Clean Sky Info Day

The CleanSky “Smart Fixed Wing Aircraft Integrated Technology Demonstrator” (SFWA-ITD)

Warsaw, 12th – 13th of September 2011

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Andrzej B. Podsadowski (GRA-PO)

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The CleanSky “Smart Fixed Wing Aircraft Integrated Technology Demonstrator”

Presentation Content

- Introduction
- SFWA-ITD key objectives
- SFWA-ITD large ground and flight demonstrators
- Conclusion
- Call #10 – Research Topics

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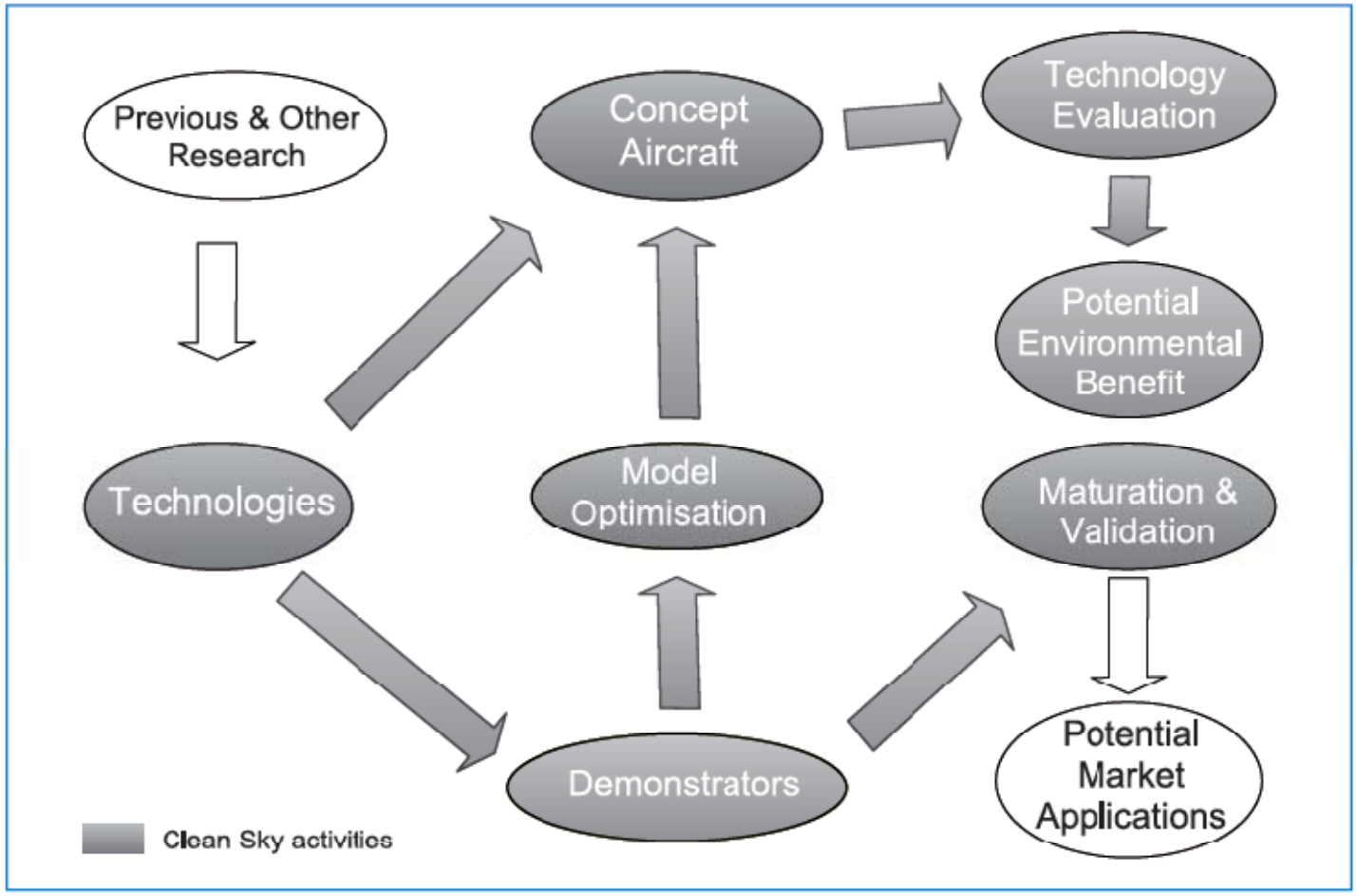
Clean Sky – Demonstration Programmes



Technology evaluation against the „reference a/c year 2000”

