The Future of `Green` Aviation and Aerospace

Aviation and Environment

ICAS Nice 21.10.2010

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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
    - Taxiing
    - 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 CO_2 emissions
- More than 40 years of innovation has led to 70% reduced aviation fuel consumption and related CO_2 emissions

Industry targets:

- Carbon Neutral growth by 2020
- 50% CO_2 reductions by 2050 compared to 2005

Sustainable Aviation Growth with Environmental targets

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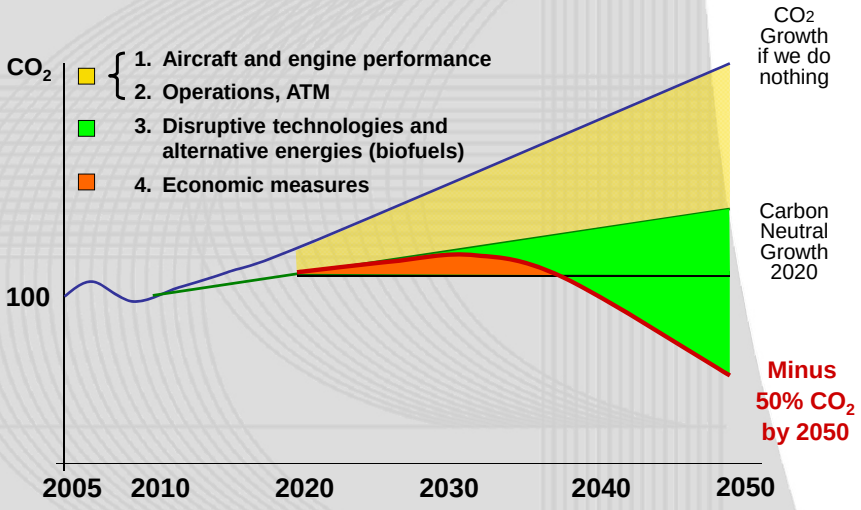
Four key strategic approaches to reducing CO2 emissions



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ACARE needs to be updated: Conclusions from the Aviation & Environment Workshop of ICAS conference in Amsterdam 09/2009

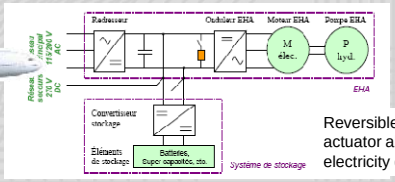
1. What metrics should be used to define environmental impact ?
   - •Life Cycle Assessment for carbon footprint
   - •Perception of noise
2. The climate impact of contrail cirrus is larger than estimated so far
   - •Contrail cirrus can be reduced by flying higher or lower, depending on the predicted 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



Reversible electric hydraulic actuator able to generate electricity during braking

Reliable and high efficiency SiC based **power modules**

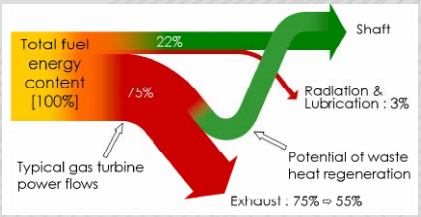
Enablers

Reliable hybrid **Supercaps** and **batteries** power supplies

Decrease emission thanks to higher efficiency and lower weight (lighter HV cables, small / light electronic boxes, energy storage when braking)

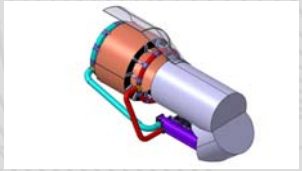
Energy Recovery

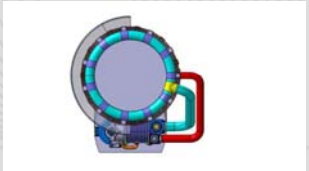
A lot of energy is lost in the form of heat



75% of the fuel energy is lost in a turbine, being turned into a high flow (7300 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

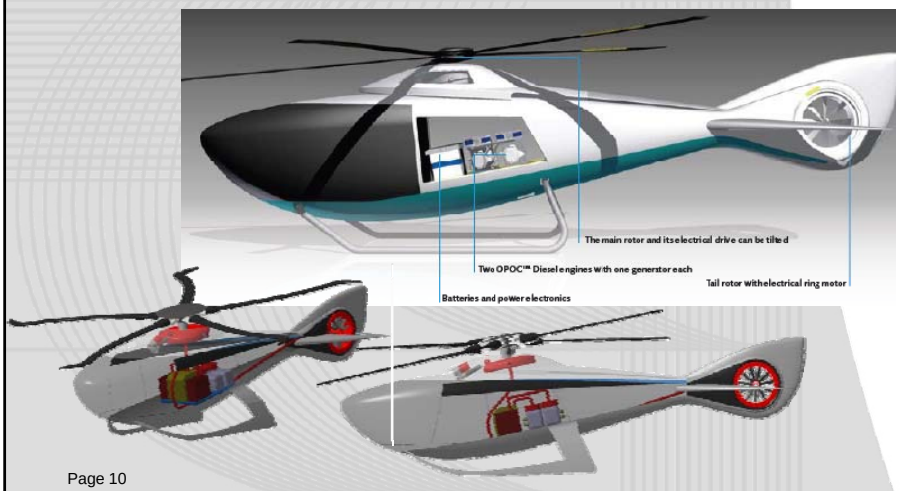
Battery need vs. energy harvester to power a wireless sensor

Thermoelectric harvester powering a wireless strain gauge

Vibration energy harvester for rotorcraft

Hybrid Propulsions 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

Alternative fuels: what are the Options?

