



Clean Sky

Une Entreprise commune européenne

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Académie de l'Air et de l'Espace
Modane, 19 septembre 2012

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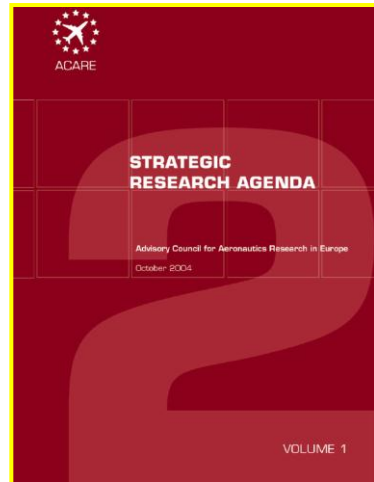
Clean Sky Background: The ACARE Vision 2020

February 2008
Take-Off

Clean Sky
Preparation



October 2004
SRA-2



October 2002
SRA-1



June 2000
Vision 2020



Flightpath
2050



ACARE and environment

Vision 2020 (January 2001)

- To meet Society's needs
- To achieve global leadership for Europe

ACARE

October 2002 : The Strategic Research Agenda (SRA) → 5 Challenges

Quality and
Affordability

Environment

Safety

Air Transport
System Efficiency

Security

October 2004 : The SRA 2 → High level Target Concepts

Very Low
Cost ATS

Ultra Green
ATS

Highly
Customer
oriented ATS

Highly time-
efficient ATS

Ultra Secure
ATS

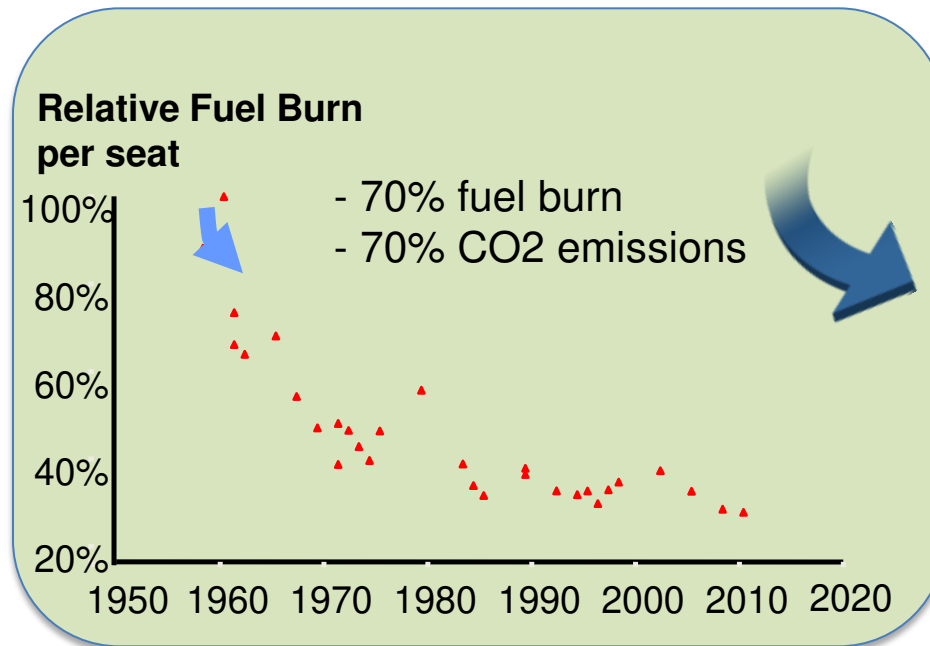
22nd
Century

- 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



Achievements

In the last 40 years, commercial aviation industry has achieved:



Drastic improvements achieved thanks to technology developments



Unique Public-Private-Partnership in Aeronautics



A Joint Technological Initiative



Europe's largest Aeronautics Research Programme ever

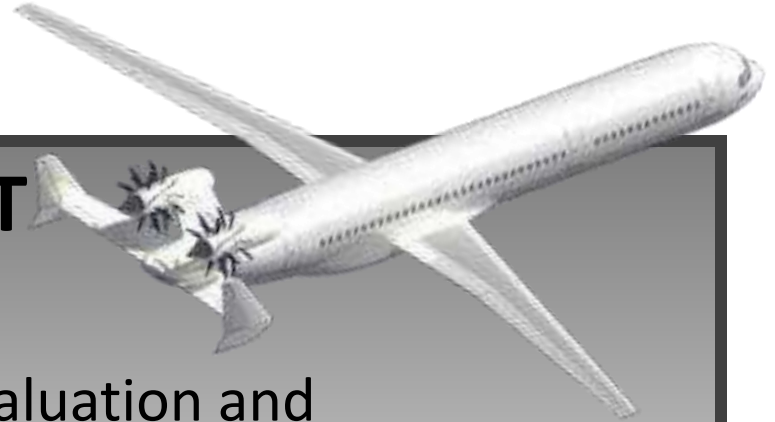
- €1.6B value, split 50/50 between the Commission (cash) and Clean Sky members and partners (in kind)
- Start February 2008; running up to 2017



Unique Public-Private-Partnership in Aeronautics

A new way of delivering R&T

- Downstream approach
- Large scale and complex testing, evaluation and demonstration
- Integrated, thematic set-up, led by the Prime Contractors
- Open Calls for engaging partners



Integrated Program Structure



Clean Sky Technology Evaluator

DLR & Thales

Concept

Aircraft

Eco-Design

Dassault & Fraunhofer

Smart Fixed Wing Aircraft

Airbus & SAAB

Green Regional Aircraft

Alenia & EADS-CASA

Green Rotorcraft

Eurocopter & AgustaWestland

Systems for Green Operations

Thales & Liebherr

Sustainable and Green Engines

Rolls-Royce & Safran

TECHNOLOGIES & DEMONSTRATORS

Environmental objectives, 2007 reference (Programme Proposal)

Programme	Smart Fixed Wing Aircraft	Green Regional	Green Rotorcraft	Sustainable & Green Engines	Systems for Green Operations	Enn Decision
Activities	Active Wing New Aircraft Configurations	Advanced Aerodynamics (Low Drag & Noise) Low Weight Structures	New Powerplants Innovative Blades & Rotors New Aircraft Configurations	Advanced L/E/HP System Technology New Engine Concepts (i.e. Open Rotor)	Mission & Trajectory Management Aircraft Energy Management	Whole Life Cycle Green Materials Environmental Impact Analysis
Targets	CO ₂ ~12 to 20% Noise ~10dB	CO ₂ ~10 to 20% Noise ~10dB	CO ₂ ~26 to 40% NO _x ~53 to 65% Noise ~10dB	CO ₂ ~15 to 20% NO _x ~60% Noise ~18dB	CO ₂ ~10 to 15% Noise ~9dB	CO ₂ ~10%

Wide body 2020



CO₂ -30%
NO_x -60%
Noise -20dB

Narrowbody 2015



CO₂ -20%
NO_x -60%
Noise -15dB

Regional 2020



CO₂ -40%
NO_x -60%
Noise -20dB

Corporate 2020



CO₂ -30%
NO_x -30%
Noise -10dB

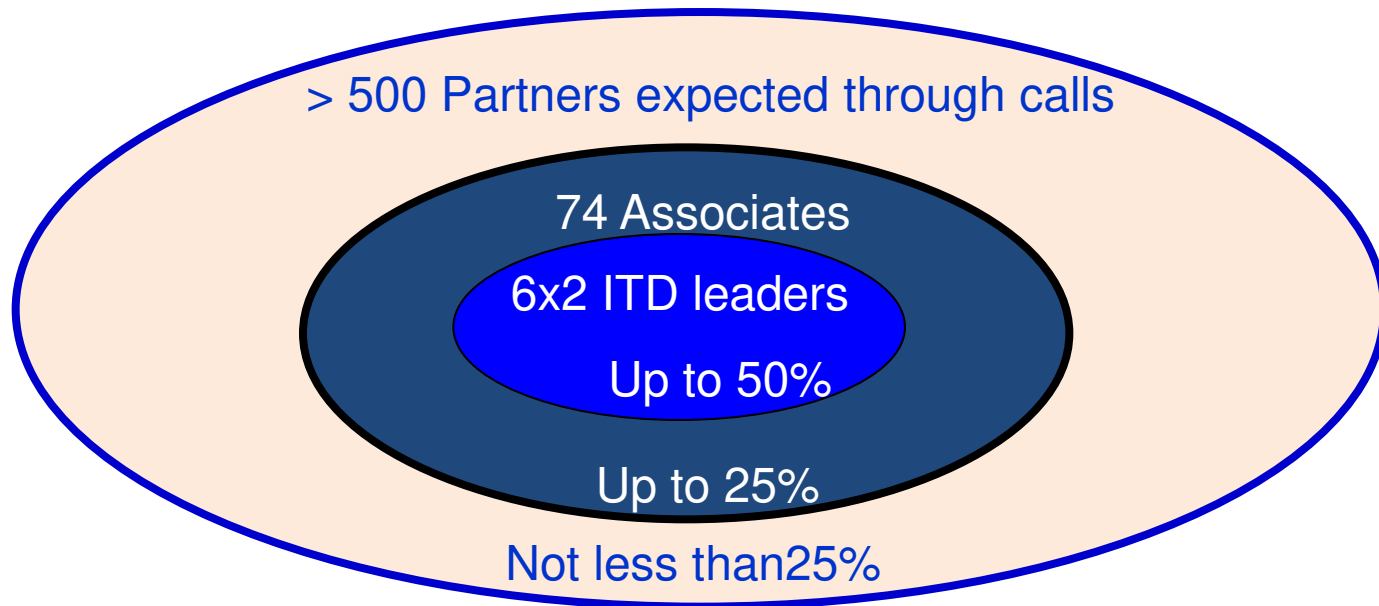
Rotorcraft 2020



CO₂ -30%
NO_x -60%
Noise -10dB



Clean Sky involves a broad and open participation



Example: Smart Fixed Wing Aircraft Members

393M€ Total Budget

„ITD-leaders“

Associate Partners

- Airbus
- SAAB
- Dassault
- EADS-CASA
- Alenia
- Thales
- Liebherr
- Fraunhofer
- SAFRAN
- Rolls-Royce

50% of Total Budget

- ❖ DLR
- ❖ ONERA
- ❖ INCAS
- ❖ NL-Cluster
- ❖ QinetiQ
- ❖ RUAG
- ❖ **2nd Call AP**

