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Clean Sky 2

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Information Day dedicated to the

11th Call for Proposal (CfP11)

Systems ITD Topics

Presented by Jean-Jacques FAGOT, Airbus SAS, on behalf of

Christoph Budzinski, Liebherr-Aerospace

February 2020

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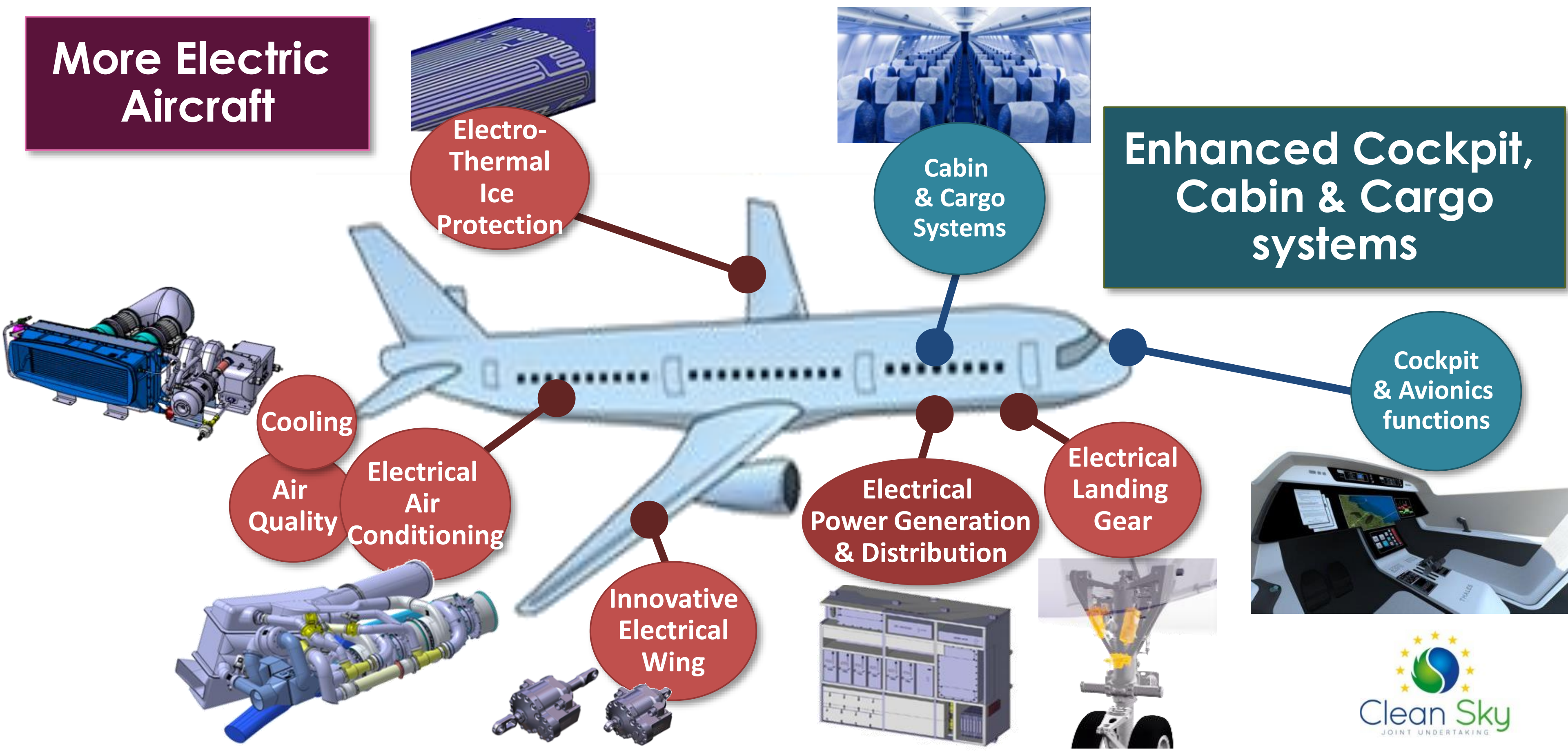
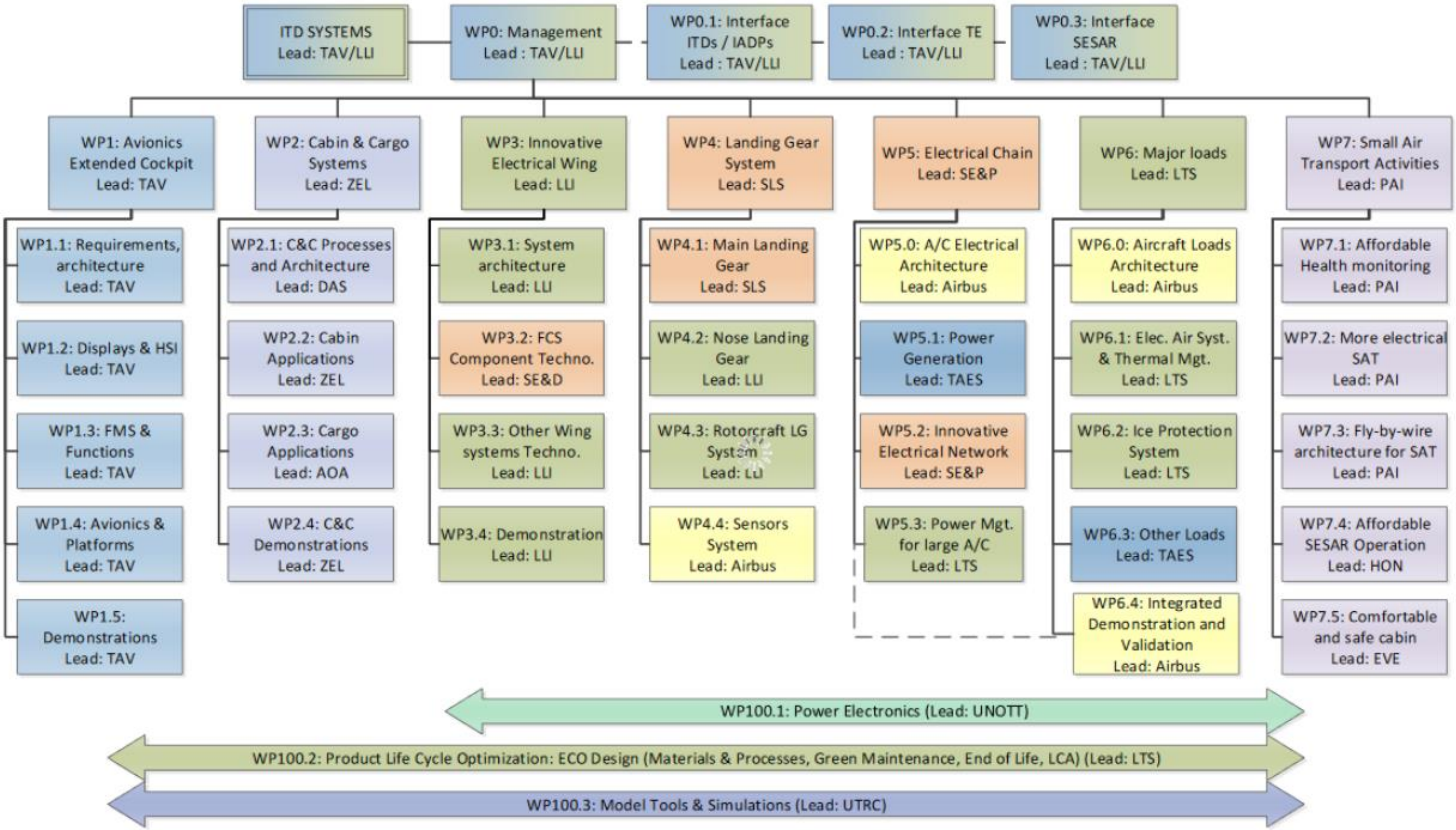
Clean Sky 2