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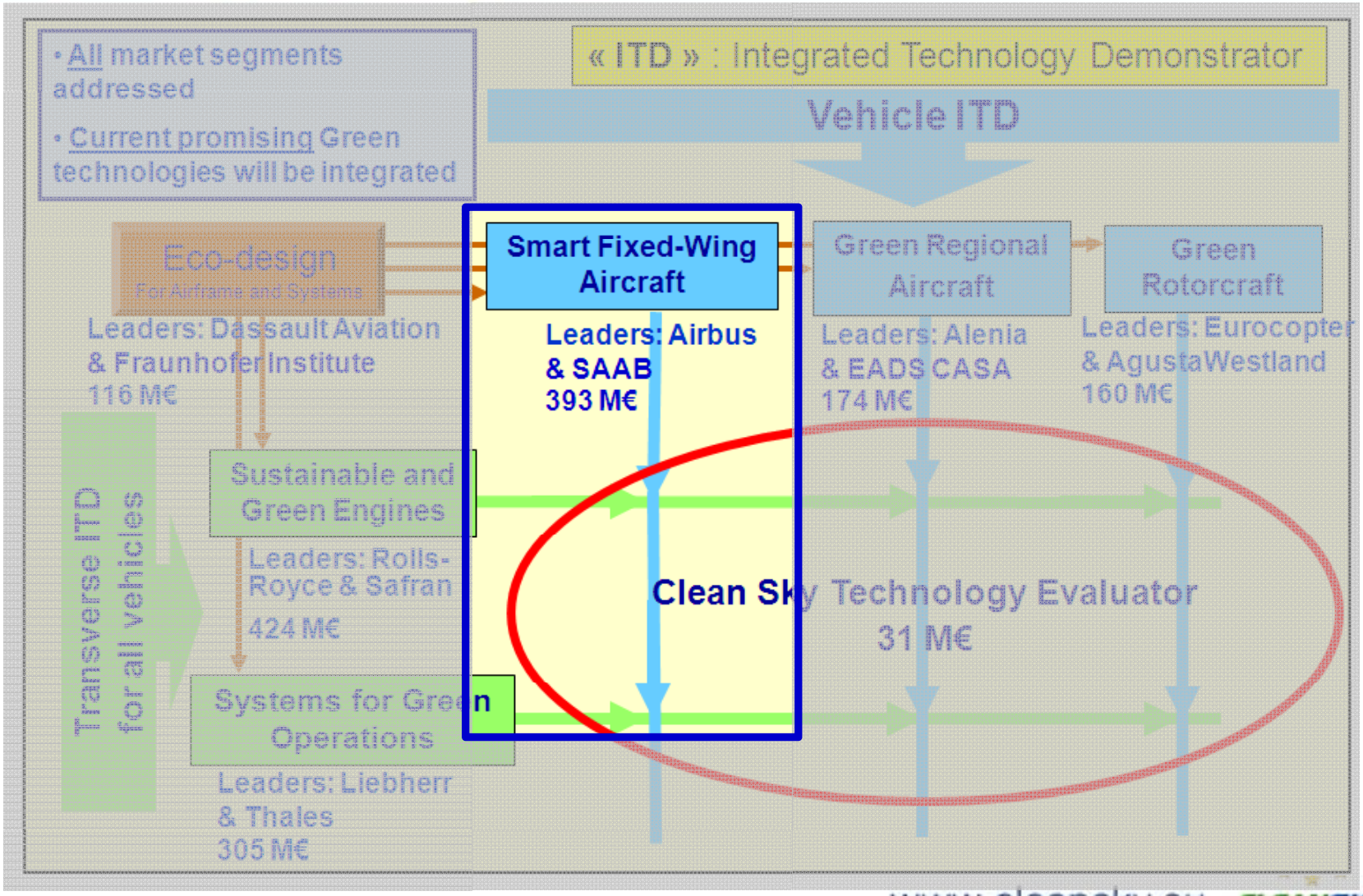
SFWA-ITD organisation and setup



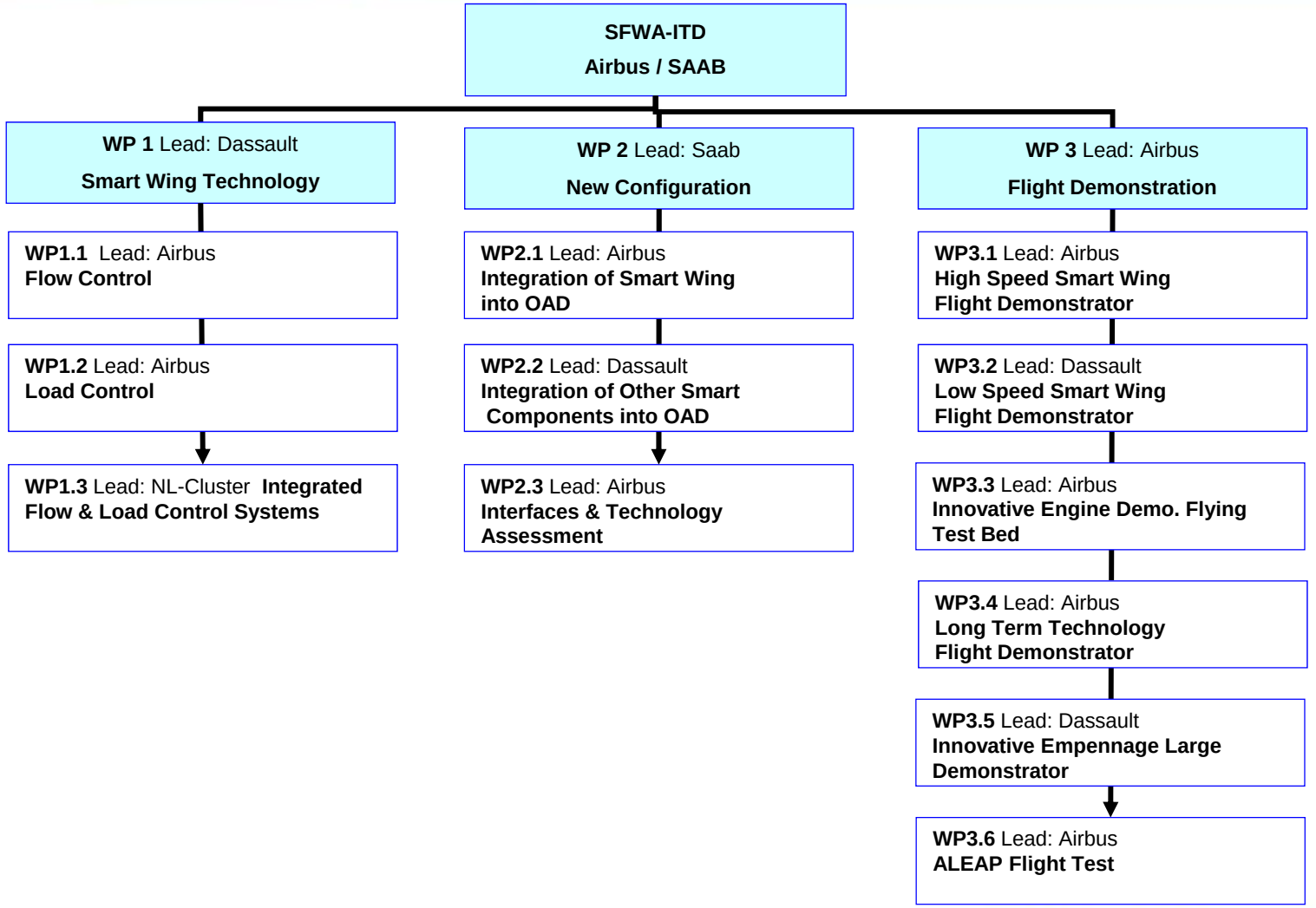
The SFWA Leadership

SFWA-ITD counts 37 beneficiaries, i.e. leaders and partners with their affiliates (Jan 2011)