25% of Total Budget

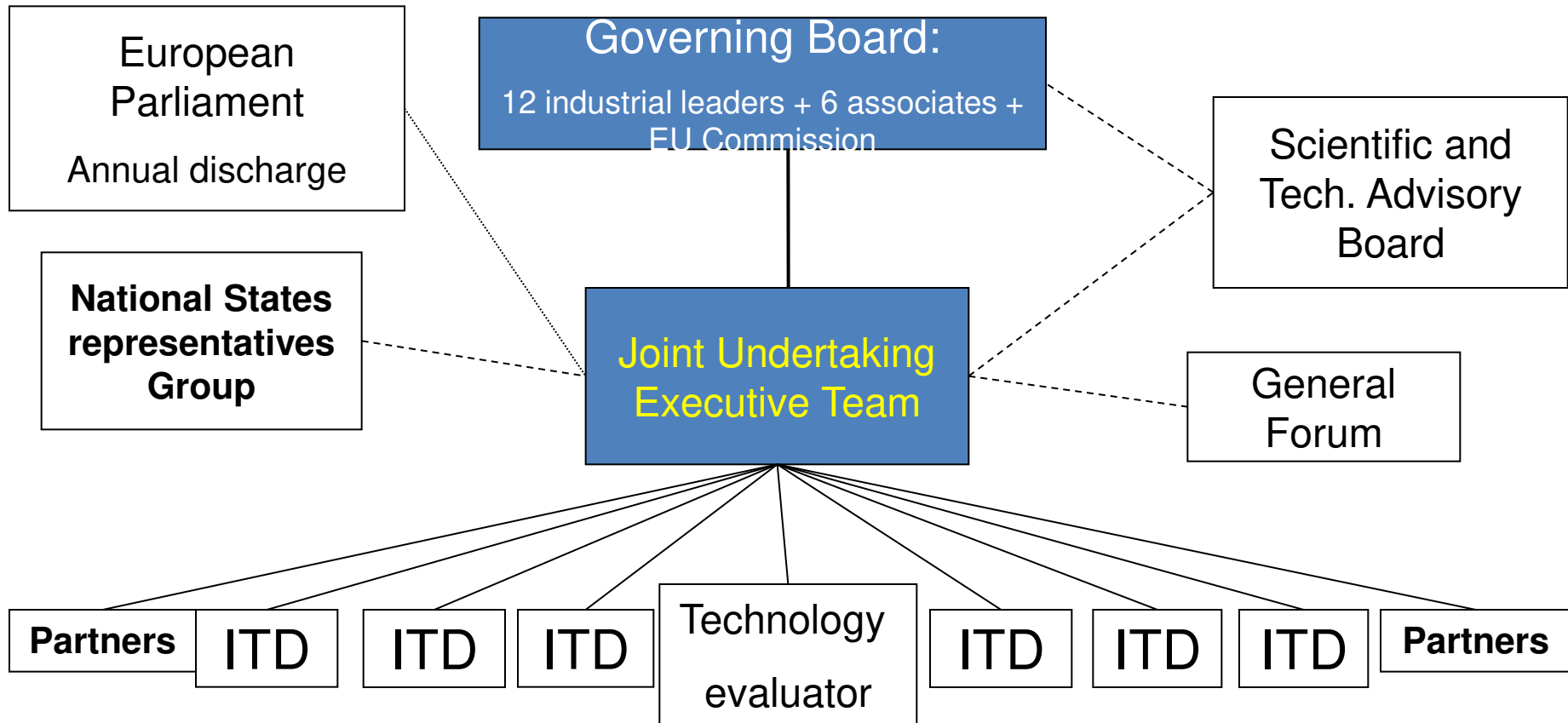
Partners

Partner participation based on Call for Proposals

25% of Total Budget

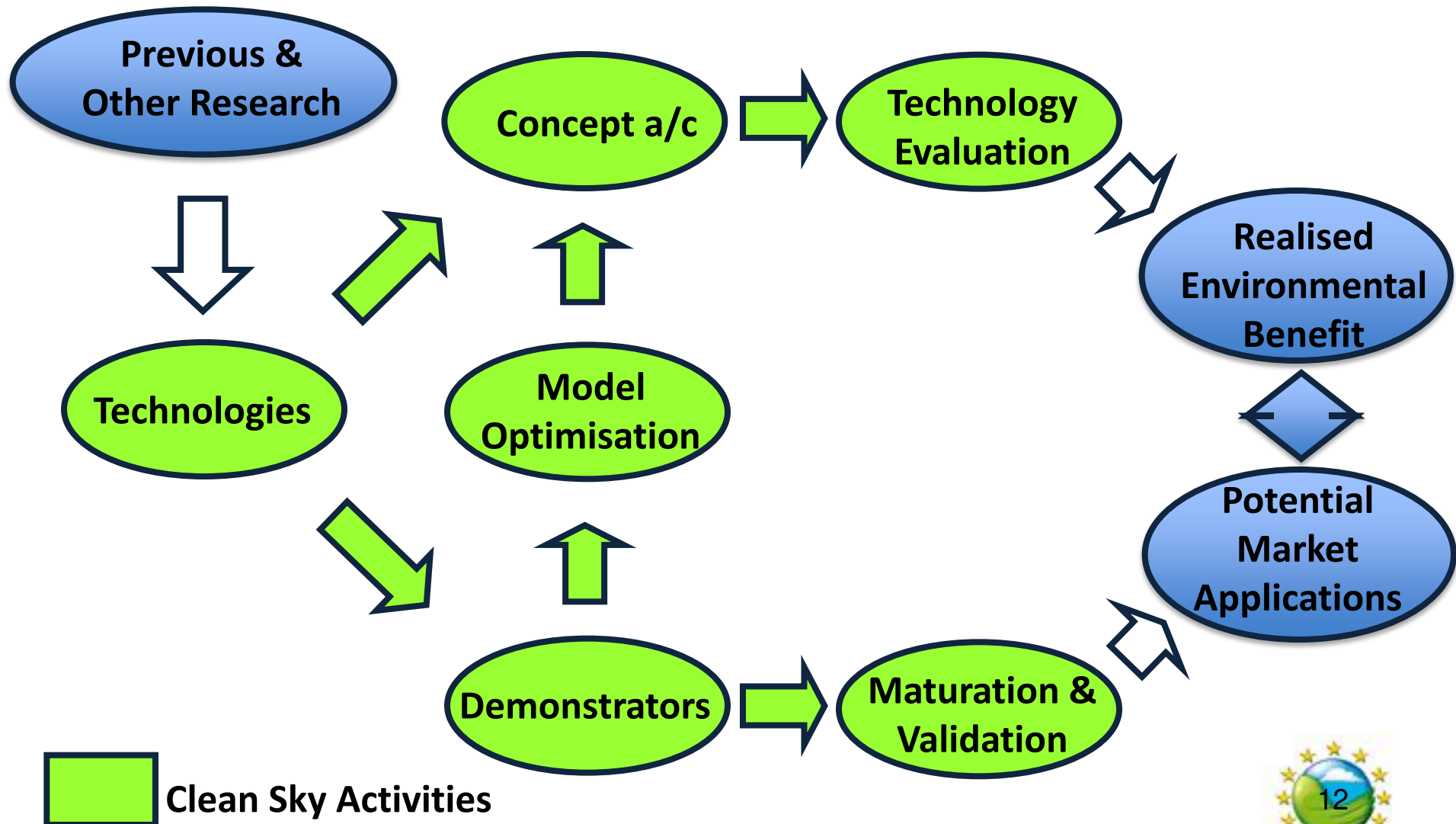


Governance



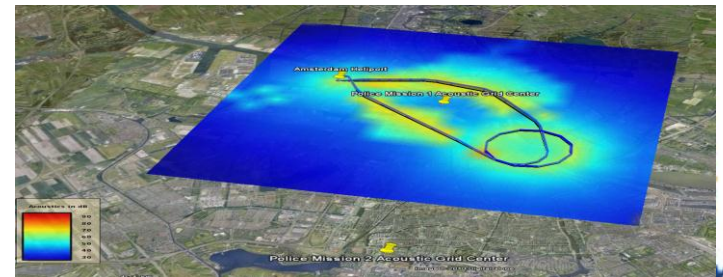
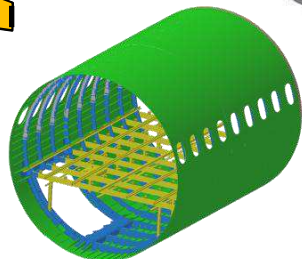
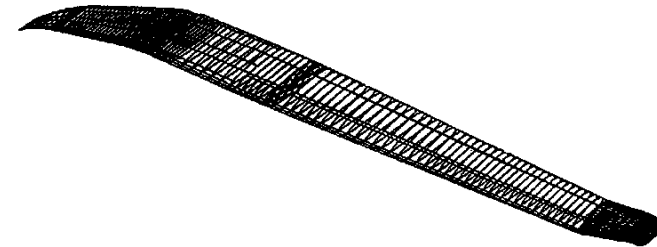
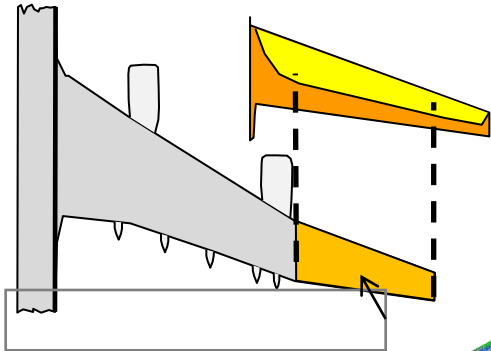
ITD: integrated Technology Demonstrator

Development, Demonstration, Evaluation



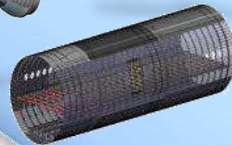
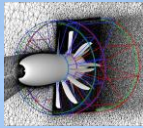
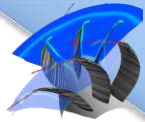
Technology streams

- Aerodynamics
- Advanced Materials and structures
- Propulsion
- On-board energy
- Trajectory



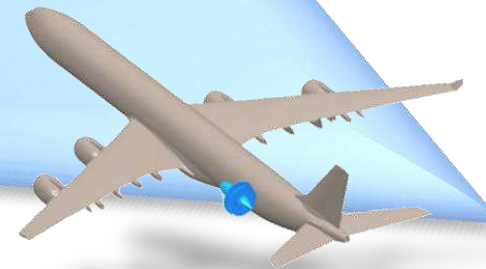
Progressing from Technology to Demonstration

Design Studies, Rig
Testing, Modelling



Engine / System
Demonstrators

Flying
Demonstrators



Risk Reduction

BLADE – Major Laminar Flow Demonstration



Q4/2014

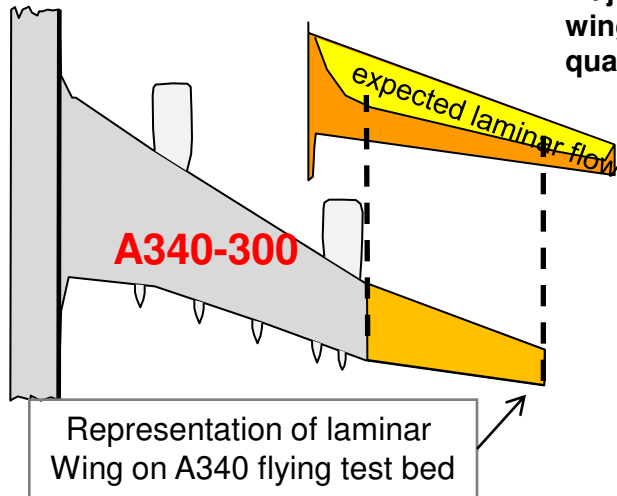
Natural Laminar Flow Wing Flying Testbed

- Advanced passive laminar flow 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 Kruger high lift device