Clean Sky 2 – SYSTEMS ITD
Overview of Technical Scope



Setup and Implementation



CFP11 Overview of Call topics

Identification Code	Title	Type of Action	Value (Funding M€)	Topic Leader
JTI-CS2-2020-CfP11-SYS-01-22	**Oxygen Absorbing Metal-Air-Batteries** for Long Term Cargo Compartment Inertisation	RIA	0.80	Diehl Aviation
JTI-CS2-2020-CfP11-SYS-01-23	Development of a **multi-position valve** with associated actuator for cargo fire protection	IA	0.50	Safran
JTI-CS2-2020-CFP11-SYS-02-62	**Thermoplastic wheel** for electrical Environmental Control System	IA	0.75	Liebherr
JTI-CS2-2020-CFP11-SYS-02-63	Decentralised **HVDC power conversion** module for innovative optimised aircraft electrical network distribution	IA	0.75	Airbus
JTI-CS2-2020-CFP11-SYS-02-64	Human Safe **HVDC Interconnection** components	IA	0.80	Airbus
JTI-CS2-2020-CFP11-SYS-03-25	Investigation and **modelling of hydrogen effusion** in electrochemically plated ultra-high-strength-steels used for landing gear structures	RIA	1.00	Liebherr
JTI-CS2-2020-CFP11-SYS-03-26	Replacement of cobalt in Environmental Control System **bleed valves**	IA	0.75	Liebherr
JTI-CS2-2020-CFP11-SYS: 7 topics			5.35	

JTI-CS2-2020-CfP11-SYS-01-22: Oxygen Absorbing Metal-Air-Batteries for Long Term Cargo Compartment Inertisation

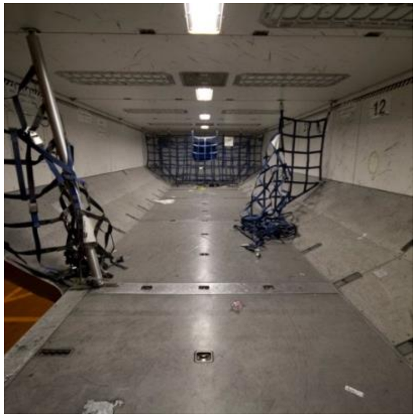
I. JTI-CS2-2020-CfP11-SYS-01-22: Oxygen Absorbing Metal-Air-Batteries for Long Term Cargo Compartment Inertisation

Type of action (RIA/IA/CSA):		RIA	
Programme Area:		SYS	
(CS2 JTP 2015) WP Ref.:		WP 2.3	
Indicative Funding Topic Value (in k€):		800	
Topic Leader:	Diehl Aviation Gilching GmbH	**Type of Agreement:**	Implementation Agreement
Duration of the action (in Months):	24	**Indicative Start Date (at the earliest)[50]:**	> Q4 2020

Topic Identification Code	**Title**
JTI-CS2-2020-CfP11-SYS-01-22	Oxygen Absorbing Metal-Air-Batteries for Long Term Cargo Compartment Inertisation
Short description	
One of the main challenges for Halon free fire suppression in cargo compartments is the long term inertisation for the ETOPS duration after the initial knock down phase. Known concepts like bottled nitrogen and OBIGGS systems are relatively heavy and have several reliability and safety issues. A novel and very innovative approach for inertisation is binding the oxygen in metal oxides instead of bringing nitrogen into the compartment. Metal-air-batteries are promising candidates for this principle as they allow for a controlled metal-air reaction. In this topic the metal – electrolyte combination shall be selected, a battery integration concept shall be created. A demonstrator shall be built and tested. Finally the demonstrator will be integrated the topic leader Fire Test Facility for long term fire suppression tests.	

Oxygen Absorbing Metal-Air-Batteries for Long Term Cargo Compartment Inertisation
JTI-CS2-2020-CfP11-SYS-01-22

- ## Background:
  - Within Clean Sky 2 a novel **environmentally friendly fire suppression system for aircraft cargo compartments** will be developed
  - System uses water mist, nitrogen and/or **oxygen depleted air** to extinguish fires instead of halon (high global warming potential)
  - After a fire event EASA and FAA regulations require **a long-term suppression of fires until a safe landing of the aircraft.** Hence, **an inert atmosphere with low oxygen levels must be maintained** for more than one hour depending on the ETOPS rating of the aircraft.
  - Known concepts for **inertisation** are bottled nitrogen or OBIGGS systems which are relatively heavy and have several reliability issues



Oxygen Absorbing Metal-Air-Batteries for Long Term Cargo Compartment Inertisation JTI-CS2-2020-CfP11-SYS-01-22

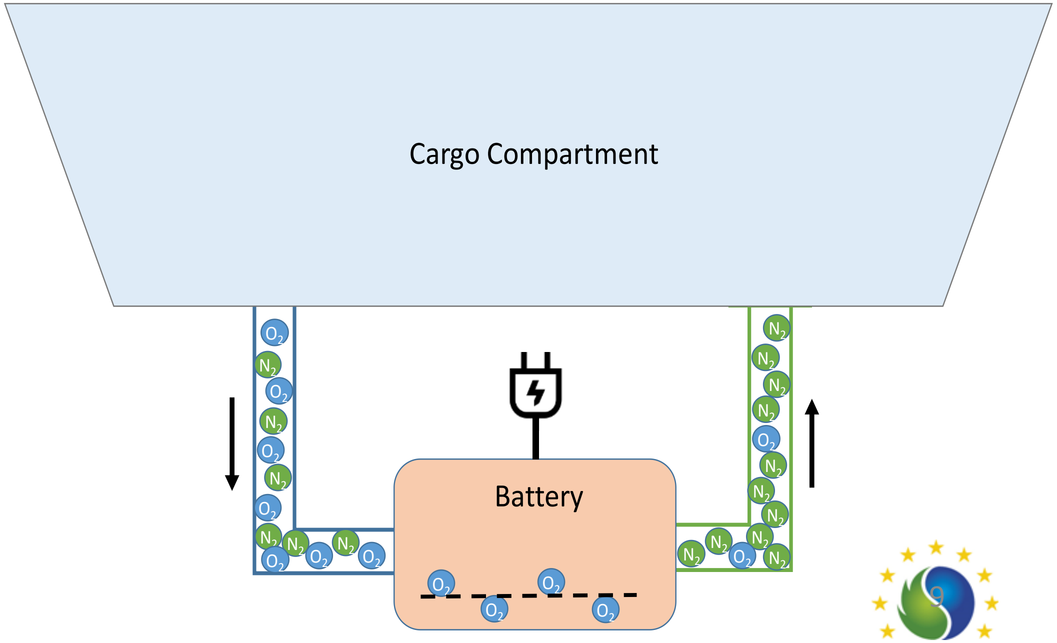
- Technical Approach by Diehl:
  - A novel approach for inertisation **is binding the oxygen within the cargo compartment in metal oxides** instead of bringing additional nitrogen into the compartment
  - **Metal-air-batteries are promising** candidates for this principle as they allow for a controlled metal-air reaction

- Objectives of the Call
  - Develop **oxygen absorbing device based on the principle of metal-air-batteries**
  - Select suitable metal and electrolyte system
  - Setup **chemical laboratory demonstrator** to **prove concept**
  - Develop and **design the battery**
  - **Assess and verify performance** battery via tests
  - Integrate verify batteries and at TM's fire suppression test rig

Oxygen Absorbing Metal-Air-Batteries for Long Term Cargo Compartment Inertisation
JTI-CS2-2020-CfP11-SYS-01-22

- Characteristics / Requirements
  - Absorption capability of 1,1g O2 per second from air with an oxygen Level of 11%
  - The use parallel batteries is possible
  - Capacity for an operation of 5 hours
  - Tolerance to fire gases (CO2, CO, Smoke, ..)
  - Compliance with RTCA DO160G (Environmental Conditions for Airborne Equipment)
  - Long term stability of 10 years for the unactivated battery

- Link to Demonstrator
  - Innovative **Cabin & Cargo Technologies**
  - The battery is **one optional component** of the system which allows for long-term inertisation



Oxygen Absorbing Metal-Air-Batteries for Long Term Cargo Compartment Inertisation JTI-CS2-2020-CfP11-SYS-01-22

