development path to deployment.

4. Develop and test the selected solutions:
   - Depending on the selected technologies and concepts a full scale prototype of the complete movable or of a critical part will be designed, manufactured and tested for mechanical and durability qualification,
   - Also depending on the selected technologies and concepts critical aero, loads and/or noise performances will be demonstrated by the applicant through large scale tests on the ground (wind tunnel) or in flight by local modifications of an existing aircraft,
   - A reference aircraft configuration for analysis of the integration will be provided by either Airbus or Dassault with reference flight points and global loading as required for the design and test of the movables, detailed loads will remain the responsibility of the applicant,
   - Extra support can be envisaged based on CfPs up to a funding equivalent to the present call, as required.

Technology base

The basic technologies considered in the exploration phase shall include (but are not limited to):

1. Conformal morphing trailing edges and air inlets:

Requirements on the overall, structural and system design overlap and a global solution must be proposed. Of particular importance is the selection of the skin material with requirements governing each specific application. Also specific solutions must minimize the number of actuators required for actuation to comply with system robustness requirements while assuring compliance with failure and hazard analysis requirements. Finally, the specific design must not only minimize the number of parts for industrial feasibility but also include aircraft operational requirements to minimize possible customer efforts.

2. Multiple degree of freedom kinematics and actuation:

Multipurpose control surfaces have high requirements in terms of movements: they should be extendable, deflectable in both directions, at high frequency and while sustaining high loads. A second actuator controlling a second movement can be the solution to achieve such requirements.

3. Smart vortex generators:

Cumulative effects on fuel burn reduction are expected. To achieve the desired take-off and landing performances, small vortex generators are currently placed on the airframe. Although their functionality is only required during these flight phases, their installation also induces small local but cumulative drag. Reliable, low-cost retraction designs are expected to achieve a significant overall drag reduction in cruise condition and are likely to benefit from developments made for conformal morphing structures and vice-versa.

4. Hydraulic, electrical and mixed flight control architectures:

Innovations to support the optimized integration of conventional innovative movables are of particular interest.

5. Thermoplastics and other innovative composite structures, and associated manufacturing processes:

They can bring weight and cost reduction for highly loaded movables.

6. Noise reduction devices :

In particular flap vortex control devices, slat gap absorbent and fillers, etc., which have been shown to be efficient in terms of acoustics and are natural candidates to be integrated in the proposed movable concepts.

7. Electric ice protection systems:

They can in particular be the solution for leading edge movable concepts which are not compatible with bleed air ice protection systems

8. Fluidic flow control:

Recent R&T programmes (e.g. CleanSky 1 SFWA) have proven that active flow control with its inherent on-demand capability is able to significantly enhance the movable performance. It is therefore a promising technology which target similar benefits as smart VGs. Fluidic type flow control techniques (with surface flush mounted unsteady jet actuation systems) have been proven to delay separational effects for generic configurations in Clean Sky 1. Due to their inherent flexibility (jet direction, frequency, mass flow etc.) of operation they can also function as load control device (reducing loads at off design conditions). Fluidic type flow control has therefore the potential to enable wing weight reductions. Additionally fluidic flow control concepts embedded into the high and low speed design process offer benefits for cruise (drag reduction via flow control adjusted camber) and low speed regimes (separation delay). Whereas a robust proof of concept (for separation delay and load reduction) is available from Clean Sky 1, a technology demonstration for a full scale prototype is required in this topic.

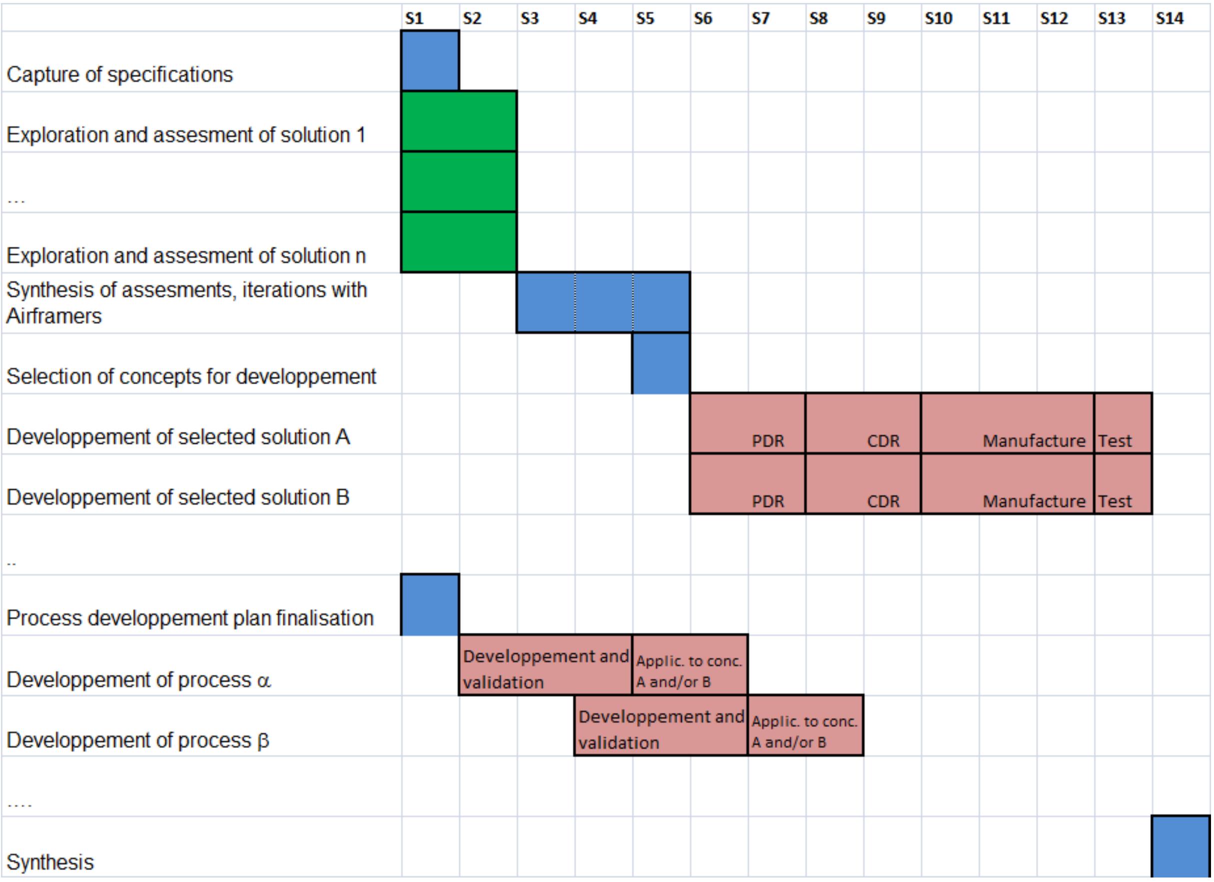
In parallel, innovative design, qualification and manufacturing processes shall be developed with respect to:

1. Hybrid test approach for certification: Model-based simulation for new movables; physical & virtual test means for movables functionalities

2. Aeroelastic tailoring
3. High fidelity multidisciplinary models in order to analyse the performances of the innovative movables with good representativeness of the new materials, manufacturing processes, actuators.

Schedule and WBS

Because of the partially "bottom up" nature of the present call, the detailed schedule and WBS is up to the applicant to adapt to the technical content of his proposal. Some guidelines & suggestions are given below but are by no means mandatory; the main requirement is the clarity of the path to deployment.
The schedule and organisation of the proposal could then be the following:



3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1.1	Synthesis of exploration of movable solutions for applications 1 to 9	R	T0+12
2.1	Synthesis of feasibility and impact on aircraft level performances of movable solutions for applications 1 to 9	R	T0+24
3.1.1	PDR of selected solution A (first concept chosen for development)	RM & R	T0+42
3.1.2	CDR of selected solution A	RM & R	T0+54
3.1.3	Review of test item A	RM & R	T0+72
3.1.4	Test report of selected solution A	R	T0+78
3.2.1	PDR of selected solution B[10] (second concept chosen for development)	RM & R	T0+42
3.2.2	CDR of selected solution B	RM & R	T0+54
3.2.3	Review of test item B	RM & R	T0+72
3.2.4	Test report of selected solution B	R	T0+78
4.1.1	Detailed development plan of process α (first process chosen for development)	R	T0+6
4.1.2	Validation of process α	R	T0+24
4.1.3	Application of process α to selected solution X	R	T0+36
4.2.1	Detailed development plan of process β[11] (second process chosen for development)	R	T0+6
4.2.2	Validation of process β	R	T0+24
4.2.3	Application of process β to selected solution X	R	T0+36
5.1	Final synthesis	R	T0+84

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Trade off synthesis and selection of concepts for development	RM & R	T0+30
2.1.1	PDR of selected solution A	RM & R	T0+42
2.1.2	Review of test item A	RM	T0+72
2.2.1	PDR of selected solution B[12]	RM & R	T0+42

[10] To be adapted depending on the number of solutions selected for development (more than 2 if relevant, but depends from the outcome of the final selection phase)

[11] To be adapted depending on the number of solutions selected for development (more than 2 if relevant, but depends from the outcome of the final selection phase)

[12] To be adapted depending on number of solutions selected for development

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
2.2.2	Review of test item B	RM	T0+72
2	Review of detailed development plan of innovative processes	RM	T0+6
3	Synthesis of validity and applicability of innovative processes	RM & R	T0+40
4	Final synthesis	RM & R	T0+84

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

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

Demonstrated capabilities on:

- Aerodynamic design with experience of qualification and certification,
- Loads assessment with experience of qualification and certification,
- Structural design with experience of qualification and certification,
- Acoustic design with experience of qualification and certification,
- Elaboration of design models,
- Aerodynamic, loads and structural testing, including support to certification,
- Configuration performance assessment,
- Innovative Manufacturing and associated cost assessment,
- Flow control technologies for application at airframe components.

In addition,

- The applicant shall have a sound R&T background in design, testing and demonstration of flow control techniques in small and mid-scale wind tunnel facilities.
- The applicant shall be able to integrate sensors and flow control actuators in wind tunnel models, manufacture flow control devices and do testing of systems for flow control applications in wind tunnels.
- The applicant shall have laboratory testing facilities and equipment necessary for flow control actuator functional testing.
- The applicant shall have the expertise to design, build and test deployable vortex generators.
- The applicant shall have the tools and expertise to design and test morphing components of inlets and outlets, incl. actuation.

5. Glossary

VG	Vortex generator
Concept A	First concept chosen for development
Process α	First process chosen for development
TE	Trailing Edge
LE	Leading Edge
TRL	Technology Readiness Level
ITD	Integrated Technology Demonstrator
WBS	Work Breakdown Structure
PDR	Preliminary Design Review
CDR	Critical Design Review

II. <u>Design, manufacture and deliver Technology Demonstrator of high visibility, crashworthy, low-drag integrated cockpit section for Next Generation Civil TiltRotor (NGCTR)</u>

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	ITD Airframe – WP B4.2		
Topic Leader	AGUSTAWESTLAND		
Indicative Funding Topic Value (in k€)	3500 k€		
Duration of the action (in Months)	68 months	**Indicative Start Date**[13]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-AIR-02-09	**Design, manufacture and deliver Technology Demonstrator of high visibility, crashworthy, low-drag integrated cockpit section for Next Generation Civil TiltRotor (NGCTR)**
Short description (3 lines)	
Design, analyze, manufacture, test and deliver a pressurised cockpit section. Cockpit comprises radome, pressurized crew compartment with seating provisions, instrument panel, avionics bays, nose landing gear bay, pressurized bulkhead, transparencies, provisions for crew emergency egress.	

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

1. Background

Next Generation Civil Tiltrotor (NGCTR) is a novel multipurpose tiltrotor design with increased range and cruise speed capabilities.
Under Clean Sky 2 AgustaWestland and a group of selected partners shall design, develop, manufacture, test and fly a full scale Technology Demonstrator (TD) of the NGCTR, representative of the foreseen production aircraft.

2. Scope of work

The scope of work of the present Call for Core Partner(s) is to design and substantiate the cockpit section (with an approximate diameter of 2,7 m and a length of 4 m, still to be confirmed) of the production aircraft to Preliminary Design Review (PDR) maturity level and, from this configuration to design, analyze, manufacture, test, supply and support through integration, test and flight, a derivative cockpit section for the fuselage of the Technology Demonstrator of NGCTR according to the requirements, specifications and directives supplied by AgustaWestland (AW).

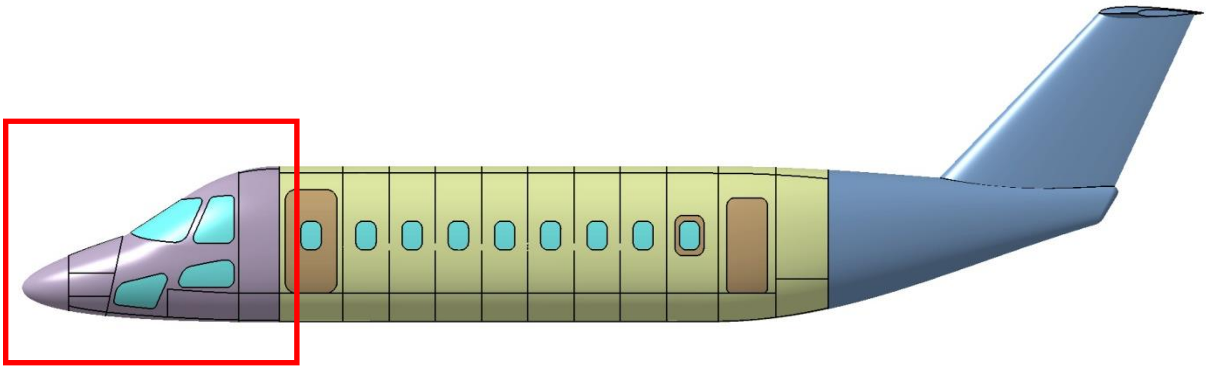


Figure 3: NGCTR Cockpit section notional configuration.

The fuselage cockpit section design has to satisfy a specified certification basis that will be supplied by AW and comprising a selection of CS25 and CS29 requirements with additional ones for the tiltrotor-specific aspects, with the overall objective of achieving a “Permit to Fly” for the complete aircraft. The selected partner shall provide appropriate documentation to substantiate compliance to the applicable requirements for the proposed configuration. The methods of compliance to the design requirements shall be agreed with AW.

General architecture of the NGCTR will be supplied by AW and any changes to this have to be agreed and approved by AW. Interfaces between NGCTR modules (Cockpit, Main Fuselage, Aft Fuselage, Wing, Doors, Landing Gear, etc.) will be controlled and checked by AW in order to guarantee mutual compatibility. The cockpit section of the NGCTR comprises radome, pressurized pilot compartment with seating provisions, instrument panel, avionics bays, pressurized bulkhead, nose landing gear bay, transparencies and provisions for crew emergency egress.

Core Partner(s) shall evaluate design and manufacturing solutions for the NGCTR cockpit section and recommend which they regard to be the most suitable (ex: metallic, hybrid (metallic and composite), etc...).
Material selection and manufacturing techniques shall be agreed with AW with the objectives of minimising cost and weight, ease of manufacture, ensuring repairability, and assessing the environmental impact of the product throughout the aircraft life cycle. Considerations should be given to such things as energy consumption during material manufacture, material processing within the REACH and other environmental frameworks and end of life disposal strategy.

Detailed design, analysis and integration of the structural elements shall respect the general architecture and weight targets of the tiltrotor and it is the Core Partner(s) responsibility to supply technically feasible solutions which are compatible with AW procedures. Systems provisions design and analysis is part of the Core partner(s) design activities based on interface requirements agreed with AW. Dedicated solutions will be integrated in the Technology Demonstrator for special safety features.

Core Partner(s) shall:

- Work within the common terms of reference of the core agreement
- Manage & coordinate directly all the WPs for which they have full responsibility
- Manage & coordinate directly the activities related to WPs for doors, hatches, seals and transparencies
- Follow the Configuration Management process throughout the duration of the entire program

It is proposed to structure the technical activities as follows:

<u>Work Package 1 – Production Aircraft Cockpit configuration design</u>

This work package (WP) covers the design of an effective and efficient cockpit section structure for the foreseen production aircraft up to the successful completion of the Preliminary Design Review (PDR).
The NGCTR cockpit section shall be optimised for weight, aerodynamics and cost using novel materials and construction techniques where appropriate.

The Core Partner(s) shall be responsible for:

- Design of the product version of the cockpit section of NGCTR to PDR maturity level as part of AW's integrated design team

- The structural layout and substantiation
- Production of a compliance plan to the agreed basis of certification
- Assisting AW with the basis of certification in areas pertinent to the cockpit design
- Performing the preliminary design and analysis of the cockpit section
- Achieving the agreed weight targets
- Selection of materials and processes (with final selection approval from AW as outlined above)
- Supporting AW aerodynamic design by ensuring close liaison between partners during the preliminary and detailed design phases
- Demonstrating that the fuselage can be manufactured in such a way as to comply with EMC requirements including direct and indirect lightning effects and HIRF
- Creating a backup design using conventional processes and materials should any new process or material under proposal prove unfeasible
- Definition of any tests required for the substantiation of the design, including test articles and equipment
- Definition of inspection and repair methods
- Producing and documenting data for life cycle assessment
- Preparing recurring cost estimations

The basic structural concept shall be the responsibility of AW including but not limited to:

- The determination with the authorities of the basis of certification
- The final selection of proposed materials
- The final selection of the proposed manufacturing and assembly process
- The final selection of the proposed inspection and repair philosophy
- The acceptance of the proposed methods of compliance and means of evidence to the requirements

Work Package 2- Technology Demonstrator Aircraft Cockpit configuration design

NGCTR Technology Demonstrator is an experimental tiltrotor that aims to prove the fundamental capabilities of the Next Generation Civil Tiltrotor architecture and technology.

The design of the experimental structure should take into account technical and technological solutions proposed for the production solution where they are shown to reduce the cost and time of development, reduce design time, ease manufacture and assembly of the Technology Demonstrator or are a necessary part of the validation programme.

All the technical and technological solutions to reduce cost and time of development, design, manufacture and assembly the NGCTR experimental structure have to be agreed with AW and shall not constrain the development of the NGCTR structure of the foreseen production aircraft.

The weight for the complete cockpit structure, including transparencies, fairings, maintenance doors, nose landing gear door, experimental installations (ex: air data system boom installation), safety requirements (egress door, ejection seats provisions), furnishing supports and system provisions should not exceed preliminary targets that will be supplied. It is the responsibility of the Core Partner(s) to achieve these targets.

In this work package, the Core Partner(s) shall be responsible for:

- Complete design of the Technology Demonstrator version of the cockpit section to support manufacturing, testing and flight clearance, as part of AW's integrated design team
- The structural layout and substantiation
- 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 AW with the basis of certification in areas pertinent to the cockpit design
- Performing the detail design and analysis of the cockpit section
- Achieving the agreed weight targets
- Selection of materials and processes (with final selection approval from AW as outlined above)
- Supporting AW aerodynamic design by ensuring close liaison between partners during the preliminary and detailed design phases
- Demonstrating that the fuselage can be manufactured in such a way as to comply with EMC requirements including direct and indirect lightning effects and HIRF
- Creating a backup design using conventional processes and materials should any new process or material under proposal prove unfeasible
- Definition of any tests required for the substantiation of the design, including test articles and equipment
- Definition of inspection and repair methods

Work Package 3 – Development Test and flight article manufacturing

This phase consists of the manufacturing of the cockpit section for the experimental air vehicle and of any test components associated to the cockpit design that would be required by either AW or the Core Partner(s) to achieve a "Permit to Fly" for the experimental air vehicle.
These test articles are likely to include a cockpit structure for bird strike testing, supply of cockpit structures to AW for incorporation into the full fuselage static and fatigue tests and any local testing required to clear new technologies present on the demonstrator.
The cockpit shall be assembled in accordance with the design developed in work package 2. The Core Partner(s) is responsible for rectifying any issues found during the construction of the cockpit section. Any non-conformance or repair shall be agreed with AW prior to acceptance. Functional testing shall be performed for fairings, supports, doors etc. in accordance with the relevant ATPs. All relevant documentation for the hardware and the compliance matrix shall be delivered as part of this phase.

The Core Partner(s) shall be responsible for:

- The execution of any tests required prior to the delivery of the prototype fuselage, including definition and manufacture or procurement of any test components required, production of qualification test schedules, ATPs, QTPs, QTRs for items for which they are responsible and design and manufacture for any tooling, rig or ground support equipment required to perform any required testing
- The manufacture and design of any tooling required to produce the prototype cockpit section
- The manufacture and delivery of a flight cleared cockpit section as part of the manufacturing of the complete Technology Demonstrator aircraft

Work Package 4 – Flight clearance documentation

This phase consists of the tasks required to support the activities needed to achieve a “Permit to Fly” for the NGCTR Technology Demonstrator.

As part of this the Core Partner(s) shall:

- Provide the required level of airworthiness evidence to allow AW to achieve a “Permit to Fly” fly for NGCTR
- 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
- Complete and report any component or full scale testing required for qualification

Work Package 5 – Support to assembly and testing

This phase consists of supporting AW during the assembly and test flying of the NGCTR Technology Demonstrator. It includes the attachment of the cockpit to the fuselage, the installation of aircraft systems and flying controls, ground integration, testing and finally flight testing.

The Core Partner(s) shall:

- Provide ongoing support to AW during the aircraft build
- Be responsible for any re-design emerging from the build process for the relevant areas of responsibility
- Provide support to any ground testing prior to flight as required by AW
- Provide support to AW flight trials program including on-site presence for telemetry monitoring etc
- Provide AW with reports regarding findings from flight trials including any suggested design changes or improvements

Moreover Core Partner(s) shall assist AW during subsequent ground and flight tests until the NGCTR reaches design maturity.

Work Package 6 - Recurring and NRC Cost Estimate for Certification and Production

This task is aimed at validating the economic viability of the proposed design. Therefore the Core Partner(s) shall provide a substantiated estimate to complete the design and full certification of the production standard module started in work package 1 incorporating any findings from the manufacture and testing of the demonstrator module if applicable, along with the recurring costs expected for a representative production batch run to be agreed with AW.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date [T0 + months]***
1	Minutes of Cabin System Requirement Review	R	T0+1
2	Minutes of Cabin PDR for Production Design	R	T0+8
3	Minutes of Demonstrator Cabin SRR	R	T0+10
4	Minutes of Demonstrator Cabin PDR	R	T0+17
5	Minutes of Demonstrator Cabin Test Plan Review	R	T0+20
6	Minutes of Demonstrator Cabin CDR	R	T0+24
7	Demonstrator Cabin Design	R	T0+26
8	Minutes of Demonstrator Cabin TRR	R	T0+37
9	Demonstrator Module Qualification Reports	R	T0+52
10	Minutes of Flight Activities	R	T0+68

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date [T0 + months]***
1	Demonstrator Cockpit Test Articles Available to AW	D	T0+39
2	Demonstrator Cockpit Hardware Available to AW	D	T0+49

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

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

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 provide large aeronautical components to recognized industrial quality standards
- 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 NGCTR components according to environmental Quality System international standards
- Be capable to manufacture, test, checks NGCTR components to assure the required production quality
- Have access to the qualification process to obtain the “Permit to Fly” of the 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

5. Glossary

ATP	Acceptance Test Procedure
AW	AgustaWestland
CDR	Critical Design Review
CPW	Core Partner Wave
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
NGCTR	Next Generation Civil Tiltrotor
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
Ta	Systems and Platforms Demonstrator
TD	Technology Demonstrator
TRL	Technology Readiness Level
WBS	Work Break Down Structure
WP	Work Package

III. Design, Manufacture and Deliver Technology Demonstrator of High Visibility, Crashworthy, Low-Drag Integrated Cabin Section for Next Generation Civil TiltRotor (NGCTR)

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	ITD Airframe – WP B4.2		
Topic Leader	AGUSTAWESTLAND		
Indicative Funding Topic Value (in k€)	3500 k€		
Duration of the action (in Months)	68 months	**Start Date**[14]	Q4 2016

Identification Number	**Title**
JTI-CS2-2015-CPW03-AIR-02-10	**Design, Manufacture and Deliver Technology Demonstrator of High Visibility, Crashworthy, Low-Drag Integrated Cabin Section for Next Generation Civil Tiltrotor (NGCTR)**
Short description (3 lines)	
Design, analyze, manufacture, test and deliver a pressurised cabin section. Cabin comprises pressurized passenger compartment with seating provisions, passenger door, transparencies, main landing gear bays, provisions for systems, cargo, passenger emergency egress, pressurized bulkhead.	

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

1. Background

Next Generation Civil Tiltrotor (NGCTR) is a novel multipurpose tiltrotor design with increased range and cruise speed capabilities.

Under Clean Sky 2 AgustaWestland and a group of selected partners, all operating in an integrated design team, shall design, develop, manufacture, test and fly a full scale Technology Demonstrator (TD) of the NGCTR, representative of the foreseen production aircraft.

2. Scope of work

The scope of work of the present Call for Core Partner(s) is to design and substantiate the cabin section (with an approximate diameter of 2,7 m and a length of 9,5 m, still to be confirmed) the production aircraft to Preliminary Design Review (PDR) maturity level and, from this configuration to design, analyze, manufacture, test, supply and support through integration, test and flight, a derivative cabin section for the fuselage of the Technology Demonstrator of NGCTR according to the requirements, specifications and directives supplied by AgustaWestland (AW).

The fuselage cabin section design has to satisfy a specified certification basis that will be supplied by AW and comprising a selection of CS25 and CS29 requirements with additional ones for the tiltrotor-specific aspects, with the overall objective of achieving a “Permit to Fly” for the complete aircraft. The selected partner shall provide appropriate documentation to substantiate compliance to the applicable requirements for the proposed configuration. The methods of compliance to the design requirements shall be agreed with AW.

General architecture of the NGCTR will be supplied by AW and any changes to this have to be agreed and approved by AW. Interfaces between NGCTR modules (Cockpit, Cabin, Aft Fuselage, Wing, Doors, Landing Gear, etc.) will be controlled and checked by AW in order to guarantee mutual compatibility.

