Smart Fixed-Wing Aircraft
→ 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
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

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

Input connecting to:

- SAGE ITD – CROR engine
- SGO – Systems for Green Operation

Output providing data to:

- TE – SFWA technologies for a Green ATS
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.
   *Airbus A340-300 with modified wing*
   **Selected in April 2009**

2. **Low Speed Demonstrator**
   **Objective:** Validation flight testing of High Lift solution to support / enable the innovative wing / low drag concepts with a full scale demonstrator.
   **2.1** Smart Flap large scale ground demo / DA Falcon type Bizjet trailing edge
   **2.2** Low Speed Vibration Control Flight Test Demonstration DA Falcon F7X
   **Selection in Q3 / 2011**

3. **Innovative Engine Demonstrator Flying Testbed**
   **Objective:** Demonstrate viability of full scale innovative engine concept in operational condition
   *Airbus A340-500 with modified wing*
   **Selected April 2010**

4. **Long Term Technology Flight Demonstrator**
   **Objective:** Validation of durability and robustness of Smart Wing technologies in operational environment
   *In Service Transport Aircraft*
   Airbus A300 “Beluga”
   **Selection(s) part of technology roadmap**

5. **Innovative Empenage Ground Demonstrator**
   **Objective:** Validation of a structural rear empenage concept for noise shielding engine integration on business jets
   *SFWA design*
   **Selected Q4 2011**
Active Flow Control: Overview
Active flow control system functionality testing

Integrated Design and Evaluation of AFC system
AFC System Modeling and Simulation
AFC System Ground Testing

Future Activities

Key message:
Good AFC system performance demonstrated in ground tests for normal operation

Le Bourget June 2013
SFWA-ITD overview

Smart Flaps

Structures and systems integration for innovative Wing

Leading Edge Coating

Load and vibration alleviation

SFWA large demo’s with focus on Bizjets

Innovative Rear Empenage

Natural Laminar Flow Wing

Krueger Flaps for laminar wing

High Aspect Ratio

Contribution in SFWA Large Aircraft Demo’s

Le Bourget June 2013
Validation plan in 2 steps

- **Phase 1: Ground Tests**
  - Validation of control law design methodology
  - Validation of ability to control vibrations due to a well known excitation force

- **Phase 2: Flight Tests**
  - Validation of vibration reduction function in real environment
High Speed Demonstrator Passive

SFWA WP3.1 BLADE

Breakthrough Laminar Aircraft Demonstrator in Europe
**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

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**Laminar Wing Ground test demonstrator to address structural, system and manufacturing aspects**

**Starboard wing**
- Laminar wing structure concept option 1

**Port wing**
- Laminar wing structure concept option 2

**Laminar Wing aerodynamic layout and performance**
SFWA-ITD overview
BLADE Partnership (Wing Perimeter)

Upper cover&LE (Starboard)
Design: GKN
Manuf: GKN

Wing Tip Body
Design: Aerinnova
Manuf: Romaero

Wing Box&Lower covers
Design: Aerinnova
Manuf: Aerinnova

Wing FTE
Design: Incas
Manuf: Romaero

Ailerons
Design: Incas
Manuf: Romaero

FTI installation
Design: Airbus (Sotech)
Manuf: Airbus

Krueger
Design: Asco
Manuf: Asco

Upper cover&LE (Port)
Design: SAAB
Manuf: SAAB

Aerofairing
Design: Dassault
Manuf: Romaero

Transition zone
Design: Airbus (Sotech)
Manuf: Romaero

Inner wing
Design: Airbus (Sotech)
Manuf: Romaero

Plaston
Design: Airbus (Sotech)
Manuf: Romaero

Systems installation
Design: Airbus (Sotech)
Manuf: Airbus

Le Bourget June 2013
Smart Wing manufacturing and assembly scenarios

The manufacturing and assembly of a future Smart Wing is of key relevance for the industrial application.

- Cost of tooling
- Cost of material and manufacturing
- Production ramp up and flexibility of production rate
- Quality of products (tolerances, ...)