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Natural Laminar flow



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

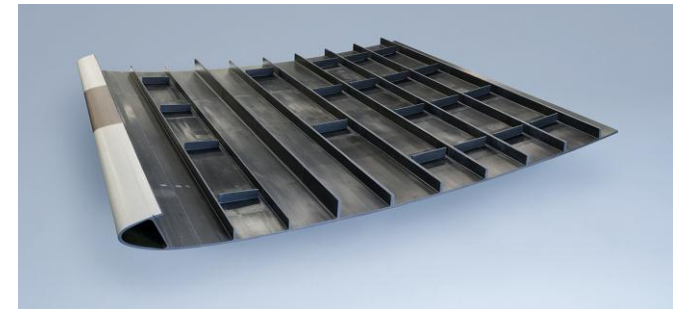
- No steps or steps with very limited step height
- Reduced waviness (either from manufacturing or deformation under cruise loads)
- Avoidance of any 3D disturbances (by insects or fasteners)
- Reduced roughness at the leading edge (either from manufacturing or erosion under operational conditions)



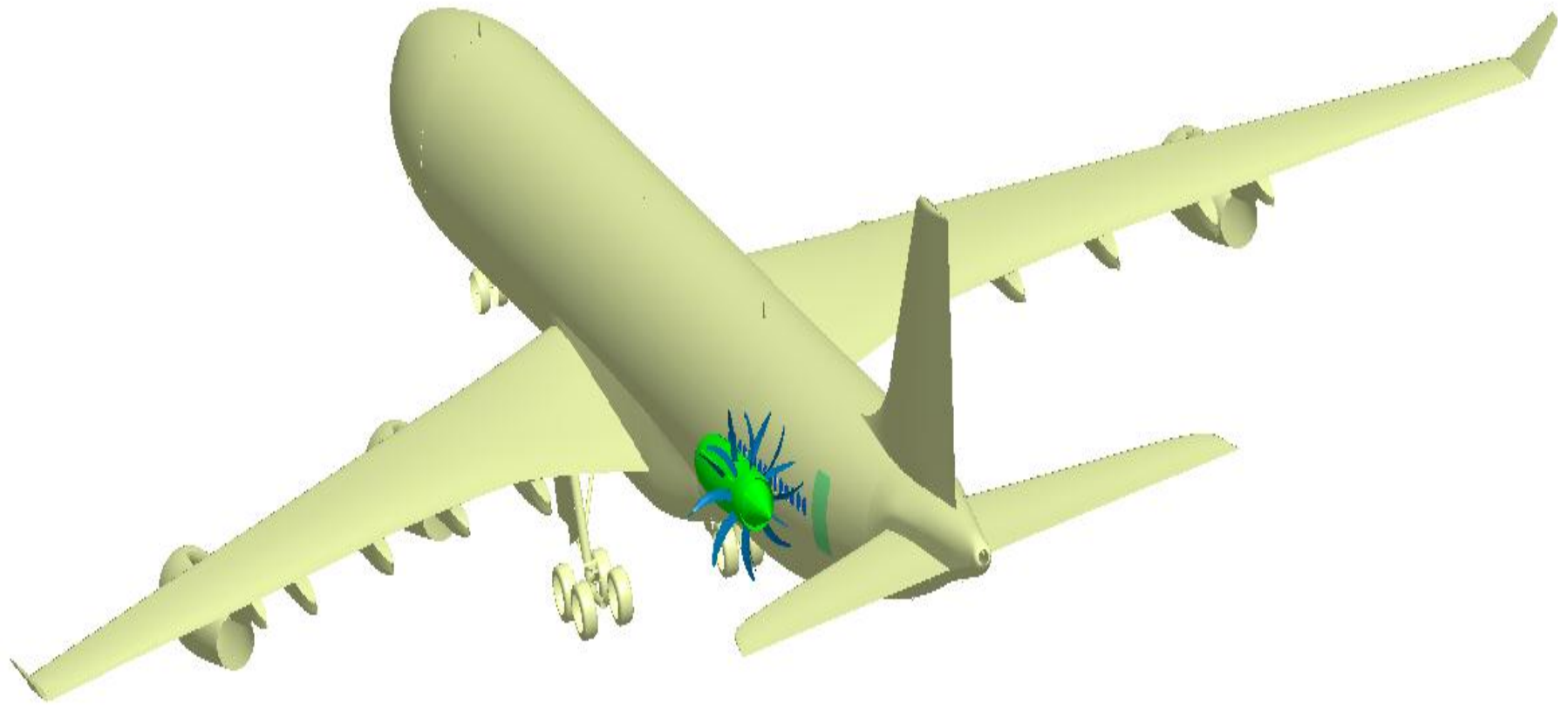
North American P-51 Mustang (1941). A laminar air foil was used at the design of the wings...



A test/trial panel manufactured and being used for several purposes, i.e. evaluation design concepts, tooling, surface measurement etc.



OPEN ROTOR Propulsion Demonstration



Q4/2016

CROR Flying Test Bed

- New propeller design
- Engine - Pylon – Aircraft integration concept
- New CROR - Engine Integration technology
- Advanced CROR aero-acoustic design

Other Large aircraft / bizjets Technology Demonstrators

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.

1. **Smart Flap large scale ground demo** / [DA Falcon type Bizjet trailing edge](#)
2. **Low Speed Vibration Control Flight Test Demonstration** [DA Falcon F7X](#)



Long Term Technology Flight Demonstrator

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

In Service Transport Aircraft

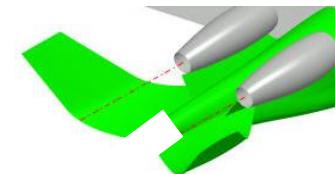
Airbus A300 "Beluga"



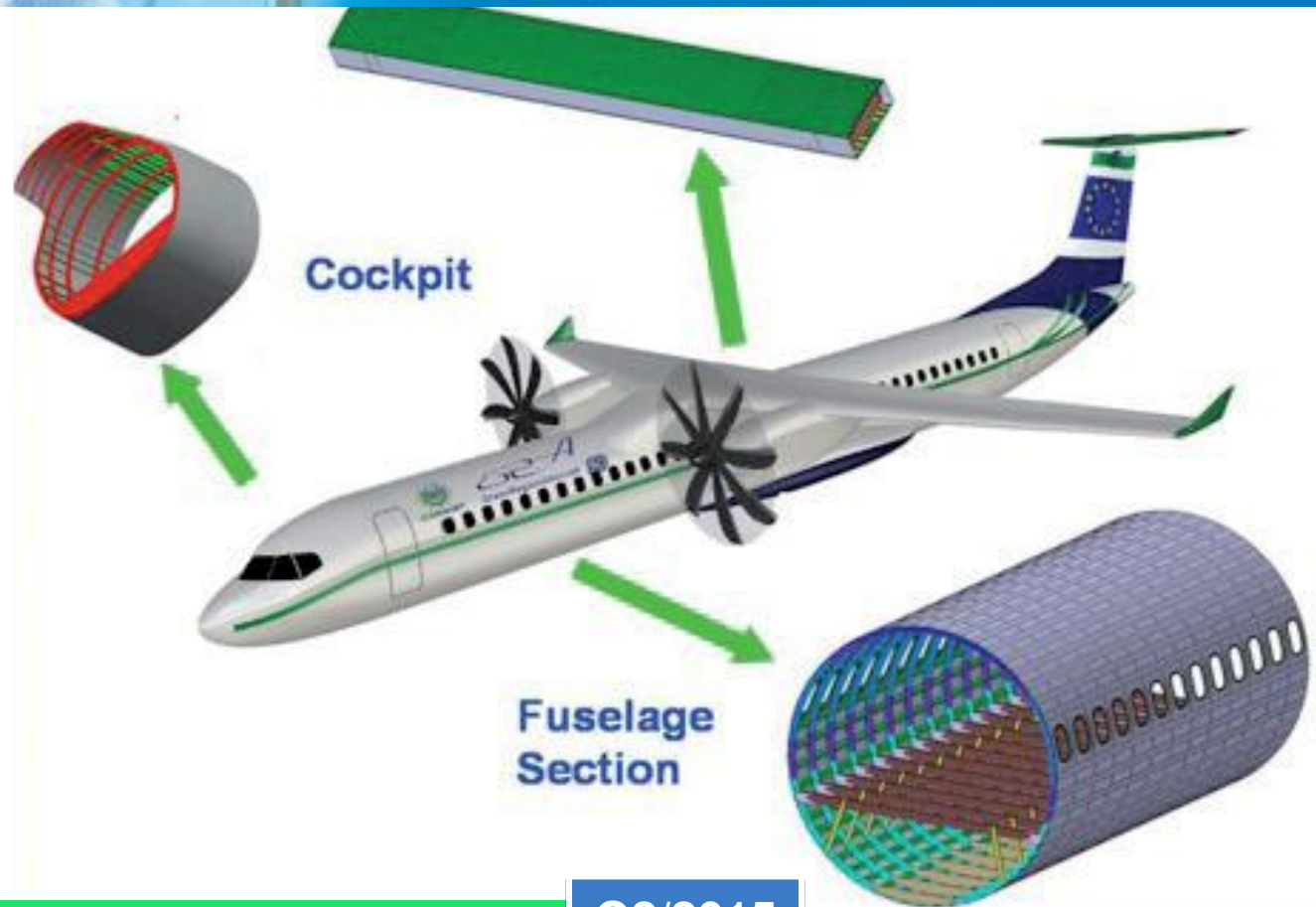
Innovative Empenage Ground Demonstrator

Objective: Validation of a structural rear empennage concept for noise shielding engine integration on business jets

SFWA design



Composite structures for regional aircraft



Q2/2015

Next Generation Regional Aircraft:

Full-scale Static and Fatigue Testing

- Advanced Al-Li structures and processes
- Multi-functional composite materials

Regional aircraft multi-layer materials

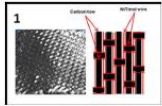


Figure 1 NiTiNiol knitted fabrics

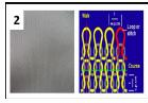
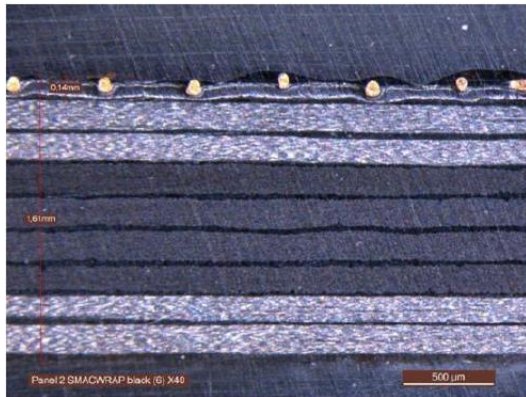


Figure 2 Hybrid Carbon/NiTiNiol woven textiles

Investigation regarding an improvement of impact resistance

Improvement of aero-acoustics properties



Panel2 SMACWRAP black (C) X40



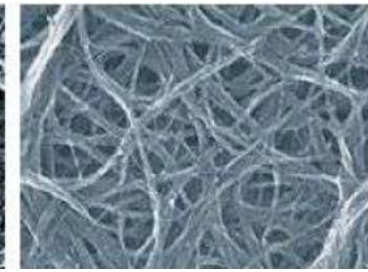
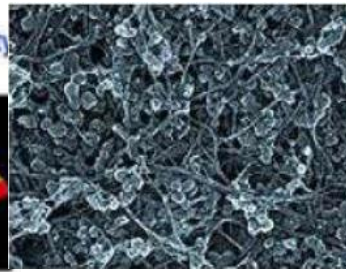
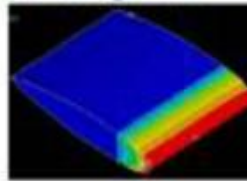
SHM (Structural Health Monitoring)