- **8 SFWA ITD Leaders**
  - Airbus Operations
  - Saab AB
  - Dassault Aviation
  - EADS-Casa
  - Fraunhofer-Gesellschaft e.V.
  - Rolls-Royce
  - Safran Group
  - Thales Group
- **7 SFWA Associate partners**
  - Aernnova Aerospace
  - DLR
  - INCAS-Cluster
  - Netherlands-Cluster
  - Onera
  - QinetiQ
  - RUAG Switzerland Ltd

Organisational Structure

Smart Fixed Wing Aircraft ITD



Aircraft Concepts

Smart Fixed Wing Aircraft ITD

- **The aircraft concepts represent a “virtual” aircraft environment for maturing SFWA technologies. The concepts are:**
  - High Speed Demonstrator Passive (HSDP)
  - Low Speed Demonstrator (LSD)
  - Short Range Aircraft Concept (SRA)
  - Low Sweep Bizjet Concept (LSBJ)
  - High Speed Demonstrator Active (HSDA)
  - Long Range Aircraft Concept (LRA)
  - High Sweep Bizjet Concept (HSBJ)
  - CROR Engine Demo FTB

Technology Streams

Smart Fixed Wing Aircraft ITD

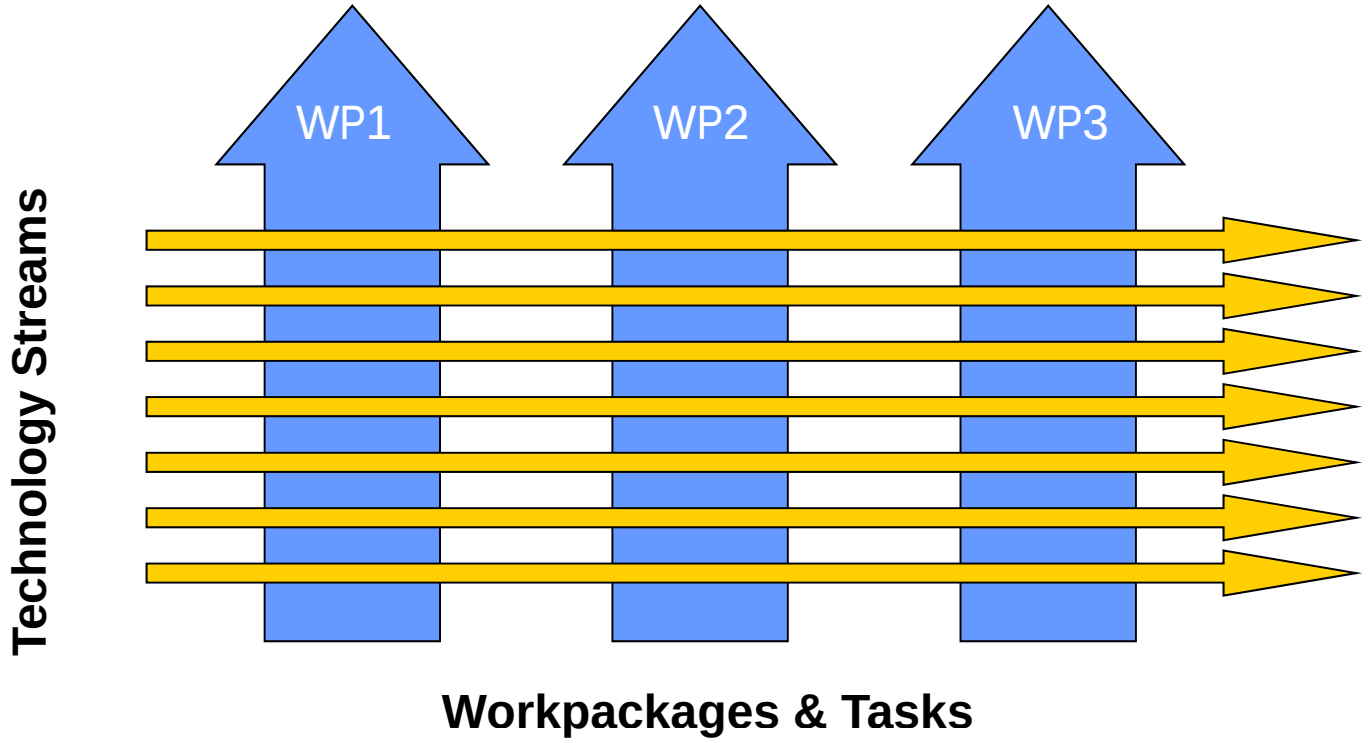
- **For bundling aircraft concept related technologies nine Technology Streams have been defined**

  - Natural Laminar Flow (NLF)
  - Hybrid Laminar Flow (HLFC)
  - Innovative Control Surfaces (ICS)
  - Fluidic Flow Control (FFC)
  - Load Control Functions and architectures (LCFA)
  - Buffet Control (BC)
  - CROR Engine Integration (CROR-EI)
  - Integration of innovative turbofan engines to bizjets (IITE)
  - Advanced Flight Test Instrumentation

Technology Stream Matrix

Smart Fixed Wing Aircraft ITD

The Technology Streams define requirements & collect the respective RTD results from the Workpackages



