Mechatronics in Aerospace

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Content

- Mechatronics A General Trend in General Industry and Aerospace
- More Electric A/C – Value Added
- Mechatronics in Aerospace – Needs for R&T
- Examples of Research Projects at EADS

  - Electrical actuation for high lift system
  - Active Rotor for Helicopter
  - Vibration Reduction for ARIANE V launcher

The Future will be more electric

Mechatronics is a general trend in industry

Rapid development of computer and power electronics foster the development of more-electric systems

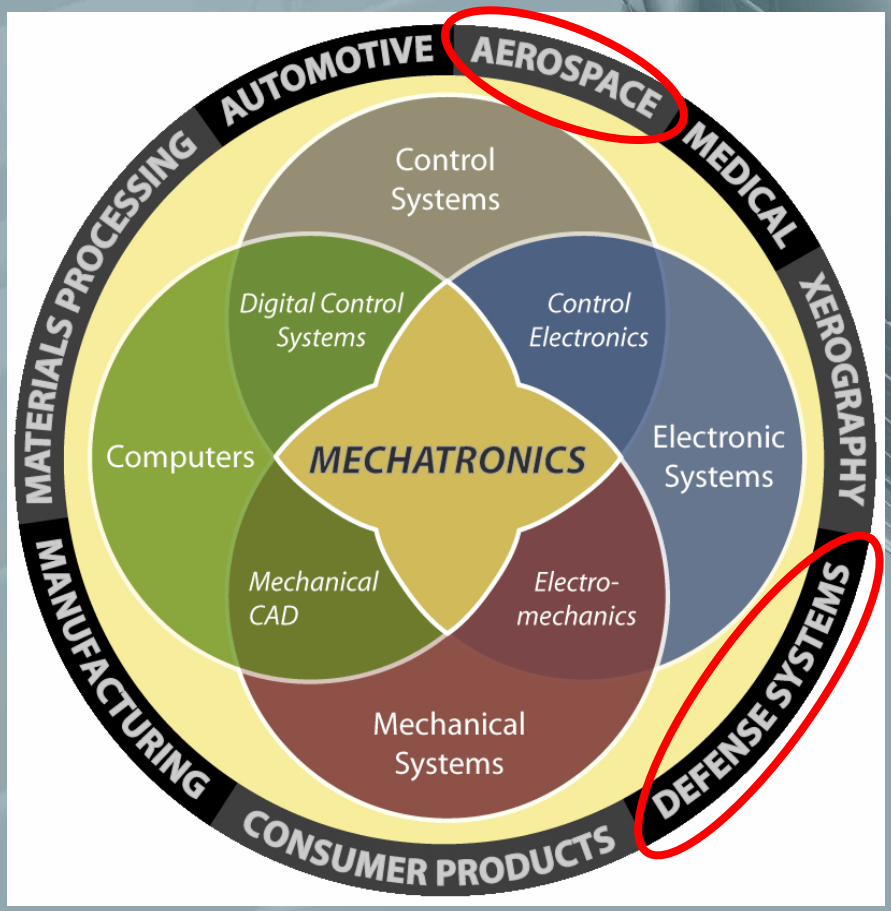
There is a clear trend towards the All-Electric Aircraft

A380: 3Hydraulics -> 2H + 2E saves 1 ton mass for PFCS!

B787: bleedless, electric ECS,
28 VDC, 115 VAC, 230 VAC, +/- 270VDC

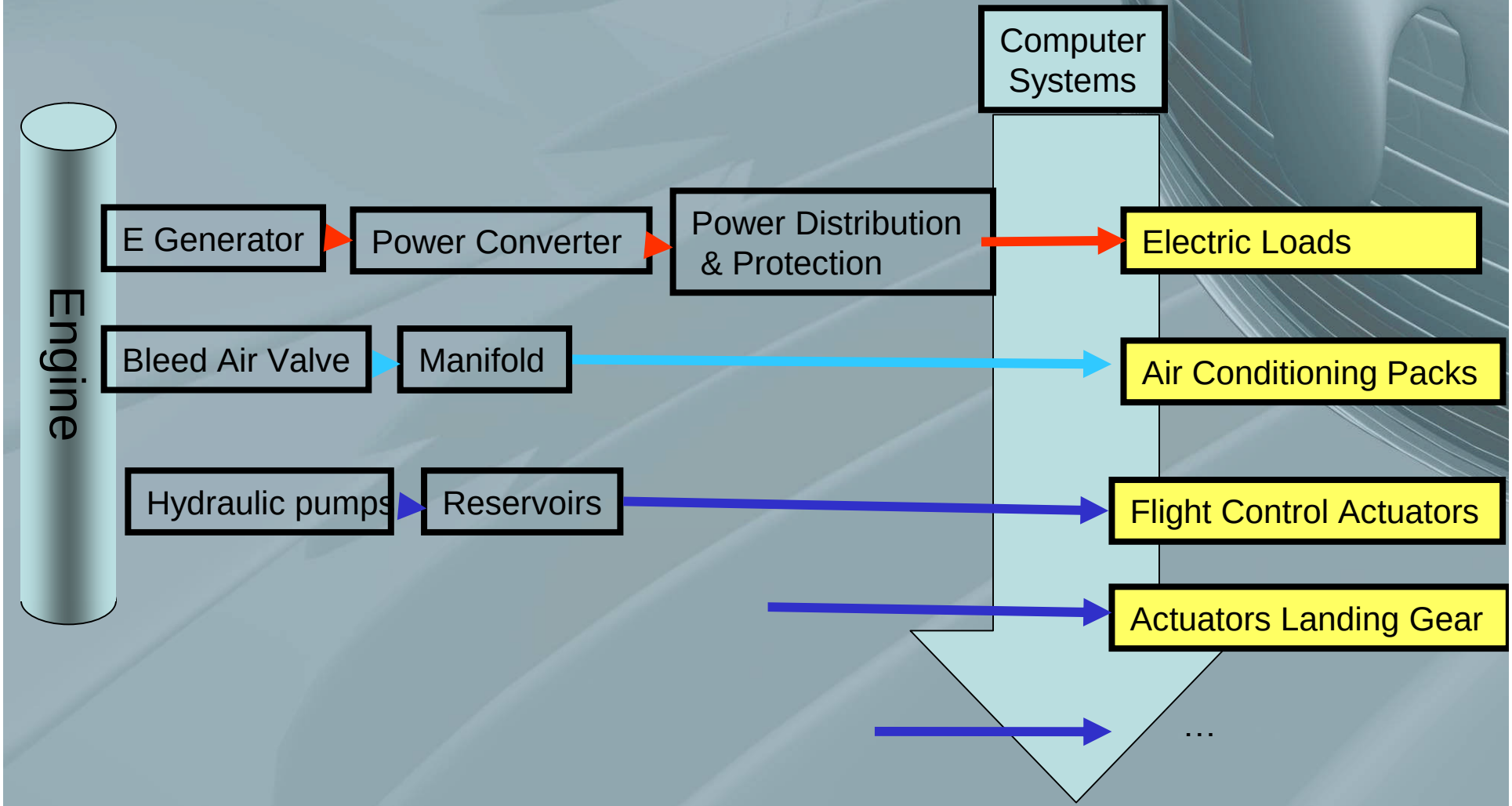
JSF, F22, more-electric, 28VDC, 270 VDC, LiIo Battery
Fighter A/C & UCAVS will be more-electric

What is Mechatronics?

