Examples of More Electric Aircraft Research in the Aerospace Research Centre

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Introduction

- What is a More Electric Aircraft (MEA)?
- Why is there so much interest in MEA?
- Examples of the challenges we are addressing at Nottingham?
Power Networks – “Conventional” Aircraft

Jet Fuel

Figures for A330/B777 size

Propulsion Thrust (≈ 40MW)

Gearbox driven hydraulic pump

Fuel pumps and oil pumps on engine

High pressure air “bleed” from engine

Pneumatic 1.2MW

Gearbox driven generators

Electrical 200kW

Mechanical 100kW

Total “non-thrust” power ≈ 1.7MW

Equivalent to 5 Nottingham trams!
“More Electric Aircraft” Concept

Rationalisation of power networks
Remove Pneumatic, Hydraulic and Mechanical networks
“Bleedless” engine

Jet Fuel

Propulsion Thrust

Engine driven generators

Expanded electrical network

Existing electrical loads

ELECTRICAL
- Cabin pressurisation
  
- Air conditioning
  
- Icing protection

ELECTRICAL
- Surface actuation
  
- Landing gear
  
- Braking + Doors

ELECTRICAL
- Fuel pumping
  
- Engine Ancillaries

New electrical loads

Electrical system power \( \approx 1 \text{MW} \) (3 trams!)
“More Electric Aircraft”
Some Motivations

- Removal of hydraulic system
  - Potentially reduced system weight
  - Ease maintenance
- “Bleedless” engine
  - Improved efficiency
- Desirable characteristics of electrical systems
  - Controllability (turn-on-and-offable)
    » power on demand
  - Re-configurability
    » maintain functionality during faults
  - Advanced diagnostics and prognostics
    » more intelligent maintenance
    » increased aircraft availability

- OVERALL
  - Reduced operating costs
  - Reduced fuel burn
  - Reduced environmental impact
Some Challenges and Research

- Huge increase in the rating of the electrical power system
- Up to 10 times more electrical power with MEA

B787 – much more electric
A380 – slightly more electric

Conventional aircraft
Some Challenges and Research

National electricity system

- “Easy” to control
- Individual loads have little influence on the system (usually – unless many act at the same time!)

Lots of relatively small loads

Huge network
Some Challenges and Research

More Electric Aircraft Electrical System

- Relatively small generators
- Some important single large loads e.g. Environmental control (>100kW), Wing anti-ice (>100kW)

- Single loads can have significant influence on the generator (and the engine driving it)
- Some research topics for Nottingham
  - How to configure network?
  - How to model network?
  - How to ensure stable operation?
  - How to deal with faults?

\[ \approx 220\text{kW} \]
Some Challenges and Research

Generator characteristics do not match load requirements

**Generator output**
Frequency “wild” AC
(frequency varies with engine speed)
Constant voltage

**Typical load requires**
Controlled frequency AC
Controlled voltage
Some Challenges and Research

“Power converters” needed between generators and loads

Generator

Power Converter

Matches load and generator and allows load to be controlled

Uses a technology called “Power Electronics”

Load

Nottingham is good at this! – amongst the World leaders
Some Challenges and Research

- Power Electronics has been the KEY enabling technology for MEA
  - Advances in power electronics have made it possible to power and control loads electrically that were impossible before

- BUT – the technology is still not good enough to capitalise fully on the potential benefits of MEA

- MEA advantages are marginal with current technology

- Advances in Power Conversion technology are essential to achieve the MEA goals and potential
Some Challenges and Research

- Surprisingly – we have not yet developed the perfect power conversion system!
  - 100% efficient (no power loss – no waste heat)
  - Zero weight and volume
  - Infinite reliability (many loads are flight critical)
  - Zero cost
- But we are working on it!
- Multi-disciplinary Team includes
  - Electrical Engineers
  - Mechanical Engineers
  - Thermal Engineers
  - Semiconductor Physicists
  - Materials Scientists
  - Metallurgists
  - Mathematicians
More Electric Aircraft concept offers huge potential for future air transport

Nottingham has one of the foremost research groups in the World in Aerospace Electrical Systems (≈ £10M funding)

Research spans:
- Basic technology research (e.g. physics of failure)
- Applied research (e.g. advanced technology demonstrators)

Expertise spans:
- Device and component technology → Complete systems
- Analysis → modelling → practical validation

We are closely engaged with the key industrials in the European supply chain and with International airframers (Boeing, Airbus, Eurocopter for example)
Thank you