- Tasks:

Tasks		
Ref. No.	***Title - Description***	***Due Date***
1	Definition and clarification of requirements, boundary conditions, testing metrics and test procedures	T0+3M
2	Selection of metal and electrolyte system	T0+8M
3	Chemical laboratory demonstrator and battery concept	T0+14M
4	Development and design of battery	TO+17M
5	Verification tests and performance assessment of the developed batteries	TO+20M
6	Manufacturing and integration of batteries at fire test facility	TO+22M
7	Proof of concept Fire Suppression tests at TM's facility	TO+24M

- Deliverables:

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Report of metal and electrolyte selection	R	T0+8M
D2	Report of chemical laboratory demonstrator & battery concept	R+HW	T0+14M
D3	Verification test report	R	T0+20M
D4	Batteries for 10 fire-tests with 1,1g/sec O_2 over 5 hours	HW	T0+22M
D5	Reference documentation of battery	D+R	T0+24M

R: Report D: Data HW: Hardware

Development of a multi-position valve with associated actuator for cargo fire protection

II. JTI-CS2-2020-CfP11-SYS-01-23: Development of a multi-position valve with associated actuator for cargo fire protection

Type of action (RIA/IA/CSA):		IA	
Programme Area:		SYS	
(CS2 JTP 2015) WP Ref.:		WP 2.3	
Indicative Funding Topic Value (in k€):		500	
Topic Leader:	Safran	**Type of Agreement:**	Implementation Agreement
Duration of the action (in Months):	20	**Indicative Start Date (at the earliest)[52]:**	> Q4 2020

Topic Identification Code	**Title**
JTI-CS2-2020-CfP11-SYS-01-23	Development of a multi-position valve with associated actuator for cargo fire protection
Short description	
Trend for new aircraft and associated systems is to limit their energy consumption. In the frame of the cargo fire protection a regulated valve piloted by an associated actuator has to be developed allowing to optimize and reduce the bleed air consumption. Optimize the weight, reliability and maintainability of such a valve will be the main targets of this study. The work in this topic will allow to provide a high reliable and low cost multi position valve for inerting applications.	

Multi positions valve for inerting system (1/2)
JTI-CS2-2020-CfP11-SYS-01-22

Objectives:

- Optimise the bleed air/energy consumption **by controlling accurately** the inert gas flow
- Select the **most suitable technology** to develop a multi position valve (mechanical part + electrical actuator)
- Develop prototypes and **prove by tests their accuracy and endurance** in an aeronautical environment

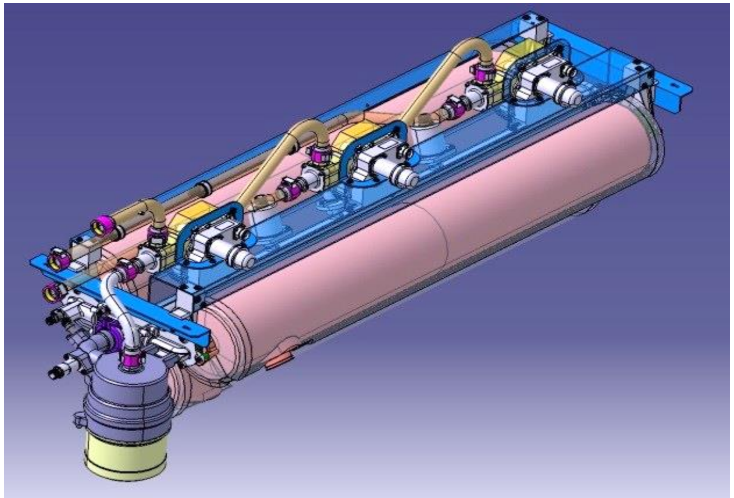
Link to ITD activities : cabin & cargo systems

- Inerting system is integrated in a **cargo green fire-suppression system** that is to replace the use of halon
- **Availability of the inerting system** is a key for this essential system

Background information:

Feedback from the existing system has shown that the flow of inert gas delivered by the suppression system is designed for a worst case and too large for most of the other cases.

Close cooperation with TM to define the best-adapted equipment, taking into account the expected gas performance, its robustness and its reliability.



Multi positions valve for inerting system (2/2)
JTI-CS2-2020-CfP11-SYS-01-22

Pneumatic characteristics:

Pressure upstream of the valve	Bar abs	5	3	1.2
Pressure downstream of the valve	Bar abs	1	1	0.3
Gas flow	g/s	40	10	2.5

- **Gas** type: dry nitrogen enriched air
- As fire suppression is an essential system, **robustness and reliability** will be key for the design of the valve

Planning activities

Tasks		
Ref. No.	***Title – Description***	***Due Date***
T1	Specification reception	T0+1M
T2	Review of the pneumatic valve technologies	T0+2M
T3	Selection of the concept via trade off analysis	T0+3M
T4	Prototypes Design	T0+9M
T5	Prototype manufacturing	T0+15M
T6	Prototypes qualification test done by the selected partner	T0+20M

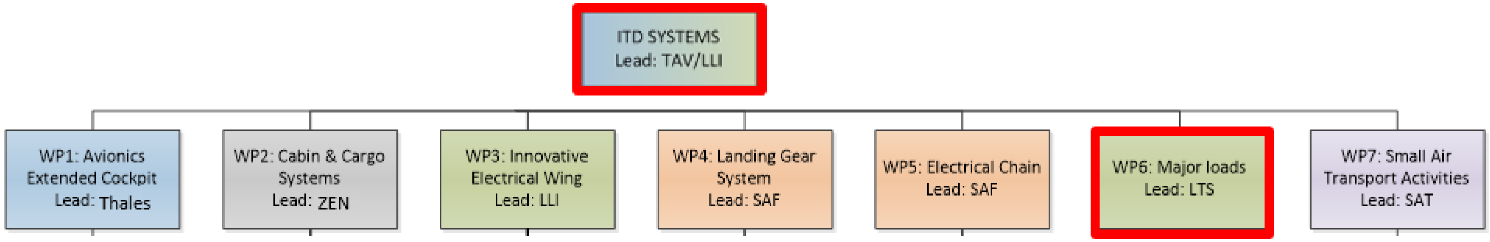
Expected skills and capabilities:

- Significant experience on **design**, qualification of very **high reliability** pneumatic valve and actuators
- Capability on industrializing aerospace **valves** and associated **actuators**
- Capability to develop according to **aerospace standards**
- Capability to provide and **test prototypes** meeting aerospace requirements

JTI-CS2-2020-CFP11-SYS-02-63: De-centralised HVDC power conversion module for innovative optimised aircraft electrical network distribution

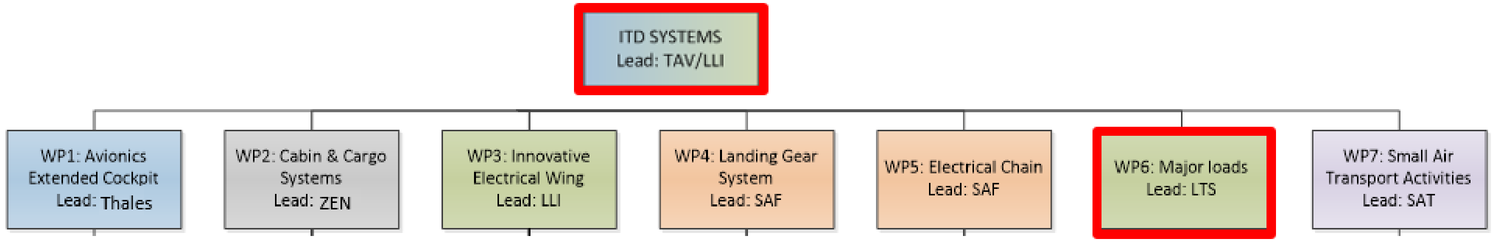
Type of action (RIA/IA/CSA):		IA	
Programme Area:		SYS	
(CS2 JTP 2015) WP Ref.:		WP 6.4	
Indicative Funding Topic Value (in k€):		750	
Topic Leader:	Airbus	**Type of Agreement:**	Implementation Agreement
Duration of the action (in Months):	30	**Indicative Start Date (at the earliest)[6]:**	> Q4 2020

Topic Identification Code	**Title**
JTI-CS2-2020-CFP11-SYS-02-63	Decentralised HVDC power conversion module for innovative optimised aircraft electrical network distribution
Short description	
The purpose of this topic is to develop optimised prototypes in size, weight and cost for HVDC/DC conversion modules to be included in innovative, decentralized, electrical power distribution network on future large passenger aircraft. These modules will convert the main HVDC network voltage into secondary DC and AC voltages to supply dedicated end-users aircraft components or systems. The required modules will be developed according to the airframer specified modular concept. The modules will be brought to TRL5 via integration into airframer HVDC network integration bench.	