Smart Wing Industrial assembly scenarios (Aernnova)

Smart Wing semi-assembly ground transportation (Aernnova)

Current manufacturing of the Smart Wing integrated upper panel (SAAB)
CROR demonstration engine Flying Test Bed

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 Flying Testbed Demonstration (FTB)

CROR design study: interference with HTP

CROR structural integration concept

Bizjet with advanced turbofan and innovative empenage

Airbus A340-600 Flying Test Bed with CROR engine
Green Regional Aircraft
GRA Team
ITD Leaders, Associates and Partners

GRA ITD Leaders

ALENIA AERMACCHI affiliate:
✓ SuperJet International

ROLLS ROYCE affiliate:
✓ Rolls Royce Deutschland
✓ Rolls Royce Corporation

SAFRAN affiliates:
✓ Snecma
✓ Messier-Bugatti-Dowty
✓ Hispano-Suiza

THALES AVIONICS affiliate:
✓ Thales Avionics Electrical System

30 Beneficiaries
A sizeable amount of activities are reserved to Call for Proposals:
✓ 163 Winners, 16 European Countries involved.

GRA Associates

30 Beneficiaries
A sizeable amount of activities are reserved to Call for Proposals:
✓ 163 Winners, 16 European Countries involved.
To demonstrate technologies for future regional aircraft aiming at the reduction of:

- Reduced fuel consumption (CO\textsubscript{2} & NOx reduction)
- External noise reduction
- "Ecolonomic" life cycle

...by interfacing with other Clean Sky technical platforms, using a multidisciplinary approach to integrate, in the Demonstrators of the Green Regional Aircraft, technical solutions from:
General state of play of GRA activities:
LWC Activity Highlights

❖ 2nd Down Selection for Low Weight Configuration Technologies:

**done** (September, 18th 2012)

- Enabling Sensors Technology for SHM
  Sensorised panel instrumented with optical sensors, AU sensors and “wireless system” in the proof machine under buckling load. *(by FhG)*

- Enabling Advanced Multifunctional Composite
  New Composite panel & Thermoplastic panel for Fuselage: Undamaged static compression. *(by ALA)*

- Enabling Advanced Metallic Material and Process
  Metallic (Alu-Li) with 4 J section welded stringers for Upper Wing Panel:
  - Undamaged static Compression
  - Damaged VID + C-Check + NDI + Residual Strength. *(by Air Green)*

- GRA – Trial of manufacturing for outer wing box stiffened panels
  A representative Flat Panel (about 2mx1,3m) manufactured to support feasibility of outer wing box. After fabrication this panel will be destructively evaluated.

- Preparation for PDR for Ground Demonstrators
  A representative small scale tool has been provided to perform test to support feasibility of single piece of barrel. After fabrication small scale single barrel has been destructively evaluated. *(by ALA)*
GRA-2011 Composite panels (ALA)

Tests performed:
- Test 1: Undamaged static compression
- Test 2: BVID, compression fatigue (90,000 cycles), NDI and residual strength
- Test 3: VID, short compression fatigue cycles and C-check and residual strength
- Test 4: Vibro-Acoustic

Failure after Test 1

Failure after Test 3

GRA-2011 Composite + Damping Veil panels (ALA)

Tests performed:
- Test 2: BVID, compression fatigue (90,000 cycles), NDI and residual strength
- Test 4: Vibro-Acoustic

Test in progress:
- Test 6: Hail Impact, tension fatigue (90,000 cycles), NDI and residual strength

Failure after Test 2

Test 4 Transmission Loss - Reverberant room side
Liquid Resin Infusion panels (ALA – SICAMB)

Manufacturing trials before LRI Wing Box full scale demonstrator

Manufacturing trials: 2,0 x 1,3 m - 9 stringers

Manufacturing trials: 3,5 x 1,3 m - 9 stringers
General state of play of GRA activities:

**Ground Demonstrators**

- **PDR for Ground Demonstrators (Fuselage Barrel & Wing Box)** held on December 17th – 18th 2012
  - **Fuselage Ground Demonstrator**
    - The IML (Inboard Manufacturing Liner) and OML (Outboard Manufacturing Liner) Tooling manufacture, under Air Green (Dema) responsibility, is in ongoing.
    - IML tool for One Piece Barrel Demonstrators (OPB) manufactured and delivered to Alenia

- **Wing Box Ground Demonstrator**
  - Final SHM Composite vs Aluminium Lithium trade off performed.
  - Test article is representative of part of internal composite wing box
  - Design for manufacturing in progress: CDR scheduled for September 2013