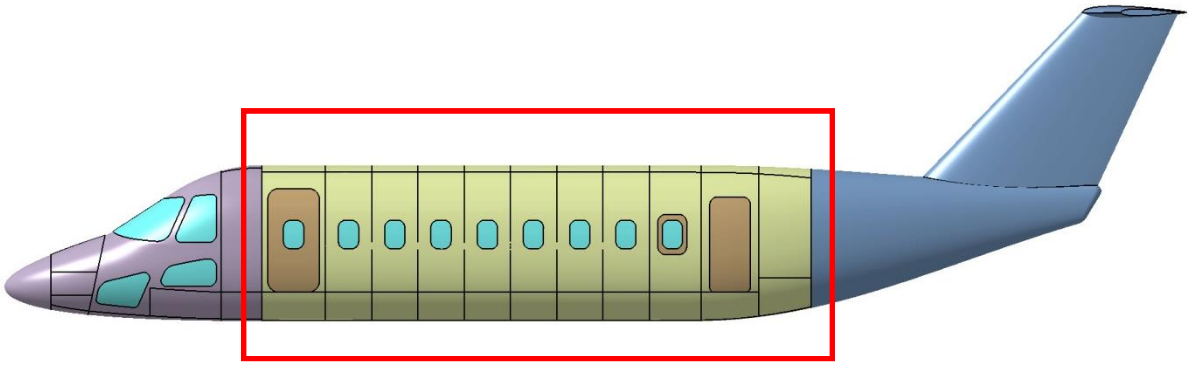


Figure 4: NGCTR Cabin section notional configuration.

The cabin section of the NGCTR comprises the pressurized passenger compartment with seating provisions, passenger door, transparencies, main landing gear bays, provisions for systems, pressurized bulkhead, cargo/luggage compartment door and passenger emergency egress.

Core Partner(s) shall evaluate design and manufacturing solutions for the NGCTR cabin section and recommend which they regard to be the most suitable (ex: metallic, composite, etc...).
Material selection and manufacturing techniques shall be agreed with AW with the objectives of minimising cost and weight, ease of manufacture, ensuring reparability, and assessing the environmental impact of the product throughout the aircraft life cycle. Considerations should be given to such things as energy consumption during material manufacture, material processing within the REACH and other environmental frameworks and end of life disposal strategy.

Detailed design, analysis and integration of the structural elements shall respect the general architecture and weight targets of the tiltrotor and it is the Core Partner(s) responsibility to supply technically feasible solutions which are compatible with AW procedures. Systems provisions design and analysis is part of the Core partner(s) design activities based on interface requirements agreed with AW.

Core Partner(s) shall:

- Work within the common terms of reference of the core agreement
- Manage & coordinate directly all the WPs for which they have full responsibility
- Manage & coordinate directly the activities related to WPs for doors, hatches, seals and transparencies
- Follow the Configuration Management process throughout the duration of the entire program

It is proposed to structure the technical activities as follows:

Work Package 1 – Production Aircraft Cabin configuration design

This work package (WP) covers the design of an effective and efficient cabin section structure for the foreseen production aircraft up to the successful completion of the Preliminary Design Review (PDR). The NGCTR cabin section shall be optimised for weight, aerodynamics and cost using novel materials and construction techniques where appropriate.

The Core Partner(s) shall be responsible for:

- Design of the production version of the cabin section of NGCTR to PDR maturity level as part of AW's integrated design team
- The structural layout and substantiation
- Production of a compliance plan to the agreed basis of certification
- Assisting AW with the basis of certification in areas pertinent to the cabin design
- Performing the preliminary design and analysis of the cabin section

- Achieving the agreed weight targets
- Selection of materials and processes (with final selection approval from AW as outlined above)
- Supporting AW aerodynamic design by ensuring close liaison between partners during the preliminary and detailed design phases
- Demonstrating that the fuselage can be manufactured in such a way as to comply with EMC requirements including direct and indirect lightning effects and HIRF
- Creating a backup design using conventional processes and materials should any new process or material under proposal prove unfeasible
- Definition of any tests required for the substantiation of the design, including test articles and equipment
- Definition of inspection and repair methods
- Producing and documenting data for life cycle assessment
- Preparing recurring cost estimations

The basic structural concept shall be the responsibility of AW including but not limited to:

- The determination with the authorities of the basis of certification
- The final selection of proposed materials
- The final selection of the proposed manufacturing and assembly process
- The final selection of the proposed inspection and repair philosophy
- The acceptance of the proposed methods of compliance and means of evidence to the requirements

Work Package 2- Technology Demonstrator Aircraft cabin configuration design

NGCTR Technology Demonstrator is an experimental tiltrotor that aims to prove the fundamental capabilities of the Next Generation Civil Tiltrotor architecture and technology.

The design of the experimental structure should take into account technical and technological solutions proposed for the production solution where they are shown to reduce the cost and time of development, reduce design time, ease manufacture and assembly of the Technology Demonstrator or are a necessary part of the validation programme.

All the technical and technological solutions to reduce cost and time of development, design, manufacture and assembly of the NGCTR experimental structure have to be agreed with AW and shall not constrain the development of the NGCTR structure of the foreseen production aircraft.

The weight for the complete cabin structure, including transparencies, fairings, maintenance doors, main landing gear doors, experimental installations, safety requirements (ex: egress door), furniture supports and system provisions should not exceed preliminary targets that will be supplied. It is the responsibility of the Core Partner(s) to achieve these targets.

In this work package, the Core Partner(s) shall be responsible for:

- Complete design of the Technology Demonstrator version of the cabin section to support manufacturing, testing and flight clearance, as part of AW's integrated design team
- The structural layout and substantiation
- 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 AW with the basis of certification in areas pertinent to the cabin design
- Performing the detail design and analysis of the cabin section
- Achieving the agreed weight targets
- Selection of materials and processes (with final approval from AW as outlined above)
- Supporting AW aerodynamic design by ensuring close liaison between partners during the preliminary and detailed design phases
- Demonstrating that the fuselage can be manufactured in such a way as to comply with EMC requirements including direct and indirect lightning effects and HIRF
- Creating a backup design using conventional processes and materials should any new process or material under proposal prove unfeasible
- Definition of any tests required for the substantiation of the design, including test articles and equipment
- Definition of inspection and repair methods

Work Package 3 – Development test and flight article manufacturing

This phase consists of the manufacturing of the cabin for the experimental air vehicle and of any test components associated to the cabin design that would be required by either AW or the Core Partner(s) to achieve a "Permit to Fly" for the experimental air vehicle.
These test articles are likely to consist of sections of cabin structures to be supplied to AW for incorporation into the full fuselage static and fatigue tests and any local testing required to clear new technologies present on the demonstrator.
The flight worthy cabin shall be assembled in accordance with the design developed in work package 2. The Core Partner(s) is responsible for rectifying any issues found during the construction of the cabin section. Any non-conformance or repair shall be agreed with AW prior to acceptance. Functional testing shall be performed for fairings, supports, doors etc. in accordance with the relevant ATPs. All relevant documentation for the hardware and the compliance matrix shall be delivered as part of this phase.

The Core Partner(s) shall be responsible for:

- The execution of any tests required prior to the delivery of the prototype fuselage, including definition and manufacture or procurement of any test components required, production of qualification test schedules, ATPs, QTPs, QTRs for items for which they are responsible and design and manufacture for any tooling, rig or ground support equipment required to perform any required testing
- The manufacture and design of any tooling required to produce the prototype cabin section

- The manufacture and delivery of a flight cleared cabin section as part of the manufacturing of the complete Technology Demonstrator aircraft

Work Package 4 – Flight clearance documentation

This phase consists of the tasks required to support the activities needed to achieve a "Permit to Fly" for the NGCTR Technology Demonstrator.

As part of this the Core Partner(s) shall:

- Provide the required level of airworthiness evidence to allow AW to achieve a "Permit to Fly" fly for NGCTR
- 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
- Complete and report any component or full scale testing required for qualification

Work Package 5 – Support to assembly and testing

This phase consists of supporting AW during the assembly and test flying of the NGCTR Technology Demonstrator. It includes the attachment of the cockpit, wing, aft section and tail to the fuselage, the installation of aircraft systems and flying controls, ground integration, testing and finally flight testing.

The Core Partner(s) shall:

- Provide ongoing support to AW during the aircraft build
- Be responsible for any re-design emerging from the build process for the relevant areas of responsibility
- Provide support to any ground testing prior to flight as required by AW
- Provide support to AW flight trials program including on-site presence for telemetry monitoring, etc.
- Provide AW with reports regarding findings from flight trials including any suggested design changes or improvements

Moreover Core Partner(s) shall assist AW during subsequent ground and flight tests until the NGCTR reaches design maturity.

Work Package 6 - Recurring and NRC Cost Estimate for Certification and Production

This task is aimed at validating the economic viability of the proposed design. Therefore the Core Partner(s) shall provide a substantiated estimate to complete the design and full certification of the production standard module started in work package 1 incorporating any findings from the manufacture and testing of the demonstrator module if applicable, along with the recurring costs expected for a representative production batch run to be agreed with AW.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date [T0 + months]***
1	Minutes of Cabin System Requirement Review	R	T0+1
2	Minutes of Cabin PDR for Production Design	R	T0+8
3	Minutes of Demonstrator Cabin SRR	R	T0+10
4	Minutes of Demonstrator Cabin PDR	R	T0+17
5	Minutes of Demonstrator Cabin Test Plan Review	R	T0+20
6	Minutes of Demonstrator Cabin CDR	R	T0+24
7	Demonstrator Cabin Design	R	T0+26
8	Minutes of Demonstrator Cabin TRR	R	T0+37
9	Demonstrator Module Qualification Reports	R	T0+52
10	Minutes of Flight Activities	R	T0+68

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date [T0 + months]***
	Demonstrator Cabin Test Articles Available to AW	D	T0+39
	Demonstrator Cabin Hardware Available to AW	D	T0+49

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

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

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 any of the following: the design and manufacturing of structures in non-conventional composite materials, conventional composite materials (thermoset and thermoplastic plus high temperature systems), innovative metallic materials and conventional metallic components
- Have the capability to manufacture and assemble composite and metallic parts as required

- 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 NGCTR components according to environmental Quality System international standards
- Be capable to manufacture, test, checks NGCTR components to assure the required production quality
- Have access to the qualification process to obtain the “Permit to Fly” of the 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

5. Glossary

ATP	Acceptance Test Procedure
AW	AgustaWestland
CDR	Critical Design Review
CPW	Core Partner Wave
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
NGCTR	Next Generation Civil Tiltrotor
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
Ta	Systems and Platforms Demonstrator
TD	Technology Demonstrator
TRL	Technology Readiness Level
WBS	Work Break Down Structure
WP	Work Package

IV. Design, Manufacture and Deliver Technology Demonstrator of High Visibility, Crashworthy, Low-Drag Integrated Rear Fuselage and Tail Sections for Next Generation Civil Tiltrotor (NGCTR)

Type of action (RIA or IA)	IA		
Programme Area	AIR		
Joint Technical Programme (JTP) Ref.	ITD Airframe – WP B4.2		
Topic Leader	AGUSTAWESTLAND		
Indicative Funding Topic Value (in k€)	3500 k€		
Duration of the action (in Months)	68 months	**Start Date**[15]	Q4 2016

Identification Number	**Title**
JTI-CS2-2015-CPW03-AIR-02-11	**Design, Manufacture and Deliver Technology Demonstrator of High Visibility, Crashworthy, Low-Drag Integrated Rear Fuselage and Tail Sections for Next Generation Civil Tiltrotor (NGCTR)**
Short description (3 lines)	
Design, analyze, manufacture, test and deliver Rear Fuselage and Tail sections. The Rear Fuselage section comprises cargo/baggage compartment and door, provisions for systems. The Tail section comprises fixed and control surfaces with the supports for the actuator systems.	

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

1. Background

Next Generation Civil Tiltrotor (NGCTR) is a novel multipurpose tiltrotor design with increased range and cruise speed capabilities.
Under Clean Sky 2 AgustaWestland and a group of selected partners shall design, develop, manufacture, test and fly a full scale Technology Demonstrator (TD) of the NGCTR, representative of the foreseen production aircraft.

2. Scope of work

The scope of work of the present Call for Core Partner(s) is to design and substantiate the Rear Fuselage and Tail sections (with an approximate diameter of 2,7 m and a length of 6 m, still to be confirmed) of the production aircraft to Preliminary Design Review (PDR) maturity level and, from this configuration to design, analyze, manufacture, test, supply and support through integration, test and flight, derivative Rear Fuselage and Tail sections for the fuselage of the Technology Demonstrator of NGCTR according to the requirements, specifications and directives supplied by AgustaWestland (AW).

The Rear Fuselage and Tail sections design has to satisfy a specified certification basis that will be supplied by AW and comprising a selection of CS25 and CS29 requirements with additional ones for the tiltrotor-specific aspects, with the overall objective of achieving a “Permit to Fly” for the complete aircraft. The selected partner shall provide appropriate documentation to substantiate compliance to the applicable requirements for the proposed configuration. The methods of compliance to the design requirements shall be agreed with AW.

General architecture of the NGCTR will be supplied by AW and any changes to this have to be agreed and approved by AW. Interfaces between NGCTR modules (Cockpit, Cabin, Aft Fuselage, Wing, Doors, Landing Gear, etc.) will be controlled and checked by AW in order to guarantee mutual compatibility. The Rear Fuselage section of the NGCTR comprises provisions for several aircraft systems such as pressurization, air conditioning and APU, while fulfilling the function of providing structural continuity between the tail and the fuselage. The Tail section comprises fixed and control surfaces with the provisions for the actuation systems.

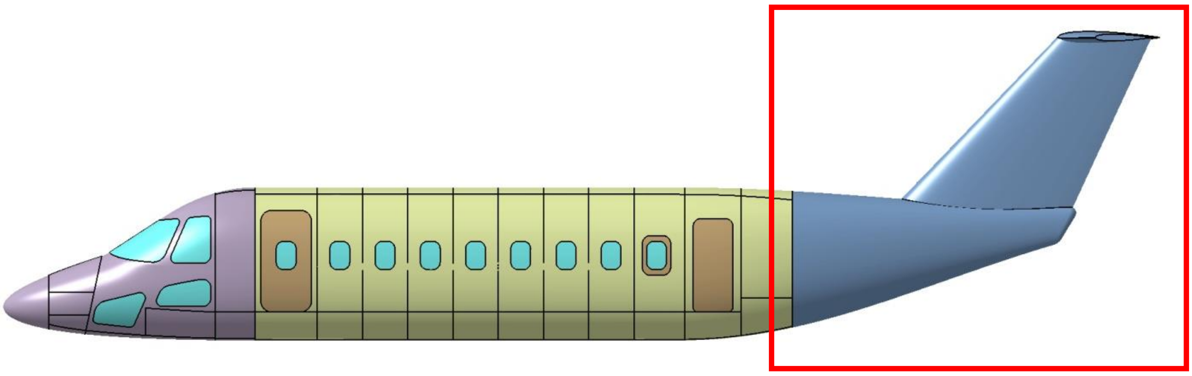


Figure 5: NGCTR Rear Fuselage and Tail section notional configuration.

Core Partner(s) shall evaluate design and manufacturing solutions for the NGCTR Rear Fuselage and Tail sections and recommend which they regard to be the most suitable (ex: thermoplastic, composite, etc ...).
Material selection and manufacturing techniques shall be agreed with AW with the objectives of minimising cost and weight, ease of manufacture, ensuring repairability, and assessing the environmental impact of the product throughout the aircraft life cycle. Considerations should be given to such things as energy consumption during material manufacture, material processing within the REACH and other environmental frameworks and end of life disposal strategy.

Detailed design, analysis and integration of the structural elements shall respect the general architecture and weight targets of the tiltrotor and it is the Core Partner(s) responsibility to supply technically feasible solutions which are compatible with AW procedures. Systems provisions design and analysis is part of the Core partner(s) design activities based on interface requirements agreed with AW.

Core Partner(s) shall:

- Work within the common terms of reference of the core agreement
- Manage & coordinate directly all the WPs for which they have full responsibility
- Manage & coordinate directly the activities related to WPs for doors, hatches, seals and transparencies
- Follow the Configuration Management process throughout the duration of the entire program

It is proposed to structure the technical activities as follows:

Work Package 1 – Production Aircraft Rear Fuselage and Tail configuration design

This work package (WP) covers the design of effective and efficient Rear Fuselage and Tail sections structure for the foreseen production aircraft up to the successful completion of the Preliminary Design Review (PDR).

The NGCTR Rear Fuselage and Tail sections shall be optimised for weight, aerodynamics and cost using novel materials and construction techniques where appropriate.

The Core Partner(s) shall be responsible for:

- Design of the product version of the Rear Fuselage and Tail sections of NGCTR to PDR maturity level as part of AW's integrated design team.
- The structural layout and substantiation
- Production of a compliance plan to the agreed basis of certification
- Assisting AW with the basis of certification in areas pertinent to the Rear Fuselage and Tail design
- Performing the preliminary design and analysis of the Rear Fuselage and Tail sections
- Achieving the agreed weight targets
- Selection of materials and processes (with final selection approval from AW as outlined above)
- Supporting AW aerodynamic design by ensuring close liaison between partners during the preliminary and detailed design phases
- Demonstrating that the fuselage can be manufactured in such a way as to comply with EMC requirements including direct and indirect lightning effects and HIRF
- Creating a backup design using conventional processes and materials should any new process or material under proposal prove unfeasible
- Definition of any tests required for the substantiation of the design, including test articles and equipment
- Definition of inspection and repair methods
- Producing and documenting data for life cycle assessment
- Preparing recurring cost estimations

The basic structural concept shall be the responsibility of AW including but not limited to:

- The determination with the authorities of the basis of certification
- The final selection of proposed materials
- The final selection of the proposed manufacturing and assembly process
- The final selection of the proposed inspection and repair philosophy
- The acceptance of the proposed methods of compliance and means of evidence to the requirements

Work Package 2- Technology Demonstrator Aircraft Rear Fuselage and Tail configuration design

NGCTR Technology Demonstrator is an experimental tiltrotor that aims to prove the fundamental capabilities of the Next Generation Civil Tiltrotor architecture and technology.

The design of the experimental structure should take into account technical and technological solutions proposed for the production solution where they are shown to reduce the cost and time of development, reduce design time, ease manufacture and assembly of the Technology Demonstrator or are a necessary part of the validation programme.

All the technical and technological solutions to reduce cost and time of development, design, manufacture and assembly the NGCTR experimental structure have to be agreed with AW and shall not constrain the development of the NGCTR structure of the foreseen production aircraft.

The weight for the complete Rear Fuselage and Tail sections structure, including fairings, experimental installations, safety requirements and system provisions should not exceed preliminary targets that will be supplied. It is the responsibility of the Core Partner(s) to achieve these targets.
In this work package, the he Core Partner(s) shall be responsible for:

- Complete design of the Technology Demonstrator version of the Rear Fuselage and Tail sections to support manufacturing, testing and flight clearance, as part of AW's integrated design team
- The structural layout and substantiation
- 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 AW with the basis of certification in areas pertinent to the Rear Fuselage and Tail design
- Performing the detail design and analysis of the Rear Fuselage and Tail sections
- Achieving the agreed weight targets
- Selection of materials and processes (with final selection approval from AW as outlined above)
- Supporting AW aerodynamic design by ensuring close liaison between partners during the preliminary and detailed design phases
- Demonstrating that the fuselage can be manufactured in such a way as to comply with EMC requirements including direct and indirect lightning effects and HIRF
- Creating a backup design using conventional processes and materials should any new process or material under proposal prove unfeasible
- Definition of any tests required for the substantiation of the design, including test articles and equipment
- Definition of inspection and repair methods

Work Package 3 – Development Test and flight article manufacturing

This phase consists of the manufacturing of the rear fuselage and tail sections for the experimental air vehicle and of any test components associated to these sections' design, required by either AW or the Core Partner(s) to achieve a "Permit to Fly" for the experimental air vehicle.
These test articles are likely to include a Tail section structure for bird strike testing, supply of Rear Fuselage and Tail structures to AW for incorporation into the full fuselage static and fatigue tests and any local testing required to clear new technologies present on the demonstrator.
The Rear Fuselage and Tail shall be assembled in accordance with the design developed in work

package 2. The Core Partner(s) is responsible for rectifying any issues found during the construction of the Rear Fuselage and Tail sections. Any non-conformance or repair shall be agreed with AW prior to acceptance. Functional testing shall be performed for fairings, supports, doors etc. in accordance with the relevant ATPs. All relevant documentation for the hardware and the compliance matrix shall be delivered as part of this phase.

The Core Partner(s) shall be responsible for:

- The execution of any tests required prior to the delivery of the prototype fuselage, including definition and manufacture or procurement of any test components required, production of qualification test schedules, ATPs, QTPs, QTRs for items for which they are responsible and design and manufacture for any tooling, rig or ground support equipment required to perform any required testing
- The manufacture and design of any tooling required to produce the prototype Rear Fuselage and Tail sections
- The manufacture and delivery of a flight cleared Rear Fuselage and Tail sections as part of the manufacturing of the complete Technology Demonstrator aircraft

Work Package 4 – Flight clearance documentation

This phase consists of the tasks required to support the activities needed to achieve a "Permit to Fly" for the NGCTR Technology Demonstrator.

As part of this the Core Partner(s) shall:

- Provide the required level of airworthiness evidence to allow AW to achieve a "Permit to Fly" fly for NGCTR
- 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
- Complete and report any component or full scale testing required for qualification

Work Package 5 – Support to assembly and testing

This phase consists of supporting AW during the assembly and test flying of the NGCTR Technology Demonstrator. It includes the attachment of the wing to the fuselage, the installation of aircraft systems and flying controls, ground integration, testing and finally flight testing.

The Core Partner(s) shall:

- Provide ongoing support to AW during the aircraft build
- Be responsible for any re-design emerging from the build process
- Provide support to any ground testing prior to flight as required by AW
- Provide support to AW flight trials program including on-site presence for telemetry monitoring etc.

- Provide AW with reports regarding findings from flight trials including any suggested design changes or improvements

Moreover Core Partner(s) shall assist AW during subsequent ground and flight tests until the NGCTR reaches design maturity.

Work Package 6 - Recurring and NRC Cost Estimate for Certification and Production

This task is aimed at validating the economic viability of the proposed design. Therefore the Core Partner(s) shall provide a substantiated estimate to complete the design and full certification of the production standard module started in work package 1 incorporating any findings from the manufacture and testing of the demonstrator module if applicable, along with the recurring costs expected for a representative production batch run to be agreed with AW.

3. Major Deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date [T0 + months]***
1	Minutes of Cabin System Requirement Review	R	T0+1
2	Minutes of Cabin PDR for Production Design	R	T0+8
3	Minutes of Demonstrator Cabin SRR	R	T0+10
4	Minutes of Demonstrator Cabin PDR	R	T0+17
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6	Minutes of Demonstrator Cabin CDR	R	T0+24
7	Demonstrator Cabin Design	R	T0+26
8	Minutes of Demonstrator Cabin TRR	R	T0+37
9	Demonstrator Module Qualification Reports	R	T0+52
10	Minutes of Flight Activities	R	T0+68

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date [T0 + months]***
1	Demonstrator Cabin Test Articles Available to AW	D	T0+39
2	Demonstrator Cabin Hardware Available to AW	D	T0+49

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

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

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
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- Have access to the qualification process to obtain the “Permit to Fly” of the 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
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R&T	Research and Technology
SAR	Search and Rescue
Ta	Systems and Platforms Demonstrator
TD	Technology Demonstrator
TRL	Technology Readiness Level
WBS	Work Break Down Structure
WP	Work Package

5. Clean Sky 2 – Engines ITD

I. HP Core Module and its Associated Control Laws and Equipment for the UHPE Demonstrator

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP2.6.1, WP 2.5.1, WP2.5.2, WP 2.5.3		
Topic Leader	SAFRAN		
Indicative Funding Topic Value (in k€)	5500 k€		
Duration of the action (in Months)	64 months	**Indicative Start Date**[16]	Q4 2016

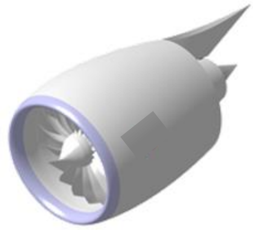
Identification	Title
JTI-CS2-2015-CPW03-ENG-01-08	**HP Core Module and its Associated Control Laws and Equipment for the UHPE Demonstrator**
Short description	
Assembly, instrumentation and supply of a HP Core Module and its associated control laws and equipment for the UHPE demonstrator; support for the HP Core Module in UHPE Ground Test; maturation of innovative technologies for combustor, HP compressor rear stages and thermal management associated to UHPE future product engine configurations .	

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

1. Background

This topic refers to the Joint Technical Programme (JTP), addressing the System and Platform Demonstrators (SPD):

- **Integrated Technology Demonstrator (ITD) Engine - WP2.** Ultra High Propulsive Efficiency (UHPE) propulsion system technologies demonstrator for Short / Medium Range aircraft (SMR). In this Clean Sky 2 ITD, SAFRAN/Snecma is the leader of a Ground Test Demonstrator (GTD) of the UHPE.


An UHPE demonstrator candidate

  WP2 aims at reaching TRL 5-6 maturation by mid-2021 for a set of specific technologies dedicated to the UHPE concept. The chosen architecture is an Ultra High Bypass Ratio turbofan (ducted architecture) with a by-pass ratio preliminary anticipated within the range of 15-20. The purpose of this WP is to:
- Demonstrate and validate the overall performances (Specific Fuel Consumption, etc.) of the UHBR concept by assessing mainly the parts brought by the low pressure components measured in actual engine environment
- Obtain certain characteristics of the new modules as well as their mechanical and dynamic behaviour in the actual engine environment
- Obtain acoustic data from engine ground tests to consolidate noise benefits at aircraft level

This topic includes:

- **Donor HP Core engine for UHPE Ground Test Demonstrator (GTD):**
  - Delivery of an equiped and refurbished HP Core engine compliant with the technical characteristic below
  - Control system adaptation in order to perfom the UHPE Ground Test at Snecma test facility
  - Instrumentation adaptation
  - Support to allow Snecma to perfom the UHPE GTD at Snecma test facility

- **Maturation of innovative technologies for :**
  - Combustor in order to improve and assess future UHPE product engine performance in terms of NOX and CO2 emissions consistently with ACARE objectives. The validation will be performed through rig test.
  - HP compressor (HPC) rear stages :
    - In order to take into account the smaller core size of future UHPE product engine , a compact and efficient design will be proposed for the rear stages of the HPC and the validation will be performed through rig test and/or on the GTD UHPE
    - in order to investigate the behaviour of the HPC in a UHPE configuration operating in various conditions ; wet and dry conditions will be investigated to

assess the performance and operability of the HPC rear stages.

