New Wing Concepts

Presentation Content

- Introduction
- SFWA-ITD key objectives; The SFWA-ITD *Smart Wing*
- Potentials and Challenges for the *Smart Wing*
- Strategy and programme to mature the *Smart Wing* in CleanSky
- Conclusion
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SFWA-ITD organisation and setup

- All market segments addressed
- Current promising Green technologies will be integrated

**Vehicle ITD**

- **Smart Fixed-Wing Aircraft**
  - Leaders: Airbus & SAAB, 393 M€

- **Green Regional Aircraft**
  - Leaders: Alenia & EADS CASA, 174 M€

- **Green Rotorcraft**
  - Leaders: Eurocopter & AgustaWestland, 160 M€

**Clean Sky Technology Evaluator**
- 31 M€

**Transverse ITD**

- **Eco-design**
  - For Airframe and Systems
  - Leaders: Dassault Aviation & Fraunhofer Institute, 116 M€

- **Sustainable and Green Engines**
  - Leaders: Rolls-Royce & Safran, 424 M€

- **Systems for Green Operations**
  - Leaders: Liebherr & Thales, 305 M€

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SFWA-ITD participants and global shares

„ITD-Leaders“

• Airbus
• SAAB
• Dassault
• EADS-CASA
• Thales
• Fraunhofer
• SAFRAN
• Rolls-Royce

Associate Partners

• DLR
• ONERA
• INCAS
• NL-Cluster
• QinetiQ
• RUAG
• Aernnova

25% of Total Budget

Partner participation based on Call for Proposals „CfP“

50% of Total Budget

393M€ Total Budget

25% of Total Budget

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Mature technologies to achieve ACARE ambitious targets

→ 50% cut in CO2 emissions

Aircraft manufacturers 20-25%
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

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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Aerodynamic drag reduction through laminar flow

Schematic Representation

Skin Friction Drag Savings at Flight Reynolds number

V at boundary-layer edge

Laminar Boundary Layer

Turbulent Boundary Layer

Aircraft surface

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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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Laminar flow flight demonstrations 1985 - 2008

Aerodynamic design feasible and high performance possible but Key for introduction of laminar technology is

- High surface quality
- Avoidance of insect contamination
- Simplified suction system
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Major aerodynamic challenges

1. Linear stability theory with determination of limiting amplification factors (N factor) in the relevant environment (wind tunnel; free flight) is a principle requirement for the aerodynamic design of laminar surfaces.

2. Finding the best compromise between sweep, extent of laminar flow, Ma-flexibility and robustness of wing design against surface imperfections is the biggest challenge for definition of best compromise on aircraft level.

3. Prediction of effect of surface imperfection (steps, waviness, roughness, 3D disturbances) on laminar flow at the relevant conditions and boundary layer stability situation and their sensitivities is the major element for definition of acceptable structure concept.
Overview about Major Wind Tunnel Testing

N-Factor limit calibration with TELFONA pathfinder model

Adjustable leading edge step
TSP coating

Testing at flight Re number & similar BL stability

Test in KRG: Pressure: 1...6 bar, Temp: Cryo
Laminar Wing surface quality issues

Major constraint for any laminar wing concept is high surface quality:

- No steps or steps with very limited step height
- Reduced waviness (either from manufacturing or deformation under cruise loads)
- Avoidance of any 3D disturbances (by insects or fasteners)
- Reduced roughness at the leading edge (either from manufacturing or erosion under operational conditions)

This has to be achieved under typical production standards (high rate, low costs) to be beneficial on aircraft level!
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Major Objective:
Demonstrate the feasibility of a structure concept enabling laminar flow

A340-300

Representation of laminar Wing on A340 flying test bed
Operational Challenges

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Laminar wing part

insect debris

Critical case
with direct transition

Critical case
with reduced transition

Insect debris not critical
minor effect on transition

Shielding effect

Anti-contamination coating

Krueger shielding

insect impact on surface

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Laminar Wing Structure Options & Validation

Examples of two upper cover options

- NLF wing section
- Joint
- Leading edge with joint to box
- Continuous surface

Validation on A340 FTD
Validation by specific ground tests

Other options under investigation

Downselection process

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Main Components of the “BLADE” Smart Wing demonstrator

NLF Wings preliminary design completed in December 2010

- Full design update following outer wing planform change to ensure compatibility with A340 inner wing.
- Very good collaboration among all partners, including partners selected in CFP call #4.
The Integrated Smart Wing Upper Cover Concept (SAAB concept)

Complexity

- The panel combines several advanced design principles into an fully integrated solution, co-cured in one step.

- Fulfilling very challenging requirements regarding surface quality

Test/Trial Panel

- A test/trial panel has been manufactured and is used for several purposes, i.e. evaluation design concepts, tooling, surface measurement etc.
Smart Wing flight test instrumentation

A340-300

Representation of laminar Wing on A340 flying test bed

Expected laminar flow

Extend of laminar flow

Smart Wing observation camera view angle from potential observer pod position (Airbus)

Infrared Image of laminar – turbulent flow transition on wing surface (ONERA)

Flush mount hot film sensor for the detection of flow separation (ONERA)

Local Drag Measurements: Wake Surveys using Lidar (ONERA)

Fiber Laser and Lidar Architecture

Velocity Field In the Wake

Infrared Image of laminar – turbulent flow transition on wing surface (ONERA)

Flush mount hot film sensor for the detection of flow separation (ONERA)
### 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#7, #8 and #9.**
Smart Wing for Year 2020 Business - Jet

- Smart Flaps
- Structures and systems integration for innovative Wing
- Leading Edge Coating
- Load and vibration alleviation
- Natural Laminar Flow Wing
- Krueger Flaps for laminar wing
- High Aspect Ratio

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New Wing Concepts – Additional Subjects

Additional major R&T subjects in progress in SFWA to contribute to the “Smart Wing”

- Maneouvre and Gust load control schemes to meeting tailored for the smart wing, including higher frequency modes

- Advanced high lift systems, able to enable a high degree of laminarity wing geometry and surfaces. This includes passive (high performance flap) and active flow control concepts.

- A new “class” of laminar wing manufacturing and assembly concepts, enabling high ramp up, high production rates at required high quality, explicitly surface quality.

- Repair and maintenance concepts for the smart wing, especially the parts / areas in which tolerances and qualities have to meet “NLF- laminarity” requirements

- *Maturing the HLFC – Hybrid laminar smart wing concept based on NLF knowledge gains*
Summary

- Laminar flow has a high potential for drag reduction
- The SFWA- “Airframer” have build up experience with laminar flow within several projects together with other R&T partners
- Key element for introduction of laminar flow is a structure concept enabling sufficient surface quality at acceptable costs and production rates
- Best compromise between aerodynamic optimum and structure constraints is important for overall benefit
- All major operation constraints have to be considered in fuel planning and performance guaranties
- The A340 flight test demonstration with representation of major elements of a future laminar wing will be the most important step for application of such a technology in the future