De-icing

Thermal conductivity due to layer modified by “nano-particles”



Heating power density and configuration



In-flight Demonstrator



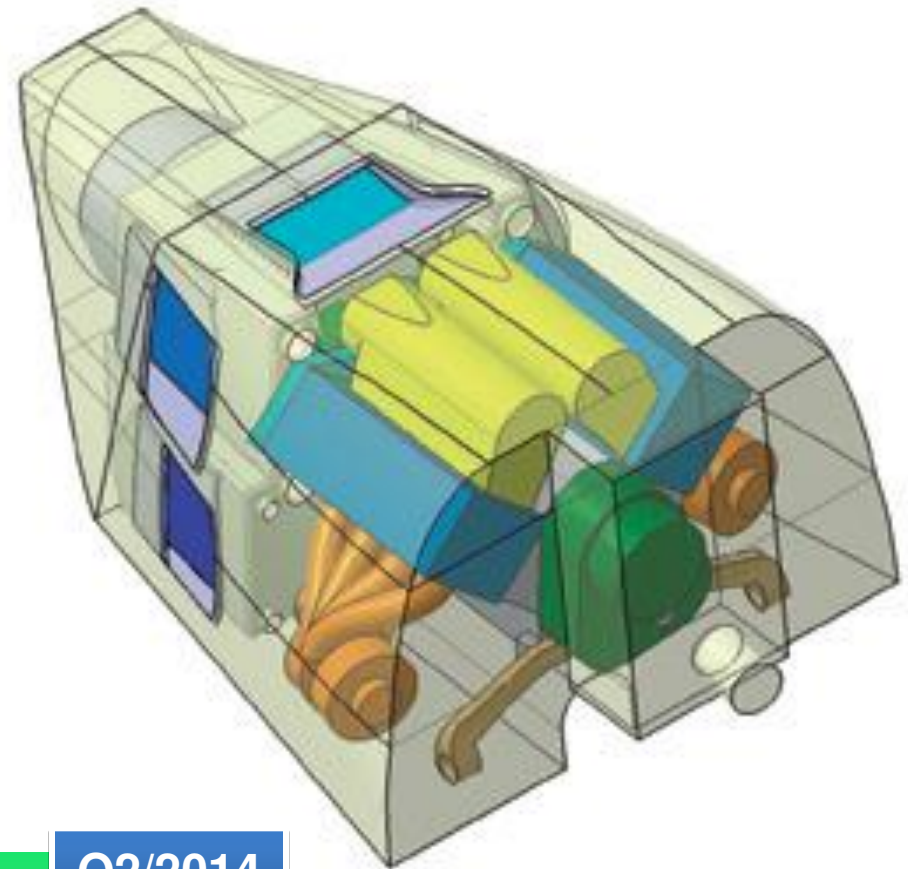
Q3/2015

Next Generation Regional Aircraft

Advanced Metallic & Composite Structure

- Structural Health Monitoring
- Electrical ECS
- Hybrid Wing Ice Protection System
- More-electric technologies and power management for regional

Diesel Engine for Light Rotorcraft

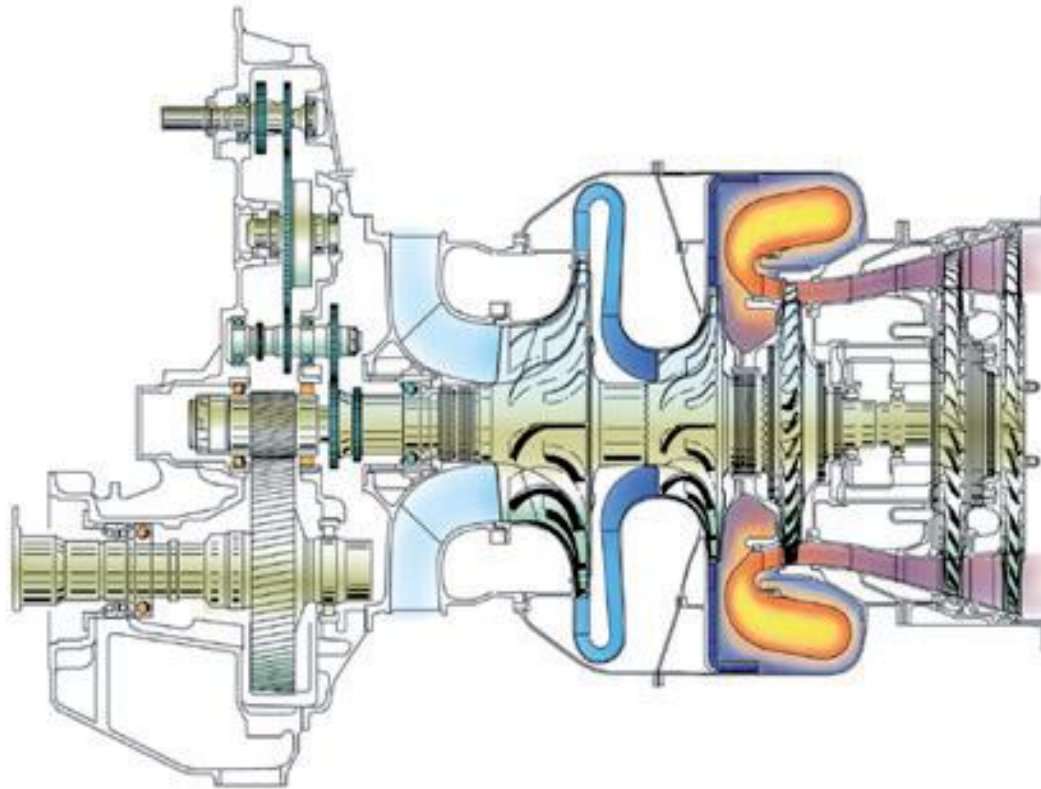


Diesel Demonstrator (Light Single Engine Rotorcraft)

- Diesel core engine
- Power pack integration

Q2/2014

Advanced Turboshaft Engine



Advanced Turboshaft Demonstrator

- High efficiency compressor and combustion chamber,
- Next Generation high- and low-pressure turbines
- Full scale & life cycle validation

Q1/2013

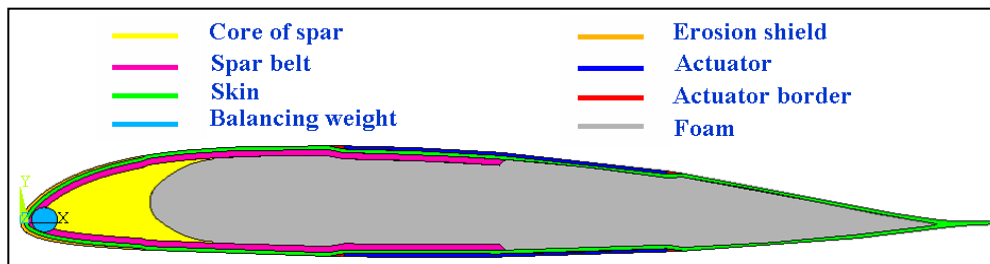
Rotorcraft morphing Blades

Objectives:

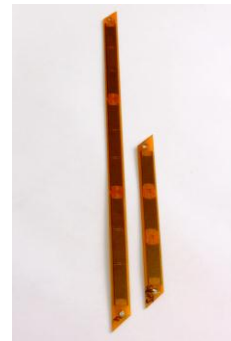
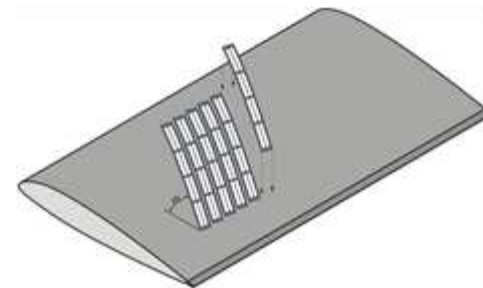
- reducing power consumption (i.e power requirement) by increasing lift during certain flight conditions
- decreasing perceived noise level mainly during take-off and landing

Technologies and solutions envisaged:

- ▶ Active Twist rotor system for power and noise reduction



Active blade deformation e.g. active twist

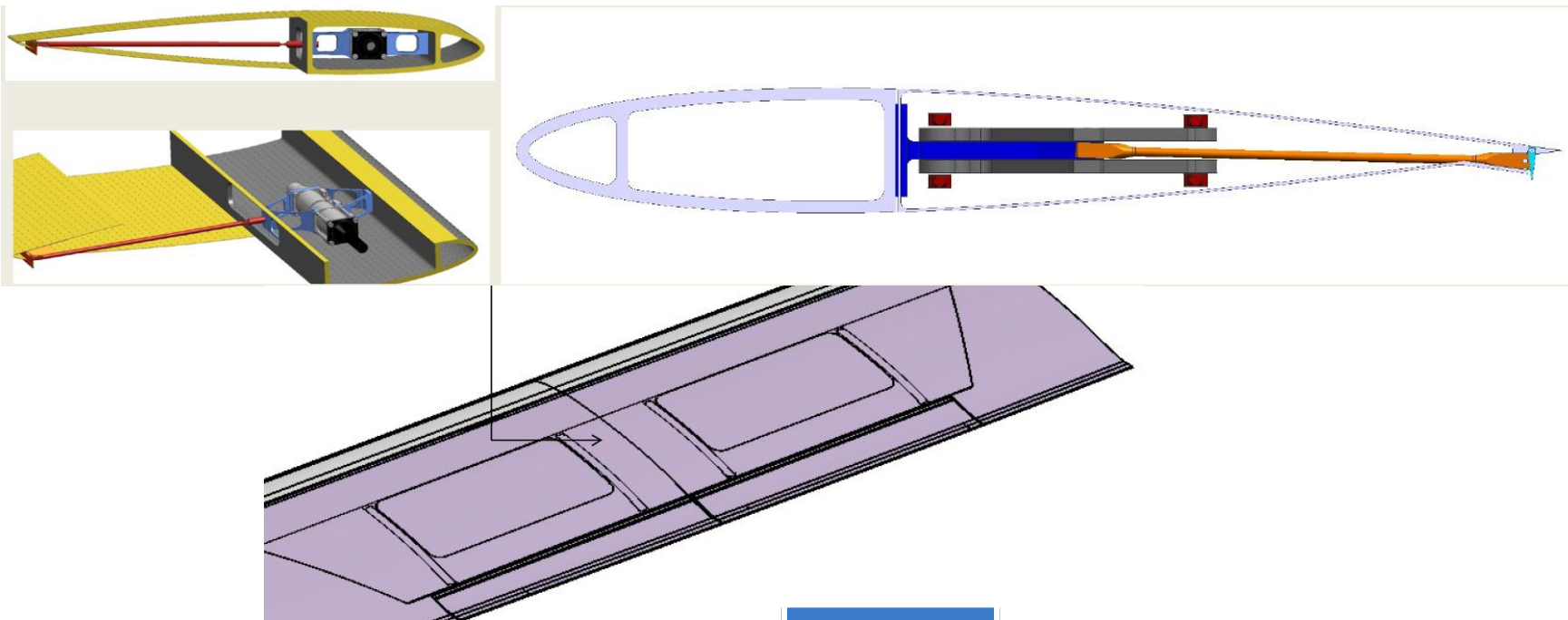


multilayer piezo-composites arrays into an active rotor blade

Rotorcraft morphing blades

Technologies and solutions envisaged(con't)