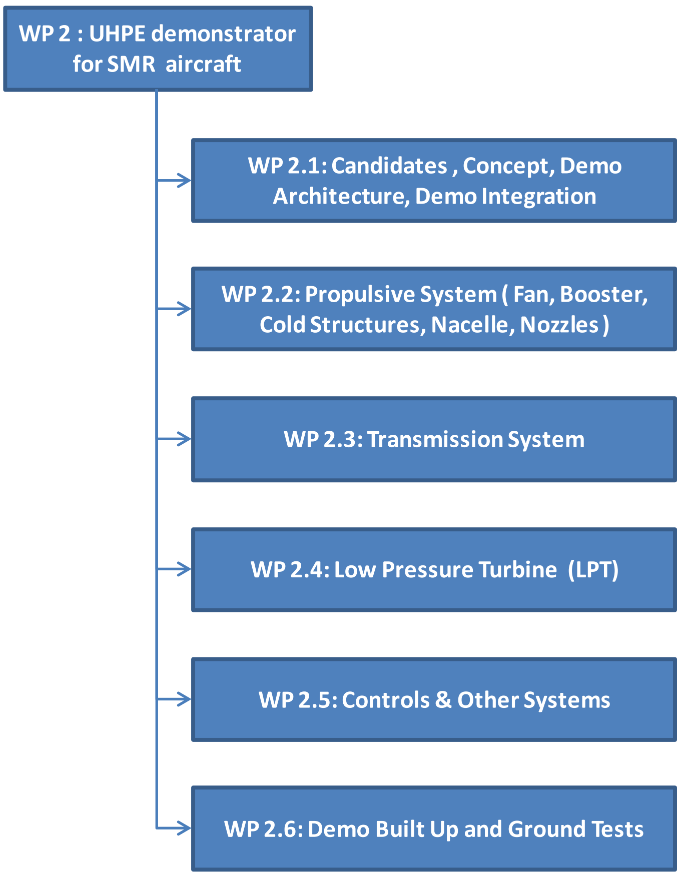
- Thermal management in order to reach higher heat rejection rate that are needed due to UHPE smaller core ; thermal management system will be optimized and high performance Heat Exchangers will be developed contributing to improved cycle performance, engine life and weight reduction. The validation of Heat Echanger Technology will be performed through rig test and/or on the GTD UHPE.

The main characteristics required for the HP Core are:

- Pressure ratio in the range 20 to 26
- Inlet Standard Flow Function in the range 21 to 31 kg/s
- Maximum Outlet temperature in the range 930 - 1000K

HP Core innovative technologies will be required in order to reach ACARE objectives in terms of Nox and CO2 emissions for future product engines, taking into account the smaller size of the outlet of HPC / inlet of combustor for SMR applications due to the increase of the bypass ratio.

The associated tasks are part of WP2.5 and WP2.6 as described in the Work Breakdown Structure (WBS) hereafter:



2. Scope of work

The scope of work deals with the following strategic objectives:

- **On the Engine Side**, provide and adapt the hardware and software of the donor HP Core and support the Ground Test the UHPE.
- **On the Module Side**, mature robust, efficient and lightweight HP Core Module technologies, up to TRL3-5 through module rig tests in order to demonstrate and validate the performances of these technologies:
  - Advanced combustor
  - HP compressor rear stages
  - Thermal management

The estimate of the breakdown of the activities described in this scope of work is roughly:

- 25 % on the engine side
- 75 % on the module side

In the frame of this Call for Core Partner, the Applicant will be responsible for the tasks linked to the HP Core Frame:

On the Engine Side

- **HP Core hardware delivery** *as part of WP2.5 (Control and Other Systems) and WP2.6 (Demo Built Up and Ground Tests), this will cover:*
  - Refurbish and/or adapt an existing HP Core (tip clearances on the blades , seals, …) , in order to be compliant with the UHPE requirements and to recover standard performance before the Ground Test Campaign
  - Instrument the HP Core Module (sensors , conditioners , …) in order to be able to acquire and exploit HP Core Module standard measurements
  - Assembly and delivery of the HP Core and its equipment (called HP Core Module [*])
  - Support the Ground Test of the UHPE Demo Engine for the HP Core module hat includes:
    - Participation in reviews before test (Test Readiness review) for the HP Core Module
    - Monitoring of the HP Core Module parameters during the UHPE Ground Test
    - Support Snecma if any partial test needs to be defined at Snecma test facility
    - Support if functions are modified/added/removed for software and control system adaptations
    - Participation in the inspection of the HP Core Module parts if needed
    - Repair or replacement of the HP Core Module parts and their instrumentation if needed
    - Delivery of test report for the HP Core Module of the UHPE GTD

*[*] **HP Core Module** is the HP Core hardware with its equipments and its adapted control system.*

- **HP Core Hardware delivery and adaptation** *as part of WP2.5 (Control and Other Systems), this will cover:*
    - Provide and/or adapt the HP Core equipment :auxiliary gearbox ,fuel system including fuel pump and fuel injectors, igniter, oil system including oil pump, air starter, equipment supports, harnesses

- **HP Core Software adaptation** *as part of WP2.5 (Control and Other Systems), this will cover:*
    - Adapt and validate the Control laws (VSVs positioning, fuel flow laws, …) of the HP Core module according to the Snecma requirements (standard functions , new functions)
    - Perform and validate new functions on DRY and/or WET system tests benches. Tests will be performed in representative conditions (Take Off, Max Climb, Idle, relight)
    - Provide the control system software allowing Snecma to perform the engine ground tests

On the Module Side, as *part of WP2.6.1 (HP Core),* this will cover the **Maturation of innovative technologies for:**

- **Combustor**
    - Develop an innovative combustor enabling :
        - low NOx and CO2 emissions
        - on a wide operability range
        - its integration in UHPE architecture : high By –pass Ratio and high Overall Pressure Ratio leading to a low value of the combustor inlet Flow Function
    - Manufacture and instrumentation of the components to be rig tested
    - Manufacture and instrumentation or adaptation of rig parts
    - Test the combustor module at scale 1 , annular or multi sector configuration:
        - Idle conditions
        - Altitude conditions
        - T/O conditions

- **HP compressor rear stages**
    - Design a compact and efficient block of rear stages including:
        - More integrated and innovative Secondary Air System
        - Non conventional HPC rear stage configurations
    - Manufacture and instrumentation of the components to be rig tested
    - Manufacture and instrumentation or adaptation of rig parts
    - Perform the aerodynamic test of the HPC rear stages at scale 1
    - Investigate the HPC rear stages performance and operability in wet and dry conditions
        - Design or adapt a HPC rig enabling a scale 1 wet and dry tests on the representative rear stages of the HPC
        - Manufacture and instrumentation of the components to be rig tested
        - Manufacture an instrumentation or adaptation of the rig parts

– Scale 1 wet and dry test

- **Thermal management**
  - Optimize thermal management system
  - Design high performance Heat Exchangers Manufacture and instrumentation of the components to be rig tested
  - Manufacture and instrumentation or adaptation of rigs parts
  - Test the Heat Exchanger at Scale 1 and assess its performance

3. Major deliverables/ Milestones and schedule (estimate)

- **On Engine side (HP Core Module)**

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D1.1	HP Core Module Development Plan and feasibility report	R and RM	T0 + 3M
D1.2	HP Core Module Contribution to Demo specifications	R and RM	T0 + 6M
D1.3	HP Core Modules for UHPE GTD : Preliminary Design Review and report	R and RM	T0 + 12M
D1.4	HP Core Modules for UHPE GTD : Critical Design Review and Detailed Design Report	R and RM	T0 + 24M
D1.5	HP Core Module for UHPE GTD : hardware delivery to engine assembly stand	D	T0 + 36M
D1.6	Results of Control system and equipment partial tests for validation Tests Report	R and RM	T0 + 42M
D1.7	Engine readiness review. Documentation for HP Core Module for UHPE GTD : - Delivered Hardware/Software status - Instrumentation - Engine Test Plan requirements	R and RM	T0 + 48M
D1.8	Engine Ground Test report for HP Core Module for UHPE GTD	R	T0 + 64M
D1.9	Lessons learnt for HP Core Module for UHPE GTD	R	T0 + 64M

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

T0: start date for the Core Partner expected to be on September 2016.

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M1.1	HP Core Module Kick Off	T0 + 1M

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M1.2	HP Core Module PDR (Premilinary Design Review)	T0 + 12M
M1.3	HP Core Modules CDR (Critical Design Review)	T0 + 24M
M1.4	HP Core Modules TRR (Test Readiness Review)	T0 + 48M
M1.5	HP Core Modules PTR (Post Test Review)	T0 + 60M

T0: start date for the Core Partner expected to be on September 2016.

- **On Module side (Maturation of Innovative technologies)**

Deliverables			
Ref. No.	***Title - Description***	***Type (*)***	***Due Date***
D2.1	HP Core Innovative Combustor and Improved Compressor rear stages : Development Plan and feasibility report	R and RM	T0 + 3M
D2.2	HP Core Innovative Combustor and Improved Compressor rear stages : Preliminary Design Review	R and RM	T0 + 12M
D2.3	HP Core Innovative Combustor and Improved Compressor rear stages : Rig tests plan and rig Tests Readiness Review	R and RM	T0 + 12M
D2.4	HP Core Module Innovative Combustor and Improved Compressor rear stages Critical Design Review and Detailed Design Report	R and RM	T0 + 24M
D2.5	HP Core Innovative Combustor and Improved Compressor rear stages : hardware delivery to rig test facility	D	T0 + 42M
D2.6	HP Core Innovative Combustor and Improved Compressor rear stages : Component testing completed (Including hardware inspection review and report)	RM	T0 + 52M
D2.7	HP Core Innovative Combustor and Improved Compressor rear stages : Rig test reports	R	T0 + 54M

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

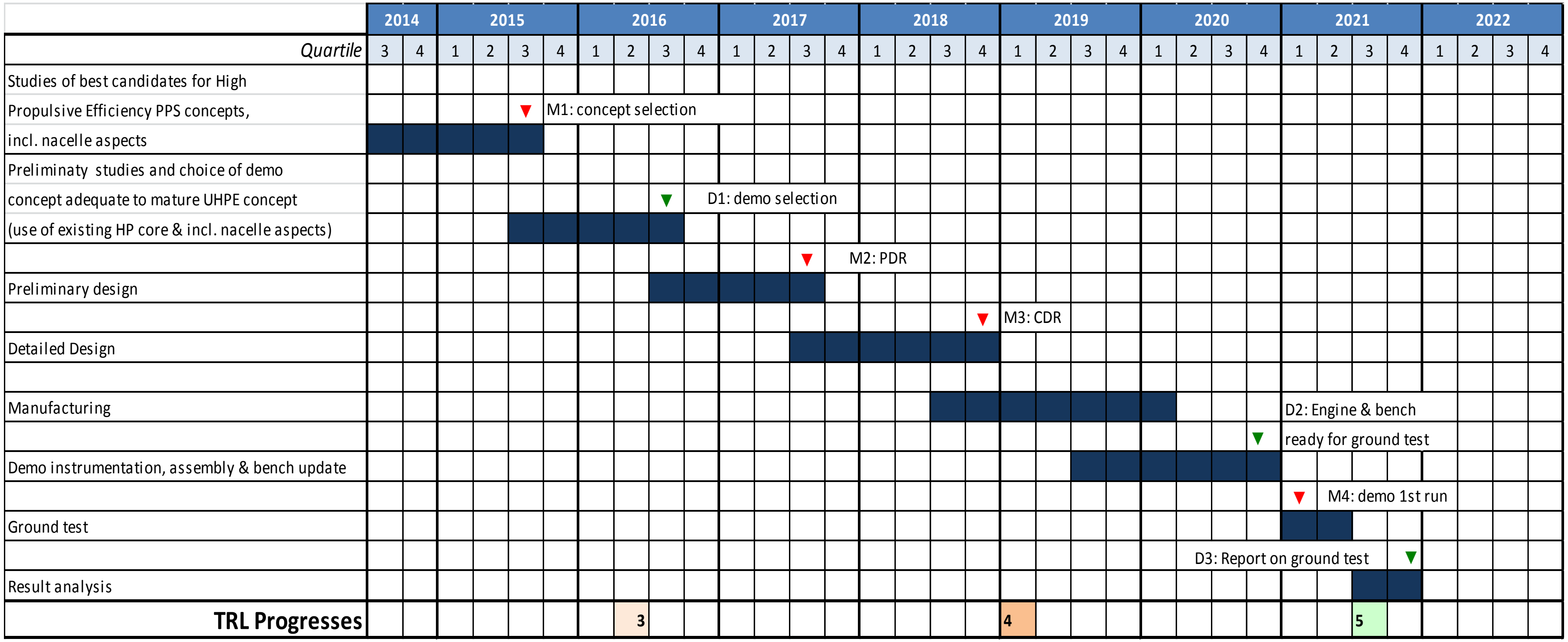
T0: start date for the Core Partner expected to be on September 2016.

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M2.1	Innovative Combustor and Improved Compressor rear stages : Kick Off	T0 + 1M
M2.2	Innovative Combustor and Improved Compressor rear stages PDR (Premilinary Design Review)	T0 + 12M
M2.3	TRL3 validation of Innovative Combustor and Improved Compressor rear stages	T0 + 18M
M2.4	Innovative Combustor and Improved Compressor rear stages CDR (Critical Design Review)	T0 + 24M

Milestones		
Ref. No.	***Title - Description***	***Due Date***
M2.5	TRL4/5 validation of Innovative Combustor and Improved Compressor rear stages	T0 + 60M

T0: start date for the Core Partner expected to be on September 2016.

Overall UHPE SN schedule



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

- Expertise and skills
  - Design of aeronautic commercial engine HP modules and systems : combustor , HP Compressor , control system
  - 3D modelling
  - Aerodynamics and 3D CFD Manufacture of aeronautic commercial engine modules
  - Inspection means and expertise for quality assessment of produced parts
  - Material characterization especially for fatigue characteristics (HCF, LCF)
  - Instrumentation and component test capability : combustor rig tests , compressor rig tests , equipment rig tests
  - 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 HP Core able to be integrated on an actual scale 1 Flying Test Bed

- Capabilities and track records
  - Company qualified as an aeronautic supplier for product commercial engine parts
  - Company certified for Quality regulations (ISO 9001, ISO 14001) and for Design of engine subsystems or modules (CSE, Part 21, Part 145)

- Competences to deal with risks associated to the action

  At SPD level:
  - Background in Research and Technology (R&T) for aeronautics especially on Turbofan Demonstrators , Design of Control Systems and HP Core Engines Operation
  - delivery of instrumented part(s) or High Pressure module(s) for scale 1 engine demonstrator
  - Experience on design, manufacturing and testing of HP Core Engines for Short and Medium Range Aircraft Applications

  At applicant level:
  - Background in R&T for aeronautics
  - Lessons learnt on former R&T European program (FP7 or Clean Sky)
  - Project Management capability for 10M€ project
  - Quality Management capability for 10M€ project
  - Exchange of technical information through network: 3D models of parts, Interface Control Documents, 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
  - Snecma will own the specification, while the Core Partner will own the technical solutions that he will implement into the corresponding modules and subsystems.
  - Snecma information related to this programme must remain within the Core Partner.
- Ownership and use of the demonstrators
  - The Core Partner will deliver demonstrator parts to Snecma. 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 Snecma 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.

5. Glossary

ACARE	Advisory Council for Aeronautics Research in Europe
AIP	Annual Implementation Plan
ATM	Air Traffic Management
CDR	Critical Design Review
CFP	Call for Proposals
CS2	Clean Sky 2
CS2 JU	Clean Sky 2 Joint Undertaking
EC	European Commission
GTD	Ground Test Demonstrator
IADP	Innovative Aircraft Development platform
ITD	Integrated Technology Demonstrator
SPD	Strategic Platform Demonstrator
STD	Strategic Topic Description
TA	Transverse Activities
TE	Technology Evaluator
TP	Technology Products
TRL	Technology Readiness Level
UHPE	Ultra High Propulsive Efficiency
WP	Work Package

II. VHBR Engine - HP Turbine Technology

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP5.2		
Topic Leader	ROLLS-ROYCE		
Estimated Topic Value (funding in k€)	4500 k€		
Duration of the action (in Months)	48 months	**Indicative Start Date**[17]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-ENG-03-03	**VHBR Engine - HP Turbine Technology**
Short description (3 lines)	
The work intended to be covered by the Core Partner selected will be twofold: developing test and analysis capability for HPT aerodynamic rig tests, and testing of HPT aerodynamic designs for typical VHBR Middle of the Market core engines and other market applications.	

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

1. Background

Through Clean Sky 2, Rolls-Royce are developing and demonstrating the complete range of technologies required for Very High Bypass Ratio (VHBR) engines. Besides technologies directly enabling VHBR engines (large fan, multi-stage intermediate pressure turbine (IPT) technology, gear-box technology), an additional key technology is the high pressure turbine (HPT) technology which forms the subject of this call.

The work intended to be covered by the Core Partner selected will be twofold: developing test and analysis capability for HPT aerodynamic rig tests, and testing of HPT aerodynamic designs for typical VHBR Middle of the Market core engines and other market applications.

The successful Core Partner will demonstrate both the capability to deliver cutting edge technology based on established track records of innovation, test facility capability and availability, as well as a proven and established capability for the delivery of well understood highly complex HPT aerodynamic rig test data. This implies demonstration of strong evidence of existing rig design and manufacturing capabilities, its demonstrated readiness and the internal capacity to deliver in the timescales required, in order to deliver world-class HPT technology for Rolls-Royce as an outcome of the joint work within Clean Sky 2.

Through Clean Sky 2, Rolls-Royce is developing and demonstrating the complete range of technologies required for VHBR engines. Within the timescales of Clean Sky 2, VHBR engines will realise significant environmental benefits:-

- Up to 25% fuel burn and CO2 emission reduction relative to year 2000 baseline (consistent with 10% reduction relative to year 2014 baseline)
- Noise levels making a significant step towards to ACARE 2035 targets (- 11 EPNdB per operation relative to 2000 situation: including engine, nacelle, aircraft technologies - airframe noise reduction, novel aircraft configurations – and ATM benefits)
- Contribute to delivery of NOX emission reductions through reduced fuel burn. Specific objectives will not be defined owing to the strong dependency on overall core engine cycle decisions.

Development of VHBR technology under consideration of the Core Engine will maintain European competitiveness for the large aircraft market. In addition, the Core Engine multi-stage HPT aspects themselves will also foster the development of world-leading European capability in the Middle of Market short range commercial and long range business aircraft segments.

Two work packages are detailed within the Engine joint technical proposal:

Work Package 5 – VHBR – Middle of Market Technology

Throughout the course of the programme, work package 5 will demonstrate a range of underlying technologies necessary for VHBR engines in all markets, although focusing on Middle of Market short range aircraft. A series of design studies and rig tests will deliver TRL4-5 for each technology by 2018.

Work Package 6 – VHBR – Large Turbofan Demonstrator

Work package 6 targets the extension of VHBR technologies to large engines for the long range airliner market.

Key to both work packages is the development of multi-stage, high pressure turbine technology which forms the subject of this call.

The high pressure turbine expands the working fluid provided to it by the combustion chamber, converting the energy stored into kinetic energy which in turn is used to drive one or more compressor stages at the inlet of the core engine. The exit flow of the HPT in addition feeds intermediate (IPT) or low pressure turbine (LPT) modules that drive the fan at the engine inlet. The HPT is an essential part of the Rolls-Royce turbofan. Understanding the aerodynamic interaction between combustion chamber, HPT and IPT/LPT is critical to the success of the VHBR and other market segment engines.

2. Scope of work

The further advancement of multi-stage high pressure turbine (HPT) technology is a key enabler for future Core Engine technology, and therefore supports the VHBR engine concept.

The over-arching theme of the work scope is to gain detailed understanding of aerothermal designs for high pressure turbines optimized for efficient multi-stage operation. Besides validating and understanding the overall module performance, key elements are the interaction aspects of the HPT with the combustion chamber and the intermediate- / low-pressure turbine. The work scope can be split into two themes:

- Developing test and analysis capability for HPT aerodynamic rig tests
- Testing of HPT aerodynamic designs for typical VHBR Middle of the Market core engines and other market applications.

The work scope will help to identify the optimised HPT solution considering maximum turbine efficiency, aerothermal validation of overall module as well as detailed performance under consideration of turbine sub-system requirements, and thereby maximising benefits for all technical accounts like minimum SFC, minimum noise, reduced weight and cost. Key architecture requirements of the HPT rig to be used for testing are:

- 2-stage HPT consisting of 4 blade rows on a single shaft
- Engine representative blade and vane cooling schemes, e.g. film cooling on blades and vanes, trailing edge cooling slot, and others
- Shroudless turbine blades on both rotor stages
- Profiled end walls on blades and vanes, if required
- Engine representative simulation of secondary air system, e.g. rim sealing flows

The resulting HPT technology and design may be ultimately deployed in a number of engine markets and therefore scalability between corporate applications, middle-of-market and large civil applications is essential.

At the beginning of this joint work with Rolls-Royce, the required test and analysis capability needs to be actively explored with the Core Partner. This early phase of the work needs to be pursued very closely with Rolls-Royce in order to arrive at a jointly agreed test strategy, including options for change of scope and test flexibility. Examples of HPT aerothermal tests to be performed will likely include, but not be limited to:

- Turbine annulus tests - including speed, pressure ratio and other parameters – in order to assess performance trades
- Assessment of off-design operating conditions including turbine maps, Reynolds correction, tip clearance variations, and others
- Tests of different combustor exit / turbine entry profile – pressure, temperature ratio, swirl, turbulence and others
- Validation of detailed HPT performance exchange rates – e.g. component cooling trades including film cooling row blanking, leakage air trades, rim sealing trades, and others
- Tests of non-conventional inter-stage / exit duct aerodynamic solutions
- Tests of aerodynamically optimised 3D geometries, including clocking studies

Based on the completed study above, the successful Core Partner will then be required to work very closely with Rolls-Royce on the specific aspects listed below:

Technologies for HPTs

1. Aerodynamic test and facility strategy
2. Rig concept studies
3. Manufacturing of rig module parts
4. Rig assembly and commissioning
5. Aerodynamic testing and data processing

The following way of working together is envisaged: following the provision of detailed aerodynamic and functional HPT designs from Rolls-Royce, it is required that the Core Partner will lead the programme and will work independently on all tasks whilst providing Rolls-Royce with clear visibility and insight into progress made and the results achieved. The agreement of suitable reviews with Rolls-Royce to buy-off technical concepts and decisions will be important to ensure the compatibility of the envisaged rig testing with the overall Rolls-Royce rig test strategy. The following paragraphs describe the individual parts of the work package in more detail.

Task 1: The Aerodynamic test and facility strategy will need to capture all aerodynamic test requirements that are needed to provide detailed understanding and validation data for the complex multi-stage HPT designs. The key challenge of capturing relevant aerodynamic details will have to be addressed through experimental testing at various levels of instrumentation. In order to allow a short test turn-around time considering changes to operating conditions as well as test rig hardware (e.g. modularity), a facility operating strategy needs to be developed and agreed.

Task 2: The Rig concept studies will focus on the development of a holistic approach with respect to rig design flexibility, modularity and interchangeability. From a mechanical point of view, the rig design will require addressing a number of challenges particularly associated to the temperature conditions in the front stage of the HPT and high-stress levels due to high rotational speeds. Optimisation of mechanical and functional rig design features and appropriate selection of materials will be critical to achieve a feasible rig design. Examples of such challenges will likely include, but not be limited to:

- Identification of component material requirements for stage 1 entry temperatures and temperature ratios
- Turbine entry aerodynamic profile setting and its variation during testing
- Component cooling and spoiling flow metering and adjustment
- Relative positioning of non-rotating components for clocking studies
- Measurement technology selection, implementation and management during test

Task 3: Apart from **Manufacturing of the rig module parts** and delivering all parts required for the assembly of the HPT aerodynamic rig, particular emphasis is to be made to the likely situation of requiring capability to manufacture parts using new manufacturing technologies, e.g. rapid prototyping, in order to reduce manufacturing lead times. The specific instrumentation requirements are yet to be defined in the course of the programme, but as part of the rig tests planned, the design and application of both standard and special instrumentation will be required to ensure sufficient data is acquired to verify all aspects of the technology development. This list of instrumentation required is likely to include Performance and Secondary Air-System surveys, blade vibration measurements, tip clearance measurements, temperature measurements to verify aeromechanical models, and others.

Task 4: All aspects of Rig Assembly and Commissioning relevant for the delivery of the HPT rig test vehicle and its readiness for testing are within the responsibility of the Core Partner. Based on the outcome of Tasks 1 and 2, rig assembly and commissioning should allow a short turn-around time for various rig builds in order allow a highly efficient test campaign.

Task 5: Execution of Aerodynamic testing and data processing will deliver detailed high quality aerodynamic test data across the entire HPT rig to allow a detailed understanding and validation of the aerodynamic design concepts and detailed studies under consideration. Key will be to pay attention to details and to filter out relevant information out of the expected huge amount of test data. The Core Partner will be responsible for test data post-processing of all test data and for capturing relevant information, and eventually for the delivery of technical reports to Rolls-Royce.

3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
1	Test requirements document issued	R	M0+3
2	Rig test strategy approved	R	M0+3
3	Concept review summary and action close-out report issued	R	M0+6
3	Test matrix issued	R	M0+6
4	Preliminary Design Review summary and action close-out report issued	R	M0+12
5	Critical Design Review summary and action close-out report issued	R	M0+15
6	Rig hardware delivery for final assembly	D	M0+15
7	Assembly Readiness Review summary and action close-out report issued	R	M0+20
8	Test Readiness Review summary and action close-out report issued	R	M0+22
9	Start of test campaign	D	M0+22
10	Completion of test campaign	R	M0+36
11	Test data issued	D	M0+42
12	Final report issued	R	M0+48

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
1	Concept review for aerodynamic rig	RM	M0+3
2	Preliminary design review for aerodynamic rig	RM	M0+9
3	Critical design review for aerodynamic rig	RM	M0+12

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
4	Assembly readiness review	RM	M0+18
5	Test readiness review	RM	M0+20
6	Intermediate rig test data review	RM	M0+27
7	TRL6 review with overview of final results	RM / R	M0+42

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

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

The unique skills expected from the successful applicant are related to the abovementioned overall programme, hence the rig test capability and the delivery of the rig module including the test data. Therefore, the following areas of expertise would have to be responded to by the candidate:

Task 1 Aerodynamic test and facility strategy: Based on the description of work detailed in Section 2, the Core Partner will be required to have both significant and demonstrated previous experience in managing and delivering complex aerodynamic rig test programmes as well as access to suitable facilities in support of this programme. Amongst others, key requirements for a suitable facility are listed below:

- Continuous high-speed multi-stage high pressure turbine aerodynamic testing capability at Rolls-Royce engine relevant non-dimensional parameters, e.g. Technology Readiness Level (TRL) 5-6. Key performance and rig parameters that need to be met at design point are:
  - Rotational speed: ~10,000 RPM
  - Expected shaft power extraction: ~700kW
  - Total HPT pressure ratio: 5-6
  - Main gas path / cooling flow temperature ratio: 2 : 1
  - Geometric scale: 1 : 1, approximate stage 1 blade height 40mm
- Highly developed rig flexibility and modularity with respect to hardware changes, e.g. tip clearance variations, platform variations, and others
- Quick adjustment of thermodynamic operating conditions, e.g. main operating point, sealing/cooling flows, turbine entry profile (combustion chamber simulator), and others
- Two-shaft capability for HPT – IPT/LPT combined testing, should it be required

In order to support the above given requirement for high level experience and understanding, the Core Partners significant experience in the aerodynamic design and understanding of HPT aerodynamics for different types of applications in multi-stage rigs is therefore critical.