CS2-2020-CFP11-SYS-02-63: Decentralized HVDC power conversion module

Links to the Clean Sky 2 Program High-level Objectives[2]	
This topic is located in the demonstration area:	*ITD Systems HVDC More Electrical Aircraft Electrical Network demonstrator*
The outcome of the project will mainly contribute to the following conceptual aircraft/air transport type as presented in the scene setter	More Electrical Large or short Medium Range Passenger Aircraft developed from 2025 onwards, with possible spin offs on new HVDC sub-network on existing Single aisle passenger aircraft.



CS2-2020-CFP11-SYS-02-63: Decentralized HVDC power conversion module

Objectives:

- Develop local electrical voltage convertor for highly decentralized distribution architecture
- Develop convertor able to provide 28VDC and 115VAC from HVDC (+/-270VDC)
- Develop isolated, line replaceable module (rackable electronic board), high efficiency (low losses), light weight

Background information:

- Input voltage from 400V to 900V DC
- Aircraft environment pressurized area (-40°C to 70°C)
- Bring technology readiness from level 3 to 5/6
- Definition, simulation, prototyping/ representative demonstrator and testing are foreseen

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

- Strong experience in Aeronautical electrical conversion
- High knowledge about electrical HVDC phenomena,
- High knowledge in power quality & filtering
- Already having a Technology Readiness Level 3 in the voltage conversion described in this CFP.

Advantageous:

- Ability/capacity to manufacture in short lead-time prototypes similar to final product (same material, same form, same functionalities) including mechanical, racking, & cooling constraints
- High knowledge in environmental effect (DO160)

CS2-2020-CFP11-SYS-02-63: Decentralized HVDC power conversion module

The tasks requested to the applicant(s) :

- Task 1: To elaborate a **project plan**, including WBS, OBS, scope & schedule
- Task 2: To elaborate the technical **specification & requirements** of the module
- Task 3: To elaborate the **preliminary study** for modular approach
- Task 4: To Elaborate the **V&V compliance** matrix for each requirements of the specification, proposing Means of Verification.
- Task 5: To define the product **preliminary design** according to specifications.
- Task 6: To define the product **detailed design** according to specifications.
- Task 7: To manufacture the building blocks **prototypes**
- Task 8: To build the models that **simulate** the modules
- Task 9: To **validate** and calibrate the building blocks (in supplier facilities)
- Task 10: To **design** the final prototype
- Task 11: To manufacture the **final prototype**
- Task 12: To **test** the final prototype in supplier's premises + update of the models
- Task 13: To **integrate** and test the prototype in A/C environment in A/C manufacturer facilities.

JTI-CS2-2020-CFP11-SYS-02-64: "Human Safe" HVDC Interconnection components

V. JTI-CS2-2020-CFP11-SYS-02-64: Human Safe HVDC Interconnection components

Type of action (RIA/IA/CSA):		IA	
Programme Area:		SYS	
(CS2 JTP 2015) WP Ref.:		WP 6.4	
Indicative Funding Topic Value (in k€):		800	
Topic Leader:	Airbus	**Type of Agreement:**	Implementation Agreement
Duration of the action (in Months):	30	**Indicative Start Date (at the earliest)[58]:**	> Q4 2020

Topic Identification Code	**Title**
JTI-CS2-2020-CFP11-SYS-02-64	Human Safe HVDC Interconnection components
Short description	
The objective of this topic is to develop innovative wiring sets (cables, contact and connector) based upon agreed requirements according to dedicated use cases, able to sustain new electrical constraint appearing with HVDC networks, during installation, operation and maintenance with a particular attention to human protection against electrical shock in case of cable damages or disconnection of a powered line. The activities will cover the design, development, prototyping and necessary tests for pre-qualification of the components. The components will be integrated and tested in HVDC network demonstrator.	

JTI-CS2-2020-CFP11-SYS-02-64: "Human Safe" HVDC Interconnection components

Objectives:

1. Develop means to **protect workers** from "powered on" HVDC cable disconnection injury
2. Develop system **monitoring ageing** of HVDC cables & connection devices, predicting component failure
3. Develop lightweight, compact, simple and reliable **systems/mechanisms to integrate** inside Cables and Connection devices (one type of connector / cable each)

Background information:

- Voltage from 500V to 1kV "Flat" or PWM
- Aircraft environment (non-)pressurized (-55°C to 200°C ; 145-1045mbar, fluid exposure..)
- Bring technology readiness from level 3 to 5/6
- Definition, simulation, prototyping and testing
- Specs for connector/cable from TM
- Spec for protection/monitoring developed by Partners

Skills, Capabilities, Certification expected from Applicant(s)

- Strong experience in
  - Aeronautical electrical connectors and contacts
  - electrical component under at least 500V DC
- High knowledge in
  - HVDC arc phenomena,
  - electrical ageing under HVDC (PWM included)
  - mechanical protection for human operators
  - early ageing sign detection and preventing method/system (having reached TRL 3)
- Already having a Technology Readiness Level 3 in the interconnection components described

Advantageous:

- Ability/capacity to manufacture in short lead-time prototypes similar to final product (same material, same tolerances, same roughness, same coating etc.).
- High knowledge in EMI effect of PWM HV, and way to prevent cables from emission/reception

JTI-CS2-2020-CFP11-SYS-02-64: Human Safe HVDC Interconnection components

The tasks requested to the applicant(s) :

- Task 1: Elaborate a **project plan**, including WBS, OBS, scope & schedule
- Task 2: Issue a synthesis about **electrical ageing knowledge**: How to detect degradation/early ageing on component such as cables, connectors and contacts (lessons learnt from TRL ≤3)
- Task 3: Elaborate **technical specification** for component degradation/ageing detection/monitoring.
  - considering integration in the components and in a larger monitoring system.
- Task 4: Elaborate **the V&V compliance matrix** for each requirements of the specification, proposing Means of Verification.
- Task 5: **Design the products** (cables, contacts, connectors, and integrated monitoring system) according to specifications.
  - Innovative solution are expected in term of building and/or material selected.
- Task 6: Assess and **validate the products compliance** to the requirements by analysis and/or tests.
  - Tests will be ran on prototypes in partner facilities / Trade-off and selection of the most appropriate solutions
- Task 7: Verify and refine the final selected products/systems with **integration test on a demonstrator(s**).
  - Building prototype for installation integration test and for integration test on Airbus functional demonstrator “PROVEN”
  - Support Airbus during integration tests
  - The expected maturity level for the final prototype is TRL5.
- Task 8: Perform **pre-qualification tests** with standard ageing and environmental tests plus a set of new tests to be specifically defined for HVDC products.
  - Tests will be ran in partner’s facilities. / The expected maturity level for the final product is TRL6.
- Task 9: To deliver a **final report**, formalizing activity and all results.

JTI-CS2-2020-CFP11-SYS-03-25: Investigation and modelling of hydrogen effusion in ultra-high-strength-steels

Overview

Type of action (RIA/IA/CSA)	RIA		
Programme Area	SYS		
(CS2 JTP 2015) WP Ref.	WP 100.2		
Indicative Funding Topic Value (in k€)	1000K€		
Topic Leader	Liebherr	Type of Agreement	Implementation Agreement
Duration of the action (in Months)	28	Indicative Start Date	> Q4 2020

Topic Identification Code	Title
JTI-CS2-2020-CfP11-SYS-03-25	Investigation and modelling of hydrogen effusion in electrochemically plated ultra-high-strength-steels used for landing gear structures

Short description
The aim of this project is to understand the underlying phenomena and create a verified model of the influence of undesirable layer structures of electrochemically deposited corrosion protection layers of ultra-high-strength-steel parts on hydrogen degassing. This shall allow predicting the remaining hydrogen concentration in steel parts and the probability for hydrogen embrittlement. The industrial objective is to minimise rework and scrap of ultra-high-strength-steel parts and the related environmental impacts.