- ▶ **Active Gurney Flap** rotor systems for reduction of main rotor noise and power requirements



Innovative Rotor blades:

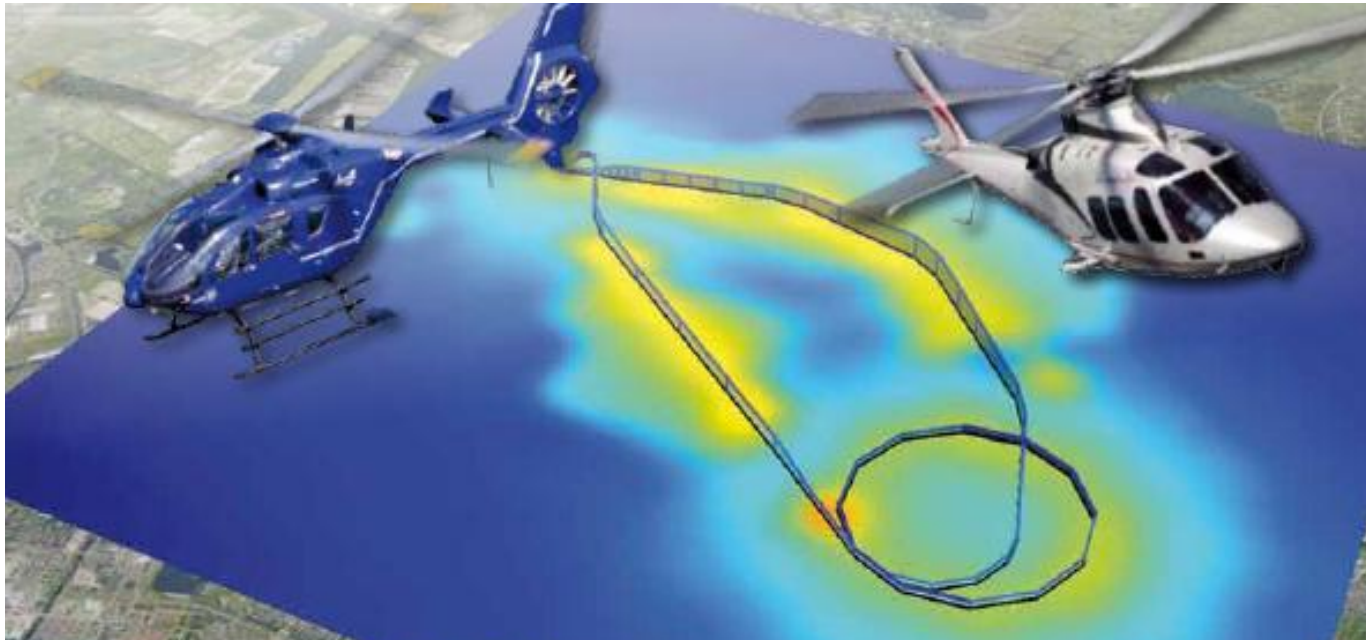
- Active twist blade
- Gurney flap rotor

Q2/2015

3D blade profile optimised for dual speed rotor

- Shape optimisation and flow separation control devices for drag reduction

Mission and Trajectory Management



Systems for flight path optimisation

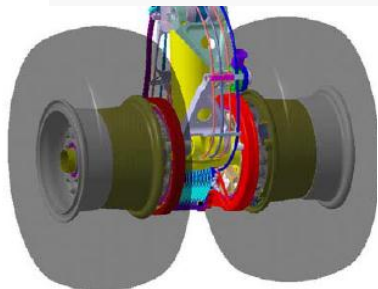
- Rotorcraft
- Aircraft
- Underpinning and complementing SESAR

Q1/2015

Towards All Electric Aircraft

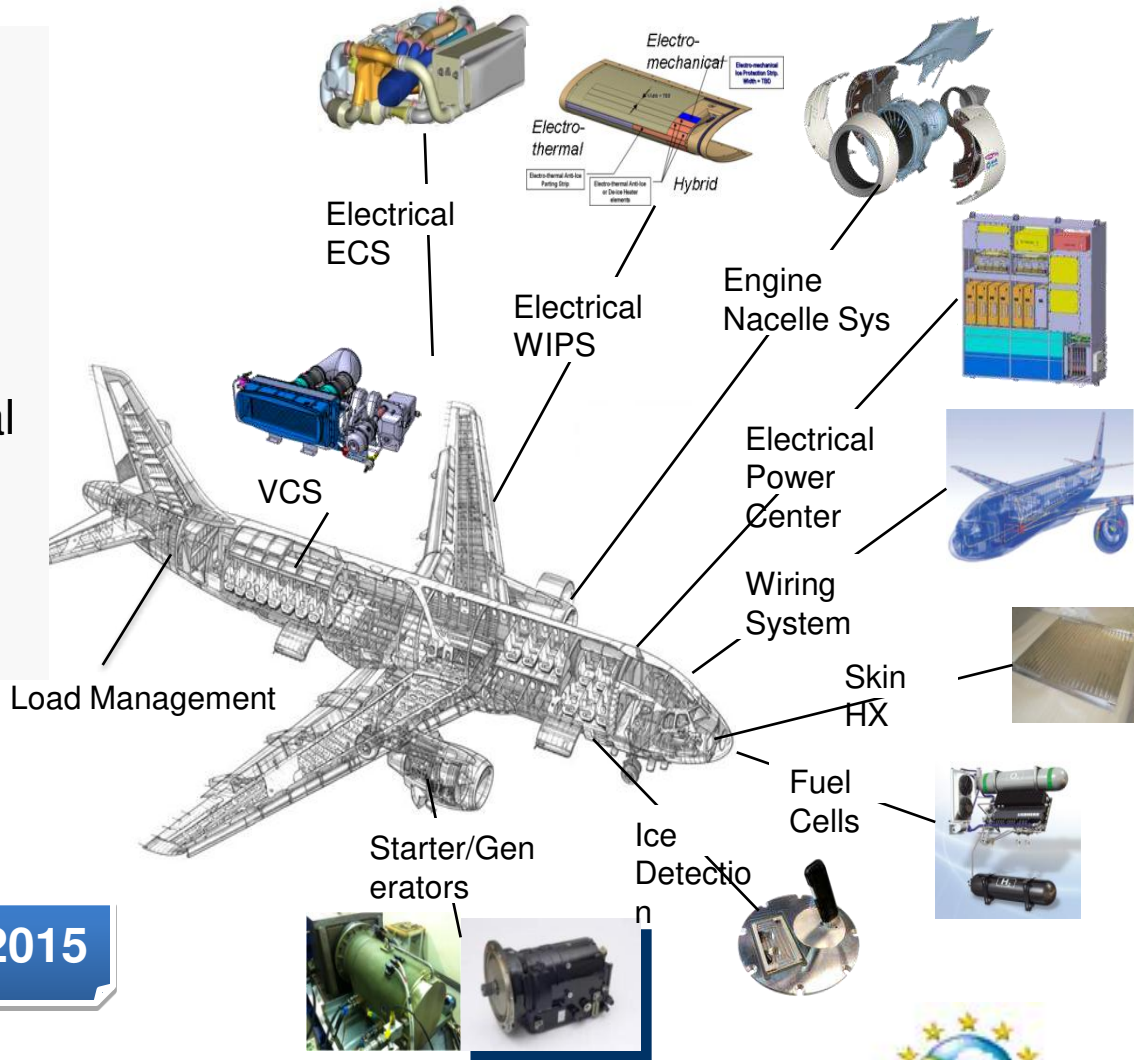
Towards . . .

- Bleed less engine with reduced emissions
- Single source of energy
- Mutualized resources
- Integrated thermal & electrical energy management
- Components: higher kW/kg, more modular, integrated intelligence



And green taxiing

Q1/2015

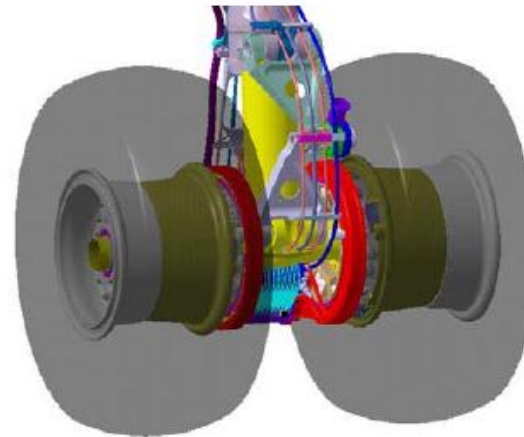


- Architecture development
- Component development

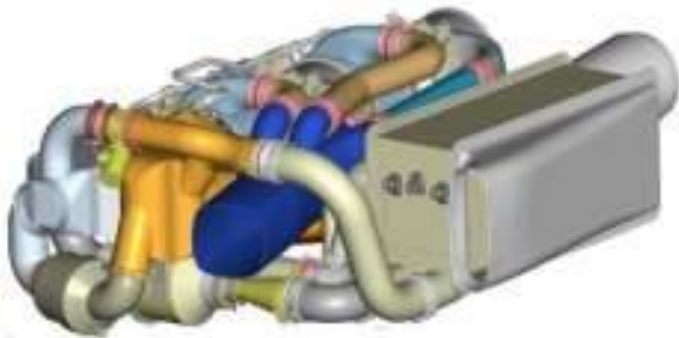
Green taxiing

Development of a fully integrated electric motor in main landing gear

- Up to 4% fuel saving for short-range
- TRL5 target end 2014



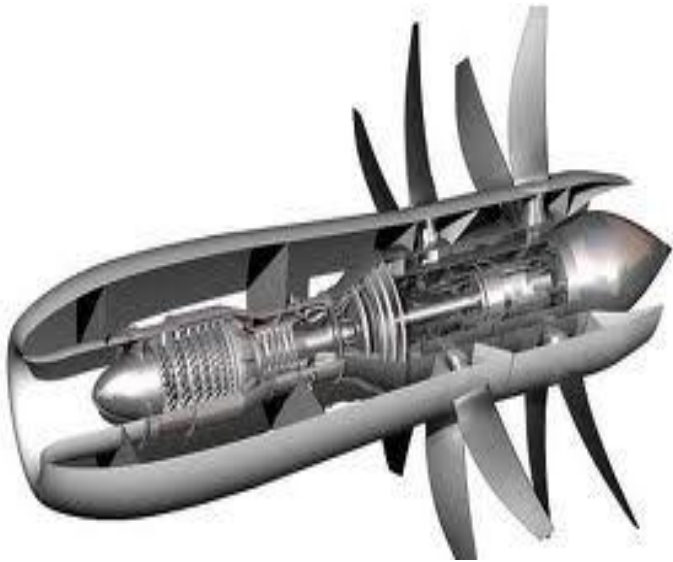
Technologies Demonstration for *All-Electric Architectures*