Task 2 Rig concept studies: Based on the description of work detailed in Section 2, the Core Partner will be required to have significant experience in the aeromechanical design of HPT rigs and rig components for different types of applications, including cooled components. Moreover, demonstrated experience in rig concept layout and understanding interfaces between rig and test facility are essential.

Task 3 Manufacturing of the rig module parts: Based on the description of work detailed in Section 2, the Core Partner will be required to have significant experience in the fields of rig detailed design, interface management and parts manufacturing. Also, the Core Partner needs to demonstrate access to an established and competitive rig supply chain, to demonstrate experience in defining and validating manufacturing methods suitable to meet Rolls-Royce quality standards as well as the capability to develop new manufacturing capability, e.g. Direct Laser Deposition for time savings. Access to test facilities on component level, e.g. cold flow test facility, material property testing, and others, is essential. The Core Partner will be required to have significant experience in the instrumentation design and integration into rig environments. Any direct and internal experience of how to design suitable instrumentation would be beneficial.

Task 4 Rig Assembly and Commissioning: Based on the description of work detailed in Section 2, the Core Partner will be required to have significant experience in the full rig assembly process and a demonstrated record of successful programme deliveries. The ability to bring complex HPT rigs to test and to react to, understand and fix arising's during commissioning is a required critical capability.

Task 5 Aerodynamic testing and data processing: Based on the description of work detailed in Section 2, the Core Partner will be required to have significant and demonstrated experience in executing complex rig test programmes and post-processing and analysing significant amounts of data from rig tests. The required rig instrumentation should cover, but is not limited to:

- Steady and unsteady pressure and temperature measurements, e.g. wall tapings, leading edge instrumentation, Kulites, strain gauges
- Measurements in stationary and rotating frame of reference, e.g. telemetry required
- Area traverse measurements behind each blade or vane row
- Measurement of turbulence parameters
- Rotor tip clearance measurements during rig running
- Highly accurate mass flow measurements in main gas path and in secondary cooling / sealing mass flows

In addition to the specific list of required skills, capabilities and equipment mentioned above in the task descriptions, other generic requirements to the successful Core Partner are listed below:

- Capability and demonstrated experience in working together with Academic Partners across Europe outside and/or within other European research programmes
- Flexible methods and tool set that can be adjusted to the Rolls-Royce system, in particular related to the CAD and data acquisition system
- For all tasks, the appropriate levels of Programme and Risk Management are to be implemented and to be pursued

5. Glossary

CAD	Computer aided design
HPT	High pressure turbine
IPT	Intermediate pressure turbine
TRL	Technology Readiness Level
VHBR	Very High Bypass Ratio

III. Demonstration of CFD Capability in the Simulation of Air-Oil Flow In Complex Aero-Engine Bearing Chambers - a Systematic Approach

Type of action (RIA or IA)	IA		
Programme Area	ENG		
Joint Technical Programme (JTP) Ref.	WP 6 – VHBR – Large engine market		
Topic Leader	ROLLS-ROYCE		
Indicative Funding Topic Value (in k€)	3500 k€		
Duration of the action (in Months)	60 months	**Indicative Start Date**[18]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-ENG-03-04	**Demonstration of CFD Capability in the Simulation of Air-Oil Flow In Complex Aero-Engine Bearing Chambers - a Systematic Approach**
Short description	
This Topic addresses the development of two-phase CFD methods for oil–air flows in gas turbine aero-engine bearing chambers, the maturing of these methods into engineering tools, a series of substantial confidence building demonstrations of the applicability of these tools including validation against experiments and the creation of a framework in which these tools will be used.	

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

1. Background

Rolls-Royce has been active in research into understanding air-oil flow behaviour in the bearing chambers and internal gear boxes of aero-engine gas turbines for many years, at least as far back as the early 1980s. The bearing chambers and internal gear boxes are subject to very harsh environments and are located at the heart of a gas turbine engine. They are thus very close to being black boxes.

The driver for the research interest in oil systems is to be able to better design bearing chambers and internal gear boxes. There is currently a clear need to reduce the number of unplanned maintenance activities and design rework associated with new oil systems, a need to make effective use of the oil, minimising the parasitic losses associated with its cooling and lubrication functions and to maximise its life. All of these can be addressed with better design and analysis tools.

Tools for understanding oil-air behaviour within bearing chambers and internal gear boxes are limited the principal ones being rig testing and Computational Fluid Dynamics (CFD). The latter technique has been a large part of RR research activities for around twenty years because of its potential as a design and analysis tool. A great deal of progress in CFD has been made over that period of time, particularly in the last 5 years, and the company now has a better understanding of the complex flow phenomena present in a bearing chamber. However the CFD tools available within R-R to address the simulation of mixed oil-air flows are far from mature and a major effort is needed in order to develop the methods further, demonstrate them in physically realistic situations and establish the confidence in their predictions that would be required of an engineering tool.

This topic is intended to give RR a validated, tested and fully understood set of CFD tools for CFD in bearing chambers and internal gear boxes.

Elements of the tool are likely to be of value to both the Advanced Core and Power Gear Box. The activities on internal gear boxes in particular are likely to be of value to those groups trying to model larger helical gear systems.

2. Scope of work

The objectives of this Topic are:

- To identify what bearing chamber and internal gear box design questions CFD can be used to answer using the tools that it is envisaged will be matured and demonstrated during this activity.
- To produce a 'ready to use', tested and validated two-phase CFD tool based on: the thin film approximation and discrete particle methods which can be applied to simulating the flow of oil and air in both full bearing chambers and ideally in an internal gear box. The limits of applicability of the tool should be clearly identified, investigated and understood. A substantial demonstration of the tool's applicability should also be provided.
- To produce a 'ready to use', tested and validated two-phase CFD tool, based on the Volume of Fluid (VoF) method and discrete particle methods, which can be applied to simulating the flow of oil and air in both full bearing chambers and ideally an internal gear box. The limits of applicability of the tool should be clearly identified, investigated and understood. A substantial demonstration of the tool's applicability should also be provided.
- The coupling of the thin-film and the VoF models needs to be demonstrated in a convincing test and shown to be 'ready to use'. This coupling would be exploited where there are both thin films and deep pools of oil in the same simulation.
- It is recognised that the thin-film, VoF and discrete particle models identified above may have some serious limitations. These will be identified and where possible remedied. An investigation of alternative CFD approaches will be performed and reported as will an investigation of alternative numerical approaches to CFD.
- To produce substantial guidance and process on how the models demonstrated and proven in the activity should be used in practice.

It is envisaged that these objectives will be met through eight technical tasks and a programme management task:

Task 0 – Programme management
The partners shall nominate a team dedicated to the project including key points of contact and should inform the consortium programme manager about the name (s) of the key staff

The partners will work to the agreed time-schedule and work-package descriptions. Both the time-schedule and the work-package description laid out in this call shall be further detailed and agreed at the beginning of the project.

For all work packages, technical achievements, timescales, potential risks and proposals for risk mitigation will be summarised monthly.

Regular coordination meetings shall be conducted either in person or via telecom or webex where appropriate. The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information. The partners shall support regular quarterly face-to-face review meetings to discuss the progress

Task 1 – Systems engineering exercise
This Task will provide an answer to the following: what fluids design questions in bearing chambers and internal gearboxes can we expect to be answered by the application of CFD and which design questions will need an alternative approach. The result above would be further refined to which of those questions that could be answered with CFD could be answered using the tools it is proposed to develop in this Topic. It is currently envisaged this task would be addressed by looking at the hierarchy of requirements flowing from the fluid design requirements for the bearing chamber.

It is anticipated that this task will involve considerable interaction with Roll-Royce personnel.

Task 2 – Sensitivity identification
This Task will look at identifying the key elements of the CFD tools that still need to be developed an example might be the importance of wetting angle. It will also be used to identify the experimental work that will be needed to generate boundary conditions for the tools and which will be needed to validate and verify them the tools. Lastly the sensitivities that will need to be explored and investigated in order to produce a 'ready to use' tool will be identified such as for example mesh dependence and number of particles needed for DPM. The experimental test material for Task 4 will also be identified here.

Task 3 – Experimental work
This task will incorporate the performance of all the experimental work identified as being needed in Task 2. The experimentation is intended as a minimum to specifically address (a) A bearing chamber flow and (b) internal gear box flows. These will be performed over a range of operating conditions. Rig testing and measurements will be performed to fully characterise the flows in both of the items identified both for validation and verification, boundary condition setting and providing any correlations required such as for example turbulence transfer between the oil and air phases.

Task 4 – Large-scale CFD simulations of experiments
This task will involve the large scale simulation of the experimental results produced in Task 3, Specifically as a minimum (a) A bearing chamber flow and (b) internal gear box flows. These will be performed at a variety of operating conditions. There will be a detailed comparison of the results and reconciliation of any differences between the two data sets. Simulation times should be long enough to fully characterise any significant long period events present (if any). The deliverable results of the simulations will need to be accepted by RR prior to issue of the deliverable reports.

Task 5 – CFD development activities and sensitivity studies
This Task will involve all of the CFD development activities and sensitivities studies identified in Task 2. The CFD development activities would include as a minimum mesh adaption and refinement for VoF, thermal transfer between phases, impact of wetting angle and improvements in the two-phase models if identified as being required.

The simulations developed in Task 4 will be the subject of sensitivity studies but it is anticipated that smaller scale investigations would be performed beforehand as well. Those studies should address as a minimum mesh sensitivity, droplet number sensitivity, boundary condition sensitivity, gear models and the effect of turbulence parameters.

Task 6 – CFD exploration of alternative models and approaches

This Task is an exploration of those CFD modelling techniques which are applicable to bearing chamber and internal gearbox problems but which have not been the preferred approaches up to this point either because of computational expense, immaturity or difficulty in physical interpretation. As a minimum the investigations should include Eulerian-Eulerian multi-scale interface models.

Task 6 also includes an investigation of alternative to traditional CFD modelling of two-phase flow. It should include an extensive literature search and include as a minimum large-scale SPH modelling of key areas of the chamber and lattice Boltzmann approaches.

The deliverable reports from this task should discuss the relative merits of the approaches and make clear evidence based recommendations as to which approaches might be used to address the questions generated in Task 1 and any gaps in the applicability of models identified in Task2

Task 7 –CFD simulations of a real bearing chamber

This task would involve the large scale simulation of a real R-R bearing chamber and internal gear box. Three levels of simulation need to be addressed a simple ‘quick' design level simulation of a chamber/gearbox, simulations of key elements or a chamber and full chamber/gearbox simulations. These would using all of the tools developed, in the rest of the programme. Ideally these simulations would be performed at more than one simulated operating condition. It is the intention of this topic to capture transient behaviors as well as steady-states.

There will be a dissemination event demonstrating the maturity and applicability of these tools to engineering teams working on these chambers in order to capture any insights they might have as a result of the material presented.

Extensive explorations of the results in collaboration with RR will be made. Candidate chambers have been identified and would be provided by RR. An approach to validating these simulations can be proposed.

Task 8 – Engineering process development

In this task a process will be developed in which the CFD analyses of a bearing chamber identified in Task 1 can be performed as a series of simple, well- defined sub-processes with well-defined interfaces using the tools developed to maturity in this activity.

It is anticipated that the results of this task will be presented in two-stages. Firstly at a draft level as

Tasks 4 and 5 near completion and then at a mature level at the end of the programme. The deliverable will involve an element of training for RR staff.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
T1-1	Systems engineering report identifying where CFD can be applied in the bearing chamber/internal gearbox design process. (Task 1)	Report	T0+6
T2-1	Report identifying tool sensitivities to be investigated and experimental results required for validation and boundary conditions. (Task 2)	Report	T0+9
T3-1	Validation data for bearing chamber (Task 3)	Data and report	T0+33
T3-2	Validation data for internal gear box (Task 3)	Data and report	T0+36
T4-1	High fidelity simulation of bearing chamber experiment using both VoF and thin-film model. (Task 4)	CFD results and report	T0+42
T4-2	High fidelity simulation of internal gear box experiment using both VoF and thin-film model. (Task 4)	CFD results and report	T0+45
T5-1	Report of sensitivity sudies containg recommendations on the limitations of applications of the CFD tools developed	Recommendations on model formulation and limitations demonstrations of same all encapsulated in same.	T0+48
T5-2	Outputs of CFD development	Recommendations on model formulation, demonstrations of same and code all encapsulated in a report	T0+51

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
T6-1	Non-classical CFD approaches to BC and IGB modelling.	Recommendations on all model formulations, demonstrations of same and code all encapsulated a report.	T0+54
T6-2	Alternative two-phase CFD approaches to BC and IGB modelling.	Recommendations on all model formulations, demonstrations of same and code all encapsulated a report.	
T7-1	Simulations and subsequent interrogation of the results of the simulation for a real R-R bearing chamber using both VoF and thin-film models. With the possibility of one other form of model from Task 6 being employed.	CFD results and report	T0+52
T7-2	Simulations and subsequent interrogation of the results of the simulation for a real R-R internal gear box using both VoF and thin-film models. With the possibility of one other form of model from Task 6 being employed/	CFD results and report	T0+56
T7-3	Dissemination event presenting the results of the demonstrations.	Presentation	T0+58
T8-1	Draft engineering process for using the CFD tools developed for bearing chambers and internal gear boxes	Process document, training	T0+36
T8-2	Final engineering process for using the CFD tools developed for bearing chambers and internal gear boxes	Process document, training	T0+58

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
T3M-1	Bearing chamber experiments year 1 report & review	Report & Review	T0+21
T3M-2	IGB experiments year 1 report & review	Report & Review	T0+23

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
T4M-1	Simulation of BC expt - year 1 report & review	Report & Review	T0+29
T4M-2	Simulation of IGB expt year 1 report & review	Report & Review	T0+32
T5M-1	Sensitivity studies year 1 report & review	Report & Review	T0+21
T5M-2	CFD development year 1 report & review	Report & Review	T0+23
T5M-3	Sensitivity studies year 2 report & review	Report & Review	T0+34
T5M-4	CFD development year 2 report & review	Report & Review	T0+36

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

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

The key skills and capabilities required to deliver the Topic are as follows:

- Experience of applying two-phase CFD to air-oil problems in strongly rotating fields, ideally in an aero-engine bearing chamber.
- Facilities and capability to perform experimental measurements suitable to validate CFD simulations within suitable experimental analogues of aero-engine bearing chambers and internal gear boxes.
- A capability to apply High Performance Computing (HPC) to CFD simulations.
- A capability in applying a systems engineering approach to developing requirements for the application of CFD tools to engineering problems.
- Expertise in training in CFD.

5. Glossary

BC	Bearing chamber
CFD	Computational Fluid Dynamics
HPC	High Performance Computing
VoF	Volume of Fluid

IV. Development of Large Volume, Mass Optimised, Integrated Oil Storage Systems for Large VHBR Engines

Type of action (RIA or IA)	IA		
Programme Area	Engine ITD		
Joint Technical Programme (JTP) Ref.	WP 6 – VHBR – Large engine market		
Topic Leader	ROLLS-ROYCE		
Indicative Funding Topic Value (in k€)	3000 k€		
Duration of the action (in Months)	40 months	**Indicative Start Date**[19]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-ENG-03-05	**Development of Large Volume, Mass Optimised, Integrated Oil Storage Systems for Large VHBR Engines**
Short description (3 lines)	
The current proposal is aimed at understanding & developing key technology items critical to the successful realisation of oil lubrication and heat management systems for future large geared gas turbine engines. This proposal will evolve the TRL of these key technology items for the large engine market VHBR engine demonstrator in WP6 of Engine ITD.	

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

1. Background

As a part of engine projects in Clean Sky 2, the topic manager will lead the design and development of VHBR technologies for VHBR engine demonstrator (WP6 of Engine ITD) for large engine market. One of the key technologies developed to meet the goals of WP6 is an efficient, mass optimised oil lubrication and heat management system

Future VHBR engines represent a significant challenge for Oil heat management System designs due to significantly increased heat loads, the attendant increase in system oil volumes that come with these heat loads, and a need for more complex control schemes to ensure optimum system performance including off-design conditions.

In order to ensure that the benefits of future VHBR products are fully realised, then these future oil systems are required to be mass optimised to ensure that the increase in system volume does not penalise fuel burn, are more efficient to ensure optimum cycle performance, and are more intelligent to ensure that oil and heat flows are managed across engine the operating range.

The current understanding held by the topic manager is built upon current civil large engine (CLE) best practice and has the following shortcomings with regard to VHBR products:

- System architecture: CLE VHBR products may have their Oil System architectures configured in a variety of schemes; single, dual or separate systems compared to current CLE products that use simple single system architectures.
- System volumes and mass: A CLE VHBR product is likely to have a system volume almost 4 times greater than the current state of the art with an attendant increase in mass.

The current proposal is expected to deliver higher TRL level understanding of the key technologies required to deliver a large volume oil system for VHBR engines, along with physical test units to the topic manager’s design.

The objectives of the current proposal are to:

- Develop manufacturing techniques for the creation of large capacity mass optimised oil tanks and research into integrated functions such as de-aeration, venting and debris monitoring.
- Research de-aeration devices and produce design rules or theoretical tools to optimise de-aeration performance and hence minimise required oil tank volume. In addition manufacture and test various de-aerator designs provided by the topic manager.
- Research opportunities for more integrated oil tanks incorporating additional oil system functions such as de-aeration, venting, debris monitoring, heat exchange, structural integration.
- Based upon the above research activities, manufacture demonstration oil tanks, to the topic manager’s design.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T1	Management	T0 + 12 months
T2	Mass optimised oil tank manufacturing techniques	T0 + 24 months
T3	Oil tank de-aeration study	T0 + 27 months
T4	More integrated oil tank investigation	T0 + 36 months

A brief description of the tasks is given below:

Task1: Management

Organisation:

- The partners shall nominate a team dedicated to the project and should inform the consortium programme manager about the name (s) of this key staff

Time schedule and work-package description:

- The partners will work to the agreed time-schedule and work-package description
- Both the time-schedule and the work-package description laid out in this call shall be further detailed and agreed at the beginning of the project.

Progress reporting and reviews:

- Five progress reports (i.e. deliverables) will be written over the duration of the programme
- For all work packages, technical achievements, timescales, potential risks and proposal for risk mitigation will be summarised
- Regular coordination meetings shall be conducted via telecom or webex where appropriate
- The partners shall support reporting and review meetings with reasonable visibility on the activities and an adequate level of information
- The partners shall support quarterly face-to-face review meetings to discuss the progress

Task-2: Mass optimised oil tank manufacturing techniques

Recognising that VHBR engines will drive significant increases in stored oil volumes relative to today's high by-pass ratio engines, this task is required to research manufacturing techniques and materials required to enable large volume oil tanks to be mass optimized. As part of this task the use of lightweight and additive layer manufacturing techniques as well as optimized fabrication techniques should be explored.

Following research sufficient physical demonstration oil tank units shall be manufactured to support compliance rig and demonstration engine testing to mature the design to TRL6/MCRL4. It is recognized that oil tank design activities would be performed by the topic manager with close liaison with the successful bidder and in correspondence with the results derived from tasks 2 and4. Test units shall also be produced, that in partnership with the topic owner, shall be certified for demonstration engine test on both bench and flight test vehicles provided by the topic owner, it is anticipated that at least 5 off test units would be required for use on the topic managers test vehicles. The aim of this test is to ensure that an oil tank manufactured using new or novel materials or techniques is compatible with the real world conditions that a VHBR engine will produce.

Task-3: Oil tank de-aeration study

Effective oil tank de-aeration performance is a key factor in sizing oil tank volumes by allowing oil residence times to be reduced. This task is required to explore the parameters governing oil tank de-aeration supported by theoretical analysis and rig test, and to develop a design toolkit that may incorporate a computational model or empirical sizing data. In addition it is anticipated that the successful bidder shall manufacture and test various de-aerator designs provided by the topic manager.

The findings from this task will inform the studies defined in task 4.

Task-4: More integrated oil tank investigation

Traditional oil systems utilise an array of individual units typically connected by a pipe system to convey oil between them. Given the increased oil volumes inherent in future VHBR oil systems mass optimization is a key aspect to research for these future systems. Research is required to investigate optimum integration schemes to combine various unit functionalities into the oil tank in order to reduce system mass. Potential integration opportunities may include, but not be limited to, debris capture and monitoring, heat exchangers, integrated pumping.

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	**Title - Description**	**Type**	**Due Date**
D1	Management report: summarise the project management of the programme, including deliverables, level of spend and dissemination	Report	T0 + 40 months
D2	Mass optimized oil tank: Results of research identifying optimum materials and manufacturing techniques for future mass optimized oil tanks and Delivery of sufficient number of physical oil tank units (anticipated to be at least 5 off) suitable for compliance rig testing and demonstration engine test, both bench and flight.	Report / H/W	T0 + 27 months

D3	De-aeration study: summary of analysis and test results and delivery of computational design tool or empirical design kit	Report	T0 + 30 months
D4	More integrated oil tank: summary of results of integration study highlighting optimum oil tank integration schemes	Report	T0 + 40 months

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

Milestones (when appropriate)			
Ref. No.	**Title – Description**	**Type**	**Due Date**
M1	Management report: summarise the project management of the programme, including deliverables, level of spend and dissemination	Report	T0 + 40 months
M2	Mass optimised oil tank: Delivery of physical unit suitable for demonstration engine test.	H/W	T0 + 27 months
M3	Definition of mass optimised oil storage system: report summarising the design of mass optimized oil storage system incorporating integrated oil system functionality	Report	T0 + 40 months

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

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

- Design and manufacture of aerospace oil tanks
- EASA certified manufacturing organisation
- Experience in composite material manufacturing
- Experience in certifying units to EASA CS-E regulations
- Oil system unit design or integration capability or ability to partner with suitably experienced partner

6. Clean Sky 2 – Systems ITD

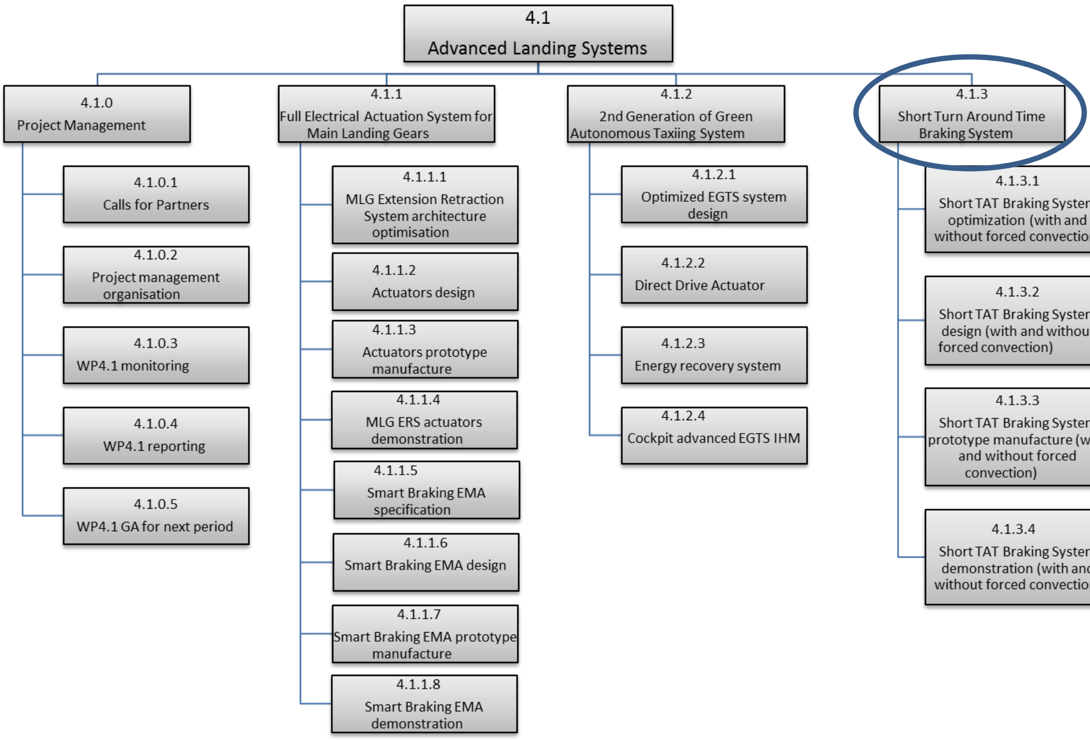
I. Short TAT Braking System - Optimized Tyre Design for Improved Brake Cooling

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP4.1 Main Landing Gear		
Topic Leader	SAFRAN		
Indicative Funding Topic Value (in k€)	3200 k€		
Duration of the action (in Months)	54 months	**Indicative Start Date**[20]	Q4 2016

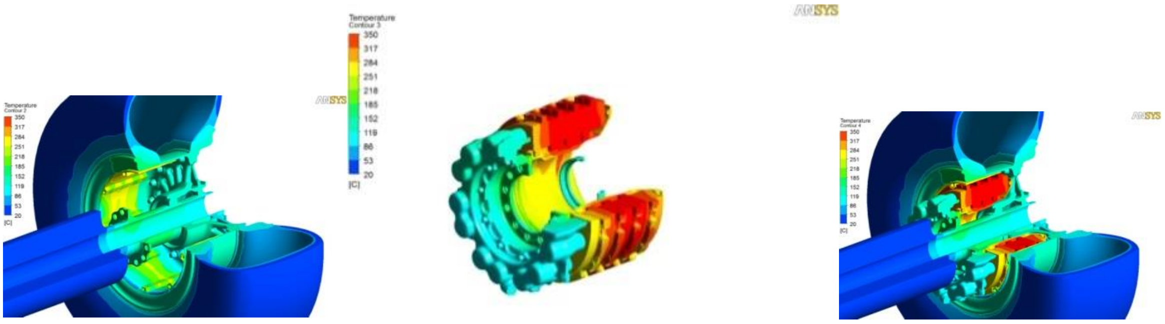
Identification	**Title**
JTI-CS2-2015-CPW03-SYS-02-03	**Short TAT Braking System - Optimized Tyre Design for Improved Brake Cooling**
Short description (3 lines)	
This project will develop a new optimized interface between the wheel rim and the tyre with angled seat, which will improve the passive brake system cooling. This new profile in the common area wheel/tyre will facilitate the flowing for hot air into the ambient air. Consequently it will reduce the Turn Around Time (TAT).	