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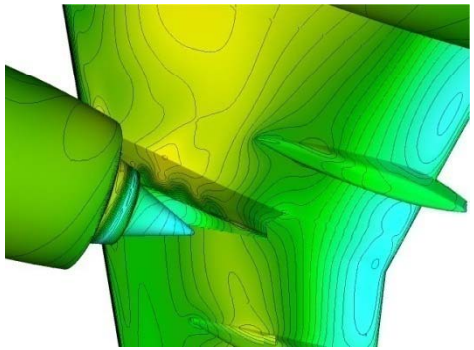
Mature technologies to achieve ACARE ambitious targets

→ 50% cut in CO2 emissions

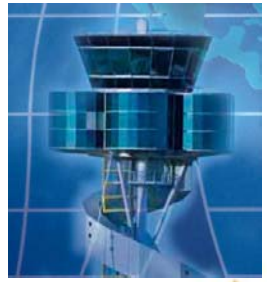
Aircraft manufacturers 20-25%



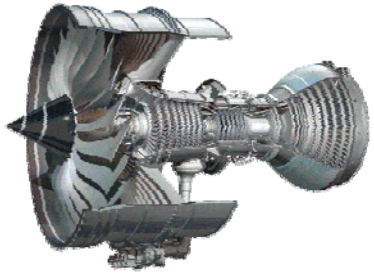
Integration

Engine manufacturers 15-20%

Operations 5-10%
Air Traffic Management



Technologies are key towards ACARE targets, but can only deploy their benefits through smart integration



ACARE: Advisory Council for Aeronautics Research in Europe

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Key Smart Fixed Wing Aircraft technologies

Technology Streams Integration and Demonstration

Input connecting to:

SAGE ITD – **CROR engine**

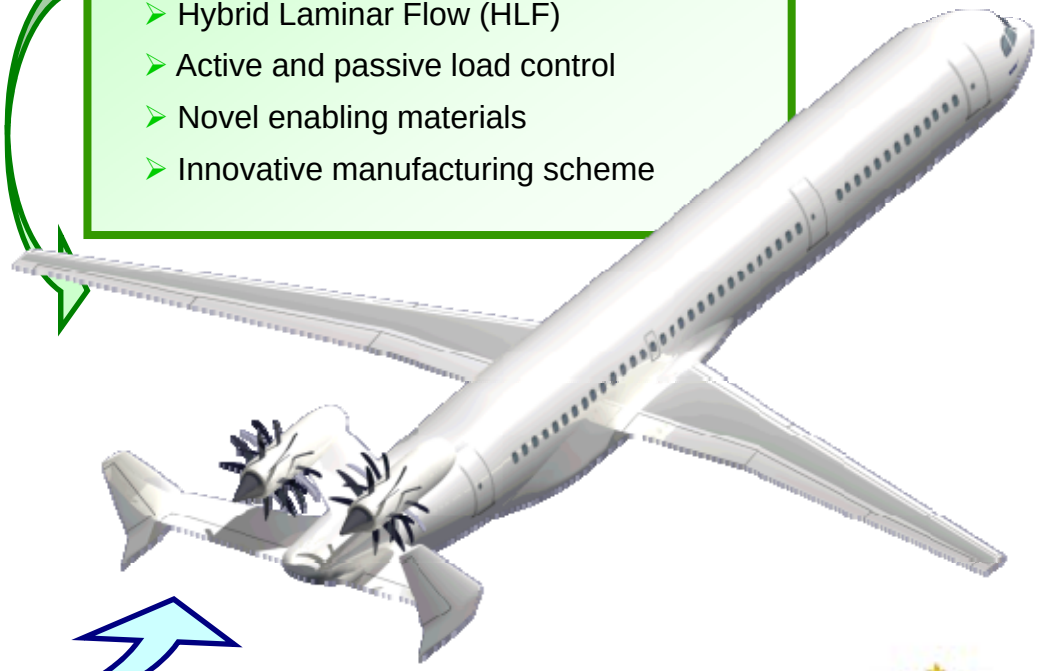
SGO – **Systems for Green Operation**

Smart Wing Technologies

- **Technology Development**
- **Technology Integration**
- **Large Scale Flight Demonstration**
  - Natural Laminar Flow (NLF)
  - Hybrid Laminar Flow (HLF)
  - Active and passive load control
  - Novel enabling materials
  - Innovative manufacturing scheme

Innovative Powerplant Integration

- **Technology Integration**
- **Large Scale Flight Demonstration**
  - Impact of airframe flow field on Propeller design (acoustic, aerodynamic, vibration)
  - Impact of open rotor configuration on airframe (Certification capabilities, structure, vibrations...)
  - Innovative empennage design



Output providing data to:

TE– **SFWA technologies for a Green ATS**

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Key Smart Fixed Wing Aircraft technologies

Enabling Technologies

Contra Rotating Open Rotor (CROR) Demo Engine Flying Test Bed

- ✓ New propeller design (high performance, low noise)
- ✓ Engine - Pylon – Aircraft integration concept
- ✓ New CROR – Engine integration technology
- ✓ Advanced CROR aero-acoustic design

Q2/2016

High Speed Demonstrator for passive laminar-flow wing technologies

- ✓ Advanced passive laminar wing aerodynamic design
- ✓ Two alternative integrated structural concepts for a laminar wing
- ✓ High quality, low tolerance manufacturing and repair techniques
- ✓ Anti contamination surface coating
- ✓ Shielding Krüger high lift device

Q4/2014

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Key Smart Fixed Wing Aircraft technologies

Low Speed Demonstrator for advanced control surfaces for high lift

- ✓ Smart flap concept, with combined function for manoeuvre control and high lift
- ✓ Active flow control at the leading edge to replace slats
- ✓ Active flow control flaps for increased high lift performance

Q4/2014

Clean Sky at a Glance

Bringing Sustainable Air Transport Closer

June 2011

Clean Sky website

www.cleansky.eu

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SFWA flight demonstrator options

1. High Speed Flight Demonstrator

Objective: Large scale flight test of passive and active flow and loads control solutions on all new innovative wing concepts to validate low drag solutions at representative Mach and Reynolds Numbers. Envisaged to be used at least in two major phases of the project.