- Environmental Control Systems
- Electrical Actuation
- Nacelle-based systems
- Anti-ice
- Electrical wheel Drive/Taxiing
- Rotorcraft: Electrical Main Rotor Actuators
- Rotorcraft: Electrical Tail Rotor

Q3/2015

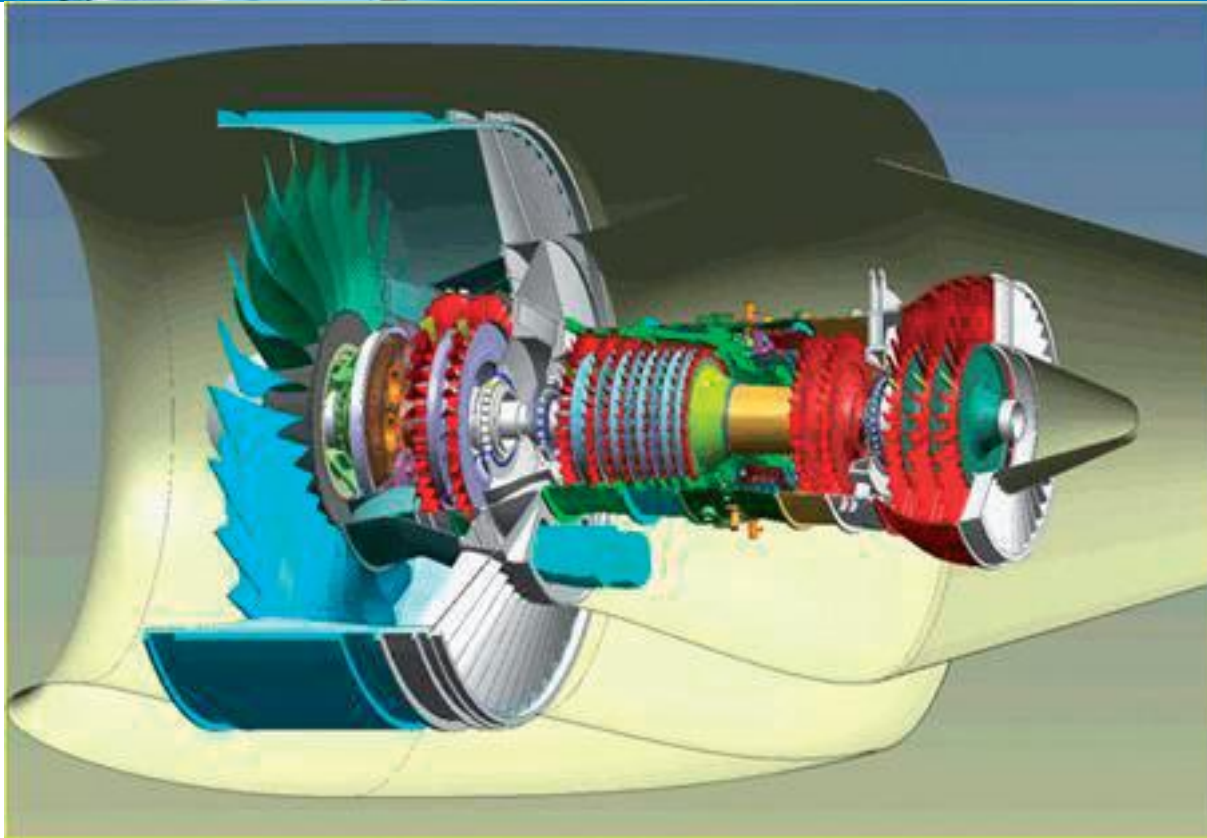
Counter-Rotating Open Rotor Ground Demonstrator



Contra-Rotating Open Rotor

- Propeller Design
- Pitch change mechanism
- Gear Box
- Rotating structure

Advanced Geared Turbofan Demonstrator



Q4/2013

- 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

Large Three-shaft Engine Demonstrator



Q3/2015

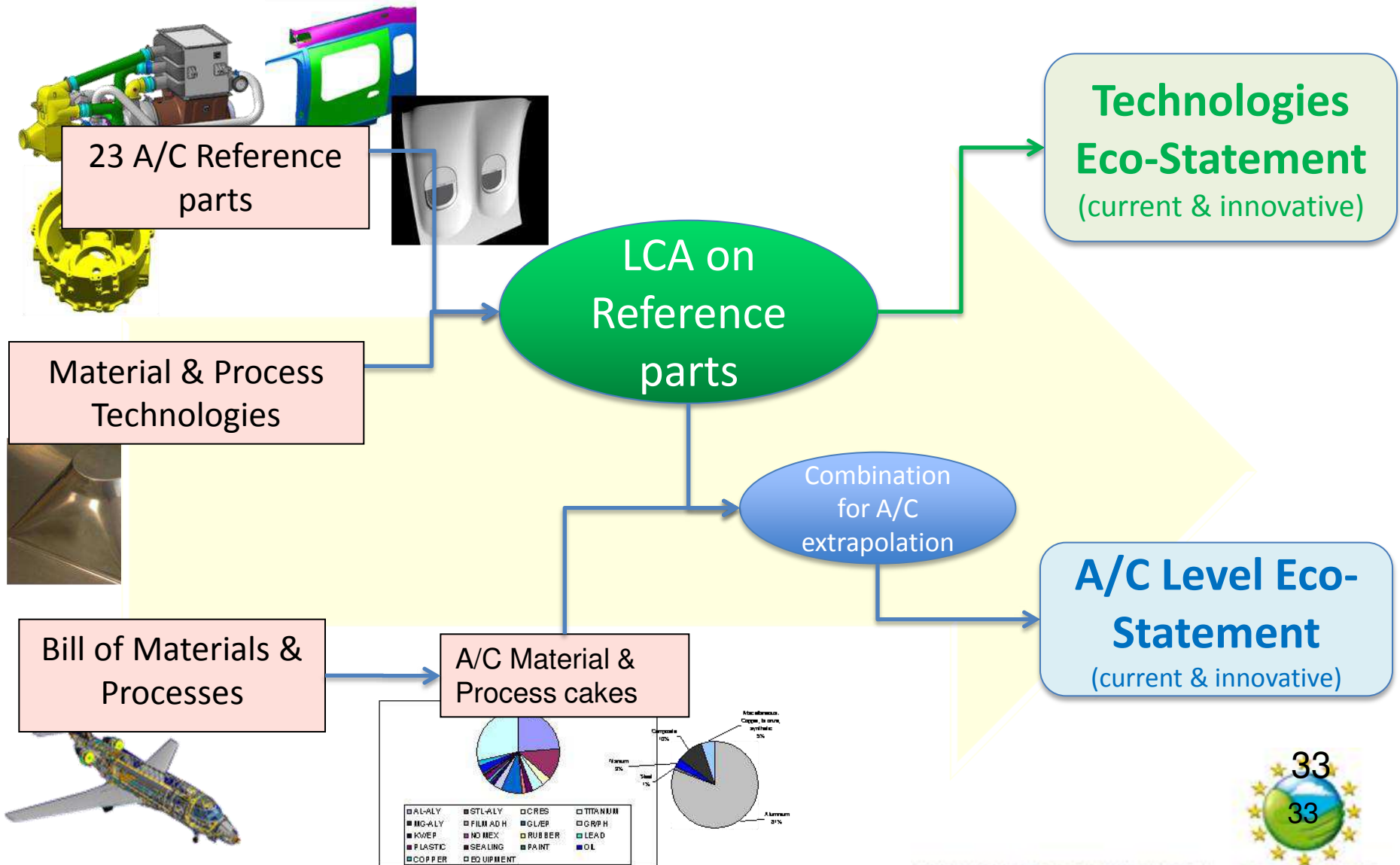
Next Generation Regional Aircraft
Advanced Metallic & Composite Structure

- Structural Health Monitoring
- Electrical ECS
- Hybrid Wing Ice Protection System
- More-electric technologies and power management for regional

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Life cycle assessment (Eco-Design)



Concept Aircraft

Integrating the technologies and enabling the assessment

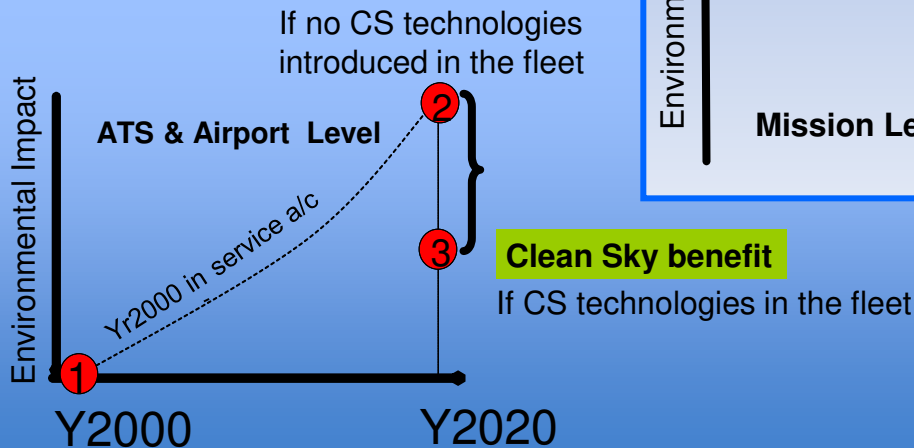
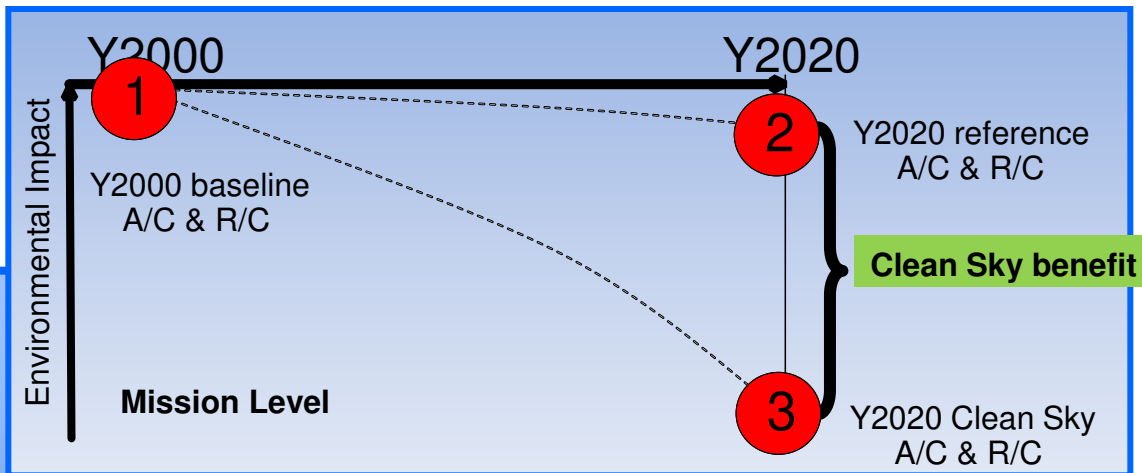
- at aircraft (mission) level
- at airport level
- at air transport system level



