New Aircraft Concept Research in NACRE
A five-year synthesis (2005-2010)

Presented by
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Outline

• Scope, Objectives, Approach

• Aircraft Design and Analysis Capabilities for Components

• Experimental Validation & Testing Techniques

• Focus on 3 Key Successes

• Summary, Conclusion, Perspectives
Context:
EU R&T Roadmap on New Aircraft Concepts

Build upon FP5
NACRE Project Scope, Facts & Figures

- Champion concepts were nurtured within NACRE, aiming at, respectively:
  - Increased Environmental performance
  - Improved Passenger experience
  - Low-Cost high-Volume

- Started in April 2005, lasted 5 years
- Budget € 30m, € 16.9m funded by EC
- 4 major aircraft manufacturers, 3 major engine manufacturers, 3 key suppliers, 10 Research Centres, 7 Universities, 4 SMEs
NACRE Objectives & Approach

- Objective within NACRE was to drive the development of the key capabilities required for the development of novel aircraft concepts:
  - New Aircraft Concepts to foster technological innovation
  - Novel Lifting Surfaces and Control for improved structure and aerodynamic efficiency through an integrated approach
  - Novel Fuselage and Cabin to develop passenger-centered concepts and cost-efficient technologies
  - Novel Powerplant Installation: challenging configurations for ambitious goals on environment protection and cost-efficiency
Key technical achievements – 1 of 2

- Multidisciplinary Design and Analysis Capabilities for Components
  - Open Rotor propulsion systems & integration
  - Powered Tail innovative integrated design & analysis
  - Natural Laminar Flow wing design & transition prediction
  - Flying Wing configuration design and multidisciplinary assessment
Key technical achievements – 2 of 2

- Experimental Validation & Testing Techniques
  - Rear-engine integration (Aerodynamics & Noise)
  - High-Energy Absorption
  - Flying Wing cabin evacuation
  - Innovative Evaluation Platform development
Focus 1: Pro-Green aircraft concepts summary

• **Pro-Green 1 concept: approx -5% BF vs. ref. PG a/c (@ design range)**
  - Contrafan compact architecture enables efficient tail integration vs. ROSAS, but jet noise remains an issue, which can be addressed with a higher by-pass ratio
  - Noise shielding is a proved concept
  - Natural laminar wing shows good potential for fuel burn reduction, but loss of laminarity induces a large penalty

• **Pro-Green 2 concept: approx -20% BF vs. ref. PG a/c**
  - Open Rotor shows very good potential for fuel burn reduction despite some weight penalty
  - Accuracy of Open Rotor noise source prediction needs to be improved
  - HARLS wing shows good potential for fuel burn reduction
  - Wing systems can be optimised for lower noise
Focus 2: Flying Wing aircraft concept summary

<table>
<thead>
<tr>
<th>Flying Wing results</th>
<th>VRef100*</th>
<th>VELA3</th>
<th>FW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area per pax (m²)</td>
<td>0.983</td>
<td>0.967</td>
<td>1.13 (+15%)</td>
</tr>
<tr>
<td>L/D</td>
<td>22.4</td>
<td>22.1 (-1.3%)</td>
<td>23.4 (+4.5%)</td>
</tr>
<tr>
<td>MWE (t)</td>
<td>330</td>
<td>327 (-0.9%)</td>
<td>309 (-6.4%)</td>
</tr>
<tr>
<td>Block fuel (t)</td>
<td>239</td>
<td>236 (-1.2%)</td>
<td>194 (-18.9%)</td>
</tr>
</tbody>
</table>

*VRef100: conventional architecture, 750-pax double-decker, 100-m span, DR 7650 nm
Focus 3: Innovative Evaluation Platform summary

• The IEP team has developed important know-how and hardware regarding an unmanned flying platform dedicated to scientific experiments
  • Design
  • Manufacturing
  • System Integration and Validation
  • Test preparation

• The IEP development in NACRE is the foundation of a new kind of test facility in Europe based on real-atmosphere free flight
Summary: New Aircraft Concepts Research in NACRE

- The two Pro-Green concepts have enabled relevant work on Powered Tails and Advanced Wings aiming at high environmental performance (noise and CO2 emissions):
  - Contrafan and Open Rotor propulsion systems were integrated with a noise-shielding empennage and assessed
  - Advanced Wings, both high aspect ratio low sweep wings and forward swept wings (with natural laminar flow), have contributed to achieving good fuel efficiency at aircraft level

- The Flying Wing configuration work has progressed the understanding of these complex configurations and opened a new path for the promising over-body-engine configuration

- Finally the IEP concept was fully developed into a demonstrator but not flight-tested yet
  - The amount of further preparation and adaptation work will require setting up a new project with a formal customer base
Conclusion:
NACRE developed innovative components

WP1: New Aircraft Concepts to foster technology innovation

WP2: Novel Lifting Surfaces and Control for improved structure and aerodynamic efficiency through an integrated approach

WP3: Novel Powerplant Installation: challenging configurations for ambitious goals on environment protection and cost-efficiency

WP4: Novel Fuselage and Cabin to develop passenger-centered concepts and cost-efficient technologies
Perspectives:
EU R&T Roadmap on New Aircraft Concepts

- EEFAE
- SILENCE®
- NEFA
- VELA
- ROSAS

2002 2005 2009
FP5 FP6 FP7

....Preparing FP7

Level of investment / Technology maturity

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Thank You