Option 1: UAV

Option 2: Alpha-Jet

Option 3: Airbus A340 with modified wing

Selected in April 2009

2. Low Speed Flight Demonstrator

Objective: Validation flight testing of High Lift solution to support / enable the innovative wing low drag concepts with a full scale demonstrator.

Option 1: Dassault Falcon

Option 2: Airbus A320

Selection scheduled for 2010

3. Innovative Engine Demonstrator Flying Testbed

Objective: Demonstrate viability of full scale innovative engine concept in operational condition

Options under investigation

Status: Preferred solution

4. Long Term Technology Flight Demonstrator

Objective: Validation of durability and robustness of Smart Wing technologies in operational environment

Option 1: In Service Transport Aircraft

Option 2: Airbus A300 "Beluga"

Option 2: Airbus A320

Selection(s) part of technology roadmap

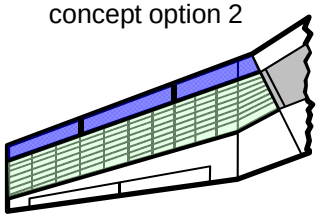
SFWA- High Speed Demonstrator Passive (HSDP)

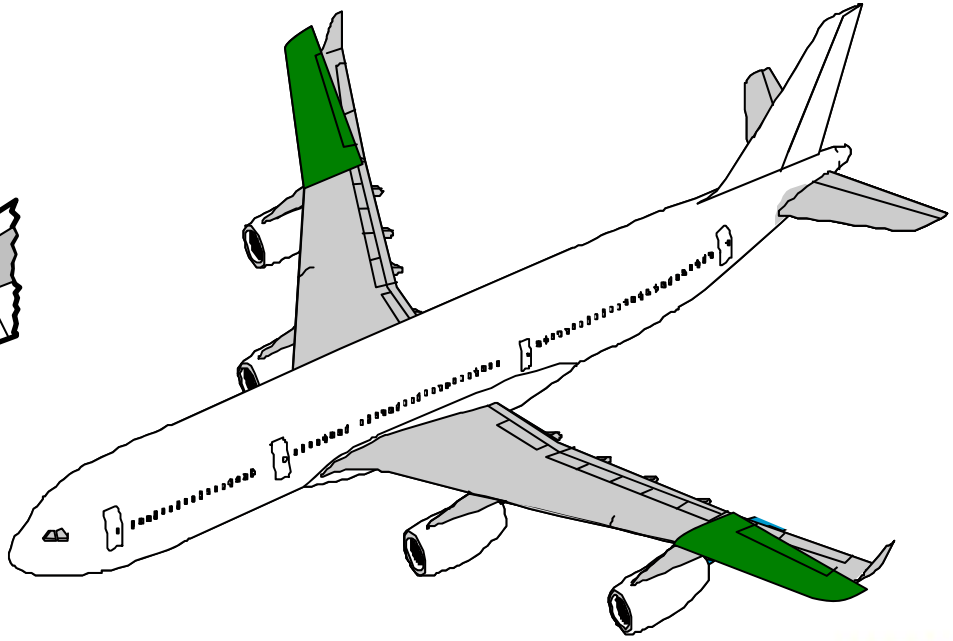
Smart Passive Laminar Flow Wing

- Design of an all new natural laminar wing
- Proof of natural laminar wing concept in wind tunnel tests
- Use of novel materials and structural concepts
- Exploitation of structural and system integration together with tight tolerance / high quality manufacturing methods in a large scale ground test demonstrator
- Large scale flight test demonstration of the laminar wing in operational conditions

Port wing

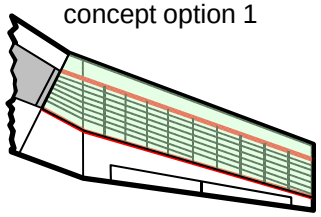
Laminar wing structure concept option 2





Starboard wing

Laminar wing structure concept option 1



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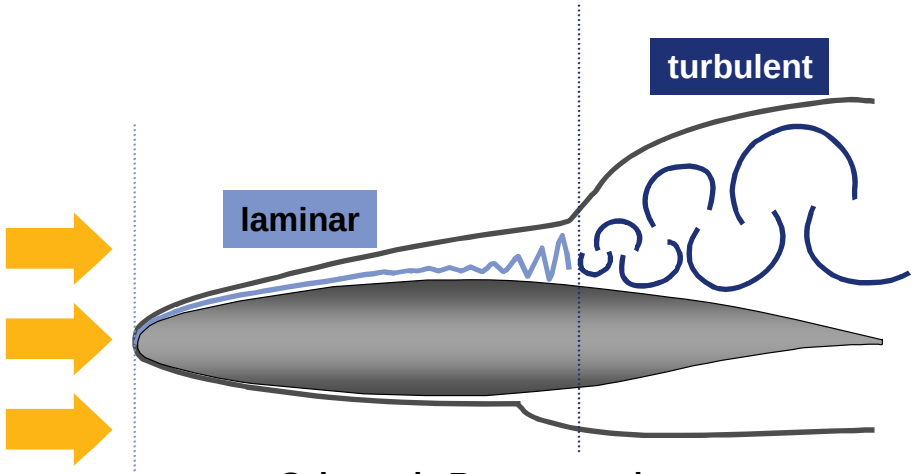
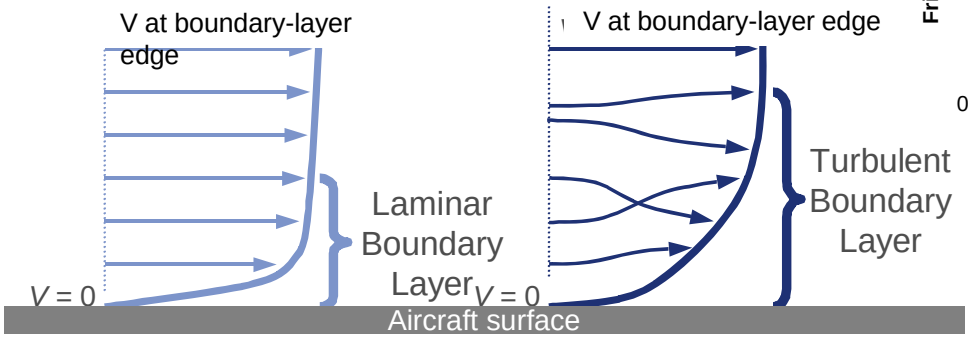
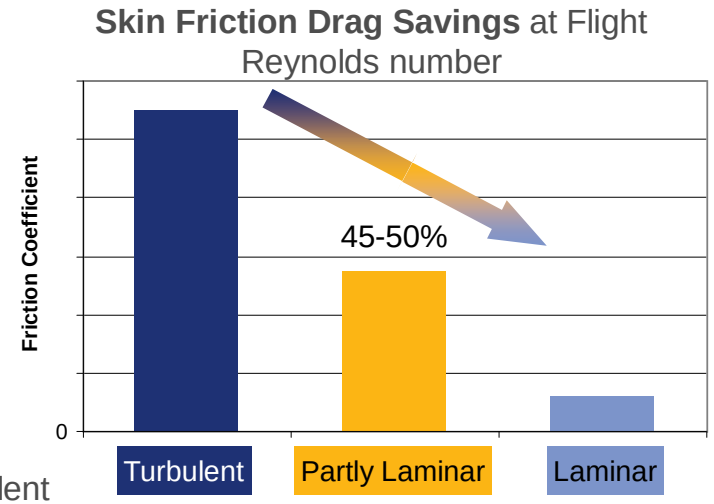
Aerodynamic drag reduction through laminar flow