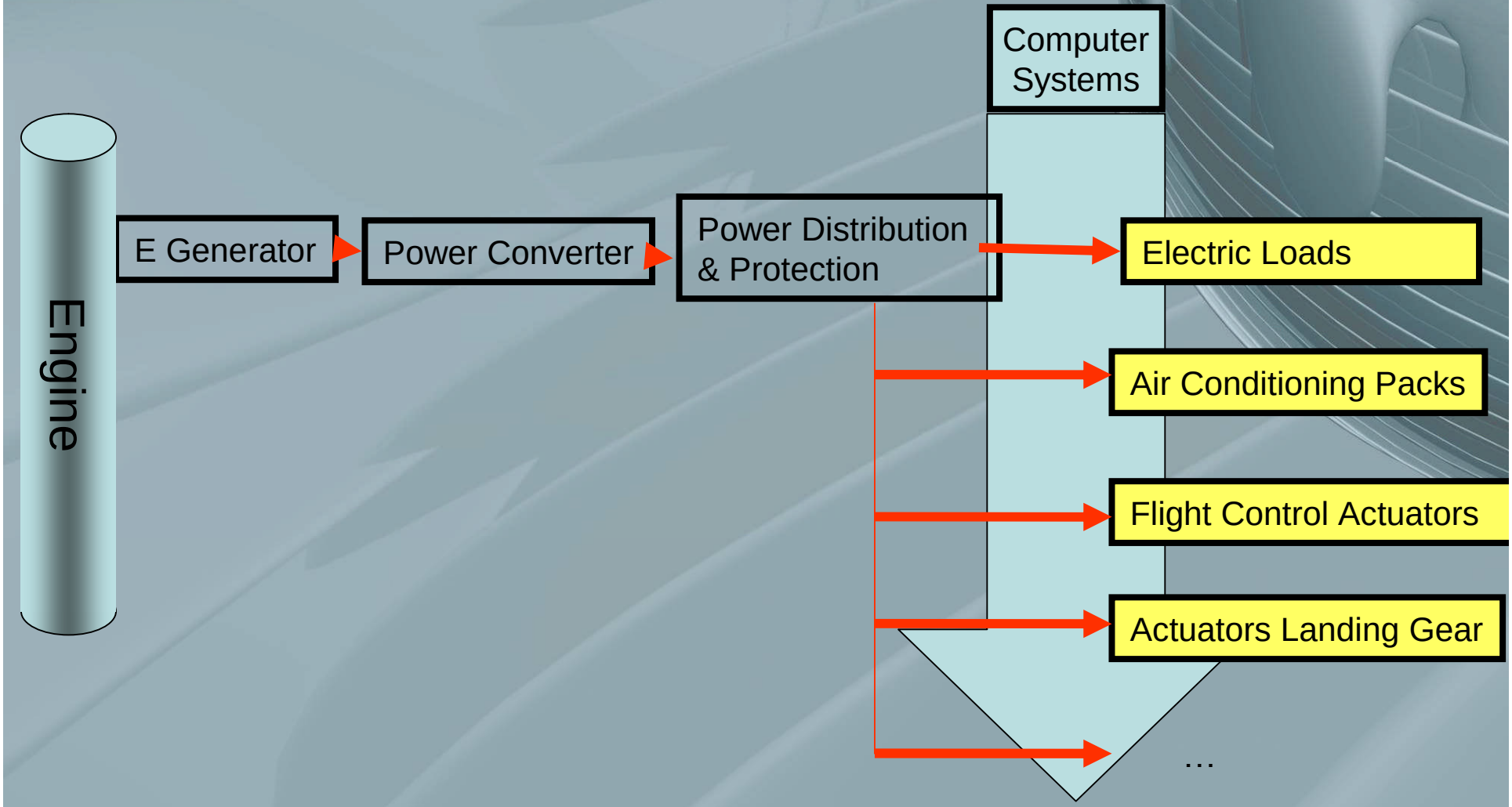


Mechatronics *is the combination of mechanical engineering, electronic engineering and software engineering. The purpose of this interdisciplinary engineering field is the study of automata from an engineering perspective and serves the purposes of controlling advanced hybrid systems.*

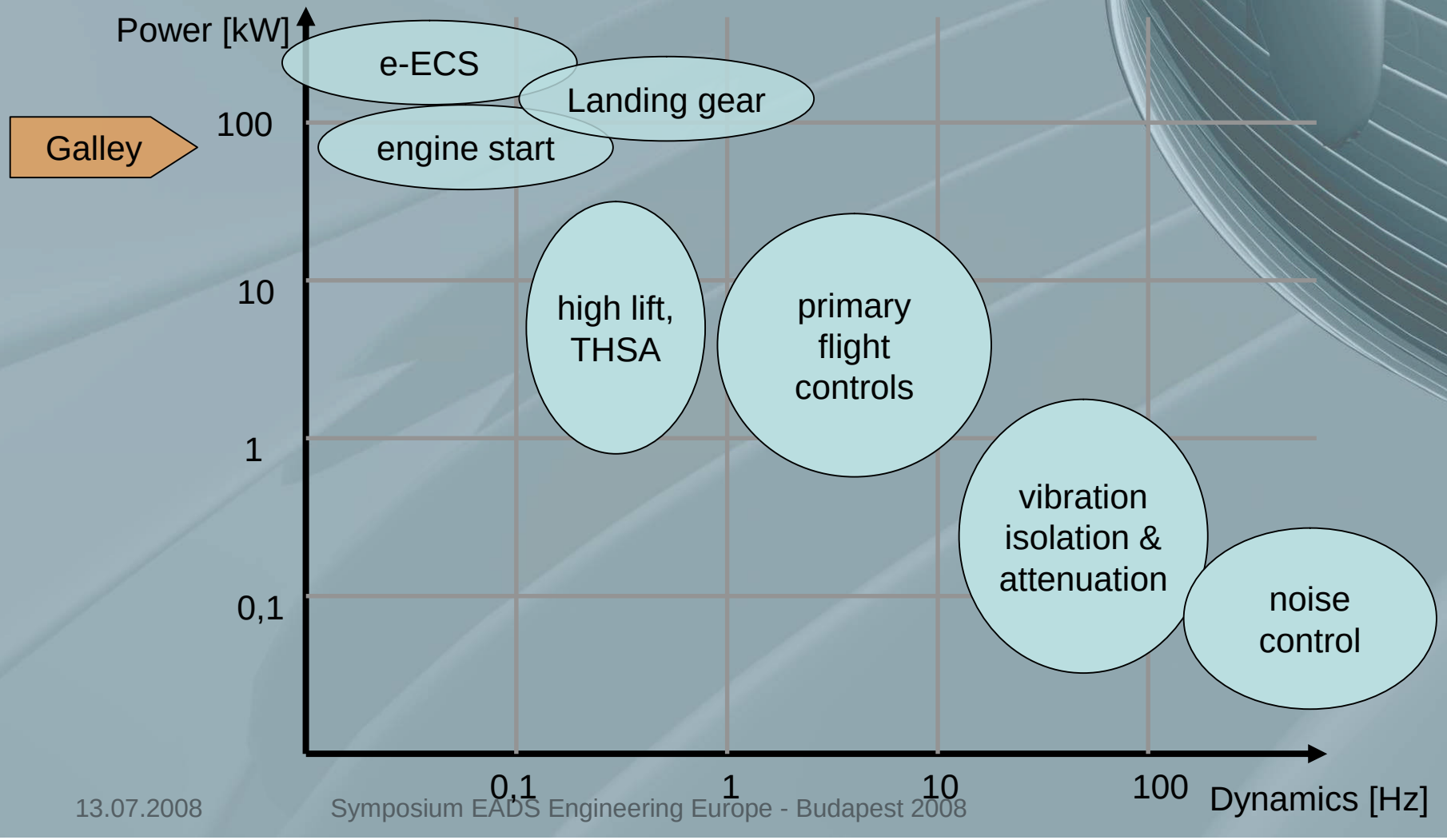
Onboard Power Architectures – Conventional A/C



Onboard Power Architectures – All Electric A/C



Where can Mechatronics be applied at Aircraft?



What Benefits Do We Expect ?