Concept Aircraft – enabling the TE to assess the Programme’s environmental benefits

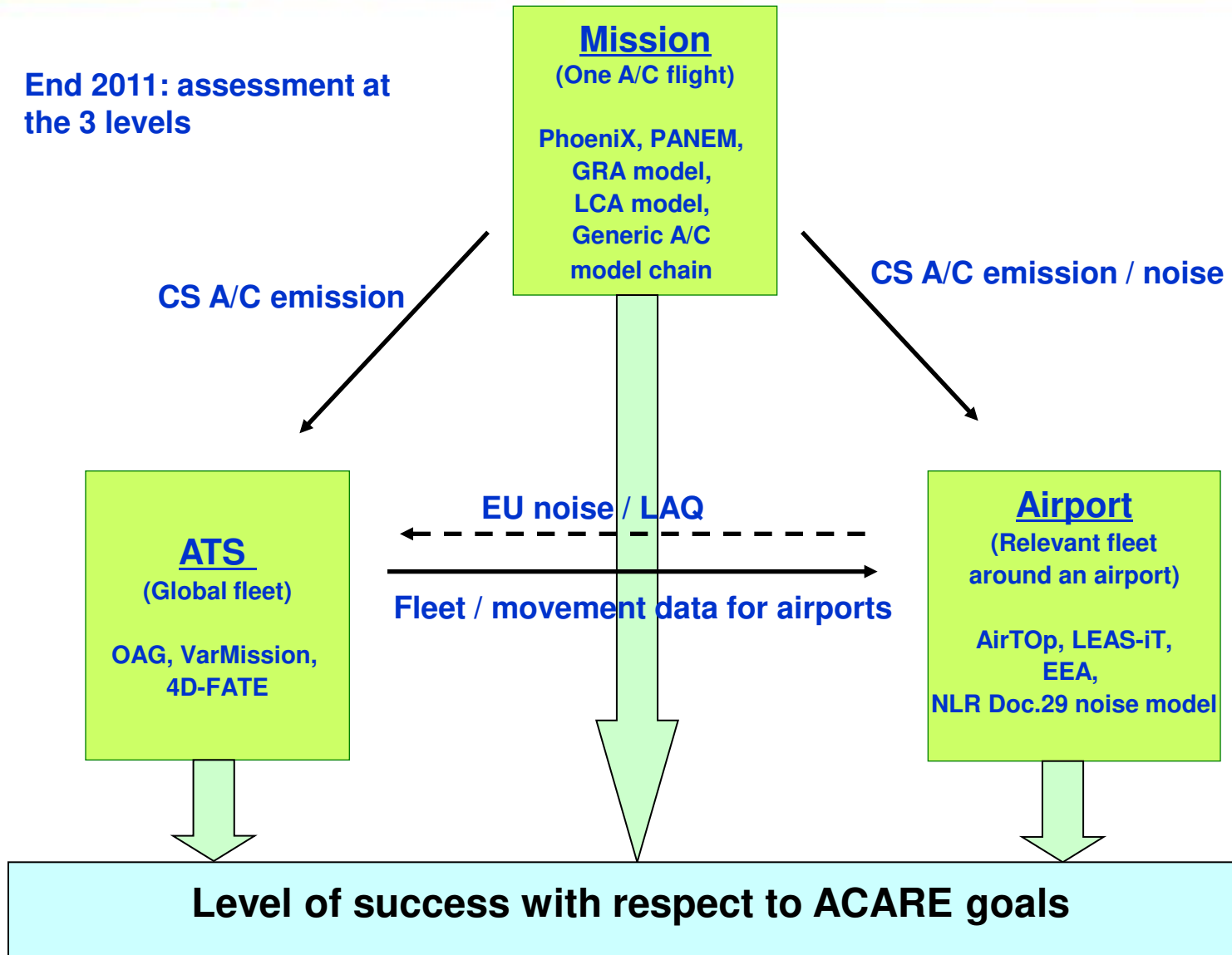
Integrating the technologies and enabling the assessment

- at aircraft (mission) level
- at airport level
- at air transport system level

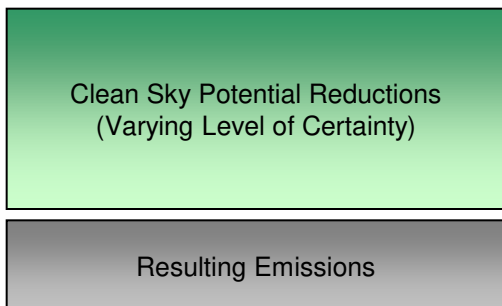
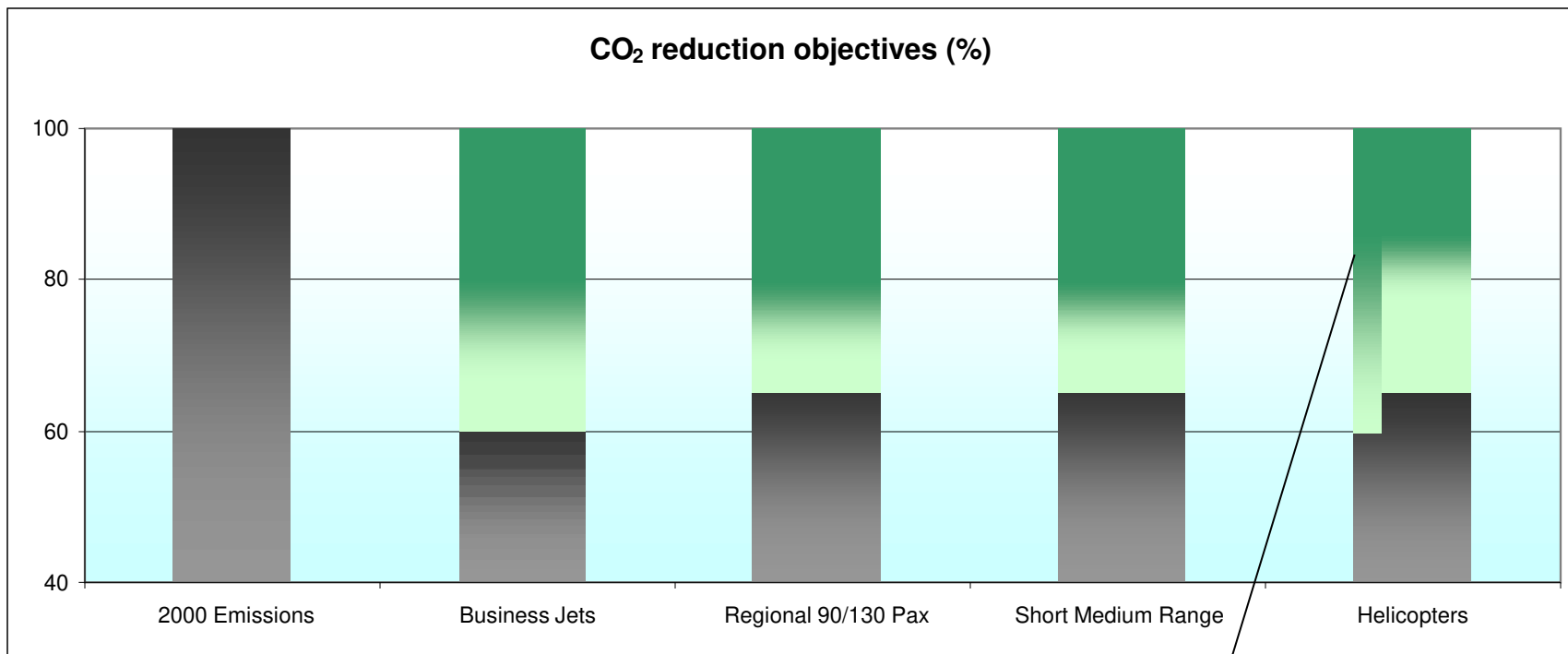


TE 2011 ('Mid-Term') First Assessment

End 2011: assessment at the 3 levels



Clean Sky CO₂ Reduction Potential

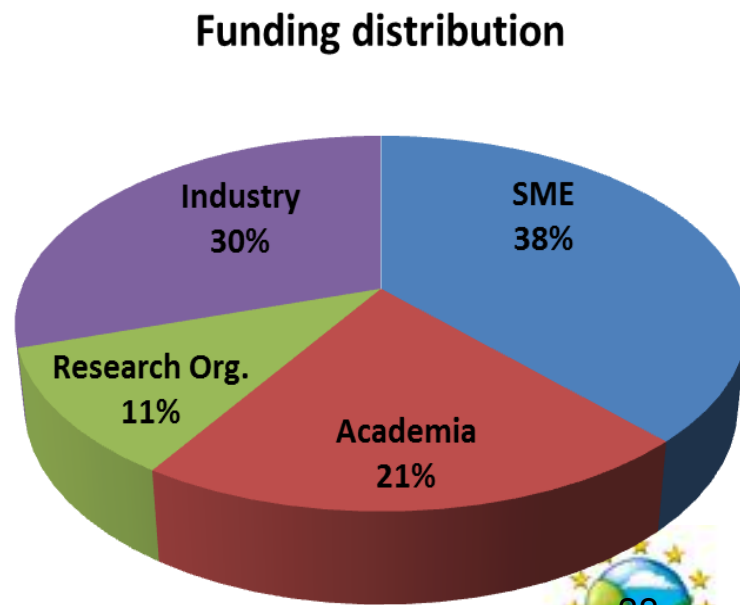
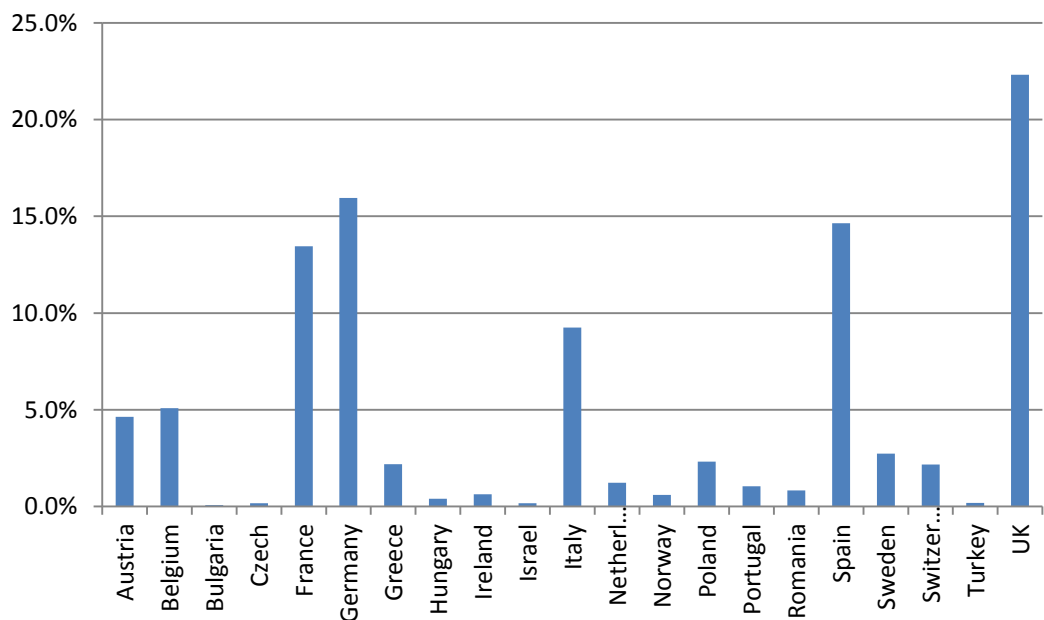