Schematic Representation





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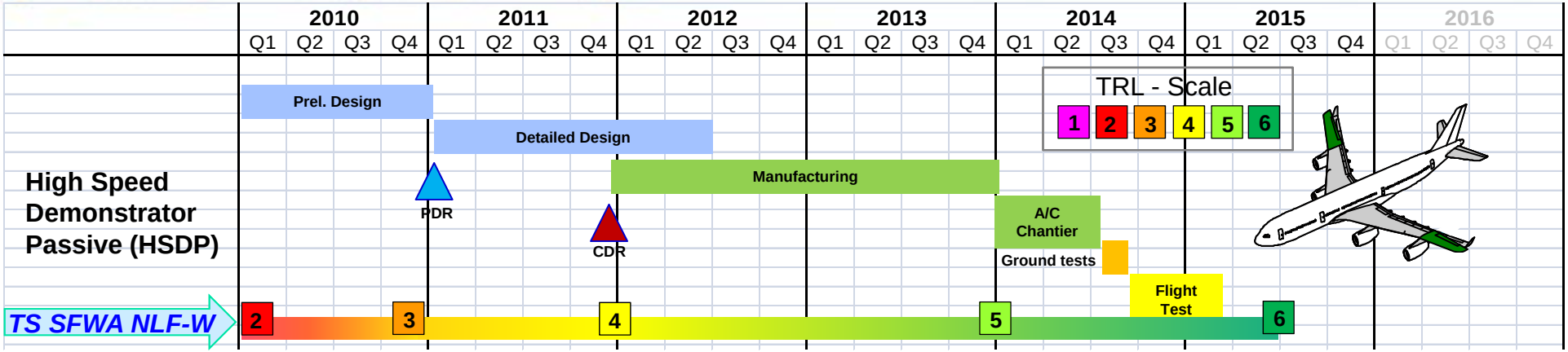
SFWA-ITD Flight Demonstrator Schedule

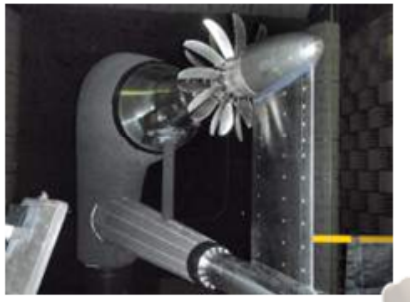


Main objectives in year 2011

- April 2011: Release Final Aerodynamic shape
- Mid 2011: Details of all interfaces of wing components and test aircraft are defined, the structural layout observation pod – aircraft fuselage is defined
- December 2011: Critical Design Review
- Launch further workpackages with CfP Partners in CleanSky Calls #8, #9 and #10 (in 2011).

SFWA- ITD integration of the CROR engine concept

CROR Aero -Acoustic experimental characterization

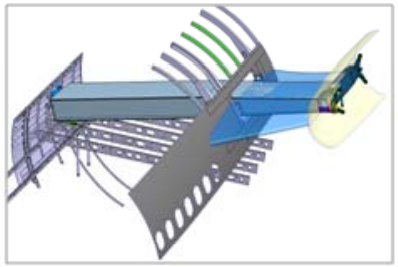


Innovative Power-Plant Integration

- Design of innovative CROR blades and pylon
- CROR installation effects: aero, noise, vibrations, handling qualities
- CROR propeller kinematics, study of fragment impact depending on size and propeller and fuselage materials
- Structural technologies for armour and shielding
- Feasibility study of a full scale CROR engine in a **F**lying **T**estbed **D**emonstration (FTB)

CROR design study: interference with HTP

Airbus A340-600 Flying Test Bed with CROR engine



CROR structural integration concept

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Aeronautics priority R&T in CleanSky

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is of major importance for European Aeronautics R&T

to fulfil on the ambitious targets of ACARE

The special priority R&T needs for large commercial Aircraft are covered in SFWA-ITD

- *by developing an all new smart low drag wing*
- *by integration of innovative power plants*
- *through large, representative flight test demonstration*
- *engaging a wide range of partners from all over Europe*

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Smart Fixed Wing Aircraft –ITD