- **Economy**
  Cost Reduction installation and maintenance
  Reducing down-times and operational interrupts
  Improving energy efficiency e.g. bleed less engines, advanced onboard power management

- **Added Functions**
  Self-diagnosis & maintenance support
  positioning e.g. differential flap setting,
  monitoring , re-configuration, automation

- **Green A/C**
  Power management, better use of available sources and buffers
  Avoid toxic and inflammable liquids
  pre-requisite for emission free ground operation

- **Safety**
  Better & simpler segregation of (electrical) power distribution

Mechatronics in Aerospace - Action Fields

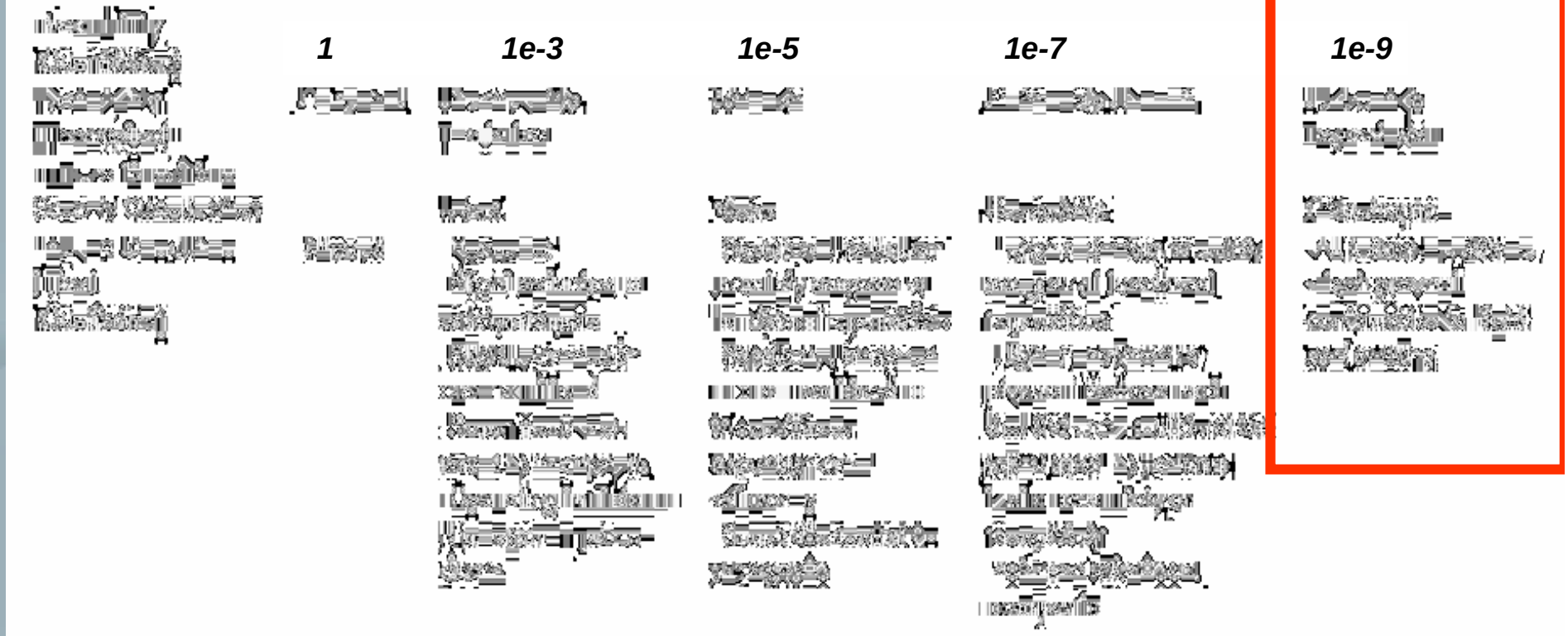
- ***Substitution* of hitherto used hydraulic actuators** by electrical actuation systems
  - flight control
  - landing gear
  - brake actuation
- ***Enabling new fields of application*** in noise and vibration control (especially when utilizing the piezoelectric principle)
- ***Compliance with demanding requirements***
  - life, reliability,
  - weight, installation space
  - environmental conditions,
- ***Main Actuation Principles*** pushed forward in the recent years are
  - electric actuators (EMA, EHA) and
  - piezoelectric actuators.
- ***Electronics***

  New actuators put *strong requirements on control and electronics systems* design. It requires highly efficient and reliable electronics to achieve flight worthy products!
- ***Electrical Power Network***

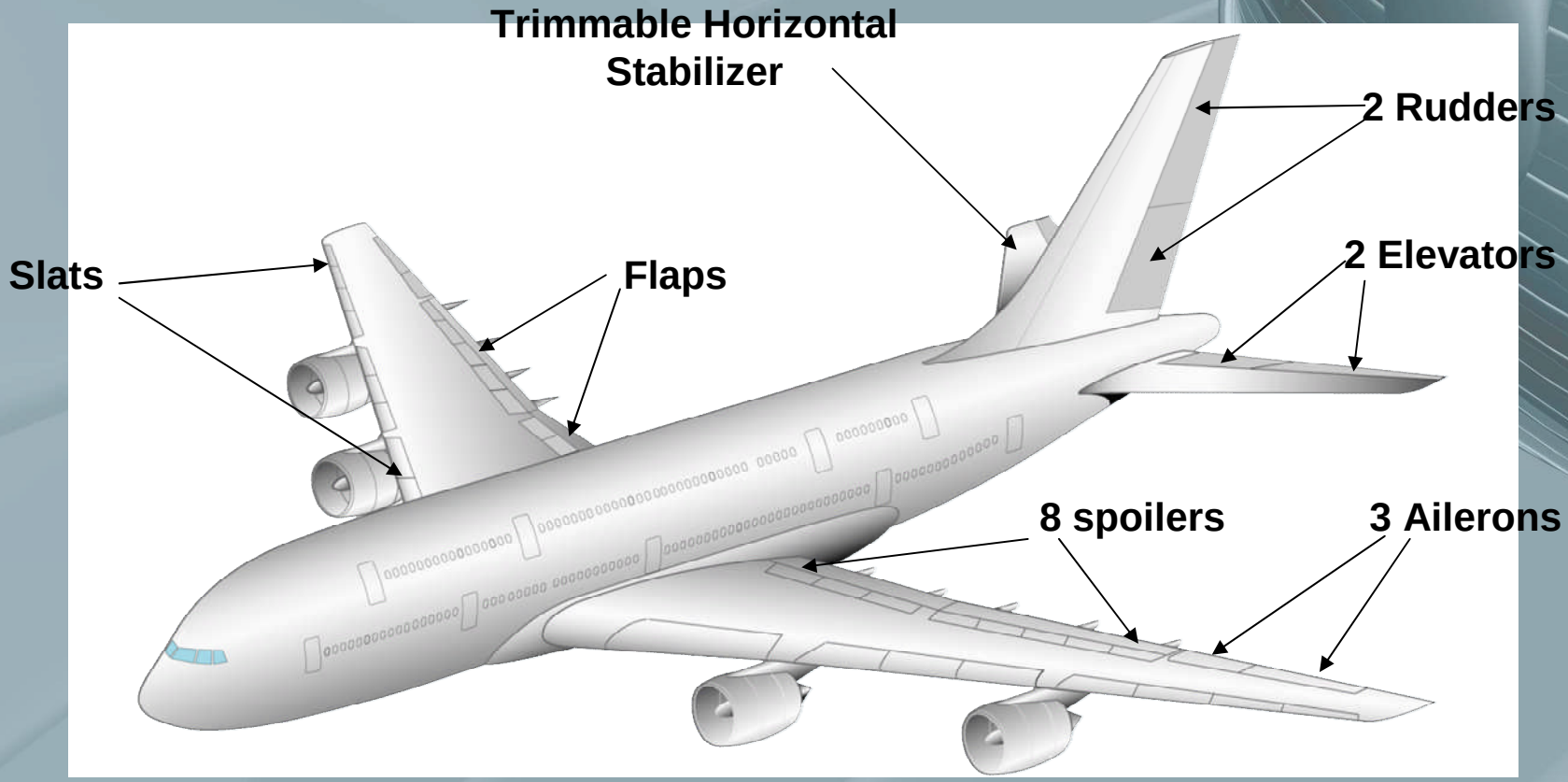
  energy generation, distribution, protection and energy management