(prepared by Air Green cluster)
**Cockpit ARCHITECTURE (Conceptual Phase)**

WP 1.5.2: DESIGN BLOCKS

1. STIFFENED SKIN
2. ELECTRICAL STR. NETWORK
3. FRAME 1- PRESSURE BULKHEAD
4. FRAME 2 & 8
5. FRAME 9, 10 & 11
6. DOME STRUCTURE
7. FLOOR BEAMS
8. WINDSHIELD
9. WINDOW CONTOUR
10. ACCESS DOOR & FRAME
11. NLG BOX
12. FLOORS

**STIFFENED SKIN**

**BIRD STRIKE SKIN SENSITIVITY**

**IMPACT ANGLE 15º**

**IMPACT ANGLE 20º**

General state of play of GRA activities:
LWC Activity Highlights
General state of play of GRA activities:
LNC Activity Highlights

- **Aerodynamic Design Optimisation of a Transonic Natural Laminar Flow Wing sized to a Green Regional GTF 130-seat Aircraft** completed

- **Aerodynamic & Aero-Acoustic 2D WTT on Wing / HLD models in INCAS** completed. Measurements Data released.

- **Mechanical Tests on prototypes of SACM** (Smart Actuated Compliant Mechanism) & DESA (Deeply Embedded Smart Actuator) **Morphing Flaps**: performed

- **High-Lift Devices Technologies**
  - **2nd Down-Selection**: done (September 25th- 26th)
Low-Noise Landing Gear Development: MLG Low-Noise Concepts Studies

- **CFD/CAA based low-noise design**
  - Initial activities by CIRA, for the design of a strut fairing, dealing with fluid dynamics numerical analyses of baseline architecture

- Preparatory work (mesh generation) by ONERA for computational analysis of MLG with bay open and partially closed

- Preliminary design by CIRA of acoustic liners applied inside the bay cavity and on the strut
Low-Noise Landing Gear Development: MLG Low-Noise Concepts Studies

Wind Tunnel Basic Aeroacoustic Tests

- First Test Campaign by FhG on a simplified MLG mock-up (gear strut, wheels, belly fairing, door) to assess different noise sources and the effect of low-noise solutions (namely acoustic liners) applied on the bay cavity and doors.

FhG IBP LABORATORY - STUTTGART
WT AERO-ACOUSTIC FACILITY

BEAMFORMING TECHNIQUE
NOISE SOURCES LOCALIZATION

BAY CLOSED  ≈ -3 dBA  BAY OPEN
General state of play of GRA activities

E-ECS for Regional Aircraft In-Flight Demonstration: Pack installation

- E-ECS pack will be installed in the RH pack bay replacing the existing pneumatic pack.
- LH Pneumatic Pack will perform essential functions for SoF

E-ECS pack will have four pneumatic interfaces:

- New interfaces
  - Scoop inlet: a new intake suited to the expected performances will be designed to target high recovery factor (>0.8)
- Existing interfaces
  - Pack discharge (modified distribution)
  - Ram Air inlet
  - Ram Air Outlet
General state of play of GRA activities:

MTM Activity Highlights

- The GRA flight simulator status:
  - Configuration:
    - Avionics, configuration, aerodynamic models is representative of ATR aircraft;
    - By end of this year is planned to target GRA TP90 pax configuration
  - Green FMS (Thales) (1st release) integration started in Dec ’12 and almost completed;
  - ATM scenario (UniBO) (first test case: Torino – Roma Fiumicino): under test;
  - Advanced GPS (ref. CfP ADAVES): integrated and tested;
  - Advanced Communication model (ELSIS): tests on going; new SW model (to fix possible problems) by end of 2013.
Sustainable and Green Engine
SAGE (Sustainable And Green Engines)

6 demonstrators with evolutionary and revolutionary technologies with challenging environmental objective

Main Members and Affiliates: Rolls Royce plc, Rolls Royce Deutschland, SNECMA, MTU, Turbomeca, Volvo, AVIO, ITP, ...