SYS-03-25 – Simulation of Hydrogen Effusion

Background (1/2)

What is the benefit of this research?

- Resource saving in production
  - Reduction of **rework**
  - Avoidance of **scrap**
- Better scientific understanding of the process may lead to…
  - **reduction of the energy**-intensive degassing step
  - **efficiency increase** in hydrogen embrittlement treatment

Which application area benefits from this study?

Highly stressed **aerospace components** that are exposed to enormous loads and therefore made of **ultra-high-strength steel** (UHS), such as landing gears.

What is the problem to be solved?

- UHS are very susceptible to **corrosion** and therefore needs protection.
- State of the art protection is the application of electrochemically applied metallic corrosion protection layers, which however generate **hydrogen**.
- Hydrogen may lead to dangerous embrittlement and is 'de-gassed' via a **heat treatment**.
- For an optimal degassing result, the protective layer must have effective **effusion paths**.
- Compact protection layer morphologies with limited effusion paths appear in production. This leads to reworking or scrapping, as there is still a ***lack of knowledge*** for proper risk evaluation.

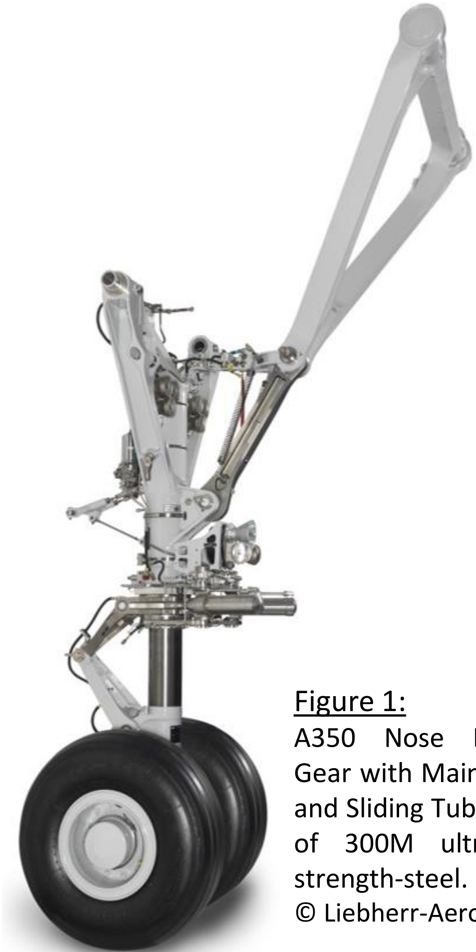


Figure 1:
A350 Nose Landing Gear with Main Fitting and Sliding Tube made of 300M ultra-high-strength-steel.

Background (2/2)

What is a compact layer?

Figure 2**a** shows a **compact layer**

- few globular structures and almost no cracks or pores.
- hardly any effusion paths for the hydrogen to leave the steel.
- can be considered „**closed**“.

What is to do?

- Identification & Characterisation of possible layer **morphologies**.
- Investigation of the **influence** of the layer structures **on** the **degassing** behaviour.
- Creation of a **computer-based simulation model**.
- Development of a **Tool for evaluation** of compact layers.
- Development of **suitable guidelines** to deal with compact layers.

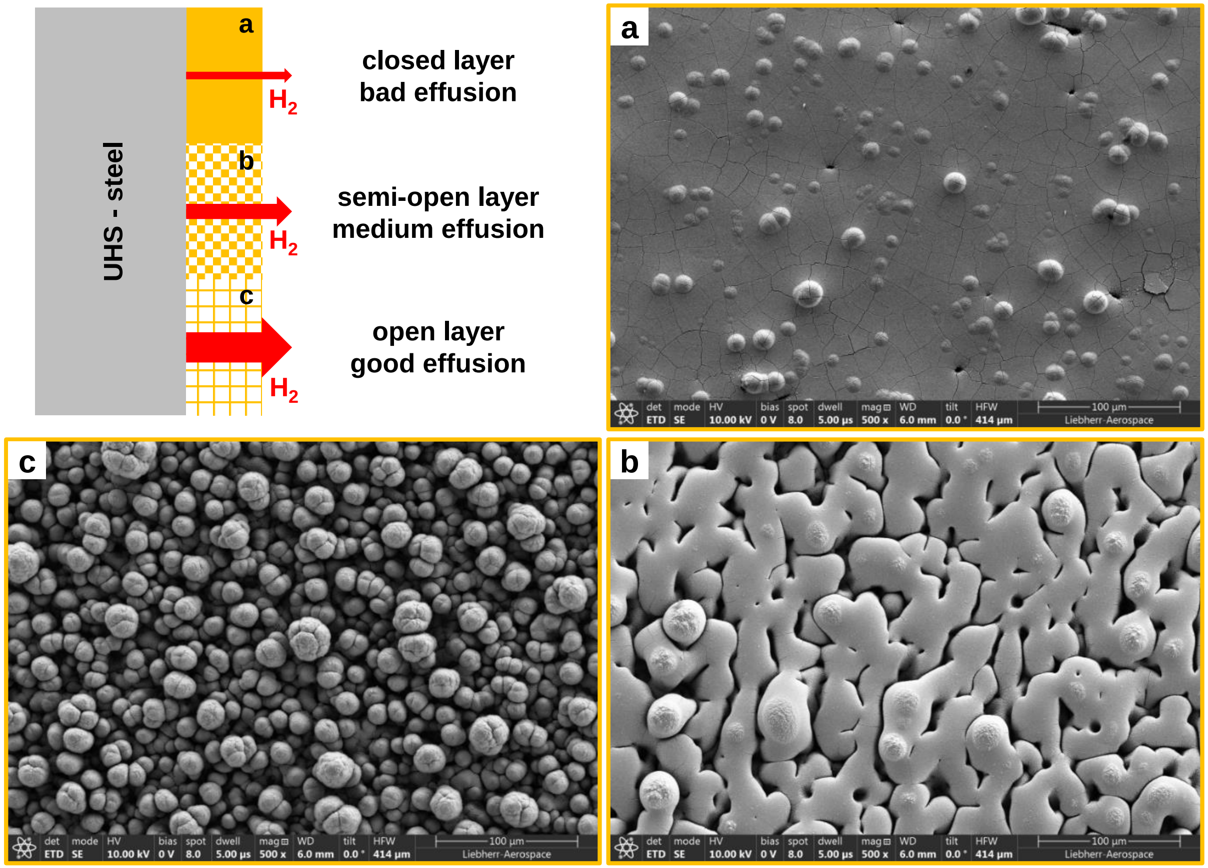


Figure 2:
Schematic view of the basic relationship between hydrogen effusion (H2) and layer morphology using the example of a) a closed-, b) a semi-open- and c) an open layer structure.
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SYS-03-25 – Simulation of Hydrogen Effusion

Scope of Work (1/3)

Task 1 – Define the necessary investigations for the creation of a realistic computer-based simulation model and produce the corresponding test specimens.
(T0+7months)

a) Define investigations for selected materials

b) Define and produce test specimens

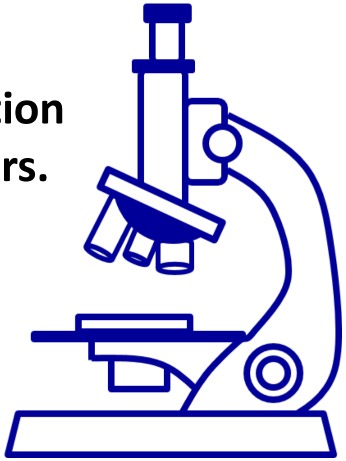
c) Identify, characterize and evaluate possible layer morphologies for both plating processes

Materials proposed for investigation	Plating processes for investigation
• 300M • Custom 465 • E35NCD16H • SAE 4340 • PH13-8Mo • EZ2NKD18	• LHE-Zinc-Nickel • LHE-Cadmium

- Minimum 4 materials to be tested, each with both electrochemical plating processes.
- Test requirements to be defined considering parameters such as:
  - hydrogen trapping effects
  - permeation characteristics
  - desorption characteristics.
  - …
- Before any investigation, the electrochemically generated layers must be examined and characterized.