Hazard levels - Civil

- Source: FAR/JAR 25



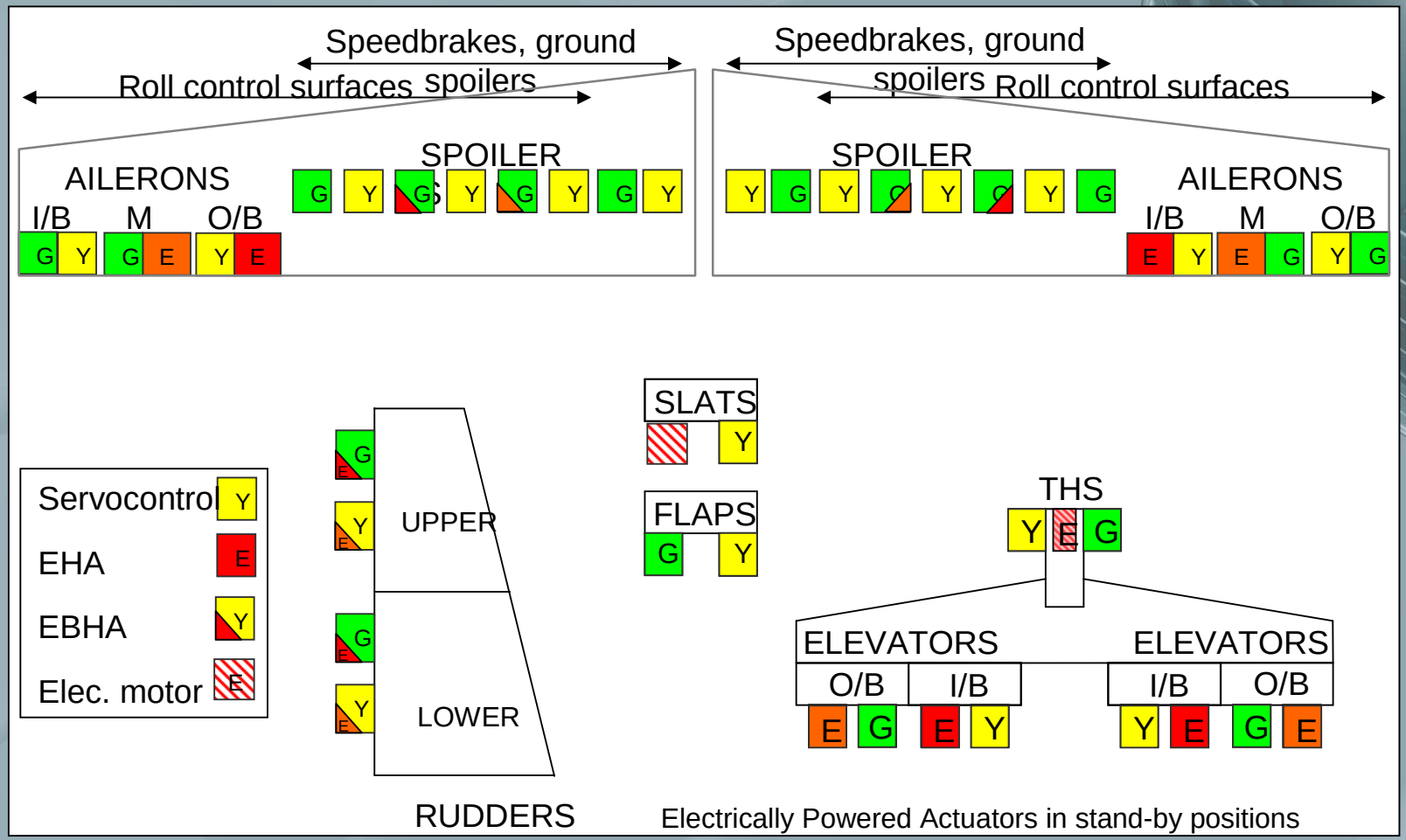
Airbus A380 – The "More Electric" Approach



A380 Flight Control Surfaces Configuration

Airbus "More Electric" Approach

✈ A380 2H/2E Power Source and Actuator Distribution



Mastering Flight Control Systems of More-Electric A/C

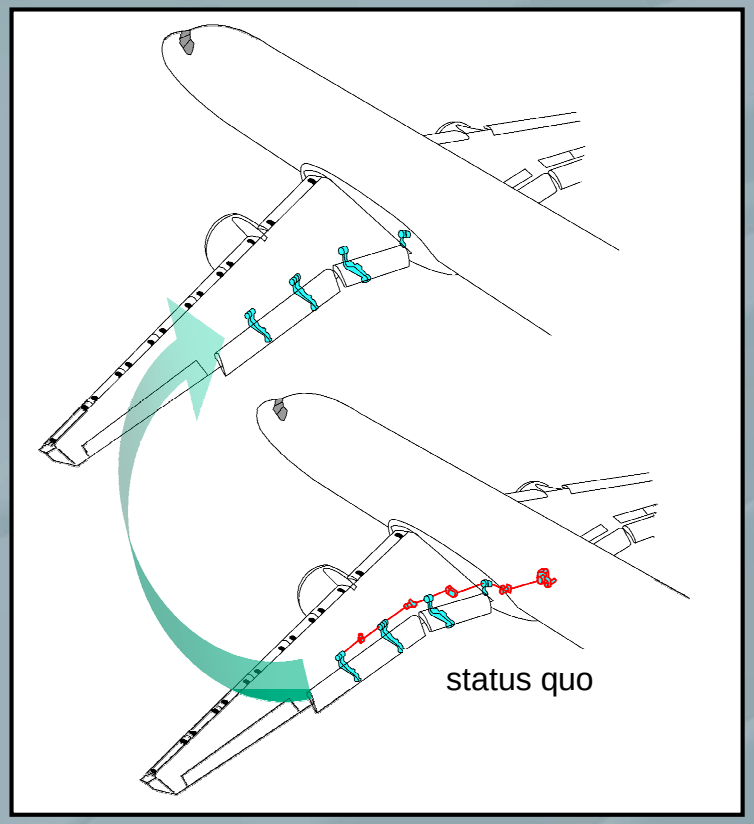
Electric Powered EHA for Primary Flight Control has been proven to be sucessfull on A380

- Weight saving.
- Improved efficiency
- Maintenance: Elimination of potential leakage sources
- Dissimilarity of power sources
- More flexible reconfiguration in case of power generation failure

Next steps are

- to fully exploit potential of Mechatronics e.g. electrically powered secondary flight control flaps
- develop highly reliable E-Motors
- improve electric converters
- develop internal redundancy, re-configuration, and fault anticipation algorithm
  optimize weight, size, and packaging = mechatronics integration