CfP Topics

Identification	ITD - AREA - TOPIC	topics	VALUE	MAX FUND
JTI-CS-SFWA	**Clean Sky - Smart Fixed Wing Aircraft**	**5**	**5.650.000**	**4.237.500**
JTI-CS-SFWA-01	*Area01 – Smart Wing Technology*			
JTI-CS-SFWA-02	*Area02 - New Configuration*		**5.650.000**	
JTI-CS-2011-3-SFWA-02-019	Investigation of Bird Strike criteria for Natural Laminar Flow wings		800.000	
JTI-CS-2011-3-SFWA-02-020	Development of an automated gap filler device		550.000	
JTI-CS-2011-3-SFWA-02-021	Fixed Leading Edge Structure and Systems Demonstrator for a Business Jet laminar wing		1.500.000	
JTI-CS-2011-3-SFWA-02-022	Design and manufacturing of an innovative cryogenic wind tunnel model with motorized empennage		1.300.000	
JTI-CS-2011-3-SFWA-02-023	Development, manufacturing and testing of two different High Load Small Space Rotary Gear Types		1.500.000	
JTI-CS-SFWA-03	*Area03 – Flight Demonstrators*		**0**	

Smart Fixed Wing Aircraft –ITD

CfP Topic

JTI-CS-2011-03-SFWA-02-019

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Investigation of Bird Strike criteria for Natural Laminar Flow wings

Feb 2012 >> Aug 2013

Topic description: Objective headlines

The objective will be to establish a validated bird strike analysis capability which enables the SFWA partners to simulate bird impact on a CFRP leading edge for a natural laminar flow wing. The analysis should be capable of predicting the extent of any damage and the particular mode of any failure e.g. de-lamination, fracture etc.

Background of the Research Topic / relationship to the SFWA-ITD

The SFWA programme is presently investigating the application of natural laminar flow (NLF) for reduced fuel burn and emissions reduction. This requires a novel structural leading edge concept without slats as well as an innovative integration for ice protection devices.

This Call for Proposal topic is to close the gaps in knowledge that relates to this scenario. The applicant is required to establish a new test programme for bird strike events and to use the acquired experimental data to validate numerical models that may be applied within the SRA design process.

Expected Outcome / key deliverables

- Analysis of bird strikes on a flat and curved panels at various angles of impact.
- Design and analysis of a supporting frame to conduct bird impact tests on flat and curved panels
- Manufacturing of an agreed number of flat and curved panels that include supporting stringers, sub-spars or other structural features
- Completion of impact tests at various angles (at least 3)
- Validation of the analysis and numerical models
- Delivery of a tool that can predict the extent of damage in a representative Composite leading edge geometry

Maximum Value of Topic

The total value of biddings for this work package shall not exceed

€ 800,000.--

Important Remarks / Requirements

- Demonstrate knowledge of the certification requirements relating to bird strike for both composite and metallic materials.
- Applicants have to either provide their own test facility or to utilize third party facilities. All costs of tests to be included as part of this CfP topic.
- Demonstrate a good track record with a variety of NDT techniques including high speed cameras, strain gauges, NDT scans for damage analysis and digital imagery.
- A proposer consortium may be set up to provide the necessary mix of experimental and analytical skills for success in this programme.


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CfP Topic
JTI-CS-2011-03-SFWA-02-020
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Development of an automated gap filler device

Jun 2012 >> Jun 2013

Topic description: Objective headlines

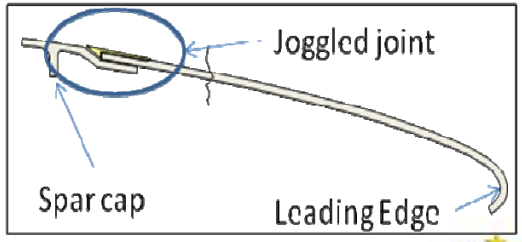
Development of a prototype tool that can apply filler into a joggled joint in a fully 3-D environment (i.e. with sweep and taper) and achieve a surface finish within tolerances suitable for laminar flow surfaces (usually <0.1 mm).

Background of the Research Topic / relationship to the SFWA-ITD

For developing Natural Laminar Flow (NLF) wings to a Technology Readiness Level (TRL) level of 6, a number of major flight and ground demonstrations are performed.

Full systems and structural integration of the leading edge zone will be demonstrated by the SFWA partners at a Ground Based Demonstrator (GBD) at full scale. The GBD will include a curved joint between the composite wing box and the leading edge box which shall adequately be filled in order to demonstrate laminar flow surface quality.

The applicant has to develop and manufacture the automated gap filler device. The device should be configured to demonstrate its function on the assembled ground based demonstrator.



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Expected Outcome / key deliverables

- Review of potential design solutions, background study
- Results from flat plate coupon tests
- Development of the final design of the gap filling device
- Results from final double curved coupon tests
- Development & manufacture of a prototype of an automated gap filler device

Maximum Value of Topic

The total value of biddings for this work package shall not exceed

€ 550,000.--

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Important Remarks / Requirements

The applicant should:

- demonstrate an awareness of the requirements for equipment to be used for commercial aircraft assembly either as part of a final assembly line or as a field repair capability.
- demonstrate a good track record of innovation in the development of new manufacturing techniques and assembly solutions.
- provide evidence of their track record in meeting tight time schedules and delivering a quality product on time and at cost.

Smart Fixed Wing Aircraft –ITD

CfP Topic

JTI-CS-2011-03-SFWA-02-021

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Fixed Leading Edge Structure and Systems Demonstrator for a Business Jet laminar wing

T0 >> T0+24

Topic description: Objective headlines

A functional prototype of partially, full scale laminar wing equipped with an electro-thermal Ice Protection Systems (ETIPS) has to be designed, manufactured and tested by the applicant in order to demonstrate compliance with manufacturing tolerances, weight/cost objectives, and icing protection requirements.

Background of the Research Topic / relationship to the SFWA-ITD

Techniques for the assembly of the leading edge, front spar and wing box covers with laminar flow surface smoothness are currently being investigated. The present ‘state of the art’ hot air system is not the main interest because in the future a generator sized for engine start-up could provide the necessary power for an Electro-Thermal Ice Protection system (ETIP) as both functions are not used at the same time.