SYS-03-25 – Simulation of Hydrogen Effusion

Scope of Work (2/3)

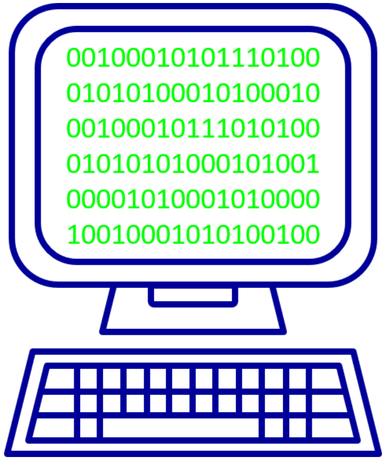


Task 2 – <u>Conduct tests</u> to develop and validate a computer-based simulation model for description of the hydrogen effusion characteristics of the layers.
(T0+15months)

a) Perform the investigations with <u>first</u> selected materials

b) Develop a computer-based simulation model

- ➢ Initial development with one material and both plating processes.
- ➢ Appropriate evidence of the validity of the model must be provided.



Task 3 – Check the <u>material dependency</u> of the computer-based simulation model with further base materials and make adjustments to the model if necessary
(T0+20months)

a) Perform the investigations with <u>further</u> materials

b) Examine and characterize possible material dependency

- ➢ Further development with minimum 3 other material and both plating processes.
- ➢ The developed computer-based simulation model(s) must be able to represent realistically all combinations of layer systems and base materials.

SYS-03-25 – Simulation of Hydrogen Effusion

Scope of Work (3/3)

Task 4 – Bring the results of the computer-based simulation model to application maturity (T0+28months)

a) Transfer the results in working practice

b) Create clear, simple rules / formulas

c) Identify or develop a method to characterize electrochemically generated layer structures, applicable in the production environment

§

$$(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$$

- The rules/formulas shall provide clear criteria in which cases a compact layer impairs standard degassing or not.
- The rules/formulas shall provide a guideline how to handle plated parts with a hydrogen effusion inhibiting layer structure.
(E.g. by extending the soak time during hydrogen embrittlement relief.)
- The rules/formulas shall be suitable for standardization / discussion in bodies.
- The **method for layer structure characterization** in production environment shall meet the following requirements:
  - non-destructive method
  - applicable on large parts
  - applicable for curved surfaces and inner diameters
  - maximum measuring time at the part 1 hour
  - result within maximum 24 hours

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

§

$$f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right)$$

§

SYS-03-25 – Simulation of Hydrogen Effusion

Major Deliverables (D) & Milestones (M)

Ref. No.	Title - Description	Type*	Due Date
D1	Definition of required examinations and test specimens.	R	T0+2
M1	All required test specimens manufactured, excluding plating.	HW	T0+7
D2	Results of completed investigations acc. Task 2.	R	T0+11
D3	Computer-based model to simulate the effusion of hydrogen depending on characteristics of corrosion protection layers.	D	T0+13
M2	Conformity of the computer-based model with reality is validated (Review)	R	T0+15
D4	Results of investigations with further UHS-steel base materials acc. Task 3.	R	T0+19
M3	Investigation results from further base materials match the validated computer-based simulation model (Review)	R	T0+20
D5	Practical rules / formulas derived from the computer-based material simulation model to be applied in a production environment.	R	T0+22
D6	Description of an operational measuring method for the characterization of layer morphologies on large parts.	R	T0+24
D7	Description of verified method(s) to characterise the protection layers on large parts in serial production.	R	T0+25
M4	Derived rules / formulas for standardization of TM´s processes are considered mature for implementation (Review)	R	T0+27

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

SYS-03-25 – Simulation of Hydrogen Effusion

Skills, Capabilities, Certification of the Applicants/Consortium *

Essential

- Strong knowledge and experience in the **development of computer-based material simulation models**.
- Strong **materials science knowledge** of ultra-high-strength steel in connection with hydrogen embrittlement.
- Knowledge about **electrochemical plating** and hydrogen kinetics.
- Capabilities required to perform the study:
  - Optical microscope, SEM-EDX, FIB and other plating structure analysis methods that will be relevant to characterise layer morphologies
  - Laboratory for metallographic preparation
  - Hydrogen analysis equipment, such as melt extraction, TD-MS, or permeation cell, which is necessary to generate the required data to create and validate the simulation model
  - Hardware and associated software for the development of complex computer-based material simulation models
  - Laboratory or facility for electrochemical plating of the test specimen

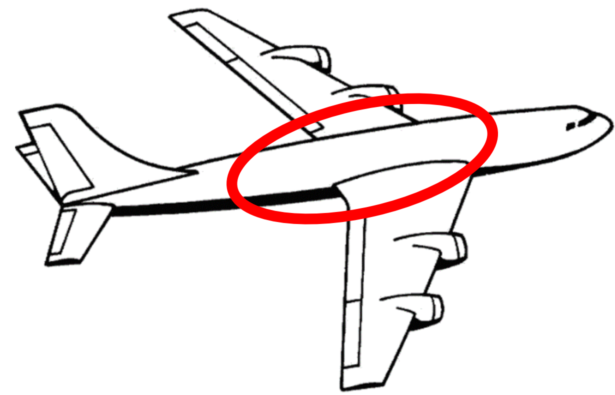
Advantageous

- Facilities for the **production of the test specimens** made of ultra-high-strength steels
- **Eco design approach**

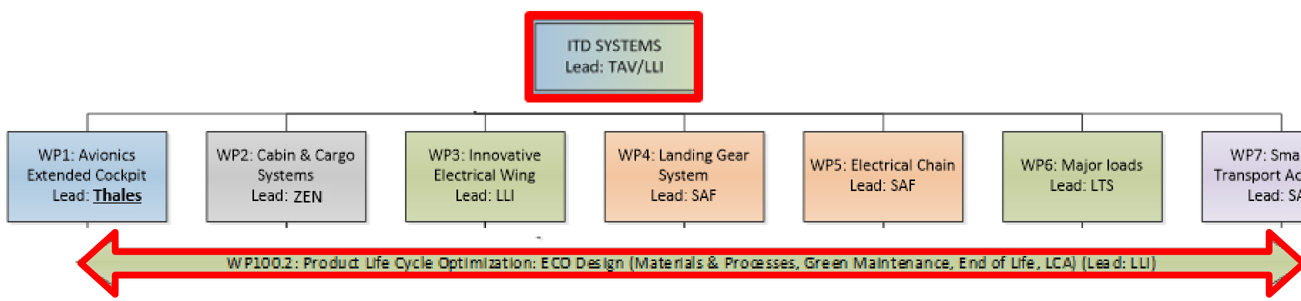
* It is welcomed to form a consortium to take on board all required skills, capabilities and certifications.