Distributed all-electric flap drive system



Benefits

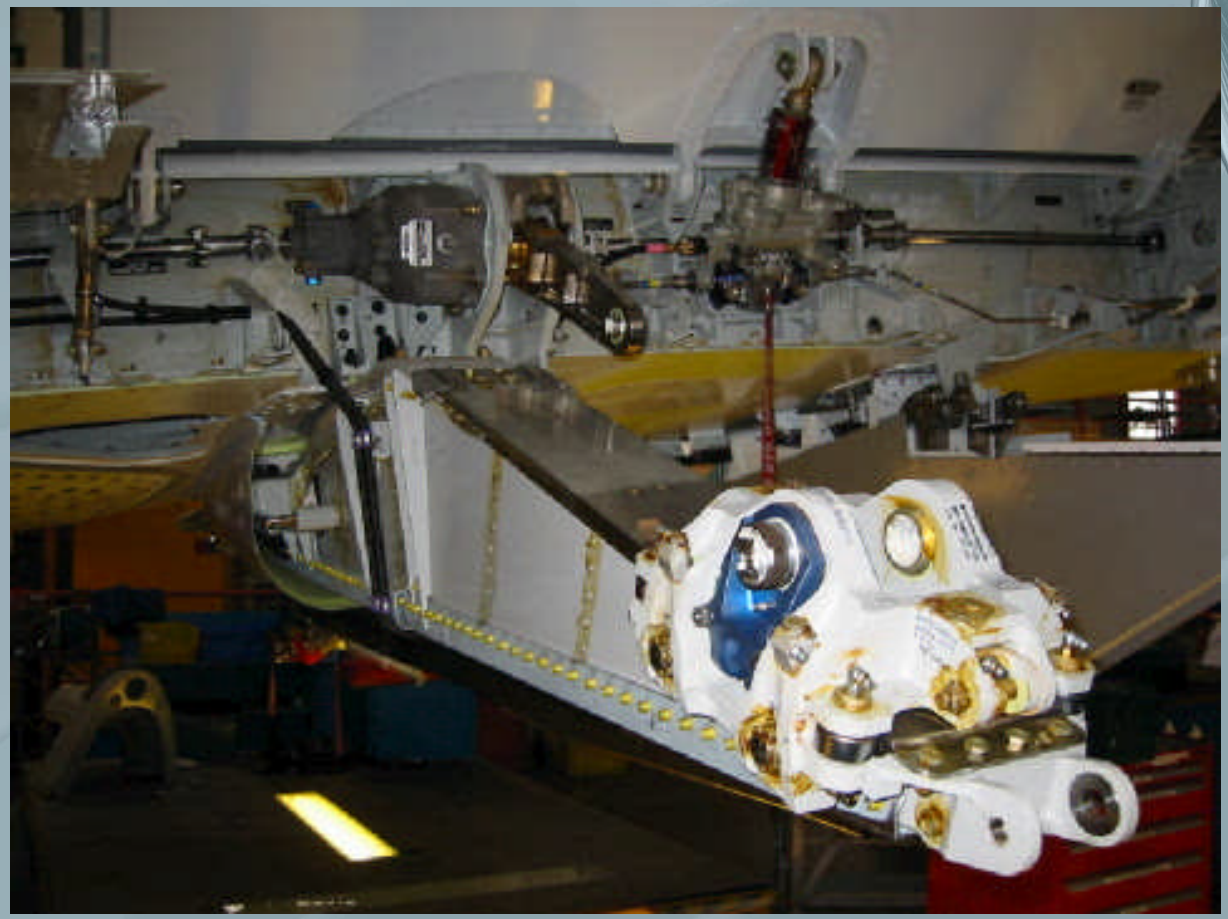
- Installation
- new functions
- maintenance friendly

Technology

- data-linked individual drives
- digitally controlled electrically powered electromechanical actuators
- Fail-safe mechanics
- **Fail-op electronics & control**

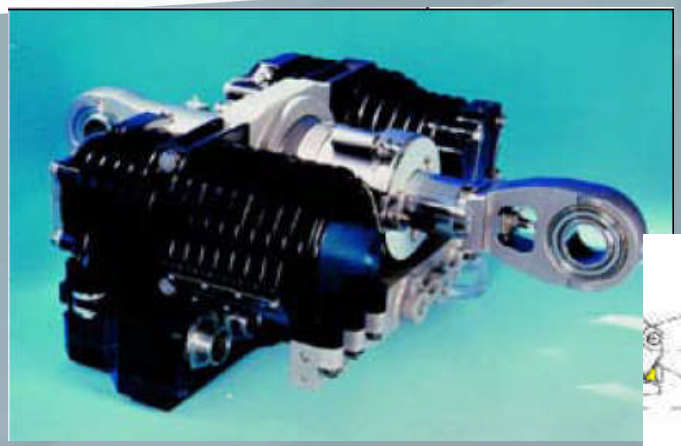
Replacement of hydraulic central drive unit by a distributed electrical flap drive system

A320 Landing Flap

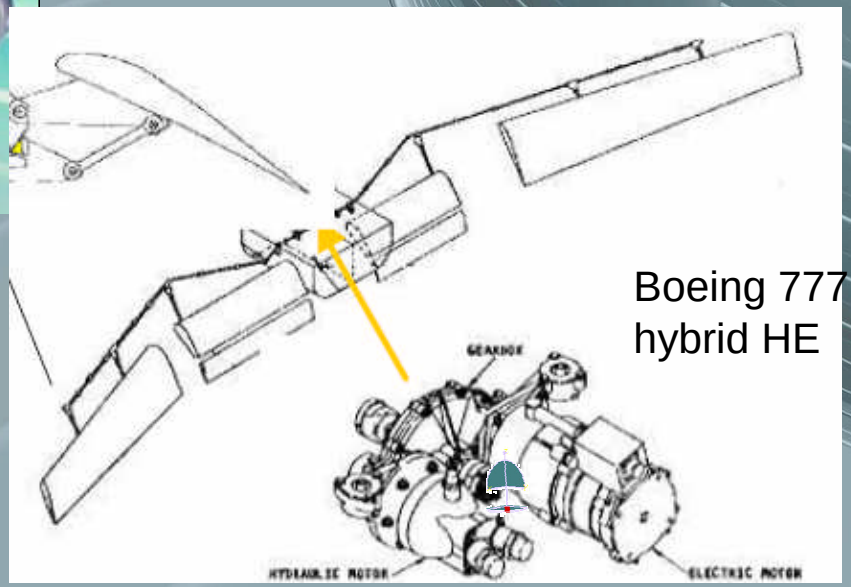


Solution Candidates for Electric Flap Actuation

EHA

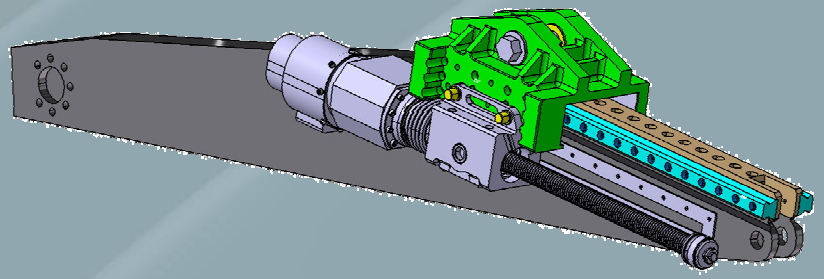


Central electric drive
replacing central hydraulic motor

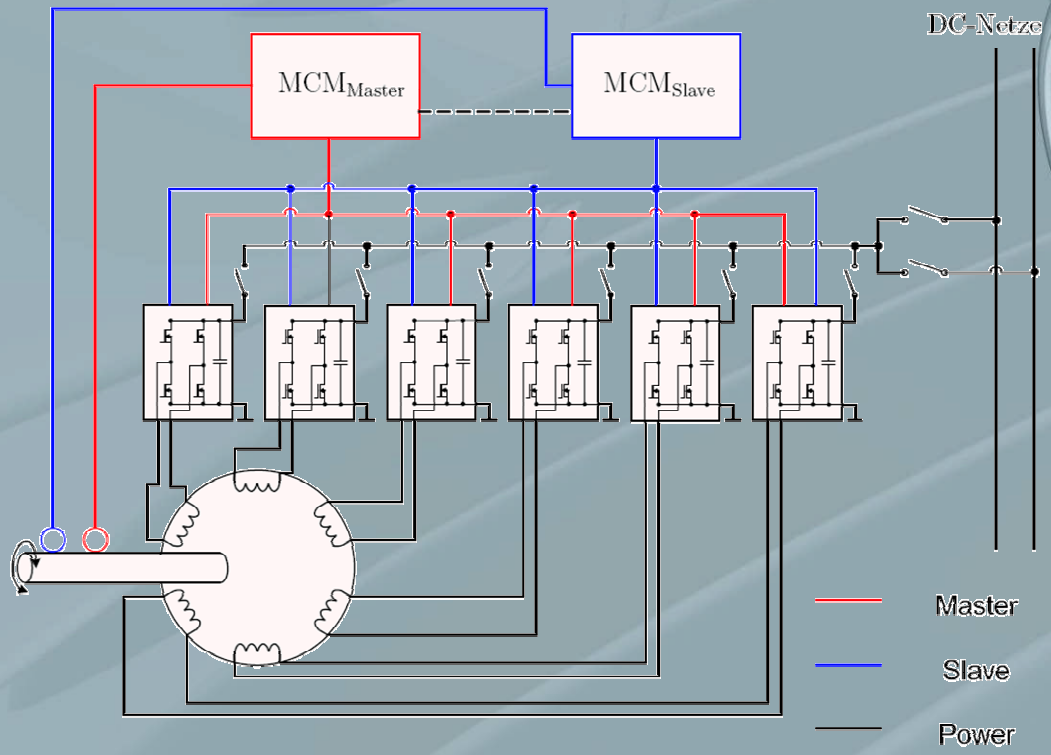


Boeing 777
hybrid HE

Distributed EMA
(EADS Concept)