Total budget > 420 M€

www.cleansky.eu
Contra-Rotating Open Rotor – Concept Challenges

- Noise & Vibration
- Propellers Pitch Change Control
- A/C Installation and wake interaction
- Protective Air Intake
- Counter-rotating propellers, noise optimised
- De-icing
- Rotating Nacelle Parts
- Operability & Power Management
- Power gearbox
- Communications via rotating systems
- Power Turbine
- Certificability & Reliability

First ground test before end 2015

www.cleansky.eu
Large 3 shaft Engine – Concept Challenges

Technologies for lightweight, efficient intercase structures

Composite fan case

Composite fan blades

Novel intake with optimised aero and acoustic liners

Intake optimised to composite fan system

Advanced integrated dressings

Lightweight annulus fillers

Advanced sealing technologies

Lightweight, high efficiency LPT

Improved controls heat management

Technologies for lightweight, efficient intercase structures

www.cleansky.eu
SAGE: Next plans and demonstrations

Contra-Rotating Open Rotor
- Propeller Design
- Pitch change mechanism
- Gear Box
- Rotating structure

Q4/2015

Advanced Geared Turbofan Demonstrator
New highly efficient HP-Compressor
- Light weight high speed Low-Pressure Turbine
- Advanced light weight and efficient Turbine Structures
- Light weight and reliable Fan Drive Gear System
- New systems for a more electric engine

Q4/2013

Large Three-shaft Engine Demonstrator
Lightweight fan system
- Advanced external engine components and accessories
- Advanced ‘inter-case’ structures
- Lightweight and efficient Low-Pressure Turbine

Q2/2013
Systems for Green Operations
Management of Aircraft Energy (MAE) aims at developing electrical system technologies and energy management functions to reduce aircraft fuel consumption through:

- Development of more-electrical system architectures and equipment
- Validation and maturation of electrical technologies by large scale ground and flight demonstrations

**SGO Technology Development & Validation of Electrical Aircraft Systems**

- Electrical Equipment
- Thermal Management Equipment
- Load Management Functions

**Stakeholders**

- Airbus
- Alenia Aermacchi
- Diehl Aerospace
- EADS
- EADS UK
- DLR
- GSAF
- LIEBHERR
- Rolls-Royce
- Saab
- SAFRAN
- Zodiac Aerospace
- Fraunhofer
MAE developments for Large Aircraft

- Electrical ECS
- Electrical WIPS
- Engine Nacelle Sys
- Electrical Power Center
- Wiring System
- Skin HX
- Load Management
- Vapour Cycle cooling system
- Generators
- Ice Detection
- Clean Sky
MAE developments for Regional Aircraft

Electrical WIPS

Electrical ECS

Electrical Architecture Optimization Tool

Generators

Delivery to Green Regional Aircraft
MAE developments for Rotorcraft

Delivery to GRC ITD
MAE developments for Business Aircrafts

Delivery to EDS ITD (Systems)
SGO – Flight test demonstrations on Airbus A320 (2015)
Eco Design
GENERAL ACARE OBJECTIVES

- 80% cut in NOx emissions
- Halving perceived aircraft noise
- 50% cut in CO2 emissions per pass-Km by drastic fuel consumption reduction
- A green design, manufacturing, maintenance and disposal product life cycle

ECO-DESIGN ITD
EDA – Airframe
EDS – Systems
Eco-Design for Airframe Technical Areas

General objectives: Eco-Design and Green Manufacturing

www.cleansky.eu
EDA Technical Overview
Technology Selection

State of the art

“Clustering” and downsizing

235 technologies

Scoping

Trade-off based on a scoring

157 Remaining technologies

110 selected technologies

Technology Development

2010

2011–2012–2013

Technologies
Materials
Products/Parts

www.cleansky.eu
EDA Technical Overview
Demonstration

10 Airframe Demonstrators

Light Alloys / Green metallics

Metallic alloys, processes and surface treatments

Low Energy Curing

Mg alloys

Panel A
Panel geometry:
Length: 40" – 80"
Radius (OML): 1100mm (43.3")

Panel B

Panel C

Panel D

Low Energy Curing

TP a/c structures

Low Energy Curing

www.cleansky.eu
EDA Technical Overview Demonstration

2 cabin interior demonstrators

- Green PU foams for seating
- Biocomposites for cabin interior applications

6 Equipment demonstrators

- Metallic alloys, processes and surface treatments
- Biocomposites for cabin interior applications
- Composites for high temperatures
- Materials for electronics
- www.cleansky.eu