JTI-CS2-2020-CFP11-SYS-03-26

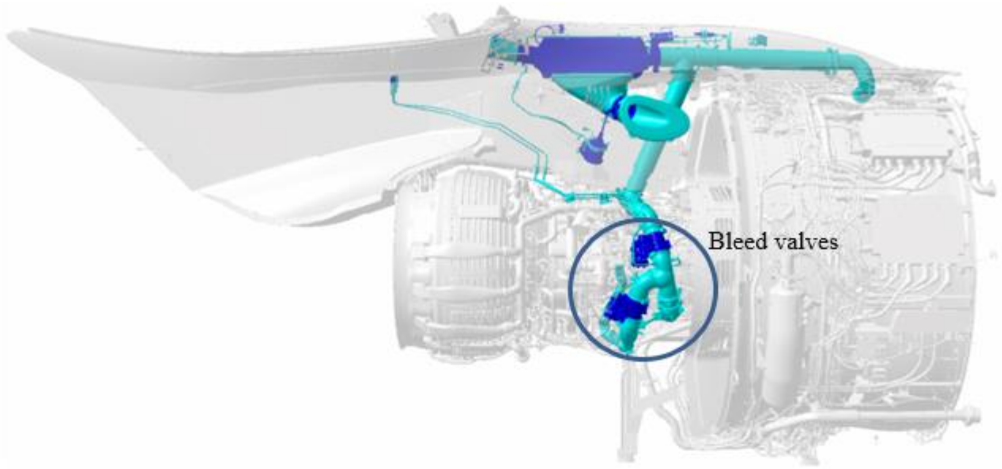
Type of action (RIA/IA/CSA)	IA		
Programme Area	SYS		
(CS2 JTP 2015) WP Ref.	WP 100.2 – Eco design		
Indicative Funding Topic Value (in k€)	750k€		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the Action (in Months)	24	**Indicative Start Date (at the earliest)**	Q4 2020



Topic Identification Code	**Topic Title**
JTI-CS2-2020-CFP11-SYS-03-26	**Replacement of cobalt in Environmental Control System bleed valves**
Short description	
The project aims at studying new nickel self-fluxing alloys and their elaboration routes for the bleed valves butterfly in replacement of cobalt alloy. This project will help to overcome potential health issues regarding wear particles of cobalt alloys in cabin air, but also the need of a higher wear resistant sealing rings and leakage free valve in new hotter and more pressurized bleed air for the future engines and the future less bleed Environmental Control Systems.	

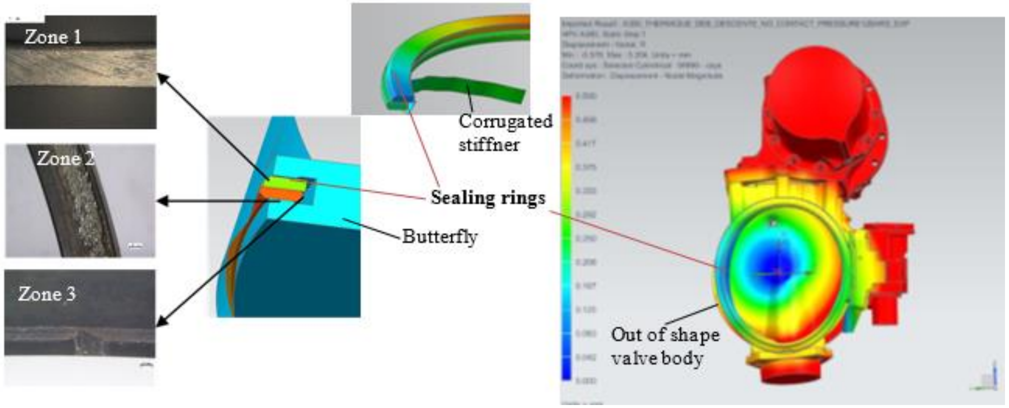


Background



The Topic Manager currently uses cobalt alloy like satellite 6 for the manufacturing of the butterfly sealing rings that slide against a hard chromium coating or a tungsten carbide-cobalt coating. High temperature wear of sealing under complex thermomechanical stresses leads to bleed valve internal leakage increase: in fact, thermal gradients and pressure leads to the loss of cylindrical shape of the valve body as shown in the figure below. These phenomena lead to 3 wear areas presented on the three micrographs below:

- Zone 1: sealing rings wear against the valve body
- Zone 2: sealing rings wear against the machined groove of the butterfly
- Zone 3: sealing rings wear against the corrugated stiffener



Scope of work

Task 1 : Definition of the requirements

Due : T0+3 months

Topic manager will define the following requirements:

- Detailed **application** and thermo-mechanical **behaviour** of the sealing rings; data on **existing solutions** and their limits will be provided.
  - The current solution contains the internal area of the valve body coated with hard chromium or tungsten carbide cobalt.
- Max. temperature and **temperature patterns** foreseen for the bleed valves in the future engines like UHBR

Based on these data, the **applicant will define** in collaboration with the TM the two or three best **grades and composition of self-fluxing nickel alloys**.

Task 2 : Processes study

Due : T0+18 months

- Potential materials are mainly available for thermal spraying. To have a competitive product, the manufacturing process should avoid metal scrapping and intensive machining.

- The partners will have to **study elaboration of cylinders** with the two or three selected materials by:
  - Centrifugal casting.
  - Direct Metal Deposition
- Produce different samples of cylinders and tubes.
  - Cylinder diameter of 4 inches.
  - Evaluate machinability or capacity of grinding.

Task 3 : Metallurgical and Tribological Characterization

Due : T0+20 months

- **Check microstructure** and hot hardness against the current solution of stellite 6 made by centrifugal casting.
- Based on the hardness and microstructure quality, **select** 3 or 4 **solutions** to be tested (2-3 samples).
- Perform **tribological tests** of sliding under high temperature (650°C) and compare solution with samples provided by the TM.
  - ➢ Tribological properties will be jointly characterized and analysed with the Topic Manager.
- **Optimization loop** will be necessary between Task 2 and Task 3 to select the best wear resistant

Task 4 : Life cycle analysis and Toxicity Characterization

Due : T0+24 months

- The applicants shall perform a **comparative life cycle analysis** between centrifugal casting and direct metal deposition for tubes elaboration with self-fluxing nickel alloys and centrifugal casting of current stellite 6.

- The objective is to **select the process** that presents the less impacts.

- The **wear particles** obtained during wear tests in task 3 will be **analysed** in terms of size, shape, composition and mass for the two of three tested solution. These data will be used to propose a first analysis of the **toxicity** of wear particles of new nickel alloys compared to current cobalt alloy.0

Task 5 : Selection for Demonstration

Due : T0+24 months

- **Produce four sealing rings**, based on the best results of previous task, for assembly in a bleed valve demonstrator submitted to an endurance test.
-
- The Topic Manager will provide all parts of the valve (except for the sealing rings), and will be in charge of the **endurance test**.

- **Analyse** the worn sealing rings.

The success of this endurance test will ensure a TRL5 for the Topic Manager.

Major Deliverables & Milestones

Deliverables			
Ref. No.	***Title - Description***	***Type****	***Due Date***
D1	Sealing rings specification and detailed state of the art on the best adapted nickel self-fluxing alloys	R	T0+3
D2.1	Centrifugal casting study synthesis	R	T0+18
D2.2	Direct Metal Deposition by laser cladding study synthesis	R	T0+18
D3	Samples tests report : hot hardness, trio tests and wear analysis	R	T0+20
D4.1	Comparative Life Cycle Analysis of Self-Fluxing nickel alloys obtained by centrifugal casting and by Direct Metal Deposition	R	T0+24
D4.2	Preliminary analysis of wear particles toxicity	R	T0+24
D5	Report of sealing rings behaviour after valve endurance test	R	T0+24

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

Special skills, Capabilities, Certification expected from Applicant(s)

Essential:

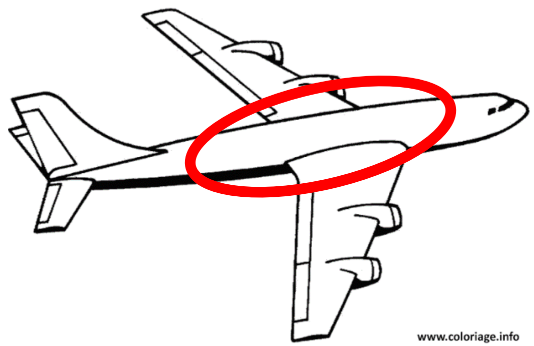
- **Centrifugal casting** capabilities
- Laser **cladding** or Direct Metal **Deposition** Skills and capabilities
- **Metallurgical skills**, with dedicated capabilities : SEM/EDX, thermogravimetric analysis, hot hardness measurement capabilities
- **Tribological test** benches with high temperature tests capabilities, wear analysis skills
- **Process life cycle analysis (LCA)**
- **Toxicology** analysis of wear particles skills and capabilities