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

1. Background



After braking at landing and taxi in, it is necessary to cool the aircraft wheels and brakes to ensure safe operations for taxi out and take-off. This cooling time is referred to as the Turn-Around-Time (TAT) and is a significant operational performance parameter of the braking system for the short/medium range aircraft segment. The maximum allowed temperature before take-off driving the TAT is defined so that there is no risk of hydraulic fluid inflammation in case of leakage ant that metallic structures and tyres remain in the authorized range of operations. The pictures below show the tyre/wheel/brake assembly temperatures after a maximum energy braking in the authorized range for nominal operations.



Wheel and brake temperature field after high energy stop

The current state of the art for short/medium range aircraft for TAT is about 45 minutes for a service landing energy with natural cooling configuration.

Preliminary study for the Short TAT demonstrated an interesting approach regarding the wheel/tyre interface evolution. The wheel rim in this area is defined by a standard called “Tyre and Rim Association” (TRA). This standard gives a wheel and tyre angle equal at 5° and fixes the form of the vertical parts of the wheel ends which block the tyres sidewall. The wheel designed in this way, the tyre is strongly stressed during the taxiing phases, especially in the turning phases when side loads are seen by the tyre. Moreover, the clearance between the wheel and the brake is very limited, and does not allow a good air flux around the brake for its cooling.

The innovating idea is to evaluate the **optimal rim and tyre angle,** ignoring the recommendations from the TRA, in order to optimize the TAT. This new interface could be positive for the mechanical stress into the wheel and the tyre and could increase the brake cooling.

The first study in order to validate this proposal was to simulate an angle of 15° - like on the lorry wheels- . Regarding the TAT improvement, according to Airbus definition, it is driven by the heat seak cooling, by heat transfer to the other equipment like the brake structure, the wheel, the axle and even the tyre. However some areas of the equipment are already at the temperature limit. So it is necessary to be attentive to the temperatures seen for these areas with the new wheel and tyre design. The heat shield between the wheel and the brake will follow the wheel angle in order to direct the brake radiation out of the wheel.

This preliminary computed impact on TAT was performed on A320D program for a new brake with a normal energy of 35MJ. Both configurations - legacy and optimized design with rim and heat shield angled - were performed in order to be compared. The temperature observed is the one of the third stator which is the longer to be cool down. The gain on the TAT at normal energy with new brake obtained for the optimized design with the angled rim and heat shield was encouraging: it allows to foresee the possibility to reach the TAT objective defined later in this document with the new design concept.

The promising results obtained by computation deserve to be supported by a detailed design and verification tests. There are the main topics motivating this call for Core Partner.

2. Scope of work

Overview

- The research activities will be conducted considering that the wheel and brake equipment is fitted with an electrical taxiing system, which induces additional design constraints compared to current configurations. The optimized wheel/brake/tyre architecture will be developed taking into account industrial and aircraft integration constraints such as volume, strength at high temperature, cooling, etc. in order to achieve a demonstration close to a TRL6 standard.
- The initial stage of the project will be a selection of a wheel/brake/tyre architecture for

design, this study will include all the stages for the joint design with the tyre manufacturer partner and the mechanical and thermal analysis. During the design phase, some subscale specimens and tests will be produced in order to mitigate the risks regarding the full scale prototype. A manufacturing study and the prototype manufacturing will be made before to test an optimized prototype, aiming at improving the passive cooling in order to reduce the TAT.

It is proposed to develop and demonstrate the short TAT operations braking system, as part of the Clean Sky 2 programme, up to TRL6 maturity level by the end 2020. In this study, the presence of the electrical wheel actuator, for taxiing operations, in the wheels and brakes area decreases the thermal performances for the braking system. Indeed, the electrical wheel actuator blocks the air flow and prevents the good equipment cooling. Thermal margins for the current design (without electrical wheel actuator) already being very small, **the targeted performance for the TAT is** to perform in natural convection as a minimum the same results for the braking system equipped with an electrical wheel actuator than without.

It is to be noted that the proposed activity - mainly the angle's optimization and its benefit for the TAT- is **aligned with the SYS ITD high level objectives** with direct contributions to environmental objectives: CO2 emissions, fuel consumption, perceived noise, air quality, weight gain. The shorter TAT shall allow avoiding the use of the fan, with positive impact on perceived noise, air quality (less brake carbon dust projected during cooling phases and less CO2 emissions during flights), gain on weight (minus 28Kg through removal of the 4 fans) and fuel saving.

The expected innovations will include:

- Aircraft main wheel architecture with non-conventional design (angled rim) ;
- New sizing for the wheel flange ;
- Innovative design for the wheels and brakes components impacted by this angled wheel evolution (torque bars, heat shields, insulators, etc.).
- Tyre architecture compatible with this wheel design and with acceptable lateral deformations in case of side load applications (in order to avoid any mechanical interference with the brake).
- Tyre chemical composition with higher thermal capability allowing to withstand the higher temperatures expected at tyre flange caused by the improved heat evacuation outside of the wheel.

The specific requirements:

- The targeted wheel size for this programme will be 21", corresponding to an in-service short/medium programme not fitted with a Brake Cooling Fan. The tyre to develop as part of this project shall demonstrate high level of performance in terms of reliability, weight and wear. For this purpose the partner shall develop a specific radial tyre (current aircraft tyre standard), this technology being the most appropriate to reach these goals, and shall have a significant in-service experience in this technology for the wheel size considered in this project. The tyre's reference considered in this project depends on the wheel's size / reference. The dimension to be considered for this reference is: H44.5x16.5R21, according to the TRA.

- The new tyre and wheel developed in this project must comply with their respective airworthiness requirements (TSO C62D/E for the tyre and TSO C135a for the wheel), along with the specific aircraft manufacturer's requirements defined for the reference wheel and tyre equipment.

Quantified objectives:

- The mass of the improved wheel and tyre assembly shall remain in the envelope of the current wheel and tyre assembly, using the reference mentioned above. The mass of the improved equipment shall then not exceed 153 kg. The tyre shall withstand, without degradation, the higher temperatures –to be determined during the project– seen at tyre flange caused by the improved heat evacuation outside of the wheel.
- Beyond the mass and thermal aspects mentioned above, the other overall equipment performances must not be below those of the tyre. Particularly the tyre wear performance and retreadability.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T4.1.3.1	**Optimisation of wheel and tyre architecture for braking system** Task aims at researching the most appropriate tyre architecture in order to meet with the future angled interface. Task will consist in : - Trade-off studies to TRL4 in order to optimise and define the angle at the interface between the rim and the tyre - Development of new tyre architecture for the application	M9
T4.1.3.2	**Architecture design for wheel & tyre for braking system** Task aims at optimizing the rim and tyre angle interface in order to increase the natural cooling for the braking system. Task will consist in : - Design of the optimized angled tyre to TRL5 - Design of the optimized angled tyre to TRL6	M42
T4.1.3.3	**Manufacturing of wheel & tyre for braking system** Task aims at producing mock-up and prototype in order to perform tests in the following task. Task will consist in : - Manufacturing of a subscale mock-up (TRL4) - Manufacturing of a full-scale mock-up (TRL5) - Manufacturing of a full-scale prototype (TRL6)	M48

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T4.1.3.4	**Testing & analysing** Task aims at performing tests in order to evaluate the real performance for the new design with right data for mass and geometry. Task will consist in : - Preliminary laboratory testing of critical technical feasibility related to optimized angle & Tests analysis for the angle optimisation (TRL4) - Integration tests in a partially representative environment & Tests analysis - Tests on prototype in operational environment & Tests analysis of the prototype (TRL6)	M54

3. Major deliverables/ Milestones and schedule (estimate)

Ref. No.	*Title*	*Type*	*Due Date*
D4.1.3.1-01	Research activities of trade-off studies for the definition of the optimized angled wheel and tyre application (TRL4)	R	M6
D4.1.3.1-02	New tyre architecture justification for the application	R	M9
D4.1.3.3-01	Sub-scale mock-up for optimized angled tyre (TRL4) manufactured	D**	M12
D4.1.3.4-01	Preliminary laboratory testing for optimized angled tyre (TRL 4)	R	M15
D4.1.3.4-02	Tests results analysis for optimized angled tyre (TRL4)	R	M18
D4.1.3.2-01	PDR for optimized angled tyre (TRL5)	R	M24
D4.1.3.3-02	Full-scale mock-up for optimized angled tyre (TRL 5)	D**	M30
D4.1.3.4-03	Integration tests for optimized angled tyre in a partially representative environment (TRL5)	R	M33
D4.1.3.4-04	Tests analysis for optimized angled tyre (TRL 5)	R	M36
D4.1.3.2-02	CDR for optimized angled tyre (TRL6)	R	M42
D4.1.3.3-03	Full-scale prototype for optimized angled tyre (TRL6)	D**	M48
D4.1.3.4-05	Integration tests for prototype with optimized angled tyre in operational environment (TRL6)	R	M51
D4.1.3.4-06	Tests results analysis for prototype with optimized angled tyre (TRL6)	R	M54

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

** D: in the context of this specific document, D means Delivery of hardware

				M1	M4	M7	M10	M13	M16	M19	M22	M25	M28	M31	M34	M37	M40	M43	M46	M49	M52
Task Ref	ML Ref	Task Description	Date	Year1		Year2				Year3				Year4				Year 5			
T4.1.3.1		**Optimisation of wheel and tyre architecture for braking system**																			
	ML4.1.3.1-01	Research activities of trade-off studues for the definition of the optimized angled wheel and tyre application (TRL4) done	M6																		
	ML4.1.3.1-02	New tyre architecture justification for application done	M9																		
T4.1.3.2		**Architecture design for wheel & tyre for braking system**																			
	ML4.1.3.2-01	PDR for optimized angled tyre (TRL5) passed	M24																		
	ML4.1.3.2-02	CDR for optimized angled tyre (TRL6) passed	M42																		
T4.1.3.3		**Manufacturing of wheel & tyre for braking system**																			
	ML4.1.3.3-01	Sub-scale mock up for optimized angled tyre (TRL4) manufactured	M12																		
	ML4.1.3.3-02	Full-scale mock-up for optimized angled tyre (TRL 5) manufactured	M30																		
	ML4.1.3.3-03	Full-scale prototype for optimized angled tyre (TRL6) manufactured	M48																		
T4.1.3.4		**Testing & analysing**																			
	ML4.1.3.4-01	Preliminary laboratory testing for optimized angled tyre (TRL 4) conducted	M15																		
	ML4.1.3.4-02	Tests results analysis for optimized angled tyre (TRL4) available	M18																		
	ML4.1.3.4-03	Integration tests for optimized angled tyre in a partially representative environment (TRL5) conducted	M33																		
	ML4.1.3.4-04	Tests analysis for optimized angled tyre (TRL 5) available	M36																		
	ML4.1.3.4-05	Integration tests for prototype with optimized angled tyre in operational environment (TRL6) conducted	M51																		
	ML4.1.3.4-06	Tests results analysis for prototype with optimized angled tyre (TRL6) available	M54																		

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

Technical skills, Capabilities & Certification expected from the Applicant:

- The applicant must incorporate an efficient Research entity capable to give its support to this project providing innovative solutions necessary to reach the project quantified performances.
- The applicant must have the capability to develop radial tyres for aircraft large wheels and shall demonstrate a significant in-service experience in this domain.
- The applicant must have the capability to manufacture tyre prototypes and to start tests using them rapidly after the project start date (one year maximum).

Process skills, Capabilities & Certification expected from the Applicant:

- The applicant must have the capability to check at an early stage in the tyre development process the possibility to reach the targeted project objectives (one year maximum).
- The applicant must have a proven track record in delivering to agreed time, cost and quality
- The applicant must have demonstrated project management and quality management capability in aerospace.

Organizational skills, Capabilities & Certification expected from the Applicant:

- The applicant must ensure resources are available for main tasks in-house and should avoid subcontracting for the research, development, simulation, and testing.
- The applicant must have reliable supply chain for all the necessary components and material.

5. Glossary

CDR	**C**ritical **D**esign **R**eview
PDR	**P**reliminary **D**esign **R**eview
TRL	**T**echnology **R**eadiness **L**evel
TSO	**T**echnical **S**tandard **O**rder

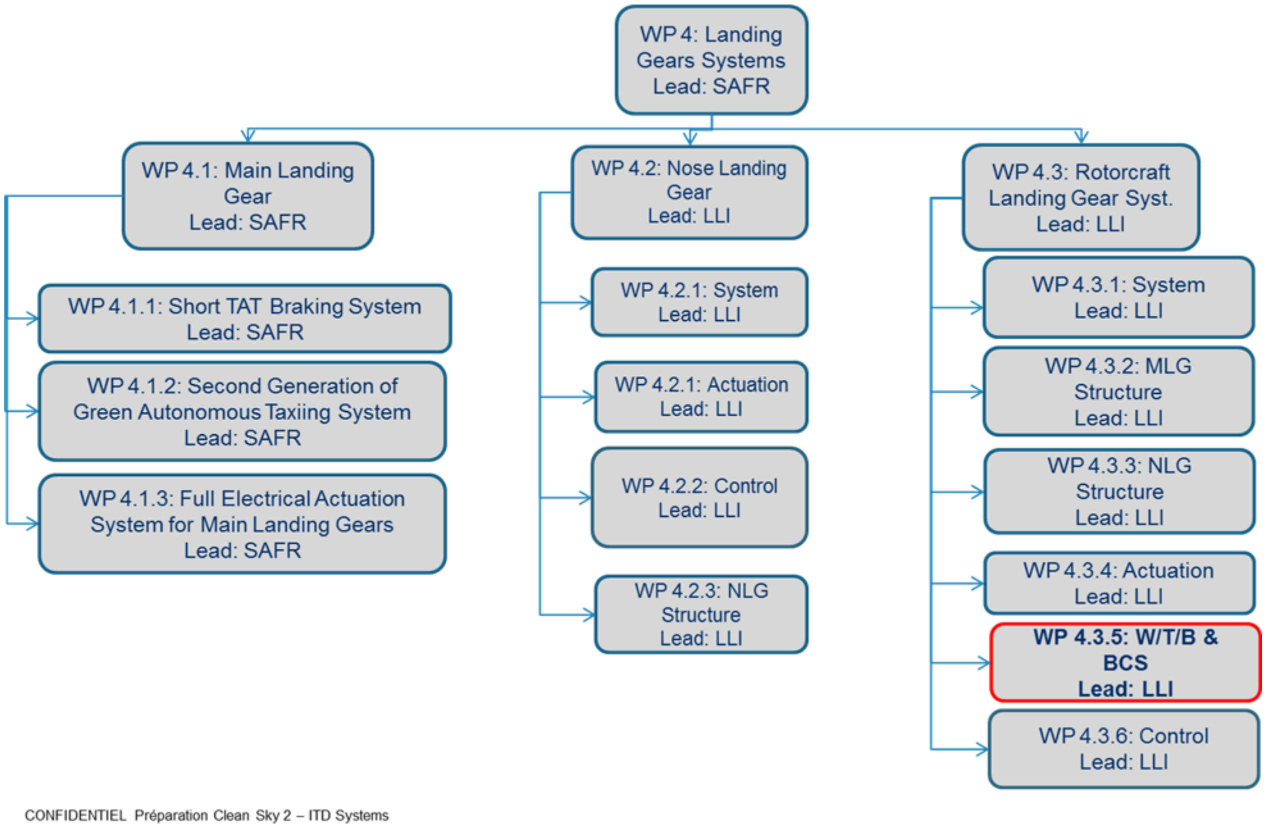
II. High Efficient Compact Electro-Mechanical Brake for Small Aircraft and Helicopters with Advanced Brake Disc Material

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP4 – 4.3 Rotorcraft		
Topic Leader	LIEBHERR		
Indicative Funding Topic Value (in k€)	4500 k€		
Duration of the action (in Months)	72 months	**Start Date**[21]	Q4-2016

Identification	**Title**
JTI-CS2-2015-CPW03-SYS-02-04	High Efficient Compact Electro-Mechanical Brake for Small Aircraft and Helicopters with Advanced Brake Disc Material
Short description (3 lines)	
The work of the partner is to develop, manufacture and test a new high efficient electro-mechanical brake for small aircrafts and helicopters considering advanced brake control laws, limited design space, cooling down performance from high temperature and lightweight construction including advanced brake disc material. The aim is to develop, manufacture and lab-/ or, and flight test this equipment.	

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

1. Background



The objective of the WP4.3.5 Wheel/Tire/Brake and Brake Control System (W/T/B & BCS) is the development of new innovative electromechanical actuated brakes (EMAB) for small aircrafts and helicopters. Electromechanical Brakes are already known in Large and Mid-Size aircrafts. For Small aircrafts and helicopters this gets more and more interesting due to more electric approaches also in these categories. The potential partner to be assigned for this work package should preferably be already experienced and established in the aeronautical business devoted to brake development, design or/and manufacturing. The potential Core Partner mandatorily needs to be established already in the industrial/automotive brake component segment. Funded knowledge on electromechanical actuation shall preferably belong already to the Core Partners' portfolio.

The first steps will focus mainly on trading today´s available EMAB technologies and identify potentially new technologies e.g. advanced disc material (ceramic or carbon or a mixture of both) or electromechanical actuator principles including strategies for reduction of the power needed to actuate the brake. Specific competence need to be a section of partners' portfolio on which friction material combination a dedicated friction coefficient do result from. The knowledge to be either available at the Core Partner itself or via a third tier supplier who is well known by the Core Partner.
Moreover efficient thermal management and cooling down performance of the electromechanical brake assembly has to be subject of the development. Therefore capabilities on thermal simulation

need to be portion of basic knowledge.
Beside the functional and performance requirements, the generation of brake noise and vibration induced into the Landing Gear structure has to be minimized. Cost and reliability values need to be in a competitive range to the market. Cost of ownership and maintenance intervals of actuators should be at least equal or better than today's solution on the market.
The challenging aspects of the WP are as follows:

- Environmental and operating conditions, such as
  - Ambient temperature (-55 °C … +80 °C)
  - Heat sink and cooling down performance
  - Minimized disk wear
  - Demanding environmental levels
  - High number of duty cycles (> 100.000 flight cycles)
- Aerospace approved materials and processes
- Aerospace requirements

Depending of the actuator type an appropriate sensing and monitoring methods shall be identified in order to ensure proper health monitoring capabilities.
For instance:

- Disk Wear monitoring
- Actuator health monitoring
- Thermal monitoring

These sensing methods and requirements will be defined jointly by the selected partner and Topic Manager.

The identified concepts shall be elaborated analysed and evaluated. Retrofit solutions shall be considered.
The function and applicability of the developed technologies shall be proven by test. Therefore corresponding functional demonstrators have to be provided in attunement with Topic Manager.
Topic Manager will provide the top level requirement for the innovative electromechanical actuated brakes.
The partner is in charge for engineering, manufacturing and providing the test facility, executing the tests and the documentation of the test results.
The demonstration phase will principally consist of functional and performance tests including vibration and high low temperature testing. In addition it is conceivable to conduct accelerated tests.
The Core Partner has to clearly depict details of test campaign (type of test, when, where, etc.) prior to test launch.

Note: Specifications of the electromechanical brake assembly will be provided by Topic Manager once the partner has been selected after signature of a Non Disclosure Agreement (NDA) between the two companies.
In case of assignment of a third tier supplier by the Core Partner the Topic Manager will be open for

conveyance of such an enterprise.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	State of the Art analysis – Analysis of existing electrical braking actuators and sensing technologies, as well as upcoming technologies enabling innovative concepts. New technologies e.g. advanced disc material and actuation principles and strategies to reduce input power will be analysed.	T0 + 6 M
T02	Concept Phase – Together with Topic Manager, the partner will propose and trade brake control law algorithm, design and monitoring concepts. Preliminary design, performance and stress analysis will support the evaluation. The technologies will be benchmarked with regards to cost, weight and reliability.	T0 + 15M
T03	Preliminary Design – Based on the outcome of the concept phase the partner will start to work out the agreed concept. The selected concepts will be matured and adapted to Topic Manager actuators in order to fit the demonstration platform of Clean Sky 2. The costs, weight and reliability impacts will be estimated and matched with market expectations.	T0 + 24M
T04	Detail Design – The preliminary design will be analysed in detail in regards to function, performance and stress. The outcome shall be then designed in accordance to the demonstration foreseen and proposed for prototyping approval. In parallel the partner shall propose an adequate test campaign to demonstrate major performance and strength parameter.	T0 + 35M
T05	Production – The partner shall build at least the necessary full functional demonstration test hardware and one marketing mock-up.	T0 + 47M
T06	Test – The partner shall be responsible for: - Planning and provision of test equipment (rigs, etc.), - Execution of verification tests, - Reporting and analysis of the test results.	T0 + 71M

3. Major deliverables/ Milestones and schedule (estimate)

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D01	State of the Art analysis report on existing electrical brake actuator principles	R	T0 + 6M
D02	Concept study electromechanical brake and brake system demonstrator definition	R	T0 + 15M
D03	Preliminary design and analysis of electromechanical brake including friction material coefficient and brake control law algorithm	R RM	T0 + 24M
D04	Detail design and analysis of electromechanical brake including friction material coefficient and brake control law algorithm Demonstration test campaign	R RM	T0 + 35M
D05	Production of demonstration test hardware and mock-ups	D	T0 + 47M
D06	Provision of D05 equipment Test report	D R	T0 + 71M

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M01	Baseline Definition	R	T0 + 15M
M02	Start Detail Design	R	T0 + 24M
M03	Start Production	D	T0 + 47M
M04	Start of technology demonstration and bench marking	R D	T0 + 32M

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

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

- Experience in the aeronautical business devoted to brake development, design or/and manufacturing and additional experience in the industrial/automotive brake component segment is welcomed
- Experience in electromechanical actuation preferably brake actuation
- Mechanical stress and finite elements calculation, CFD and thermal analysis capabilities especially for static and dynamic brake actuation as well as thermal simulation
- Sensors capabilities for control and health monitoring
- Environmental conditions
- (knowledge of aerospace requirements as e.g. RTCA DO-160)
- Knowledge on advanced brake disc and friction materials (ceramic or composite or a

combination of both)

5. Glossary

BCS	Brake Control System
CSJU	Clean Sky 2 Joint Undertaking
EMAB	Electromechanical actuated Brakes
MLG	Main Landing Gear
NDA	Non Disclosure Agreement
NLG	Nose Landing Gear
RTCA DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
SPD	Systems and Platforms demonstrators
TAT	Turn around time
W/T/B	Wheel / Tire / Brake
WBS	Work Breakdown Structure
WP	Work Package

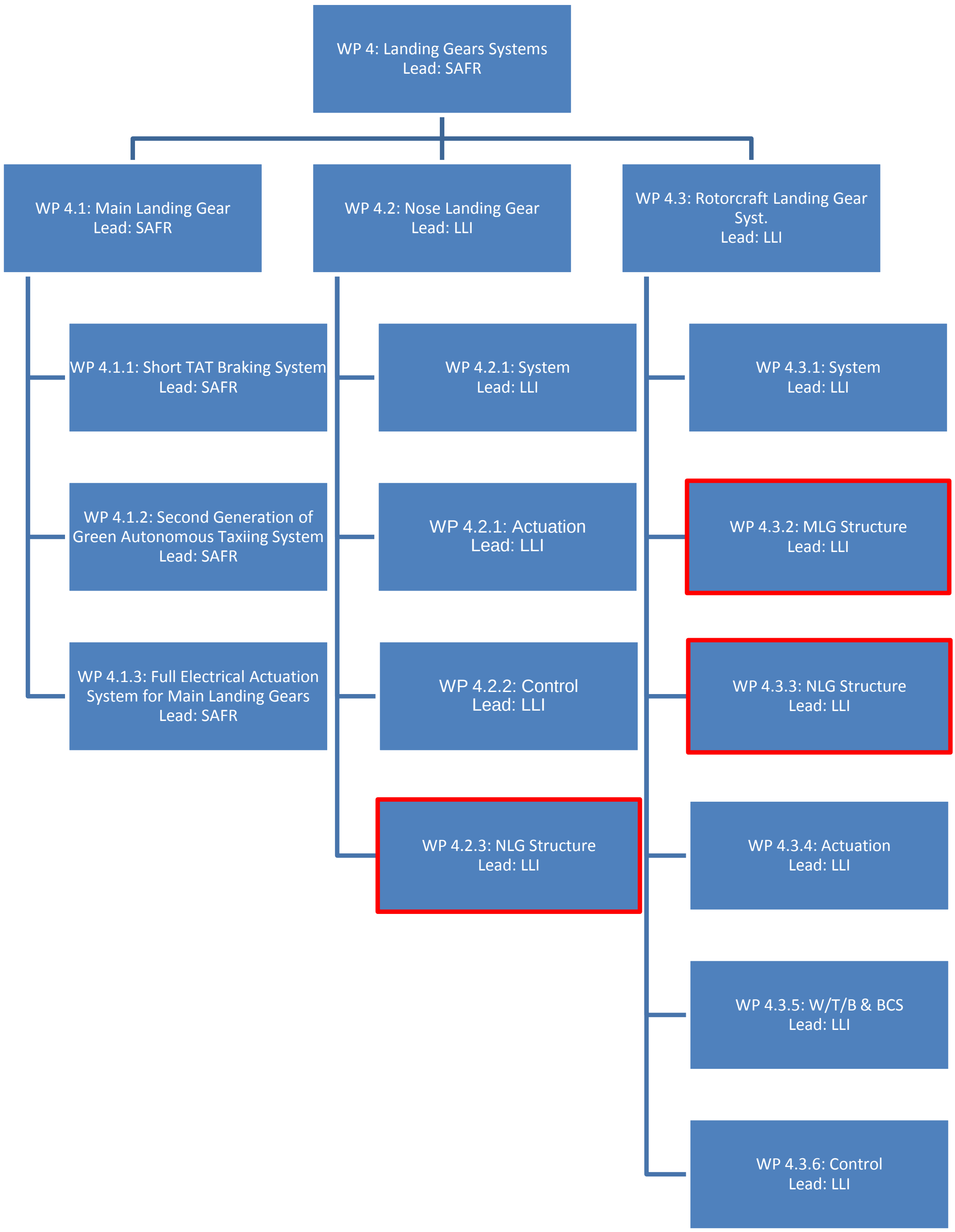
III. High Efficient Structural Landing Gear Parts based on Advanced Carbon Fiber Material Systems and Highly Automated Production Technologies for Helicopter and Aircraft

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP4 – 4.2 Nose Landing Gear WP4 – 4.3 Rotorcraft		
Topic Leader	LIEBHERR		
Estimated Topic Value (funding in k€)	4000 k€		
Duration of the action (in Months)	72 months	**Indicative Start Date**[22]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-SYS-02-05	**High Efficient Structural Landing Gear Parts based on Advanced Carbon Fiber Material Systems and Highly Automated Production Technologies for Helicopter and Aircraft**
Short description (3 lines)	
The work of the partner is to develop, manufacture and test high efficient structural landing gear parts for helicopter and aircrafts based on advanced carbon fiber material systems and highly automated production technologies considering lightweight construction principles, dedicated certification strategies and overall cost of ownership. The aim of the project is to develop, manufacture and lab-/ or, and flight test this equipment in relevant environment.	