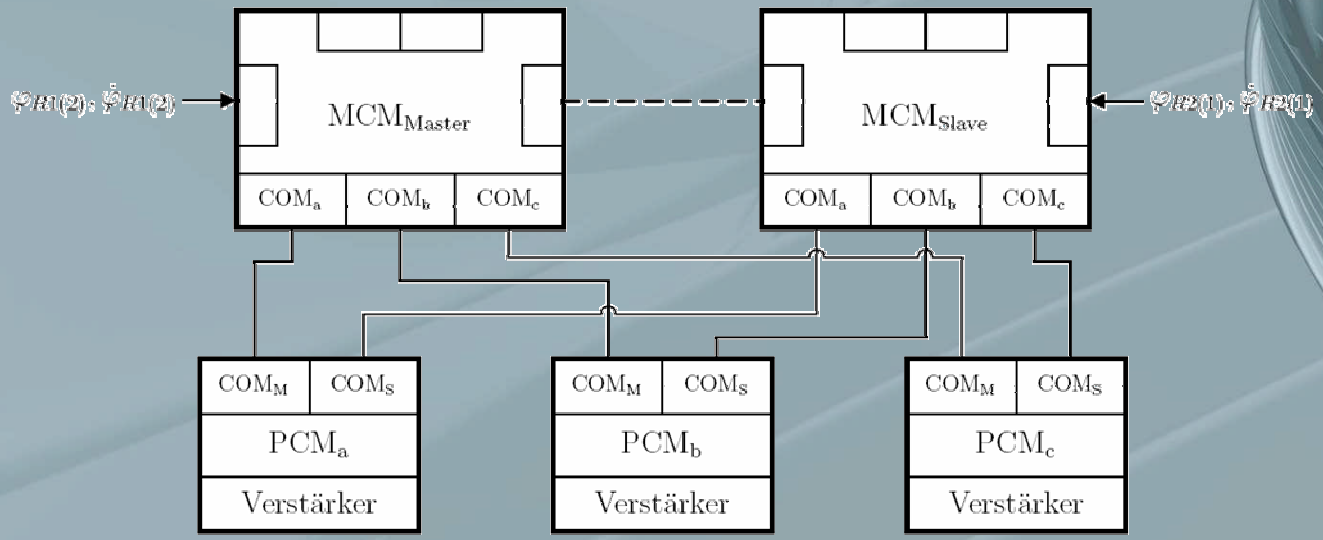


Redundancy by phase-modular design and physical isolation of the motor phases



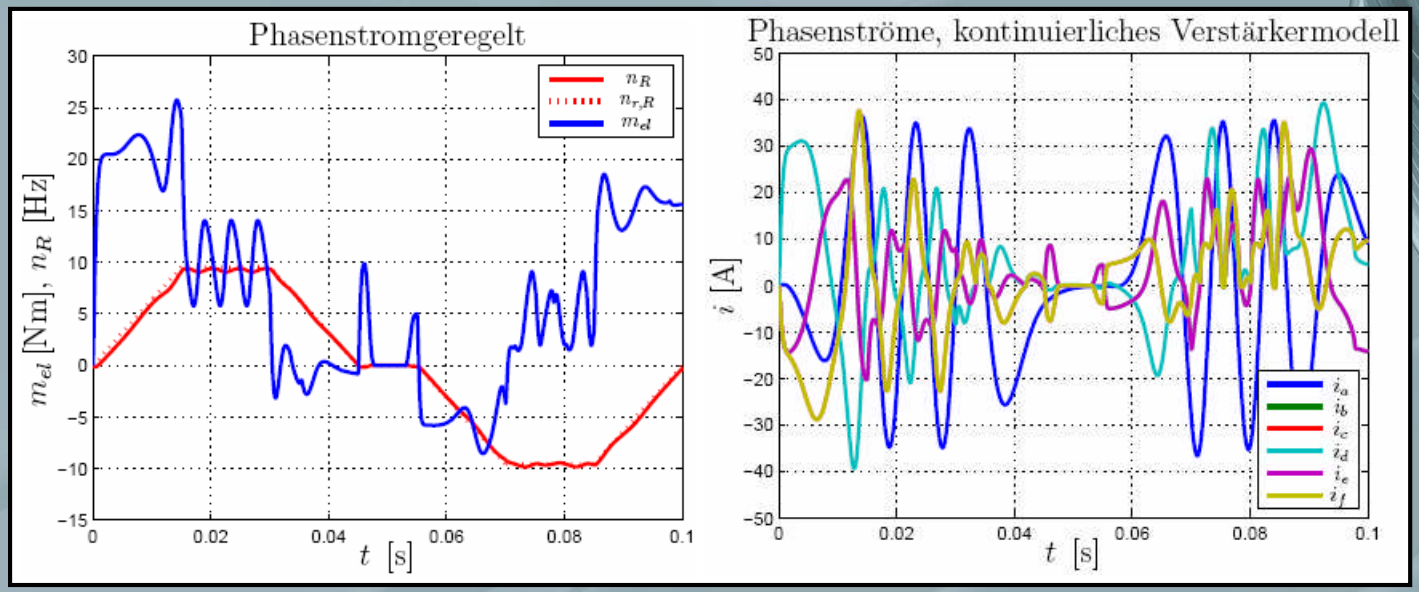
- Six phase machine, driven by separate power amplifier modules
- Active-standby dual-duplex control system

Local redundant motor control system architecture



- Master-slave-configuration of motor control computers
- N out of m redundant phase control modules
- Double star communication topology
  - Control is reconfigured from MCM_{Master} to MCM_{Slave} in case of controller or sensor faults

Fault tolerant EMA – Simulation of motor operation with internal fault



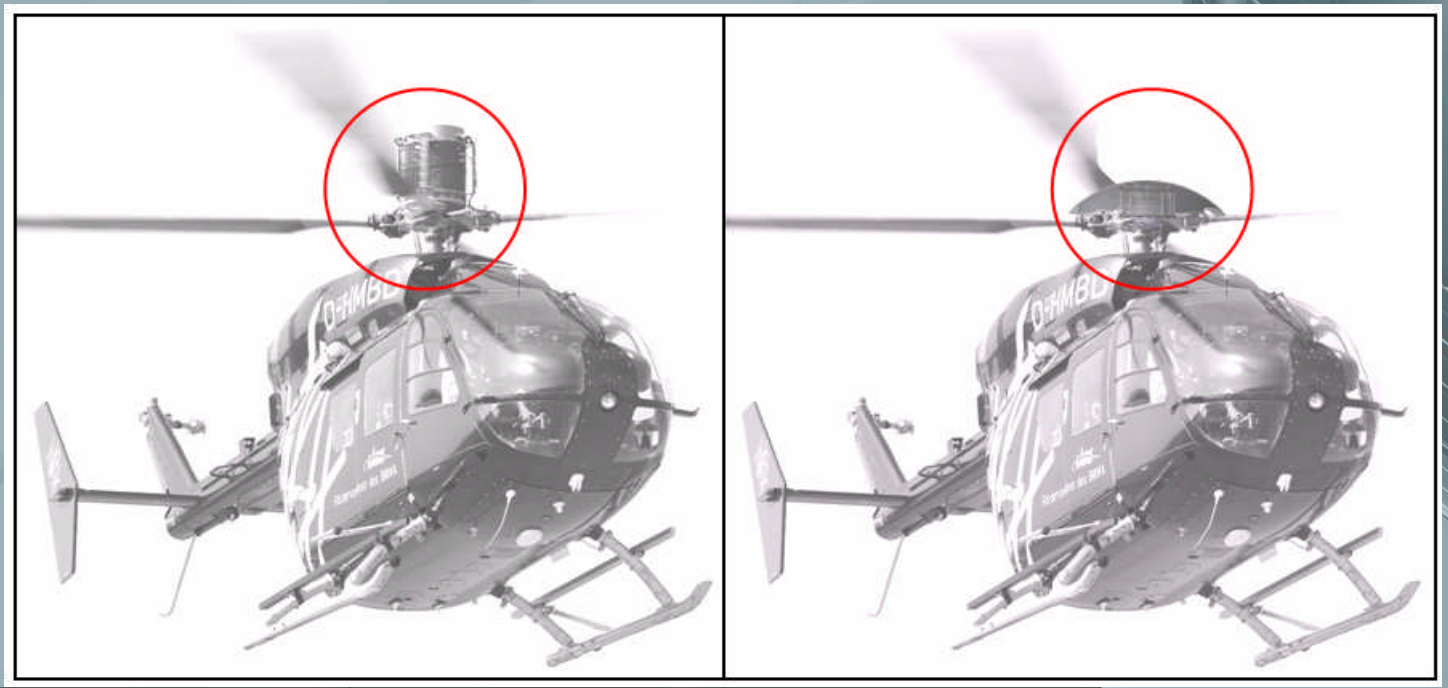
- Motor can follow the reference speed command with sufficient accuracy
- Significant torque ripple
- Operation with aiding loads still possible