Advantageous:

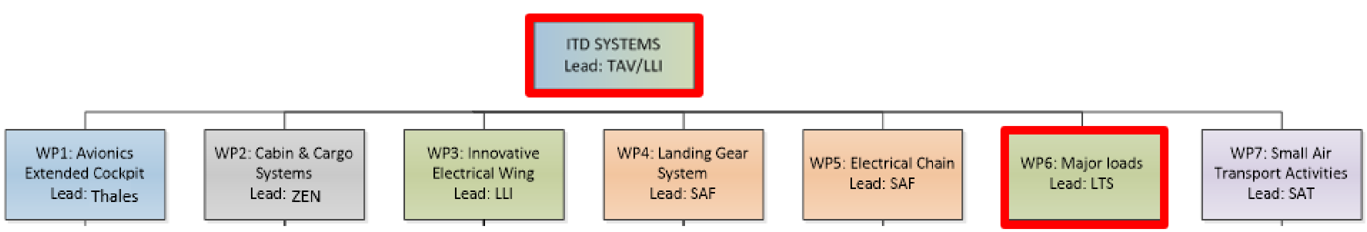
- Machining and grinding capabilities

JTI-CS2-2020-CFP11-SYS-02-62

Type of action (RIA/IA/CSA)	IA		
Programme Area	SYS		
(CS2 JTP 2015) WP Ref.	WP 6.1 – Electrical air system and thermal management		
Indicative Funding Topic Value (in k€)	750 k€		
Topic Leader	Liebherr	**Type of Agreement**	Implementation Agreement
Duration of the Action (in Months)	30	**Indicative Start Date (at the earliest)**	Q4 2020



Topic Identification Code	**Topic Title**
JTI-CS2-2020-CFP11-SYS-02-62	**Thermoplastic wheel for electrical Environmental Control System**
Short description	
Several technology bricks are developed to address needs for a future Electrical ECS allowing significant benefits in terms of fuel consumption reduction through more efficient use of aircraft energy. **Air cycle machines** used in air cooling systems integrates usually one of several thermodynamic stages composed of a wheel. The aim of the topic is to develop a process to realize a **flange wheel in thermoplastic composite** (PAEK) to reduce weight and optimize the performance of the turbine wheels or compressor.	



JTI-CS2-2020-CFP11-SYS-02-62

Background

Air cycle machines (ACM) used in air cooling systems integrates usually one of several thermodynamic stages (turbine or compressor) composed of a wheel (rotating part), a potential stator stage (injector or diffuser) and a scroll (See Fig. 1).

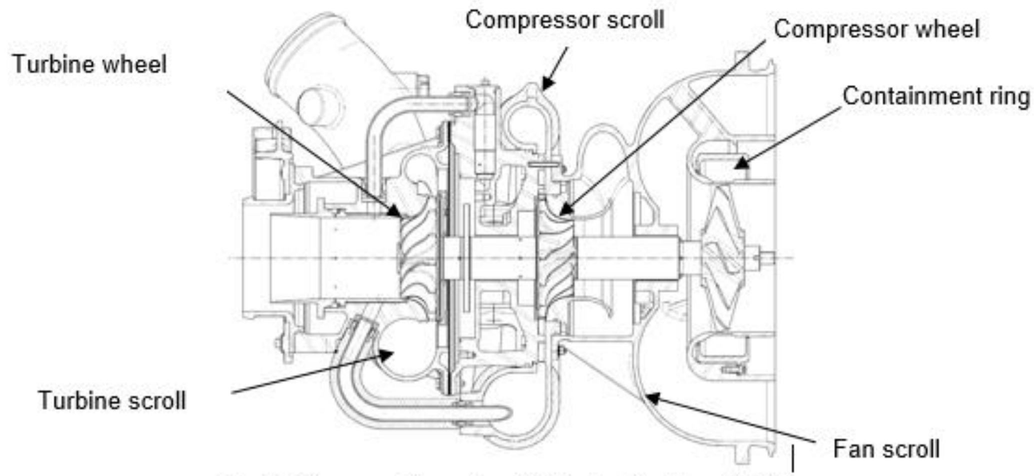


Fig. 1: Cross section of an Air Cycle Machine (ACM).

The capability of manufacturing flange compressor wheel for electrical ECS, or flange turbine wheel for pneumatic ECS would result in an important gain:

- The efficiency of the turbine or compressor will increase of 5 to 10 points as already observed in previous project.
- For pneumatic ECS this efficiency gain will result in a lower air bleed consumption and then directly reduce the aircraft fuel consumption,
- For electrical ECS, this efficiency gain will result in lower electrical consumption and lower maximum power consumption that drives the electrical motor and power electronic design
- The size and mass of the motor and power electronics will decrease and then reduce the aircraft consumption.

→ Challenges: Capacity to produce a flange wheel in a lighter material & meeting design constraints to allow its use in an ECS / e-ECS application

Scope of work

Task 1 : Definition of the requirements

Due : T0+2 months

The Topic manager will define the requirements:

- Nature of the material with PAEK family (sub-family of PEEK and PEKK)
- Conditions during service : speed, pressure, temperature, atmosphere, stress

Task 2 : Choice of the flange wheel

Due : T0+6 months

The selected flange wheel that will be developed in collaboration with the TM and according to the feasibility of the part with respect to the technology.

The technical requirements and inputs related to the selected part will be provided by the TM.

> Potential dimensions are 70 - 160mm diameter and 20-50 mm length.

Task 3 : Definition, design, calculation of a flange wheel

Due : T0+12 months

The definition and design must take into account the constraints of the process (homogeneous, dimensions tolerances, thickness, radius).

Mechanical performance must be ensured by calculation of stress. The final design and the stress calculation will be carried out and validated in collaboration with the Partners and TM.

Task 4 : Conception and manufacturing mould and injection of flange wheel prototypes
Due : T0+26 months

The phase consists in;

1. **Designing** the wheel including rheological simulation
2. **Manufacturing** of the mould as required
3. **Characterization** of first prototypes -- destructive/non-destructive (e.g. tomography)

   The number of first flanges wheels should be sufficient:
   - To check the thickness homogeneity ,
   - To check the position of the insert (if necessary),
   - To control geometry and its compliancy with design,
   - To identify potential defects (porosity, fibres repartition, other defects).

4. **Optimize** design and process according to test results until requirements are met
5. **Manufacture** the final flange wheel demonstrators.
6. Propose a **solution** for an industrial process including economic analysis

Task 5 : Characterization and testing of the flange wheel on the air cycle machine

Due : T0+30 months

- **Check** the geometry of the demonstrators with non-destructive test technologies.
- **Integrate and test** a final demonstrator into an Air Cycle Machine on specific test benches.

The success of this task will ensure a TRL5 for the Topic Manager.

Major Deliverables & Milestones

Deliverables			
Ref. No.	***Title - Description***	***Type***	***Due Date***
D1	Design of the flange wheel	R	M6
D2	Stress calculation Report	D	M9
D3	Process definition report	R	M9
D4	Design of the manufacturing tools	R	M12
D5	Quality control of the flange wheel and iteration	D + R	M22

Milestones (when appropriate)			
Ref. No.	***Title - Description***	***Type****	***Due Date***
M1	Kick of Meeting	R	M0
M2	Manufacturing of first prototypes	HW	M20
M3	Integration of flange wheel in air cycle machine and test on the specific bench	R	M30

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

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

Essential:

- Extensive experience and strong **knowledge on thermoplastic injection** moulding
  (process, design, preparation, calculation, rheological simulation)
- Strong knowledge on **PEEK reinforced with short fibers** and its manufacturing by injection moulding.
- Extensive experience and **capabilities for characterizations** via destructive and non-destructive technologies of reinforced thermoplastics

Advantageous:

- Facilities for implementing the processes in an **industrial scale** and ensuring aeronautical production rates.

Any questions?

Info-Call-CFP-2020-01@cleansky.eu

Last deadline to submit your questions:
13 March 2020, 17:00 (Brussels time)

Thank You

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