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

1. Background



The objective of the WP4.2.3 NLG Structure, WP4.3.2 MLG Structure and WP4.3.3 NLG Structure is the development of new innovative high efficient structural landing gear parts for helicopter and aircrafts based on advanced carbon fiber material systems and highly automated production technologies considering lightweight construction principles, dedicated certification strategies and overall cost of ownership.

Composite landing gear braces are already known in large aircrafts which up to now have not reached robust in service production and quality maturity. For helicopters and aircrafts the composite technology gets more and more interesting due to the achievable weight saving and cost potentials by improvements in material systems (fiber and matrix), analysis methods and highly automated production technology.

Today's single load path structural landing gear parts are based on state of the art materials such as aluminum, stainless steel, ultra-high strength steel or titanium. Using these materials either a limited weight saving is achieved or high manufacturing cost and/or material cost have to be considered. Special care for corrosion protection is necessary to be compliant with todays and future aircraft and REACH requirements.

The goal of this topic is to establish the basis for the development and manufacturing of high efficient structural landing gear parts made out of composites, to save weight and improve cost of ownership in comparison with current isotropic material applications. The main focus shall be made firstly on parts such as MLG and NLG braces because of their less complex stress loading (mainly tension and compression loads) and their support and connection interfaces. In a second step also more complex structural landing gear parts such as for e.g. main fittings, sliding tubes, trailing arms shall be considered.

The parts shall be developed by the potential partner in full compliance to the high level requirements of typical helicopter and aircraft application, these requirements are but not limited to:

- Interfaces and maximum design envelop
- Complete load set as ground, landing, flight and vibration loads)
- Natural frequencies and stiffness
- Environmental conditions as high/low temperature, moisture, fluid susceptibility and ultra violet radiation
- Sustainability to impact strength as particular risk scenarios, hail, FOD and bench handling
- Other not yet defined requirements for composite parts in aircraft applications.

Furthermore the developed parts must have an overall benefit in weight and cost to current aluminum, steel and titanium applications.

The potential partner to be assigned for this work package shall preferably be already experienced and established in the aeronautical business devoted to composite development, design or/and manufacturing. The potential Core Partner mandatorily needs to be already established in the

industrial/automotive composite component segment and shall be proficient with the challenge of the development of highly loaded composite parts used in harsh environments.
Funded knowledge in the simulation and the development of single load path, safety critical aircraft structures in composites for landing gear applications up to a maturity level of demonstration flight shall preferably belong already to the Core Partner's portfolio.

The first steps will focus mainly on trading today´s available RTM composite technologies and identify potentially new technologies e.g. advanced matrix systems, preform methods and high automated manufacturing technologies to support and assure production robustness, decrease cutting losses and scrap rate including strategies for improved fiber strength utilization and state of the art manufacturing.
The Topic Manager does see the RTM production method as mandatorily to assure the later robust serial production and high quality target.

Specific competence need to be a section of partner's portfolio on which fiber, fabric and matrix system combination results in dedicated material allowable. Furthermore the potential partner shall have competence on various manufacturing technologies involving thick walled composite aircraft structures, preferably based on own manufacturing facilities. The knowledge for the whole production chain/process shall be either available at the Core Partner itself or via a third tier supplier who is well known by the Core Partner.

Moreover efficient design, analysis and simulation methodology has to be subject of the development. Proven experience in numerical analysis methods and process simulations of complex composite materials to predict mechanical behavior and in actual and new certification strategies of composite aircraft structures is seen as advantageous to fulfill the Topic Managers weight reduction target.

Beside the functional and performance requirements the cost and reliability values need to be in a competitive range to the market. Cost of ownership and maintenance intervals of composite structural landing gear parts shall be at least equal or better than today's solution on the market.

The challenging aspects of the WP are:

- Operating and environmental and conditions, such as
    - Safety criticality of single load path structure
    - Ambient temperature (-55 °C … +80 °C for braces, … up to + 220°C for Major Structural Parts)
    - Impact resistance for different impact scenarios during in service as take-off, flight, landing and transportation/handling
    - Demanding environmental levels
    - High number of duty cycles (> 100.000 flight cycles)
    - Test the parts under harsh environment and conditions
- Aerospace approved materials and processes

- Aerospace requirements

The identified concepts shall be elaborated analyzed and evaluated. Retrofit solutions shall be considered.

The function and applicability of the developed technologies shall be proven by test. Therefore corresponding functional demonstrators have to be provided in attunement with Topic Manager.
Topic Manager will provide the top level requirement for the high efficient structural composite parts. The partner is in charge for engineering, manufacturing and to provide the test facility, executes the tests and the documentation of the test results.

The demonstration phase will principally consist of functional and performance tests including vibration and high/low temperature testing. In addition it is conceivable to conduct accelerated tests. The Core Partner has to clearly depict details of test campaign (type of test, when, where, etc.) prior to test launch.

Note: Specifications for the high efficient structural composite parts will be provided by Topic Manager once the partner has been selected after signature of a Non-Disclosure Agreement (NDA) between the two companies.
In case of assignment of a third tier supplier by the Core Partner the Topic Manager will be open for conveyance of such a consortium.

This call for proposal is a scientific and industrial challenge and provides opportunity of competitiveness on improvement of costs, manufacturing and economy of parts used in e.g. landing gear applications for European partners of Clean Sky.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	State of the Art Analysis – Analysis of today's available RTM composite technologies and identification of potentially new technologies e.g. advanced matrix systems, preform methods and high automated manufacturing technologies to assure production robustness, decrease cutting losses and scrap rate including strategies for improved fiber strength utilization and state of the art manufacturing.	T0 + 3M

Tasks		
T02	LC - Concept Phase “Braces”– Together with Topic Manager, the partner will propose and trade design and production concepts. Preliminary design and stress analysis will support the evaluation. The technologies will be benchmarked with regards to weight saving potential and cost of ownership.	T0 + 9M
T03	LC - Preliminary Design “Braces” – Based on the outcome of the concept phase the partner will start to work out the agreed concept. The selected concepts will be matured and adapted to Topic Manager part interfaces in order to fit the demonstration platform of Clean Sky 2. The weight saving and cost of ownership will be estimated and matched with market expectations.	T0 + 14M
T04	LC - Detail Design “Braces” – The preliminary design will be analyzed in detail in regards to function and stress. The outcome shall be then designed in accordance to the demonstration foreseen and proposed for prototyping approval. In parallel the partner shall propose an adequate test campaign to demonstrate major functions and strength parameter.	T0 + 21M
T05	LC - Production “Braces” – The partner shall build at least the necessary full functional demonstration test hardware and one marketing mock-up.	T0 + 24M (partly parallel to T04)
T06	LC - Test “Braces”– The partner shall be responsible for: - Planning and provision of test equipment (rigs, etc.), - Execution of verification tests, - Reporting and analysis of the test results.	T0 + 39M
T07	MC - Concept Phase “Major Structural Parts”– Together with Topic Manager, the partner will propose and trade design and production concepts. Preliminary design and stress analysis will support the evaluation. The technologies will be benchmarked with regards to weight saving potential and cost of ownership.	T0 + 24M
T08	MC - Preliminary Design “Major Structural Parts” – Based on the outcome of the concept phase the partner will start to work out the agreed concept. The selected concepts will be matured and adapted to Topic Manager part interfaces in order to fit the demonstration platform of Clean Sky 2. The weight saving and cost of ownership will be estimated and matched with market expectations.	T0 + 31M

Tasks		
T09	MC - Detail Design "Major Structural Parts" – The preliminary design will be analyzed in detail in regards to function and stress. The outcome shall be then designed in accordance to the demonstration foreseen and proposed for prototyping approval. In parallel the partner shall propose an adequate test campaign to demonstrate major functions and strength parameter.	T0 + 40M
T10	MC - Production "Major Structural Parts" – The partner shall build at least the necessary full functional demonstration test hardware and one marketing mock-up.	T0 + 43M (partly parallel to T09)
T11	MC - Test "Major Structural Parts"– The partner shall be responsible for: - Planning and provision of test equipment (rigs, etc.), - Execution of verification tests, - Reporting and analysis of the test results.	T0 + 58M
T12	Certification Phase – The partner shall be responsible for: - Execution of certification tests, - Supporting the flight test campaign - Reporting and analysis of the test results.	T0 + 66M

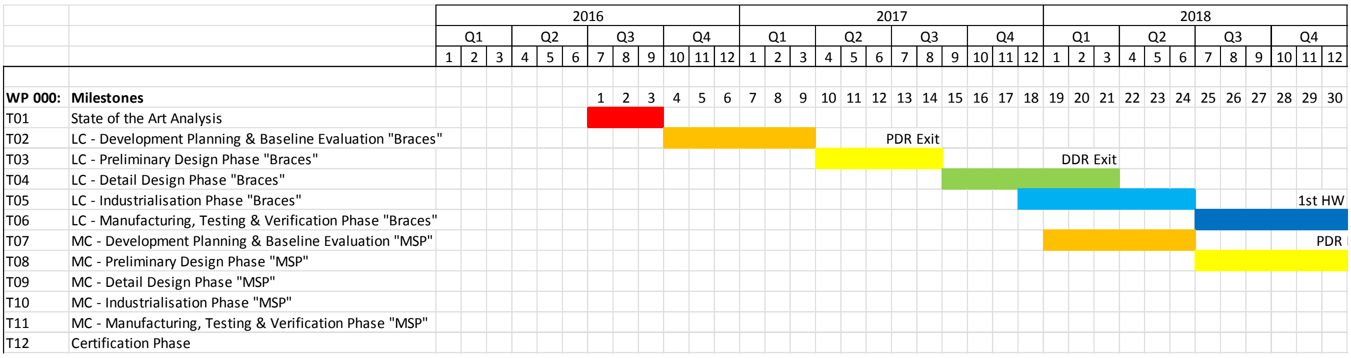
3. Major deliverables and schedule (estimate)

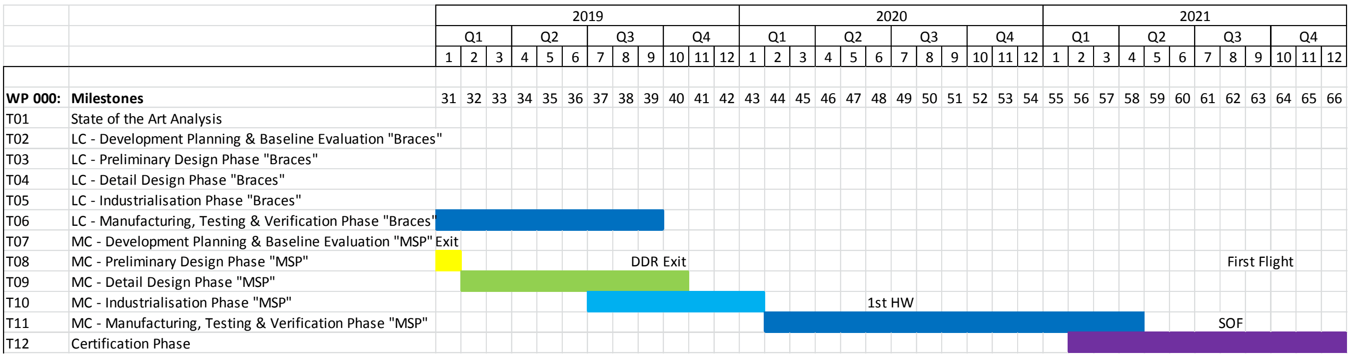
Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D01	State of the Art Analysis	R	T0 + 3M
D02	LC - Concept Study for Braces	R	T0 + 9M
D03	LC - Preliminary design and analysis of Braces	R	T0 + 14M
D04	LC - Detail design and analysis of Braces	R	T0 + 21M
D05	LC - Production of Demonstration Hardware and Marketing Mock-Up for Braces	R	T0 + 21M
D06	LC - Qualification Test Campaign for Braces	R	T0 + 25M
D07	MC - Concept Study for Major Structural Parts	R	T0 + 24M
D08	MC - Preliminary design and analysis of Major Structural Parts	R	T0 + 31M
D09	MC - Detail design and analysis of Major Structural Parts	R	T0 + 40M
D10	MC - Production of Demonstration Hardware and Marketing Mock-Up for Major Structural Parts	R	T0 + 40M
D11	LC - Qualification Test Campaign for Major Structural Parts	R	T0 + 44M
D12	Certification Test Campaign	R	T0 + 58M

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

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
M01	LC - Start Baseline Definition “Braces”	RM	T0 + 10M
M02	LC - Start Detail Design “Braces”	RM	T0 + 15M
M03	LC - Start Production “Braces”	RM	T0 + 18M
M04	LC - Start of Technology Demonstration “Braces”	RM	T0 + 25M
M05	LC - 1st Hardware Delivery “Braces”	D	T0 + 30M
M06	MC - Start Baseline Definition “Major Structural Parts”	RM	T0 + 25M
M07	MC - Start Detail Design “Major Structural Parts”	RM	T0 + 32M
M08	MC - Start Production “Major Structural Parts”	RM	T0 + 37M
M09	MC - Start of Technology Demonstration “Major Structural Parts”	RM	T0 + 44M
M10	MC - 1st Hardware Delivery “Major Structural Parts”	D	T0 + 49M
M11	Start of Flight Test Campaign	RM	T0 + 56M

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





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

- Experienced and established in the aeronautical business devoted to composite development, design or/and manufacturing but mandatorily industrial/automotive background
- Funded knowledge in the development of single load path, safety critical aircraft structures in composites for landing gear applications preferred.
- Specific competence on which fiber, fabric and matrix system combination results in dedicated material allowable.
- Competence of the various manufacturing technologies involved of thick walled composite aircraft structures, preferably own manufacturing facilities.
- Experience in numerical analysis methods and process simulations of complex composite materials to predict mechanical behavior.
- Knowledge in actual and new certification strategies of composite aircraft structures.
- Knowledge of aerospace environmental conditions requirements as e.g. RTCA DO-160

5. Glossary

CSJU	Clean Sky 2 Joint Undertaking
LC	Less Complex
MC	More Complex
MLG	Main Landing Gear
MSP	Major Structural Part
NDA	Non-Disclosure Agreement
NLG	Nose Landing Gear
RTCA DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
RTM	Resin Transfer Molding
SPD	Systems and Platforms demonstrators
WBS	Work Breakdown Structure
WP	Work Package

IV. HVDC Power Center and Functions

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 5.2.2.1 PMC for Large Aircraft and WP 6.4		
Topic Leader	LIEBHERR / AIRBUS		
Estimated Topic Value (funding in k€)	6500 k€		
Duration of the action (in Months)	90 months	**Indicative Start Date**[23]	Q4 2016

Identification	**Title**
JTI-CS2-2015-CPW03-SYS-02-06	**HVDC Power Center and Functions**
Short description (3 lines)	
This call deals with a HVDC power center wich contains distribution and protection devices. This power center will be designed in order to minimise weight and cost. A prototype will be delivered in order to be integrated in a global demonstration at system level.	

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

1. Background

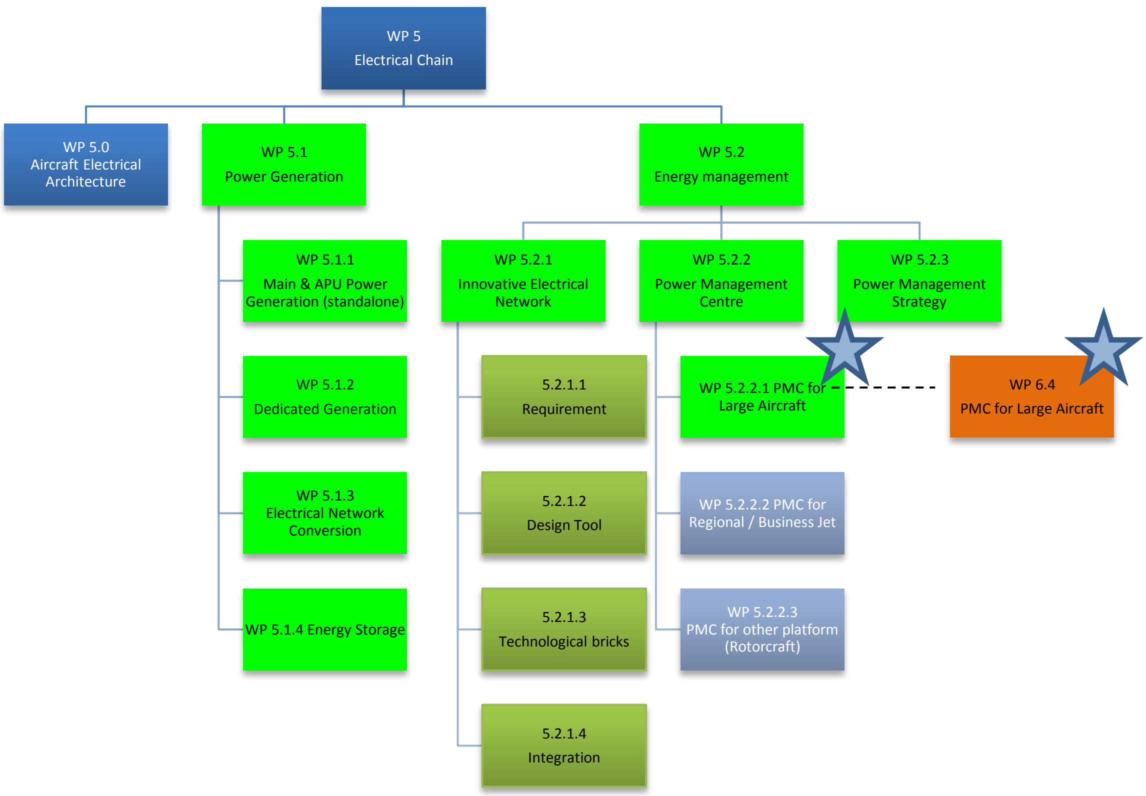
The electrification of functions initially powered by hydraulic or pneumatic energy is a key feature for simplification and improvement of Aircrafts (More Electrical Aircraft).
This involves the need to manage high electrical power.
Preceding work (Cleansky 1) have shown the interest of an HVDC network (HVDC = High Voltage Direct Current).

2. Scope of work

Scope
This call addresses components compatible with the HVDC network and which will be part of a power electrical architecture dedicated to a More Electrical Aircraft concept.
The components considered in the frame of this call will be

- developed in WP 5.2.2.1
- integrated on a global Clean Sky 2 ITD System demonstrator at Airbus PROVEN test bench in WP 6.4 during the last phase of the project (integration).

The components shall be integrated into power management centers optimising weight, space & cost.



The applicant will have to design, develop and manufacture components / power centers. He will then have to test them in his facilities and support their integration at Architecture level on a global architecture test bench (Airbus PROVEN Test bench). Preliminary pre-integration phases will be performed on other test benches before the PROVEN one in order to ease the final integration.

Target of the call

The target of the call is to improve the state of the art of components. The improvements to consider are the following:

- increase the compactness of components (weight and volume)
- decrease the cost of components.

General Constraints and requirements

Maturity level

The final requested maturity level is TRL6.

For each component, the supplier will describe the lag between the delivered prototype 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 increase within the project.

Target weight/volume

For each component, the partner will numerically describe its state of the art. When applicable this state of the art will be considered in development activities but also in potential previous research program, in order to show the progress in terms of performances proposed in the frame of Cleansky 2 compared to the previous programs.

For each component, the applicant will describe the targeted level of performance in Cleansky 2 program. This level of performance will be defined **numerically** and will be compared to the level reached in previous developments or research programs as well as state of the art level. The applicant will describe the subcomponents, technical perimeter or concepts which will be used to perform the improvement.

Target cost

Detailed system description shall be provided by the applicant.

He will explain how the technical choices proposed will lead to a cost minimised solution at equipment level.

The applicant will also describe how the components can be industrialised to a minimum cost (e.g. use of COTS components, use of other industries high production volume components, modular approach, standardization,…)

Models

For each component, accurate SABER RD simulation models at several levels (behavioural and functional levels) will be delivered by the partner in order to feed a global simulation at system level. These models shall allow to perform:

- Power Quality and Stability studies

- Power budget assessment and control logic studies

Three levels of models are considered:

- preliminary: First model issue
- consolidated: representative of final hardware design
- refined: refined with measurement data done on the prototype.

Missing data

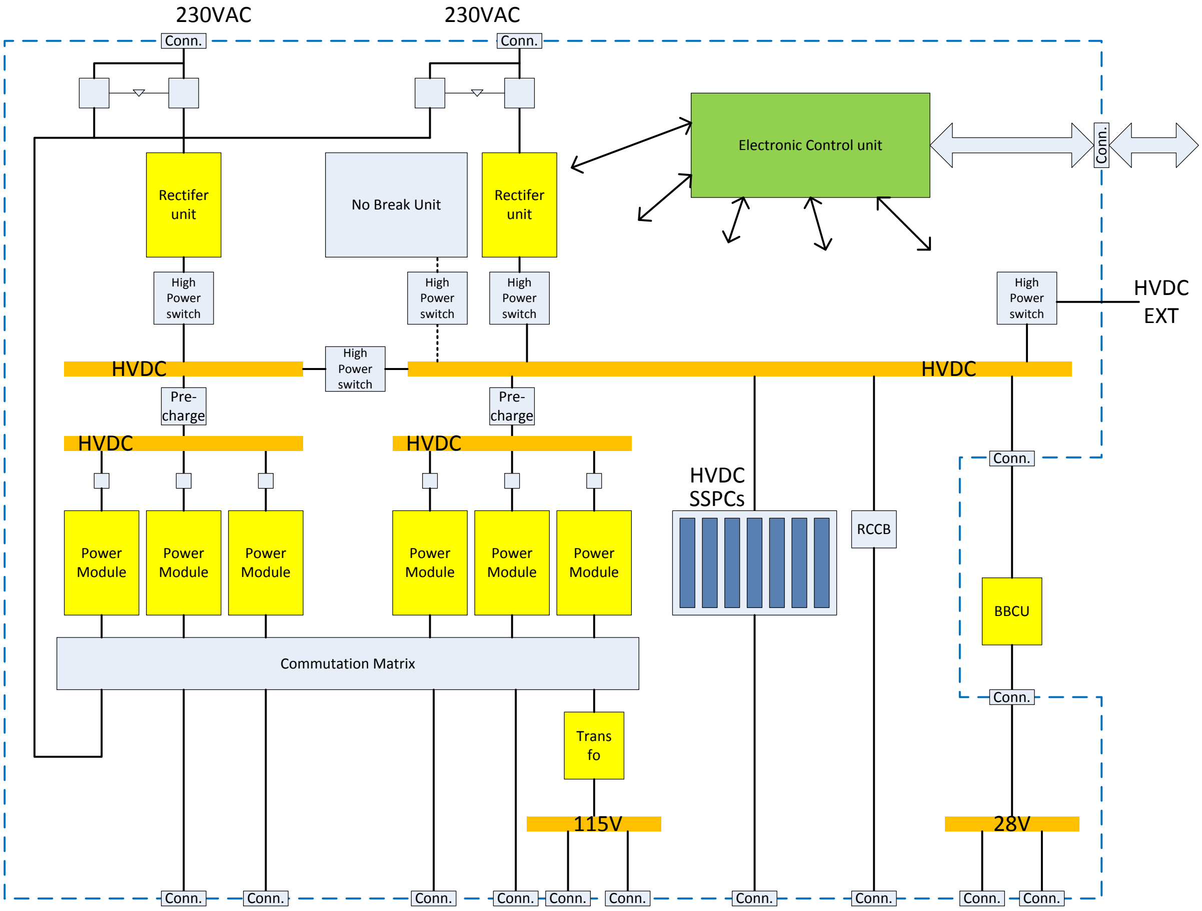
The level of details in this call is considered sufficient to allow the applicant to provide a consolidated dossier including numerical data.

If the partner considers that some key data are missing, he will take some assumption, describe them, and then give the answers to the questions and requirements.

Component description

The figure below describes the components that are in the scope of the call.

The yellow boxes (Power Electronic Module (PEM), transformer, BBCU, Rectifier Unit) are out of the scope but will need to be integrated functionnaly and/or physically with the technical content of the current call. The topic leader will provide the corresponding interface specification.



Note: the HVDC network is obtained from AC sources such as main generators, through rectifying and filtering. This network is governed by a HVDC standard which will be provided by the topic leader

Commutation matrix

The commutation matrix is a device that enables to change the connections between inverters (PEMs) and the loads in order to be able to reallocate the AC power availability to the loads depending on the context.

Component aim:

To ensure supply of IMPEC loads by Power Electronic Modules (PEMs)

Commutation matrix architecture

The architecture of the matrix will be provided as an input specification at the beginning of the project. The order of magnitude of commutation devices within the matrix is 30.

Technology

The known technology for this matrix is contactor, which is not adapted to the problem as the power cutting is not required.