Active Rotor Control using Piezo Technology

- Reduction of BVI noise and cabin vibrations
- Automatic tracking / balancing
- Improvement of aeromechanical stability
- Delaying of stall flutter onset, ...

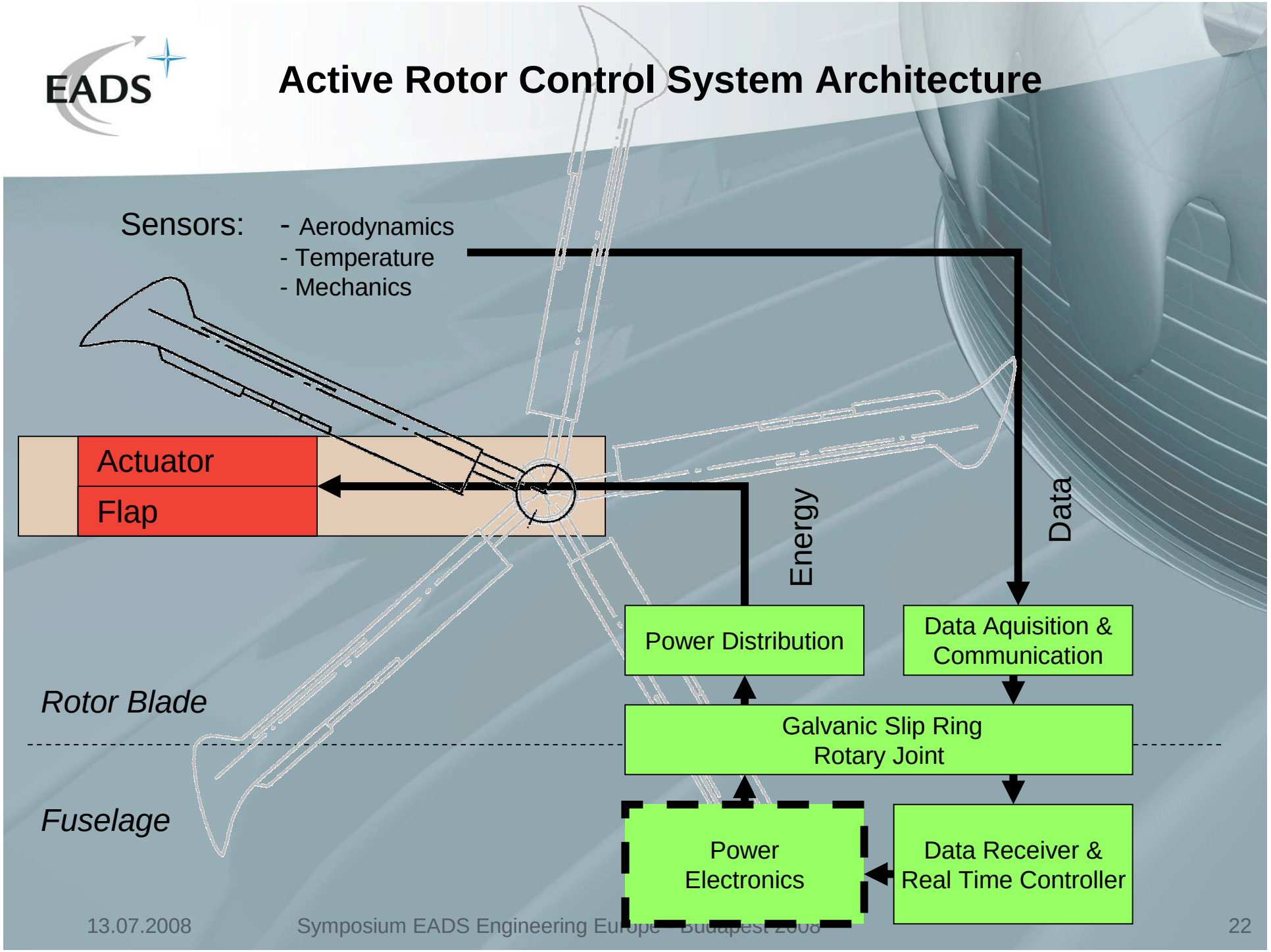
- **World first flight in September 2005**

Status and Challenge



System	MARK I	MARKII
Volumen	21 dm^3	5 dm^3
Gewicht	~ 68 kg	~ 10 kg

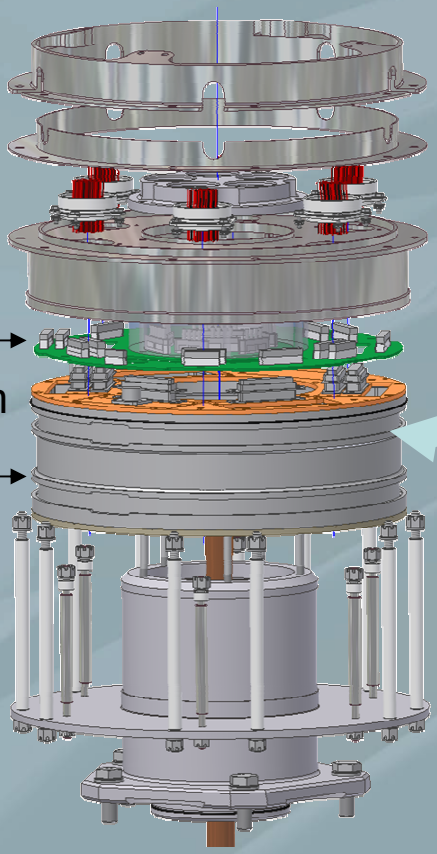
Active Rotor Control System Architecture