Potential Diesel Engine Impact



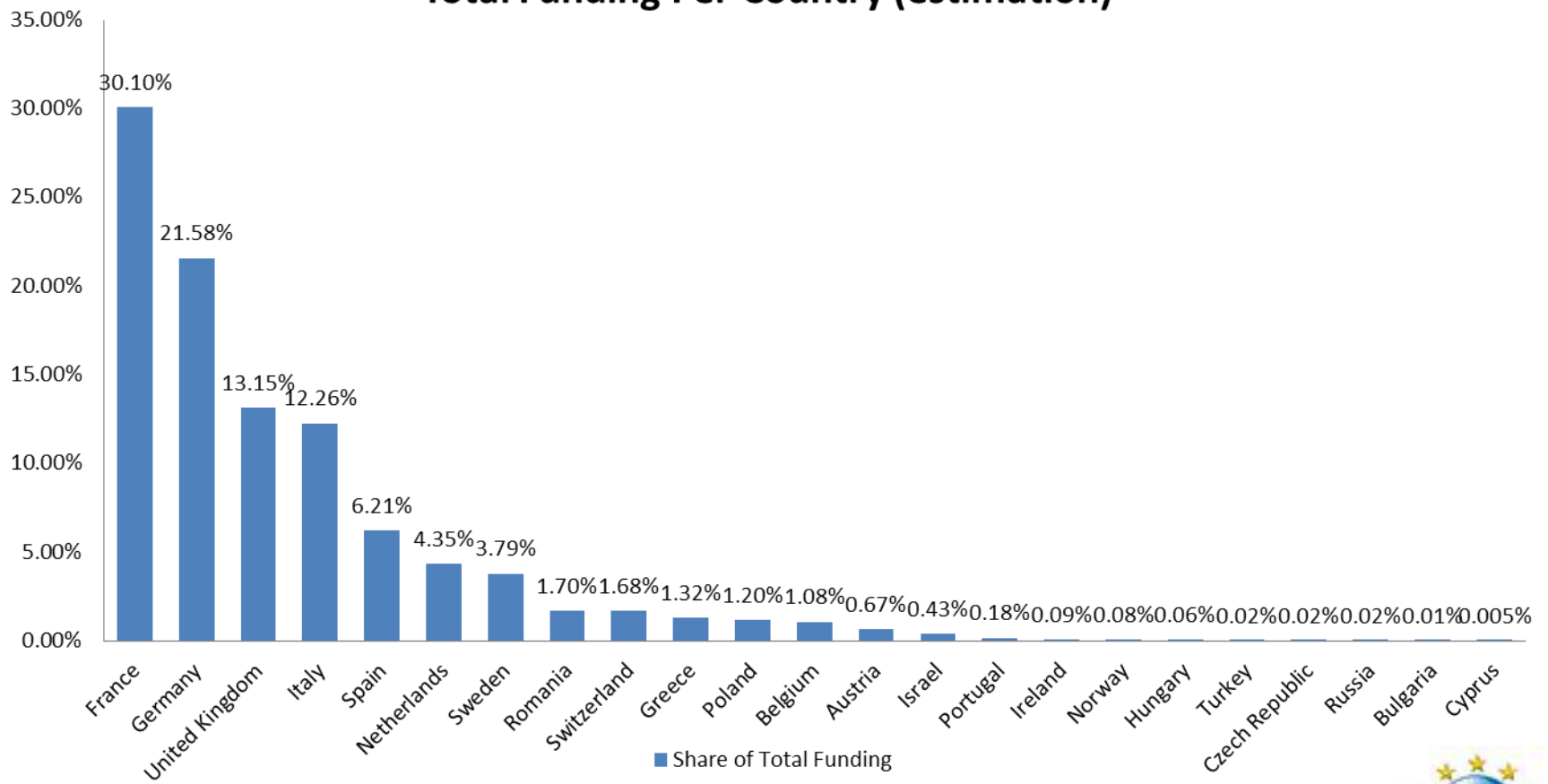
Clean Sky Calls for Proposals are successfully attracting SMEs and academia

- ✓ More than 400 topics
- ✓ > 30% success rate for applicants
- ✓ Average topic cost 500 K€
- ✓ > Towards 400 partners involved (i.e. towards 500 participants incl. Members)
- ✓ > 50% of newcomers, not involved in previous European programmes



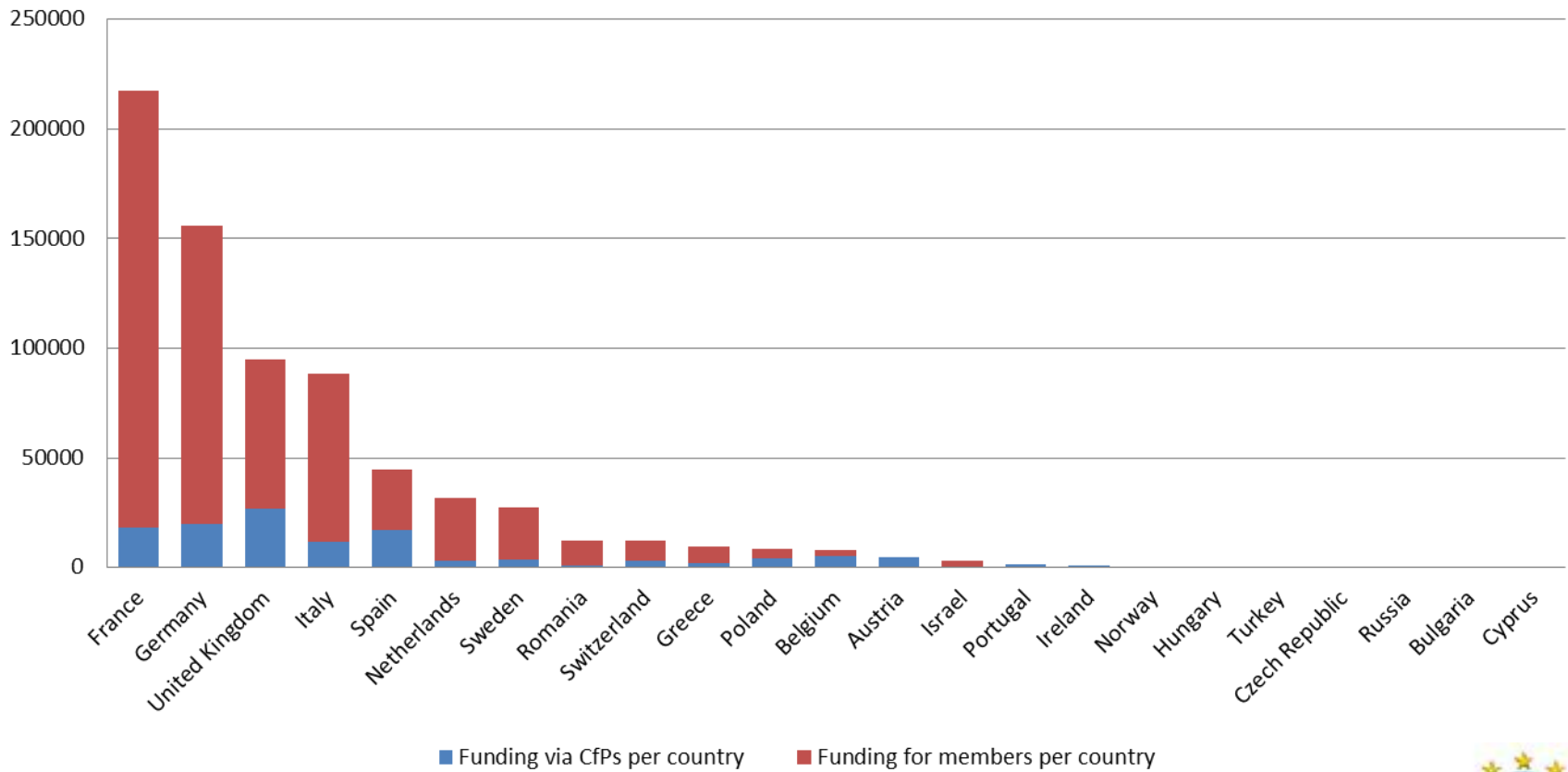


Total Funding Per Country (estimation)





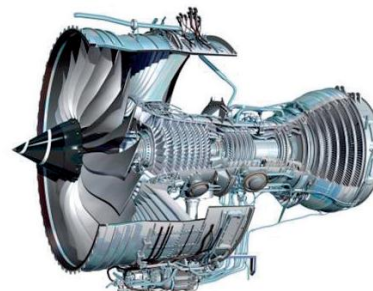
Funding in Clean Sky (estimation)



2012: Clean Sky reaches half way, progressing well towards its objectives

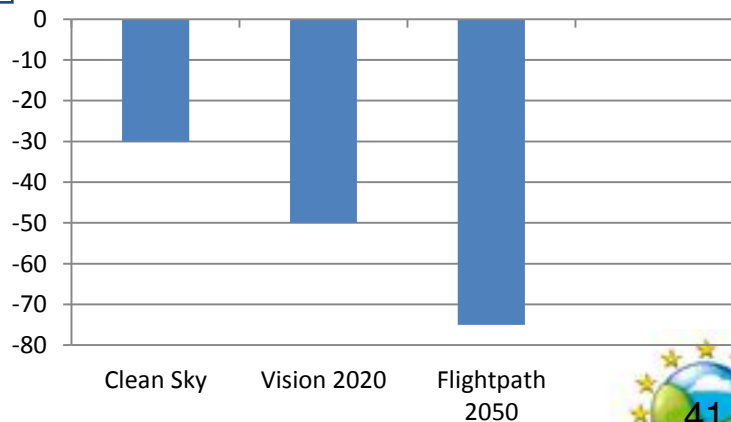
50% of the activities to completion have been executed in average, and 50% of the budget spent

*First engine demonstration just started (Large engine)
Turboshaft engine demonstration to start in late september*



Roughly 80% of the Calls for Proposals budget already committed - last calls planned in 2013

First Technology Evaluator assessment completed: initial objectives confirmed
Clean Sky average targets are in the range of 30% of CO2 reduction / noise reduction





Towards Clean Sky 2

Flighpath 2050

Europe's Vision for Aviation Maintaining Global Leadership & Serving Society's Needs

- Meeting Societal and Market Needs
- Maintaining and Extending Industrial Leadership
- Protecting the Environment and the Energy Supply
- Ensuring Safety and Security
- Prioritising Research, Testing Capabilities and Education

Flighpath 2050 was presented at Aerodays in Madrid 30/03-01-04 2011

see <http://ec.europa.eu/research/transport/publications>



IADP

Vehicle
Platforms

Rotorcraft

Large Aircraft

Regional Aircraft

**ITD
Platforms**

Large
Systems

Airframe ITD

Engines ITD

Systems ITD

Technology evaluator

Letter of Intent signed in ILA, Berlin, Sept. 12th





Questions?

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