The supplier will propose alternate technologies that will be able to insure only the required function without any oversizing and overquality.

The two following technologies will have to be addressed in the proposal

- semiconductor device
- electromechanical device without cutting power

The proposal can also address other technologies proposed by the supplier.

Cooling

The cooling will be forced convection with air coming from the avionic bay.

The air cooling information (flow rate, inlet temperature, pressure drop,…) will be defined during the conception phase by combining contraints at A/C level and component level.

Control interface:

The communication BUS will be defined later in the project

Power

The power coming out from each PEM is about 50kVA.

During the project, the 2 above mentioned technologies will be worked in order to perform a trade off and select the technology that will be developed.

High power switch

Technology

The power line switching is currently performed thanks to contactors.

This technology leads to high weight and volume.

The supplier will propose solutions to reduce this weight impacts.

The high power SSPC technology will at least need to be addressed, but can be challenged with other technologies.

Cooling

Air cooling, to be described by the applicant

Control interface:

The communication BUS will be defined later in the project

HVDC SSPC

The target in this field is to improve the state of the art of HVDC SSPC technology.

Layout

The accurate layout of the boards (number of channel, ratings,…) will be specified during the project (see planning)

Functions

On top of classical features, the HVDC SSPC will include the following functionalities.

- protection functions (thermal memory, fail safe, Ground Fault Protection, overheating)
- ability to perform high speed commutations
- high speed failsafe.
- ability to programm protection functions, including the fail safe.
- communication through data network of the state and measurement of each channel.
- others to be proposed by the applicant if they drive to lower cost.

Cooling

Air cooling, to be described by the partner (natural convection, other possibilities,…

RCCB HVDC

The HVDC power centre shall include RCCB HVDC for secondary power distribution

Rating

The ratings to be provided are 100A and 300A

Function

The HVDC RCCB will include the following functions:

- Protection functions: thermal memory, fail safe, Ground Fault Protection, overheating.
- Configurability of the protection functions, including fast trip curves.

Pre-charge function

A device featuring PEM capacitor pre charge shall be provided. This device is located between the RU and the power modules. The main objective is to limit the inrush current during start sequence.

Power

Compatible to the electrical power of the power electronic module (PEM)

Technology

Devices integrating semiconductors components shall be evaluated as candidate components.

Overall power center

The different components described above will be integrated in power center(s).

On the scheme above, the yellow boxes on the scheme above will be delivered outside from this call.

The interface specifications for those components will be delivered by the topic leader.

The final layout will be defined jointly by topic leader and applicant during the project (monument vs modular/split integration)

The power center(s) will have to be optimised in cost and weight on top of the optimization of the components they have inside.
As said in "General requiements" The partner will describe its state of the art and improvement in this field. For this topic, it is obvious that the integration within the aircraft can lead to savings. Nevertheless, the partner will describe and lay emphasis on innovations that lead to cost/weight/volume improvements at concept level without regarding a specific integration requirement (i.e. generic and general improvements).

ECU

The power center will have an electronic control unit. The functional perimeter of this unit will be specified later in the project; this will involve a trade-off between the hosting of the functions within the power center or within shared data processing ressources.

Communication

The communication architecture will be depicted later on the project. Nevertheless, the supplier will have to deliver a prototype compatible with the global Topic Leader requirement on this topic in order to be compliant with the other contributors to the project.

Additional components

Some additional filtering or switching devices (e.g. HVAC (230V) contactors) might be added to the power center(s) during the first phase of the project

Cooling

The overall power center will need to be air cooled.
the cooling will be forced convection with air coming from the avionic bay.
The power center will take care of the cooling of all the components embedded.
The air cooling information (flow rate, inlet temperature, pressure drop,…) will be defined during the conception phase by combining contraints at A/C level and component level.

Prototypes

One prototype of the power center including all the internal devices needs to be delivered to PROVEN test bench.

No Break Power Unit

The applicant will propose a device that will enable to perform a no break power function on the HVDC bar. This means that the device should enable a power supply of the HVDC bar even if the bar is no more supplied by a generator.
Depending on the proposed device and technology, the caracteristics and the performances of the no break function will be defined during the first stage of the project.

Demonstration

Support of integration tests

The applicant will take into account the fact that it will have to provide ressources on the Airbus rig (PROVEN) to perform integration and support the test campaign in order to insure the full performances of its equipments delivered in the frame of this call.

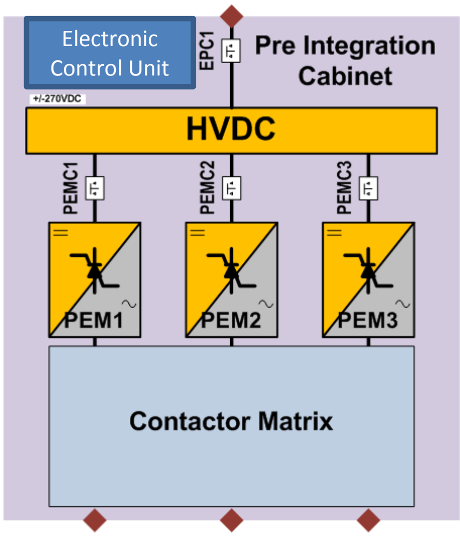
Pre integration phase

Before the integration phase on PROVEN test rig, some partial integrations need to be done on other test rigs in order to ease the final integration.

Considering that the devices subjects of the present call are at the center of the electrical architecture, some of the functions of those devices will need to be delivered through a pre integration cabinet on the pre-integration test benches in order to ease the integration of other components (such as electrical sources, loads, conversion units,…).

It is not required that the pre integration cabinet delivered for this phase are the one that will be delivered for the PROVEN test bench, however, they will need to have the same functionnal behaviour, as presented in the following figure.

- PEM capacitor pre charge function – device EPC1 on scheme below.
- PEM protection function – PEMCx on scheme below.
- Commutation matrix – this matrix will be more simple than the one that will be delivered for the PROVEN test bench. The order of magnitude of commutation devices within this matrix is 10
- Capacity to host 3 PEM and to control them. The same communication and controle protocole than the Power Center that will be delivered for the PROVEN test bench shall be used
- 4 Power interfaces:
  - 1 Interface for HVDC voltage
  - 3 interfaces for alternative voltage (triphased side of PEMs)
- ECU developped for the final power center.



Deliveries	Date	Quantity
Pre-integration Cabinet	Q1/2021	3

The pre-integration cabinets will be delivered to the different topic managers who deliver PEMs in order to make them able to perform the pre-integration tests in their onwn facilities before final integration on PROVEN test bench.

Integration phase
In this phase, the components will be integrated on PROVEN test bench.
For this demonstration, the components will have to be in their best level of performances and at the expected level of maturity.
The list of the required components is given in the table below:

Deliveries	**Date**	**Quantity**
Commutation matrix	Q4/2017	2
High power switch	Q4/2021	10
HVDC SSPC	Q4/2021	10 boards
HVDC RCCB 100A	Q4/2021	20
HVDC RCCB 300A	Q4/2021	10
Pre-charge functions	Q4/2021	6
No break unit	Q4/2021	1
Power center	Q4/2021	1*

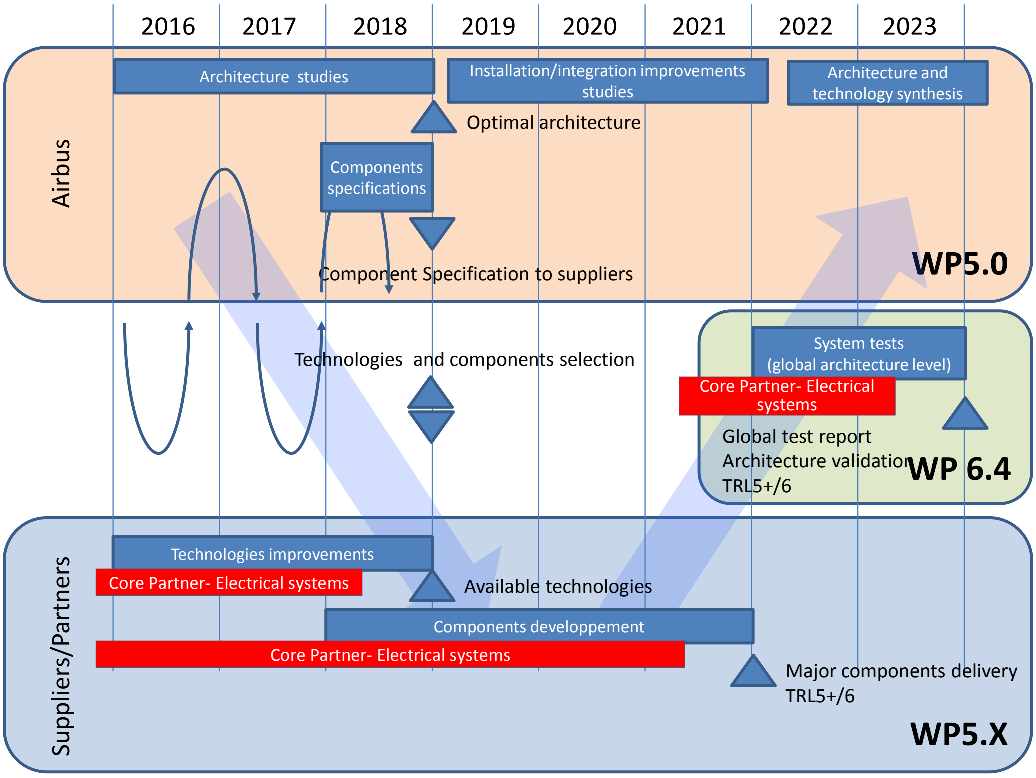
* in this hypothesis, it is considered that one power center contains all the functions described above. If the architecture studies finally lead to a split into several small power centers, this number could be higher. Nevertheless the total number of embedded functions and sub components would remain the same.

Planning
The figure below shows the global planning of the WP5. The red boxes “Core Partner Electrical System” depicts the contribution linked to the present call.
All items (except the one described below) in the call will be specified beginning 2019 for a delivery end 2021.

The pre-integration phase will start beginning 2021 (Q1) at the topic manager(s) test benchs and will last 12 months. It will be based on the pre-integration cabinet.

The integration phase will start end 2021 at Proven test bench and will last 2 years.

The following equipments need to be delivered on a faster schedule.
- Commutation matrix (specification beginning 2016, delivery end 2017)



3. Major deliverables and schedule (estimate)

Deliverables			
Ref. No.	**Title - Description**	**Type**	**Due Date**
	Status on opportunities brought by new technologies applicable to the components and the overall power center of the call (conclusions of “technology improvement” phase). GO/NOGO review on those technologies	RM	Q4/2018
	Commutation matrix – definition dossier with expected performances	R	Q4/2016
	High power switching device – definition dossier with expected performances	R	Q4/2019
	HVDC SSPC – definition dossier with expected performances	R	Q4/2019
	HVDC RCCB – definition dossier with expected performances	R	Q4/2019
	Pre-charge function – definition dossier with expected performances	R	Q4/2019

	Overall power center – definition dossier with expected performances	R	Q4/2019
	No break unit – definition dossier with expected performances	R	Q4/2019
	Commutation matrix (hardware)	D	Q4/2017
	High power switching device (hardware)	D	Q4/2021
	HVDC SSPC (hardware)	D	Q4/2021
	HVDC RCCB (hardware)	D	Q4/2021
	Pre-charge function (hardware)	D	Q4/2021
	Overall power center (hardware)	D	Q4/2021
	No break unit (hardware)	D	Q4/2021
	Model of Commutation matrix	D	Prelim.:Q1/2017 Consolidated.: Q3/2017 Refined.:Q1/2018
	Model of High power switching device	D	Prelim.:Q1/2020 Consolidated.: Q1/2021 Refined.:Q3/2022
	Model of HVDC SSPC	D	Prelim.:Q1/2020 Consolidated.: Q1/2021 Refined.:Q3/2022
	Model of HVDC RCCB	D	Prelim.:Q1/2020 Consolidated.: Q1/2021 Refined.:Q3/2022
	Model of Pre-charge function	D	Prelim.:Q1/2020 Consolidated.: Q1/2021 Refined.:Q3/2022
	Model of Overall power center	D	Prelim.:Q1/2020 Consolidated.: Q1/2021 Refined.:Q3/2022
	Model of No break unit	D	Prelim.:Q1/2020 Consolidated.: Q1/2021 Refined.:Q3/2022
	Pre-integration rig	D	Q1/2021

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
	Commutation matrix design validation meeting	M	Q4/2016
	High power switching device design validation meeting	M	Q4/2019
	HVDC SSPC design validation meeting	M	Q4/2019

	HVDC RCCB design validation meeting	M	Q4/2019
	Pre-charge function design validation meeting	M	Q4/2019
	Overall power center design validation meeting	M	Q4/2019
	No break unit design validation meeting	M	Q4/2019
	ECU design validation meeting	M	Q4/2019
	Commutation matrix acceptance meeting	M	Q1/2018
	High power switching device acceptance meeting	M	Q3/2021
	HVDC SSPC acceptance meeting	M	Q3/2021
	HVDC RCCB acceptance meeting	M	Q3/2021
	Pre-charge function acceptance meeting	M	Q3/2021
	Overall power center acceptance meeting	M	Q3/2021
	No break unit acceptance meeting	M	Q3/2021
	ECU acceptance meeting	M	Q1/2021
	Pre-integration cabinet acceptance meeting	M	Q1/2021

*** design validation meeting: the expected characteristics and performances are defined and accepted by all parties

** acceptance meeting: the prototype chacracteritics are shown and shared before acceptance of the prototype on the PROVEN test rig

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

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

The applicant should have the following knowledge & equipment:

- Strong knowledge of primary and secondary distribution for aircraft application.
- Strong experience of the deliveries of certificated electrical protection and commutation equipment for aircraft industry.
- Strong experience in the development of certified Power management center for aircraft industry (power distribution bay)
- Strong experience of HVDC power center and P/C devices.
- The applicant will have to be able to perform tests of its components inline with TRL6 expectations in its own facilities.

5. Glossary

HVDC	High Voltage Direct Current (=+/- 270V i.e. 540V)
HVDC standard	Standard for HVDC voltage network provided by topic leader
ECU	Electronic control unit
RU	Rectifier unit
BBCU	Buck Boost Converter Unit (bidirectional DC/DC converter)
IMPEC	Integrated Modular Power Electronic Component (concept of mutualisation of the power electronics)
PEM	Power electronic module
P/C	Protection and commutation

V. Detection and Characterization of Icing Conditions Contributing to Ice Protection Optimization

Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 6.2		
Topic Leader	AIRBUS		
Estimated Topic Value (funding in k€)	3700 k€		
Duration of the action (in Months)	60 months	**Indicative Start Date**	Q4 2015

Identification	**Title**
JTI-CS2-2015-CPW03-SYS-02-07	**Detection and Characterization of Icing Conditions Contributing to Ice Protection Optimization**
Short description (3 lines)	
The aim of the project is to develop mature in-Flight Ice / Icing Detection System for the detection, discrimination and characterization of icing conditions. Primary function for the automatic activation of Ice Protection System should be also investigated including opportunity for advanced control of the Ice Protection System.	

1. Background

Modern aircraft are equipped with a wide variety of equipment allowing detecting and alerting the crew of the presence of hazardous weather conditions and over the years, a wide variety of ice detection systems have been developed mainly based on the effects of ice accretion on cold surfaces of the airframe. These systems are not able to detect the encounter of glaciated icing conditions, as ice crystals bounce off the cold surfaces of the aircraft neither discriminate SLD nor provide accurate characterization of encountered icing conditions.

It is in this context, CP "*Detection and Characterization of Icing Conditions Contributing to Ice Protection Optimization*" is proposed.

Main objective of this core partnership is to **develop mature in-Flight Ice / Icing Detection System for the detection, discrimination and characterization of all icing conditions** including supercooled large droplet and glaciated and mixed phase icing conditions. Primary function for the automatic activation of Ice Protection System shall be also investigated including opportunity for advanced control of the Ice Protection System.

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

- *Develop, Validate and Implement an* ***Ice Accretion Rate function*** *within existing PFIDS technology (Primary in-Flight Ice Detection System) for advanced control of the Ice Protection Systems.*
  Based upon the work performed in previous actions of research, the objective is to implement an Ice Accretion Rate function in existing PFIDS technology (it is expected the technology to be at TRL5 at the start of the project) in order to characterize the encountered icing conditions and thus allow optimized control of the Ice Protection Systems and significant reduction of power off take. The function shall be validated through a series of small scale and large scale icing wind tunnel tests. For large scale demonstration, the primary aim of the tests is to validate PRIMARY function by demonstrating the capability of the system to detect ice accretion, before ice built-up on the airfoil, in the whole targeted flight and icing envelope and to assess and fine tune detector sensitivity. In a second step, the PFIDS shall be installed together with a full scale airfoil equipped with electrical wing ice protection system in order to demonstrate potential power savings (airfoil and embedded electrical ice protection system will be provided by the WP leaders. The function is limited to Appendic C icing conditions.
- *Mature Primary in-Flight Icing Conditions Detection System able to detect, discriminate and characterize all icing conditions including supercooled large droplet (Appendix O) and glaciated and mixed phase icing conditions (Appendix D/P).*
  Based on the work performed in previous actions of research, the objective is to mature icing conditions detection technology (it is expected the technology to be at TRL3/4 at the start of the project) and demonstrate compliance with industrial requirements of performance, operability, reliability, weight and cost. Perfomance shall be demonstrated through a series of small scale icing wind tunnel tests and in accordance with the update of the ED-103 Minimum Operational

Performance Specification under definition within the EUROCAE WG95. The contractor should also assess and fine tune detector sensitivity according to aircraft manufacturer requirements. The capability to discriminate and characterize encountered icing conditions will also allow WP leaders to comply with new regulation and to optimise the operation and power consumption of the Ice Protection Systems.

Indeed, if the airplane is not equipped for sustained flight in SLD conditions, the system will be used to tell the crew to exit these icing condtions. A primary ice detection system can also be used to selectively allocate power either to extended areas corresponding to SLD conditions or to the smaller areas concerned by maximum rate of accretion conditions (SLD does not induce the maximum liquid water content – LWC). An aircraft equipped with less capable ice detectors may waste power by trying to simultaneously cover SLD and max LWC conditions which cannot coexist. However, the design of an ice protection system is always a trade-off between optimally low consumption and system complexity.

The implementation of work shall follow a TRL process for the assessment of the maturity of the technologies developed as part of the project. It will be based on the TRL methodology used in European Aeronautical industry and in Clean Sky projects, originally developed by USA institutions (NASA, DoD) and summarized here under. It has been designed considering the risks associated to the integration of sub-systems from suppliers and the derived need for a systematic approach of risk-reduction management. All dimensions of maturity and risks associated to Performance & Integration, Engineering, Manufacturing, Operations and Value & Risks shall be addressed.

The following steps, to be monitored through project milestones with associated technical reviews, are proposed within the project:

- **Proof of concept (TRL3):** A complete set of requirements, a preliminary technology description and evidence of feasibility including an assessment of the performances through icing wind tunnel tests and an evaluation of potential limitations
- **Validation in laboratory environment (TRL4):** Rigorous tests and analysis of critical performance with identification of performance limitations
- **Prototype (TRL5):** Technology sizing and integration supported by a rigorous proof of critical characteristics including performances, environmental qualification (lightning strikes, hail, EMI,…), operability (reliability,…), benefit (weight, size, cost,…), ….
- **Validation in representative environment (TRL6):** Delivery of ready to fly representative prototype and Validation of the fully developed technology in a representative environment

No dedicated flight tests for validation of PFIDS and PFIcDS in representative environment will be performed. However, pending maturity of the technologies (Decision gate at TRL4) and flight test opportunities, technologies could be installed on flight test aircraft for validation in dry air environment and/or natural icing conditions. Thus, ready to fly prototype(s) shall be delivered at the end of the project. Decision to fly the detection technologies will be taken by aircraft manufacturer WP leader as a function of the demonstrated maturity and flight test opportunities.

2. Scope of work

The activities of this CP call will take place within the Clean Sky 2 ITD Systems, within the WP6.2 “Wing ice protection systems”.

This CP shall contain three work packages: two technical work packages and one management work package, each of them containing several tasks:

- **WP1 Ice Accretion Rate Function** develops, validates and implements an Ice Accretion Rate function within existing PFIDS technology (Primary in-Flight Ice Detection System) for advanced control of the Ice Protection Systems.
- **WP2 Primary in-Flight Icing Conditions Detection System** develops advanced on-board detection systems complying with the industrial requirements of performance, operability, reliability, weight and cost, and able to detect, discriminate and characterize the different icing conditions encountered.
- **WP3 Consortium & Technical Management** is in charge of the project monitoring, administration, dissemination and reporting and ensures the technical consistency and convergence towards project high level objectives. It implements the TRL process and roadmap agreed with WP leaders. It also ensures consistency with on-going standardization activities as part of the EUROCAE WG95.

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP11	***Primay in-flight Ice Detection System / Ice Accretion Rate Function Development & Performance Assessment*** – Based on requirements defined within the System Requirement Document (WP leaders input) and EUROCAE ED-103 Minimum Operational Performance Specification, the contractor shall develop an Ice Accretion Rate Function. In particular the work shall include an assessment of the effects of the collection efficiency (β) and freezing fraction (η) on the robustness of the information provided within the whole aircraft flight envelop and an evaluation of potential limitations. Such demonstration shall be performed through a series of small scale icing wind tunnel test(s) in classical icing conditions (Appendix C, Appendix O is likely).	Q3 2017
WP12	***Primay in-flight Ice Detection System / Ice Accretion Rate Function Integration*** – Implement the Ice Accretion Rate Function developed as part of the WP11 within the Primay in-Flight Ice Detection System. To do so, the contractor shall improve Hardware and Software anticipating the need for any additional aircraft information such as Static and Total Temperature, True Air Speed,…	Q3 2018

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP13	***Primay in-flight Ice Detection System / Ice Accretion Rate Function Validation & Verification*** - Conduct in a large scale Icing wind tunnel, simultaneous test with a representative full scale critical surface comprising an integrated IPS and the PFIDS improved as part of the WP31 and WP32. The airfoil model will be provided by the aircraft manufacturer WP leader whereas the integrated Ice Protection System will be provided by the other WP leader. The objective is first to demonstrate that the PFIDS is able to detect ice accretion before any ice formation on the representative critical surface whatever the aero-icing conditions are and thus to validate the primary function of the system. The second objective is to assess potential power saving thanks to the advanced controlled of the IPS based on the Ice Accretion Rate Function.	Q3 2019
WP21	***Primary in-flight Icing Conditions Detection System / Development & Performance Assessment*** – based on previous actions of research, the contractor shall develop Primary in-flight Icing Conditions Detection System able to detect, discriminate and characterize all types of icing conditions including Supercooled Large Droplet and glaciated and mixed phase icing conditions. The contractor shall pay particular attention to the optimisation of the system in terms of size, weight and cost. Performances shall be assessed through a series of icing wind tunnel tests and in accordance with the requirements defined within the System Requirement Document (WP leaders input) and EUROCAE ED-103 Minimum Operational Performance Specification. The contractor will be able to take credit of demonstration activities performed in previous projects.	Q2 2017
WP22	***Primary in-flight Icing Conditions Detection System / Integration*** – In accordance with aircraft manufacturers, the first objective is to investigate potential opportunities for system optimisation and maximisation of benefit at aircraft level thanks to the specialisation of the functional capabilities of the system as a function of the type of aircraft (eg large A/C or bizjet). The second objective is to optimize the control of the Ice Protection System thanks to the discrimination and characterization of icing conditions. In particular, the contractor will interact with the WP leaders to include the Primary in-flight Icing Conditions Detection System into the Ice Protection System architecture and will provide information about signal to be exchanges, accuracy and reliability of the signals,...	Q4 2019

Tasks		
Ref. No.	***Title – Description***	***Due Date***
WP23	***Primary in-flight Icing Conditions Detection System / Validation & Verification*** – The contractor shall define and perform V&V activities in accordance with WP leaders and associated Design Directives. This includes, but is not limited to, environmental qualification, reliability/fatigue demonstration, robustness/ageing demonstration,…	Q2 2021
WP31	**Technical Management** - Coordinate overall technical activities of the project and ensure that the work is carried out in accordance with the specifications and the schedule. WP31 also include the management of the activities in accordance with the TRL methodlogy and the organisation of TRL gate reviews.	Q4 2021
WP32	**Consortium Management** - Set up and maintain the project management infrastructure (committees, quality plans, procedures, risk register, project management tools, etc) ; Provide technical and administrative assistance to the consortium throughout the project ; Provide financial and contractual management of the Consortium, including maintenance of the Grant Agreement, Description of Work and Consortium Agreement ; Provide IPR related advice to partners and assist in resolving any IPR issues ; Monitor that the rules of the Grant Agreement and Consortium Agreement governing IPR, liability, confidentiality, etc. issues are respected by all the partners	Q4 2021

3. Major deliverables and schedule (estimate)

When the deliverable is a validation, the deliverable is a report of the successful validation tests or simulations.

For experimental validations, physical tests on implementations at the required TRL level are required, and the deliverable is the test report containing test configuration, with details on the test article, test procedures and raw test results, plus the analysis of the tests and the justification for a "test passed" synthesis.

When the deliverable is a validated item, the item itself shall be delivered, after it successfully passes the tests specified in the manufacturing control sheet and/or acceptance test procedure and/or validation tests.

When the milestone is a TRL milestone, all the corresponding proofs will be at the disposition of WP Leaders, for review with the partner, and the deliverable will be complete when all the commonly accepted TRL criteria are passed.

The yearly progress reports will be delivered as a draft 3 months before the due date, and the draft and final report due dates will be set according to the global Clean Sky 2 requirements set by the CSJU. These reports will feed the periodic reporting of CS2 activities to the CSJU.