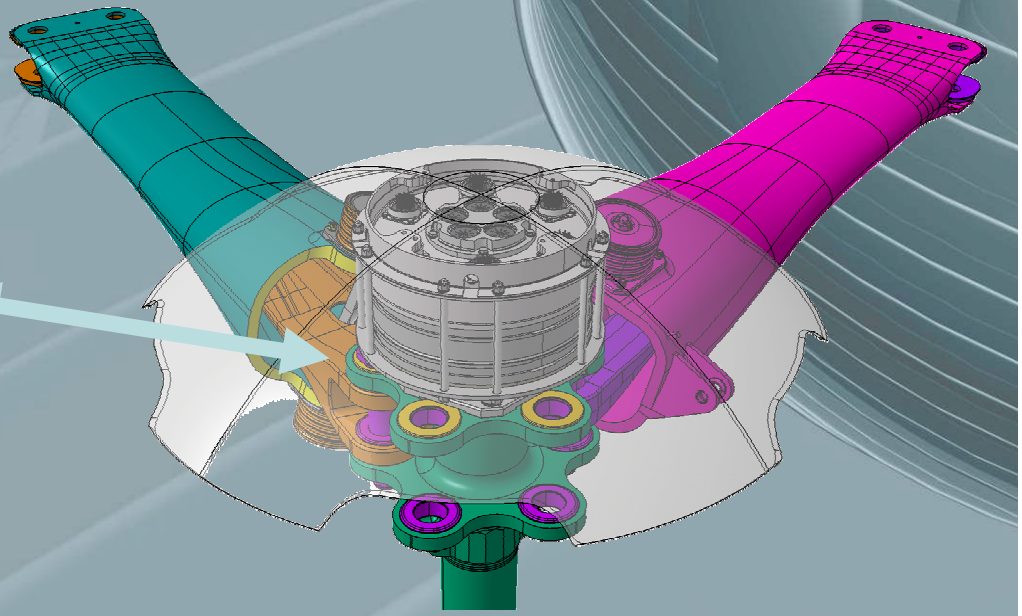


Power Electronics System Integration

- power & data distribution board
- PCM Data Acquisition
  - A/D converter
  - signal conditioner
  - PCM encoder

rotor flange





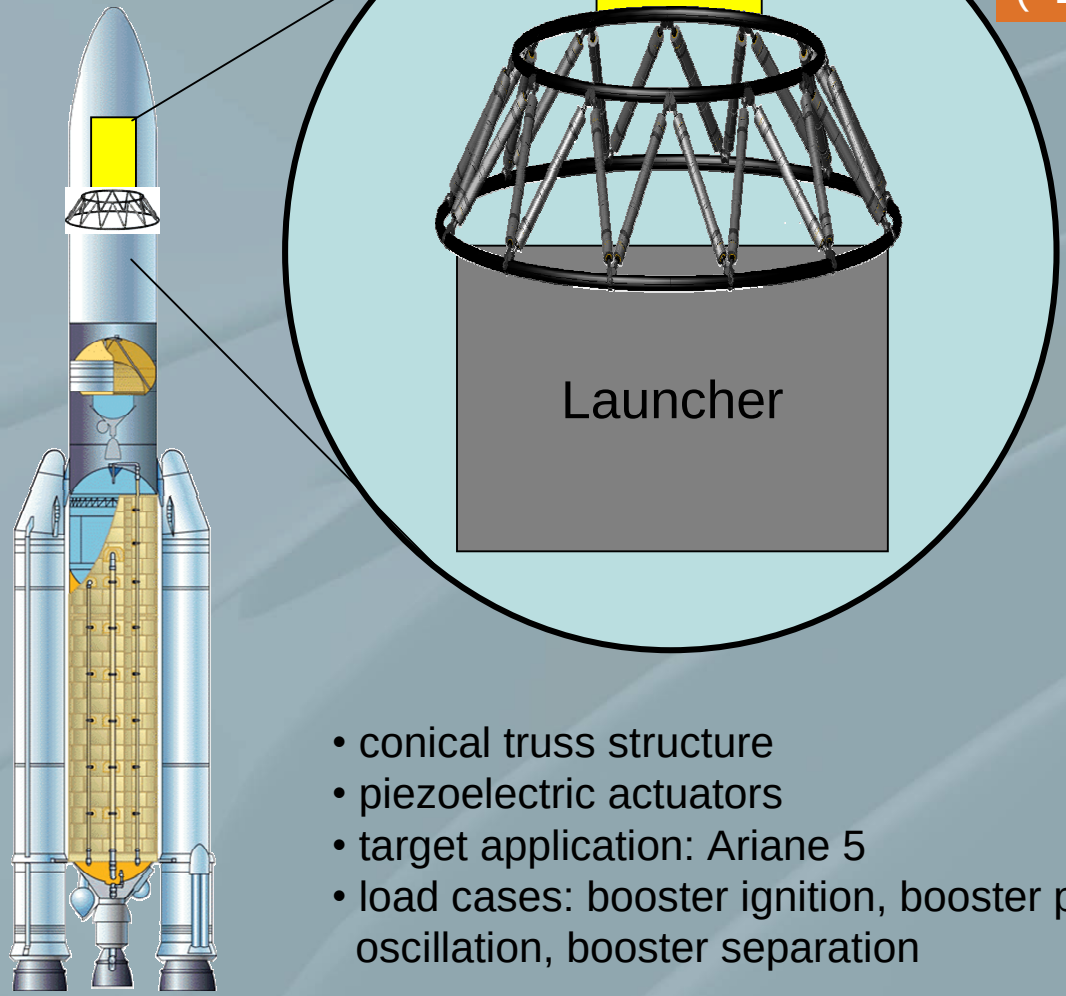
Hub Electronics Integration

Slip ring

Active Payload Adapter for Launcher

Objective:

reduce low frequency vibration (<100 Hz) of the payload by > 12 dB



- conical truss structure
- piezoelectric actuators
- target application: Ariane 5
- load cases: booster ignition, booster pressure oscillation, booster separation

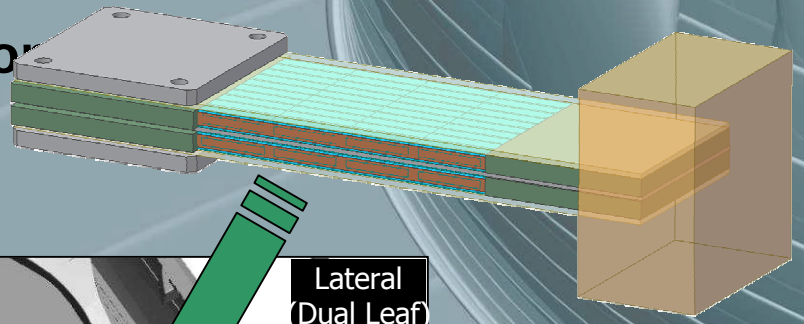
Active Vibration Control for Helicopter

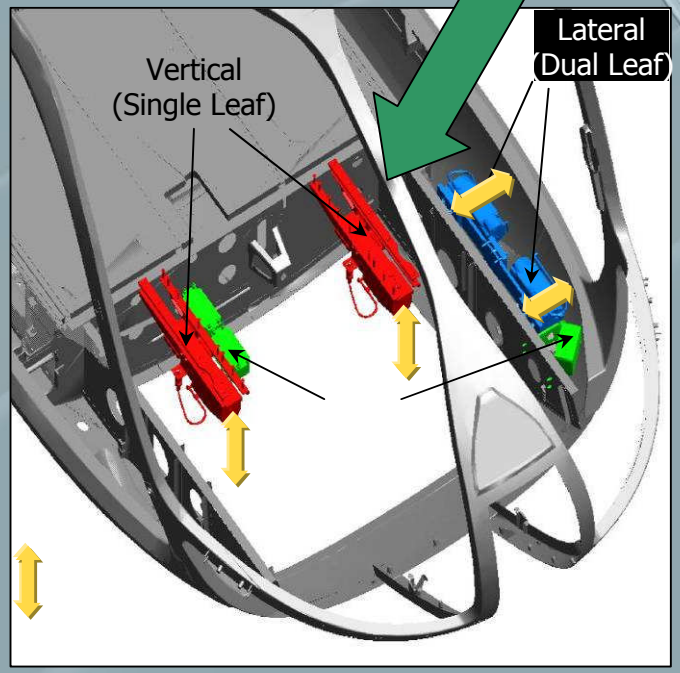
smart piezo force generators instead of semi-active absorbers

active remote control of fuselage vibratio

airframe acceleration sensors

adaptive feedforward filtering x-LMS





Conclusion

- Future aircrafts will be more-electric and comprise complex mechatronic systems
  - Installed electric power on aircrafts steadily increases
  - Electromotors replaces hydraulics and pneumatics
  - optimization of electrical power system
- To master future technical challenges, EADS requires to enhance skills in
  - + mechatronics integration technologies
  - + electrical power management, motor control
  - + concurrent modelling and engineering of mechanical and electrical systems

THANK YOU!!