The Future of `Green` Aviation and Aerospace

Aviation and Environment
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Yann Barbaux, Head of EADS Innovations Works
EADS Corporate Technical Office

Aviation: the environmental footprint

- **Products**
  - Materials
    - Carbon balance
    - Toxicity
    - Recyclability
    - Performance
  - Manufacturing processes
    - Energy
    - Emissions
    - Needs in water

- **Operations**
  - Aircraft performance
    - Fuel burn
    - Emissions
    - Maintainability
  - Ground operations
    - Taxing
    - Inter-modality
    - Airport
  - Air Traffic Management
Eco-Efficient Aviation

THE FACTS:
- Aviation has been and is critical to global development
- Aviation continues to flourish with reduced environmental impact

Important Figures:
- 8% Global GDP
- 2% man made CO₂ emissions
- More than 40 years of innovation has led to 70% reduced aviation fuel consumption and related CO₂ emissions

Industry targets:
- Carbon Neutral growth by 2020
- 50% CO₂ reductions by 2050 compared to 2005

Sustainable Aviation Growth with Environmental targets

Four key strategic approaches to reducing CO₂ emissions

- 1. Aircraft and engine performance
- 2. Operations, ATM
- 3. Disruptive technologies and alternative energies (biofuels)
- 4. Economic measures

CO₂ Growth if we do nothing

Carbon Neutral Growth 2020

Minus 50% CO₂ by 2050
ACARE needs to be updated:  
Conclusions from the Aviation & Environment 
Workshop of ICAS conference in Amsterdam 09/2009

1. What metrics should be used to define environmental impact?
   • Life Cycle Assessment for carbon footprint
   • Perception of noise

2. The climate impact of contrail cirrus is larger than estimated so far.
   • Contrail cirrus can be reduced by flying higher or lower, depending on
     the predicted weather situation. This causes a small CO2 - Radiative
     Forcing - increase but compensated by a larger contrail RF reduction.

3. The NOx impact is less important than thought when formulating
   ACARE objectives in 2000

4. The CO2 impact remains very important for centuries
   • Limiting global warming to less than 2°C requires quick actions on all
     warming contributions, including contrails and soot

Main tracks in the domain of energy management to further reduce CO2 emissions

- New engine technologies
- More electric aircraft
- Energy recovery / harvesting
- Hybrid solutions
- Bio-fuels
More/All Electric Aircraft and Helicopters

Replacement of hydraulics and pneumatics circuits in platforms

Enablers

- Reversible electric hydraulic actuator able to generate electricity during braking
- Reliable and high efficiency SiC based power modules
- Decrease emission thanks to higher efficiency and lower weight (lighter HV cables, small / light electronic boxes, energy storage when braking)

Energy Recovery

A lot of energy is lost in the form of heat

- 75% of the fuel energy is lost in a turbine, being turned into a high flow (7360 kg/h) of hot gas (650°C).
- Potential energy recovery

This energy can be recovered partly through a heat exchanger and turned into electrical or mechanical power.
Energy Harvesting

Aircrafts (fixed wing and rotorcraft) offer interesting energy harvesting possibilities, which may be used in different applications:
- Fixed wing aircraft flight profiles exhibit high temperature changes which can be exploited
- Rotor-induced oscillations of helicopters enable resonant vibration harvesting

Both harvesting principles provide sufficient energy for powering wireless sensors
- Wireless sensors and networks require an independent ‘maintenance-free’ power source
- Today’s availability of low power consumption electronics allows perpetual operation by energy harvesters

Hybrid Propulsion Systems: Hybrid Helicopter at ILA 2010

- Exhaust emissions reduced BY Up to 50%
- Quieter and safer flights with the hybrid system
Cri-cri Electrical Propulsion Demonstrator

- Three flights 20 minutes 1200 feet – Sept 2010
- First ever four engine all electric aerobatic aircraft
- The Cri-Cri is a low-cost test bed for system integration of electrical technologies in support of projects including our hybrid propulsion concept for helicopters

Battery location: 3.55 kWh
4 electrical brushless motors of 22 kW
4 tree-blade propeller in monolithic carbon
Carbone canopy
Carbone front nose
Carbone fairing

Alternative fuels: what are the Options?

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Conventional (&quot;Kerosene&quot;)</th>
<th>Alcohol</th>
<th>Bio Esters</th>
<th>Synthetic Fuels</th>
<th>Hydrogenated Biomass</th>
<th>Cryogenic Fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Renewable (Fossil)</td>
<td>Jet Fuel</td>
<td>BIO- JET FUELS</td>
<td>CTL</td>
<td>GTL</td>
<td>Hydrogenated Biomass Oils (HBO)</td>
<td>Liquid Hydrogen</td>
</tr>
<tr>
<td>Renewable</td>
<td>Ethanol … 35% lower energy content</td>
<td>FAME 10% lower energy content, -5°C Freeze point</td>
<td>BTL</td>
<td></td>
<td>CTL, GTL &amp; BTL = Coal, Gas or Biomass to Liquid</td>
<td>Liquefied Natural Gas</td>
</tr>
</tbody>
</table>

* FAME = Fatty Acid Methyl Esters

Not all options are suitable for aviation today
Bio Jet Fuels: Feedstock

- Food Crops **NO**
- Halophytes (?) (Salicornia)
- Jatropha ?
- Rotation Crops (?) (Camelina)
- Algae ?
- Yeasts ?

For all potential solutions, sustainability is key

Bio Fuels: Focus on Value Chain Projects

- EADS & Airbus acting as a Catalyst for the implementation of a Biofuel supply chain
- A secure value chain means that everybody must make money…
  - Farmers, Refiners, Investors, Airlines…
- Closed loop process to reduce CO₂ emissions

Develop projects that speed up sustainable commercialization
World’s First Bio Algae Powered Flight

• Flight with Diamond DA42 at Berlin Air Show in July 2010
• One Austro AE300 engine powered by algae biofuel
• Lower fuel consumption rate than Jet A1

• Algal oil provided by Biocombustibles del Chubut of Argentina and processed by VTS Verfahrenstechnik Schwedt of Germany
• HC reduced by 87%, NOx by 40% and SO2 by 98%

Where we are:

- Alternative Fuels work
- Aviation has very limited solutions to replace fossil fuels
- Other industries have more alternatives
- Large scale Biofuel Commercialization is 7 – 10 years away
- Cross Industry Collaboration is essential

30% Aviation Biofuels by 2030?
What's Next?

- Some R&T has already been delivered
  - Common sustainability criteria
  - Lifecycle analysis

- More R&T needed on potential feedstock, in particular on algae
  - Also building on early industrial experience

- Government support through policy and incentives
  - Prioritization of Energy types for different transport modes
  - Tax incentives / carbon credits

What's next?

- Cross industry approach
  - Aircraft / Engine Manufacturers to provide technical support for qualification
  - Airlines to commit to using and buying bio-fuels

- Investors needed!
  - Growing local economies in various world locations
  - Sustainability criteria
  - Joint ventures with airlines and stakeholders

Alternative fuel business model must be commercially viable...
All Parties Involved and Committed for Greener Skies Ahead

Aircraft manufacturer  Fuel producers
Engines manufacturer  Airlines
Research  Pilots
Authorities  Air Traffic control

A key topic, a global concern, particularly relevant for international collaboration...
Thank you for your attention