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
SYS-W2-IDS-D1.1	Small scale icing wind tunnel tests for development of the Ice Accretion Rate Function and assessment of potential limitations (TRL3)	D	2017
SYS-W2-IDS-D1.2	Preliminary System Description Document providing a description of the PFIDS with Ice Accretion Rate Function embeded (TRL3)	R	Q3 2017
SYS-W2-IDS-D1.3	Small scale icing wind tunnel tests for validation of the Ice Accretion Rate Function performances (TRL4)	D	Q3 2017
SYS-W2-IDS-D1.4	Updated System Description Document providing a description of the PFIDS with Ice Accretion Rate Function embeded (TRL5)	R	Q3 2018
SYS-W2-IDS-D1.5	Ready to test prototype of Primary in-Flight Ice Detection System including Ice Accretion Rate Function (TRL5)	D	Q3 2018
SYS-W2-IDS-D1.6	Large scale icing wind tunnel tests together with airfoil equipped with electrical ice protection system (TRL6)	D	Q4 2018 / Q1 2019
SYS-W2-IDS-D1.7	Final System Description Document providing a description of the PFIDS with Ice Accretion Rate Function embeded (TRL6)	R	Q3 2019
SYS-W2-IDS-D1.8	Ready to fly prototype of Primary in-Flight Ice Detection System including Ice Accretion Rate Function	D	Q3 2019
SYS-W2-IDS-D2.1	Preliminary System Description Document providing a description of the Primary in-Flight Icing Conditions Detection System (TRL3) including FHA (Functional Hazard Analysis)	R	Q2 2017
SYS-W2-IDS-D2.2	Ready to test prototype of Primary in-Flight Icing conditions Detection System (TRL4/5)	D	2017/2018
SYS-W2-IDS-D2.3	Series of small scale icing wind tunnel tests for validation of the performances of the Primary in-Flight Icing conditions Detection System. The tests shall cover classical, SLD and glaciated and mixed phase icing conditions (TRL4/5)	R	2017/2018
SYS-W2-IDS-D2.4	Environmental qualification dossier (including the plans at TRL3, the procedures at TRL4, the reports at TRL5) of the Primary in-Flight Icing conditions Detection System in accordance with aircraft manufacturer Design Directives (TRL5)	R	Q4 2019
SYS-W2-IDS-D2.5	Updated System Description Document providing a description of the Primary in-Flight Icing Conditions Detection System (TRL5) including PSSA (Preliminary System Safety Analysis)	R	Q4 2019

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
SYS-W2-IDS-D2.6	Final System Description Document providing a description of the Primary in-Flight Icing Conditions Detection System (TRL6) including SSA (System Safety Analysis)	R	Q2 2021
SYS-W2-IDS-D2.7	Ready to fly prototype of Primary in-Flight Icing Conditions Detection System	D	Q2 2021
SYS-W2-IDS-D3.1	Yearly progress report on all open tasks 2016.	R	Q4 2016
SYS-W2-IDS-D3.2	Yearly progress report on all open tasks 2017.	R	Q4 2017
SYS-W2-IDS-D3.3	Yearly progress report on all open tasks 2018.	R	Q4 2018
SYS-W2-IDS-D3.4	Yearly progress report on all open task 2019.	R	Q4 2019
SYS-W2-IDS-D3.5	Yearly progress report on all open tasks 2020.	R	Q4 2020
SYS-W2-IDS-D3.6	Topic Final Report	R	Q4 2021

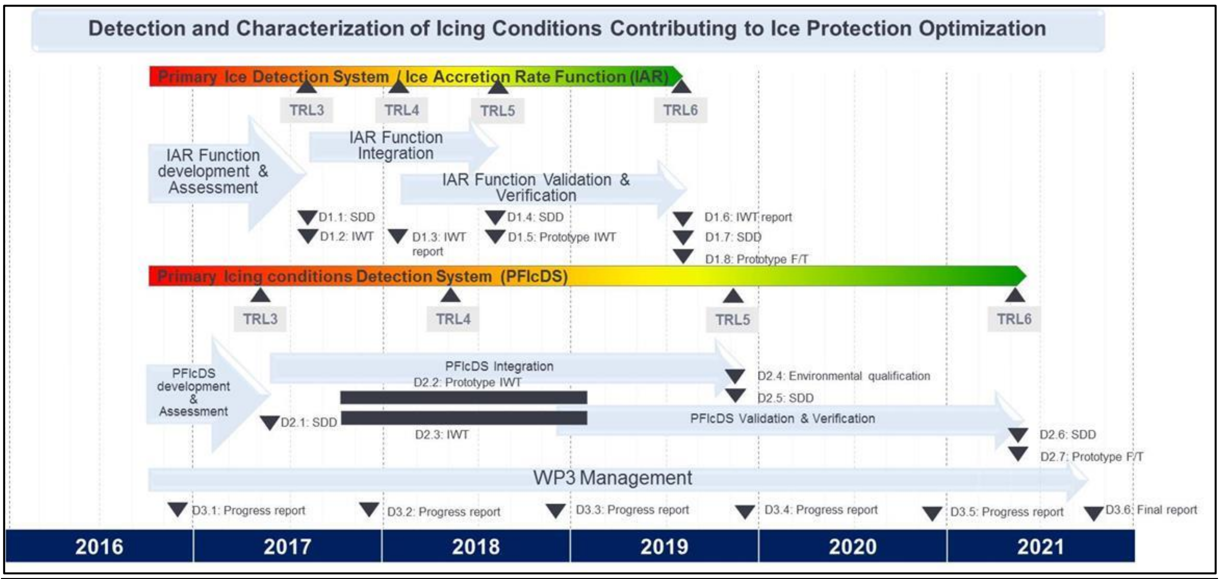
*Type: R: Report, RM: Review Meeting, D: Delivery of hardware/software

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
SYS-W2-IDS-M1.1	TRL3 Ice Accretion Rate Function	RM	Q3 2017
SYS-W2-IDS-M1.2	TRL4 Ice Accretion Rate Function	RM	Q1 2018
SYS-W2-IDS-M1.3	TRL5 Ice Accretion Rate Function	RM	Q3 2018
SYS-W2-IDS-M1.4	TRL6 Ice Accretion Rate Function	RM	Q3 2019
SYS-W2-IDS-M2.1	TRL3 Primary in-Flight Icing Conditions Detection System	RM	Q2 2017
SYS-W2-IDS-M2.2	TRL4 Primary in-Flight Icing Conditions Detection System	RM	Q2 2018
SYS-W2-IDS-M2.3	TRL5 Primary in-Flight Icing Conditions Detection System	RM	Q4 2019
SYS-W2-IDS-M2.4	TRL6 Primary in-Flight Icing Conditions Detection System	RM	Q2 2021
SYS-W2-IDS-M3.1	Kick-off meeting	RM	Q32016
SYS-W2-IDS-M3.2	Progress review at M6	RM	Q1 2017
SYS-W2-IDS-M3.3	Progress review at M12	RM	Q3 2017
SYS-W2-IDS-M3.4	Progress review at M18	RM	Q1 2018
SYS-W2-IDS-M3.5	Progress review at M24	RM	Q3 2018
SYS-W2-IDS-M3.6	Progress review at M30	RM	Q1 2019
SYS-W2-IDS-M3.7	Progress review at M36	RM	Q3 2019
SYS-W2-IDS-M3.8	Progress review at M42	RM	Q1 2020
SYS-W2-IDS-M3.9	Progress review at M48	RM	Q3 2020
SYS-W2-IDS-M3.10	Progress review at M54	RM	Q1 2021

Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***
SYS-W2-IDS-M3.11	Progress review at M60	RM	Q3 2021

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

Inputs		
Ref. No.	***Title – Description***	***Due Date***
SYS-W2-IDS-I1	Large passenger aircraft System Requirement Dossier (SRD)	Q3 2016
SYS-W2-IDS-I2	Business jet System Requirement Dossier (SRD)	Q3 2016
SYS-W2-IDS-I3	EUROCAE ED-103 update (Minimum Operational Performance Specification)	Q3 2016
SYS-W2-IDS-I4	Large passenger aircrafticing wind tunnel model	Q3 2018
SYS-W2-IDS-I5	integrated electrical ice protection system	Q3 2018



High level schedule

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

- The contractor should demonstrate good knowledge on the impact of SLD and Glaciated & Mixed Phase icing conditions on aircraft
- The contractor should demonstrate good knowledge in the new EASA/FAA icing regulations for SLD and Glaciated & Mixed Phase icing conditions
- The contractor should have demonstrated prior experience, as part of previous national and/or european funding projects, on in-Flight Ice / Icing Detection System for classical (App C), SLD (App O) and Glaciated and Mixed Phase (App D/P) icing conditions. In particular, it is expected the following maturity of the technologies at the beginning of the project:
  - TRL5 for the Primary In-flight Ice Detection System (WP1 / Classical icing conditions): Ready to fly prototype available (w/o Ice Accretion rate function), performance validation through a series of icing wind tunnel tests (w/o Ice Accretion rate function), environmental qualification (w/o Ice Accretion rate function).
  - TRL3/4 for the Primary In-flight Icing conditions Detection System (WP2 / classical (App C), SLD (App O) and Glaciated and Mixed Phase (App D/P) icing conditions): Prototype for tests in icing wind tunnel available, performances assessed through a series of tests in icing wind tunnel covering classical (App C), SLD (App O) and Glaciated and Mixed Phase (App D/P) icing conditions.
- The contractor should have demonstrated previous experience in preparation and conduction of icing wind tunnel tests
- The contractor could subcontract small scale and large scale icing wind tunnel tests according to best value for money principle
- The contractor should have demonstrated previous experience in System development and industrialisation
- The contractor should be involved in the EUROCAE WG95
- The contractor should have demonstrated previous experience in research project management

5. Glossary

CP	Core Partner
CS2	Clean Sky 2
CSJU	Clean Sky Joint Undertaking
LWC	Liquid Water Content
PFIDS	Primary in-Flight Ice Detection System
PFIcDS	Primary in-Flight Icing conditions Detection System
SLD	Super-Cooled Large Droplets
TRL	Technology Readiness Level

VI. Electro-Thermal Wing Ice Protection System for Large Aircraft

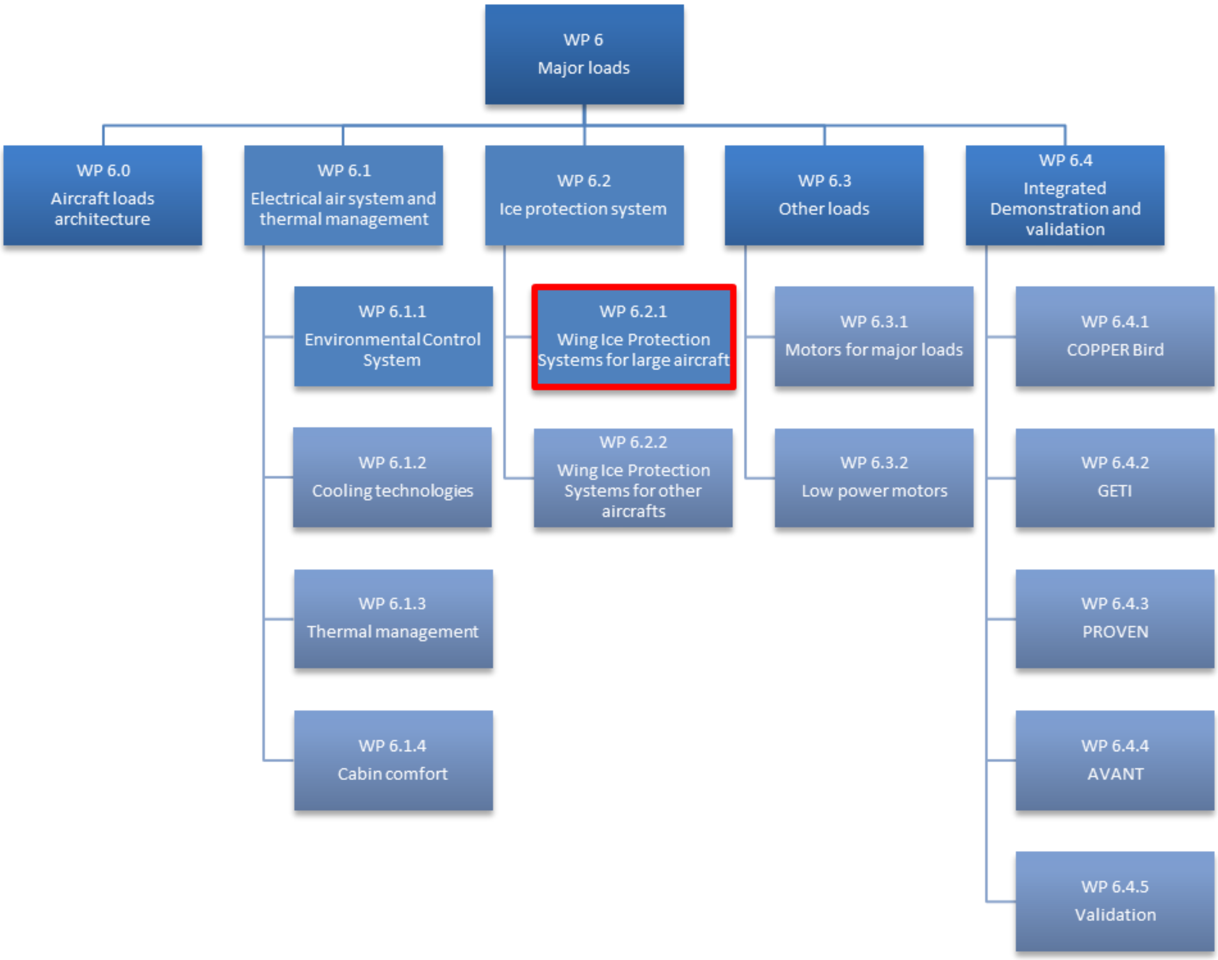
Type of action (RIA or IA)	IA		
Programme Area	SYS		
Joint Technical Programme (JTP) Ref.	WP 6.2.1 Wing Ice Protection System for Large Aircraft		
Topic Leader	LIEBHERR		
Indicative Funding Topic Value (in k€)	5000 k€		
Duration of the action (in Months)	60 months	Indicative Start Date[24]	Q4 2016

Identification	Title
JTI-CS2-2015-CPW03-SYS-02-08	Electro-Thermal Wing Ice Protection System for Large Aircraft
Short description (3 lines)	
The Topic objective is to select partner who will support the Topic Manager for designing an electro-thermal wing ice protection system for large aircraft fully integrated in the leading edge and optimized regarding performance, reliability, maintainability, and reparability. The expected final maturity is TRL 5.	

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

1. Background

Electrical Ice protection System is part of the WP6 which is dedicated to the major loads of the aircraft, as shown here under:



The Topic Manager has developed an electro-thermal solution for future Wing Ice protection System dedicated to typical large aircraft wing leading edge. The performance objectives in anti-icing and de-icing mode have been reached.
Some major aspects like reliability, robustness, leading edge integration, Power transfer assembly need to be improved in order to propose a competitive solution for future single aisle aircraft.
It is in this context, that this Topic "Electro-Thermal Wing Ice Protection System for Large Aircraft" is proposed.

The objectives of this WP6.2.1 are therefore as follows:

- To optimize system architecture for subsequent reliability improvement.
- To address new regulations (CS25- Appendix O) applying to ice protection system performances.

- To develop novel integration concepts of the wing ice protection system within an advanced leading edge structure to optimize weight saving while ensuring manufacturing quality, reparability and maintainability.
- To demonstrate maturity of the technologies at TRL 5 level through demonstrations in representative environment
- Additionally, to address integration of the ice protection system into HLFC future wing and subsequently demonstrate TRL3 maturity.

2. Scope of work

Tasks		
Ref. No.	***Title - Description***	***Due Date***
T01	Anti-Icing / De-Icing architectures and performance	T0 + 12
T02	System control and monitoring in Anti-Icing / De-Icing modes	T0 + 12
T03	Structural integration of an electro-thermal wing ice protection system	T0 + 24
T04	Power Transfer Assembly design	T0 + 24
T05	Innovative industrialization and manufacturing processes	T0 + 36
T06	Validation through testing & airworthy prototype	T0 + 60
T07	Ice protection for future wing technologies	T0 + 54

Detailed description of Task T01: Anti-Icing / De-Icing architectures and performance

T01 shall enable to demonstrate the capabilities of evaluating wing ice protection system performances in both Appendix C and O, and for both anti-icing and de-icing operating modes.
Specific phenomena linked to Appendix O conditions shall be analyzed and taken into consideration to define areas to be protected and electrical power required.
Validation of numerical models shall be demonstrated using icing wind tunnel test results.
All justifications shall be put together through a report.

Detailed description of Task T02: System control and monitoring in Anti-Icing / De-Icing modes

T02 aims to define robust control laws and monitoring means for the electro thermal wing ice protection system. Usage of control and monitoring sensors shall be reduced to the minimum number.
Future In flight primary ice detection system (PFID) providing icing conditions characteristics (LWC, MVD, kind of rain,…) shall be considered as available to define control/monitoring laws.
Strategy of control shall be defined in order to get a robust and failure tolerant system, in cooperation with the Topic Manager.
Monitoring shall be ensured to protect aircraft structure against overheat and low power as well.

<u>**Detailed description of Task T03**</u>: Structural integration of an electro-thermal system

In order to optimize weight and cost, ice protection devices shall be incorporated in advanced wing leading edge structure made from metallic and/or composite materials.
The integration shall account for the interaction between the system and the structure (thermal fatigue, thermal differential expansion, transient temperature mapping, ageing of the materials due to system operation, damage detectability…) and special attention shall be paid to connection between ice protection devices and aircraft wiring.
Furthermore, the concept shall address reparability and maintainability keeping in mind that the target is to propose solutions at least as convenient as presently in-service systems & structure. Demonstration of leading edge integrity shall be provided by analysis (Finite Element Modelling & stressing) and full scale testing, addressing all kinds of stresses as mechanical (static, fatigue, damage tolerance…), electrical (lightning strike,…) and environmental including bird impact and other lower energy impacts (hail, accidental damages…)

<u>**Detailed description of Task T04**</u>: Power Transfer Assembly design

Power Transfer Assembly (PTA) is part of the scope of work. The objective is to design a mean of supplying electrical power to the leading edge when deployed. Main drivers are the weight and the reliability of this component. Main difficulties may be the highly restricted space allocation to install this component in outboard leading edges and compatibility with fixed and moveable leading edges relative normal & parasitic displacements while ensuring a load free guiding of the wiring bundle.
PTA concept shall enable physical segregation and environmental protection of power & signal cables.
PTA shall withstand cycles of extension/retraction and all applicable environmental constraints particularly when deployed.
Installation of PTA shall be demonstrated including electrical wiring moving capacity. Electrical cables shall be suitable to electrical network (HVDC).
Reliability, maintainability, reparability shall also be addressed for the assembly PTA and electrical wiring.

<u>**Detailed description of Task T05**</u>: Innovative industrialization and manufacturing processes

Based on experience already accumulated through previous projects or applications, manufacturing process of the system integrated into an advanced leading edge structure shall be optimized to get more industrial process, compared to development process. Specifically, higher dimensional quality shall be searched for better aerodynamic performances and weight reduction.
Investigations on innovative manufacturing techniques to produce heating skins, preferably integrated in a structural skin, shall be performed in order to select the most robust one.
Nondestructive investigation shall be developed to ensure structural integrity of leading edge when manufactured to prevent from failures.

<u>**Detailed description of Task T06:**</u> Validation through testing

Testing is required in order to validate advanced concepts of ice protection system and PTA as well.

On one hand, performances' testing has to take place to demonstrate thermal efficiency of ice protection system through full scale icing wind tunnel including both slat configurations (retracted and deployed). Furthermore, both modes anti-ice mode and de-ice modes shall be considered.

The associativity between the Wing ice protection system and PFID will be evaluated in order to optimize the monitoring and control laws. A dedicated demonstration in full scale icing Wind tunnel test will be performed accordingly.

On the other hand, endurance testing has to be achieved to get data about new design of ice protection devices and PTA as well. Maturity of the proposed concept, which is one of the main drivers, has to be shown.

Finally, environmental test campaign shall be performed to demonstrate adequate design through operating conditions.

Detailed description of Task T07: Ice protection for future wing technologies

T07 shall address the electro-thermal ice protection system in the context of HLFC (Hybrid Laminar Flow control) wing. Conceptual studies shall be performed to ensure that both suction & ice protection functions can be combined succesfully on a typical leading edge component. The studies has to be supported by performances calculations & design studies adressing specifically the integration of suction & heating zones in adjacent areas. Dedicated sub-scale demonstrations in IWT shall be conducted to demonstrate TRL3 maturity.

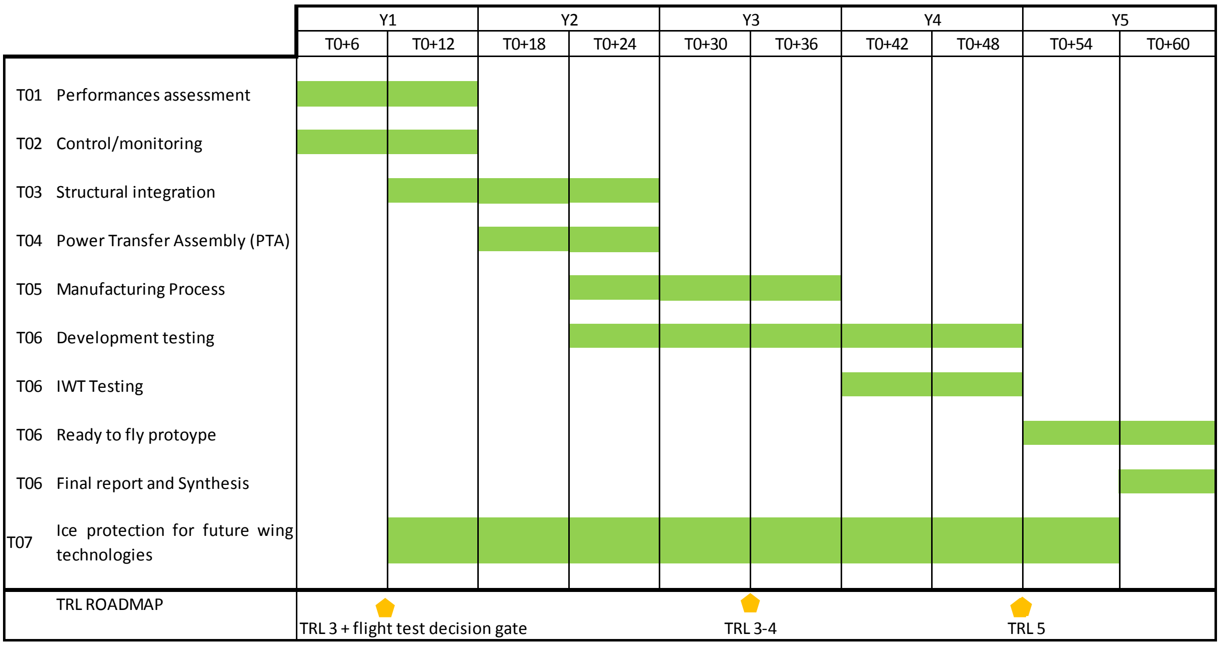
3. Major deliverables/ Milestones and schedule (estimate)

Note on hardware deliverables:

- The Partner is expected to deliver all hardware necessary for the demonstrations planned in T01 to T07:
    - In particular, participation to two full scale IWT campaigns (with dedicated hardware deliveries) is expected in the frame of this call :A leading edge demonstrator (A320 geometry) with integrated ice protection system shall be delivered to evaluate its associativity with Future In flight primary ice detection system in the frame of a dedicated IWT campaign planned in end of Y2 (in Ice detection topic proposed in Core Partner dedicated).
    - A second full scale IWT campaign dedicated to validate Ice protection system performance will be performed Y4. A TRL 5 maturity is expected after this campaign.
- Dedicated demonstrations have to be addressed for others topics (PTA, new wing technologies…)
- It is not expected to perform flight tests as part of the project. However, an airworthy prototype with complete Safety of flight justification shall be delivered at the end of the project. Decision to fly will be taken by the Topic Manager during the TRL3 review (decision gate).If decision gate validates the flight tests, then TRL 6 maturity will be expected after this campaign.

Deliverables			
Ref. No.	***Title – Description***	***Type***	***Due Date***
D01-1	Preliminary Architecture Performance report including numerical code validation justification	R	T0 + 06
D01-2	Final Architecture Performance report including numerical code validation justification	R	T0 + 12
D02-1	Control and monitoring definition and specifications	R	T0 + 12
D02-2	Safety and reliability report	R	T0+12
D03-1	Definition report of the structural integration concepts	R	T0+12
D03-2	Reparability & maintainability plan	R	T0+18
D03-3	Leading edge demonstrators (A320 typical geometry) to support test campaigns	H	T0+24
D03-4	Validation report of the structural integration	R	T0+24
D04-1	Power Transfer Assembly design justification including electrical wiring	R	T0+24
D04-2	Power Transfer Assembly demonstrator to support test campaigns	H	T0+24
D05-1	Manufacturing process justifications and industrialization plan	R	T0+36
D06-1	IWT test + PTA test report	R	T0+45
D06-2	Environmental test report	R	T0+45
D06-3	Ready to fly prototype (A320 typical slat geometry)	H	T0+60
D06-4	Final Synthesis report	R	T0+60
D07-1	Concept & system performances study on ice protection for HLFC wing	R	T0+24
D07-2	Sub-scale demonstrators to support test campaign	H	T0+36
D07-3	Final report of ice protection for HLFC wing	R	T0+54

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



Milestones (when appropriate)			
Ref. No.	***Title – Description***	***Type***	***Due Date***

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

Applicant shall show a strong experience in the following fields :

- Numerical tools availability to assess thermal performances in both Appendix C and O conditions
- Numerical models used by partner used for icing and thermal performances predictions shall be compatible and comparable with Topic manager one : to be discussed and agreed through more detailed technical discussions with Topic manager.
- Numerical tools availability to assess structure resistance under different kinds of steady and transient loads (thermal, mechanical, impact…)
- Validation of numerical tools against previously performed test campaigns (icing wind tunnel, structural testing, impacts…)
- Capability to evaluate interaction between thermal and mechanical loads,
- Extensive experience on slat manufacturing and associated quality controls compliant with aero requirements

- Extensive in service experience regarding leading edge use enabling to define acceptable defects and repair process,
- Proven experience in advanced composite structure manufacturing and assembly into a complete leading edge structure.Experience in incorporating ice protection devices inside leading edge structure (typical A320 leading edge).
- Safety of Flight justification capability.
- Basic knowledge of integration constraints related to HLFC wing.

Applicant should demonstrate previous experience in preparation and conduction of icing wind tunnel tests.

Applicant could subcontract icing wind tunnel tests according to best value for money principle.

5. Glossary

CS	Clean Sky
HVDC	High Voltage Direct Curent
HLFC	Hybrid Laminar Flow control
IWT	Icing Wind Tunnel
LWC	Liquid Water Content
PFIDS	Primary in-Flight Ice Detection System
PTA	Power Transfer Assembly
TRL	Technology Readiness Level