For laminar wings ETIP will be fitted to a fixed leading edge.

Other electrical icing removal systems are not applicable to a laminar wing as, either they will not remove all the ice (de-icing systems) or they are based on structural deformation not compatible of the laminar wing waviness requirements.

Expected Outcome / key deliverables

- ETIPS structural and layout trade-off study for laminar wing
- Conducting of an ETIP system architecture definition for a laminar wing
- Manufacture of a functional, scale 1, prototype of a part of the laminar wing equipped with ETIPS for the icing tests
- Performance of icing wind tunnel tests to prove the efficiency of the developed Wing Ice Protection System

Maximum Value of Topic

The total value of biddings for this work package shall not exceed

€ 1,500,000.--

Important Remarks / Requirements

- Innovative solutions are expected in the domain of heater mats assembly, leading edge and wing cover manufacturing and compliance with the waviness requirements for the initial and repaired structure.
- Innovative solutions are expected in the domain of slat material and heater mats technology to reduce weight and maintenance cost.
- Innovative solutions are expected also in the heater mats themselves for various aspects (reliability, power density, heat transfer & heat losses, thickness of assembly, repair easiness, tolerance to damage…etc).
- Some innovative solutions may not be selected for the prototype realisations for various reasons but they shall clearly appear in the trade-off with the current maturity level, and time to market provided.

Requirements

The applicant shall have knowledge of the following standards:

- *MIL-STD-704F* Aircraft electrical power characteristics (as a guide line)
- *MIL-HDBK-217F* Reliability prediction for electronic component
- *DO160F* Environmental conditions and test procedures for airborne equipment
- *DO178B* Software considerations in airborne systems and equipment certification
- *DO254* Design assurance guidance for airborne electronic hardware
- *CS25- Amendment 10- Appendix C* Icing conditions- stratiform and cumuliform clouds
- *CS 25- Amendment 10- Appendix O* Icing conditions- SLD: Super Large Drooplets (Freezing drizzle, freezing rain)
- *AMC 25-21G* Performance and handling characteristics in icing conditions constraints in appendix C of CS25
- *AMC 25-1419* Ice protection
- *CRI Fxx* Special conditions to be released by EASA in the frame of new programs for a/c with MTOW< 60000lb


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CfP Topic
JTI-CS-2011-03-SFWA-02-022
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Design and manufacturing of an innovative cryogenic wind tunnel model with motorized empennage

May 2012 >> May 2013

Topic description: Objective headlines

The subject is the design and manufacturing of a full aircraft model for high speed, high Reynolds number wind tunnel test in a cryogenic test facility.

Background of the Research Topic / relationship to the SFWA-ITD

A high-speed business jet model will be used for a wind tunnel test at flight Reynolds numbers to ensure the potential of laminar flow technology and to consolidate the choices in terms of cruise flight design point (Mach, altitude) and airfoil design.

This wind tunnel test is therefore the most important milestone in pushing forward the design of a future business jet based on natural laminar flow wing technology.

A large number of steady and unsteady measurement sensors are to be integrated in the wing of the model while maintaining a very high surface quality. The design options and the manufacturing approach for the wing (waviness, interchangeability of parts) and the integration of the pressure probes have to fulfill strong shape tolerance constraints of laminar wings.

Expected Outcome / key deliverables

- Design and structural stress description of the model
- Complete manufactured model including instrumentation
- Geometric inspection
- Instrumentation inspection

Maximum Value of Topic

The total value of biddings for this work package shall not exceed

€ 1,300,000.--

Important Remarks / Requirements

The applicant should

- have a large experience in designing and manufacturing wind tunnel models for the aeronautical industry.
- comply with Dassault-Aviation procedures concerning wind tunnel model design and manufacturing. These procedures will be provided in the model requirement document by Dassault.
- have confidentiality agreement(s) with all partners participating in the High Speed Platform.
- be proficient in using Dassault Systèmes CATIA V5 Software.


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CfP Topic
JTI-CS-2011-03-SFWA-02-023
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Development, manufacturing and testing of two different High Load Small Space Rotary Gear Types for a Ground Based Systems Demonstrator

Dec 2011 >> Dec 2014

Topic description: Objective headlines

Develop, manufacture and test rotary gears for the drive-system of Krueger Flap components and sub-systems to enable final assembly and demonstration of the ground based wing demonstrator.

Background of the Research Topic / relationship to the SFWA-ITD

For the design, manufacture, test and demonstration of an integrated Natural Laminar Flow wing leading edge a Ground Based Demonstrator (GBD) will be used. Previous Call for Proposal (CfP) topics are considering a wing ice protection system and the detailed design of the fully integrated leading edge zone. This CfP topic is concerned with the development of the rotary gear for a Krueger high lift leading edge device for the GBD on a ‘zone’ demonstrator. The latter is a wing section including all systems, e.g. the leading edge assembly.

The applicant has to develop, manufacture and test rotary gears for the drive-system of selected Krueger Flap components and sub-systems for the GBD.

Expected Outcome / key deliverables

- 2 pieces Rotary-Drive-Type for Krueger Device **Type A** to be developed & tested; basic requirements: max. Diameter less or equal 120mm, max. operating torque > 2,000 Nm, actuation angle 180°
- 2 pcs. Rotary-Drive-Type for Krueger Device **Type B** to be developed & tested; basic requirements: max. Diameter less or equal 80mm, max. operating torque > 900 Nm, actuation angle 180°
- cross shaft including its supports (might be procured)
- 4 downdrive gearboxes & shafts (might be procured)

Maximum Value of Topic

The total value of biddings for this work package shall not exceed

€ 1,500,000.-

Important Remarks / Requirements

The applicant should have

- a sound industrial background in development and manufacturing of drive system components in an aerospace environment.
- a full ISO14001 certification

Aeronautics priority R&T in CleanSky

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