CATEGORY	Conventional ("Kerosene")	Alcohols	Bio Esters	Synthetic Fuels	Hydrogenated Biomass	Cryogenic Fuels
Non-Renewable (Fossil)	✓ Jet Fuel	BIO-JET FUELS		CTL, GTL — Exist, Approved		Liquefied Natural Gas ✗
Renewable		Ethanol … 35% lower energy content ✗	Fame 10% lower energy content, -5°C Freeze point… ✗	BTL ✓	Future: Hydrogenated Biomass Oils (HBO) ✓	Liquid Hydrogen ✗ Low energy content per unit volume, Availability, Infrastructure

* *FAME* =*Fatty Acid Methyl Esters*

CTL, GTL & BTL =*Coal, Gas or Biomass to Liquid*

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

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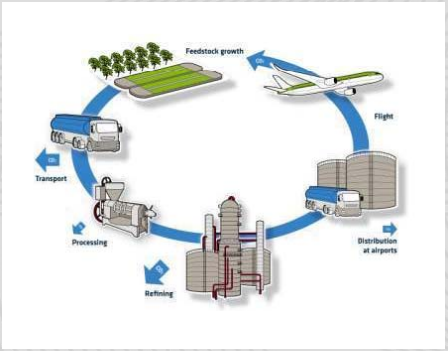
Bio Fuels: Focus on Value Chain Projects



Source: ATAG Biofuels Beginners Guide

- **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 CO_2 emissions**

Develop projects that speed up sustainable commercialization

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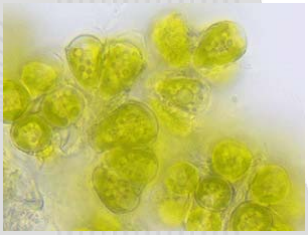
World´s First Bio Algae Powered Flight

- 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 Chibut of Argentina and processed by VTS Verfahrenstechnik Schwedt of Germany
- HC reduced by 87%, NOx by 40% and SO2 by 98%



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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?

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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

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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…

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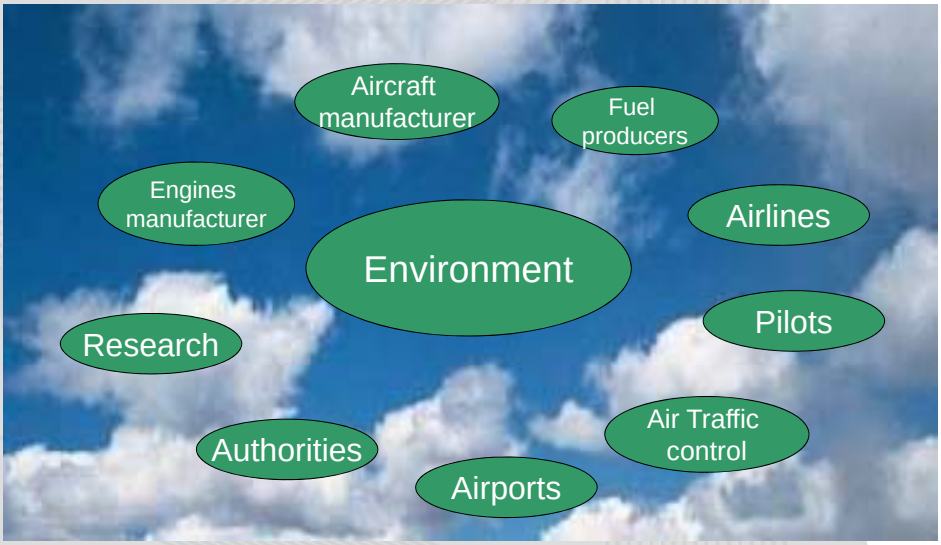
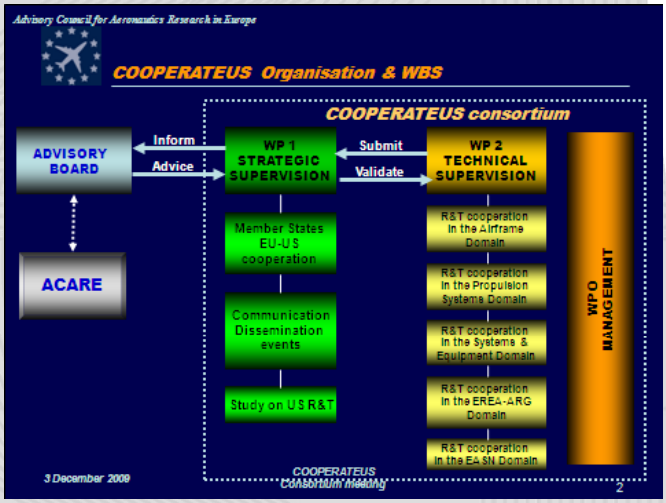
All Parties Involved and Committed for Greener Skies Ahead



A key topic, a global concern, particularly relevant for international collaboration…



Thank you for your attention