



## GEA Tianjin / 中国民航大学中欧航空工程师学院

04.09.2015

### Agenda (2/3)

- Module 4 – Design requirements and Safety process
  - 4-1 Requirements
  - 4-2 Safety process
- Module 5 – Aircraft power systems
  - 5-1 Hydraulic power systems
  - 5-2 Electric power systems
- Module 6 – Aircraft Control systems Architectures
  - 6-1 Hydro Mechanical Systems
  - 6-2 Fly by wire systems
  - 6-3 Fly by wire systems new generation incl future
  - 6-4 A320 FAL Visit

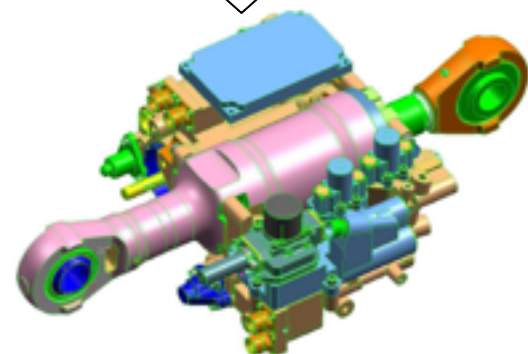
## Outlines

- Generals : Control surfaces & Cockpit controls
- Mechanical control systems (ATR)
- Hydromechanical control systems (A300/A310/B737 etc)
- First generation Fly by Wire systems (A320/A330/A340/B777)
- New generation, hybrid power sources, full Fly By Wire systems (A380/A400M/A350/B787)
- Future trends, smart and more electric actuation

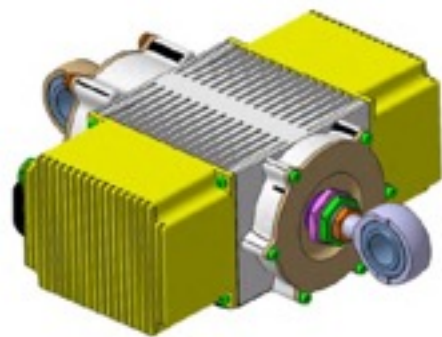
## GEA Tianjin / 中国民航大学中欧航空工程师学院

04.09.2015

FCRM



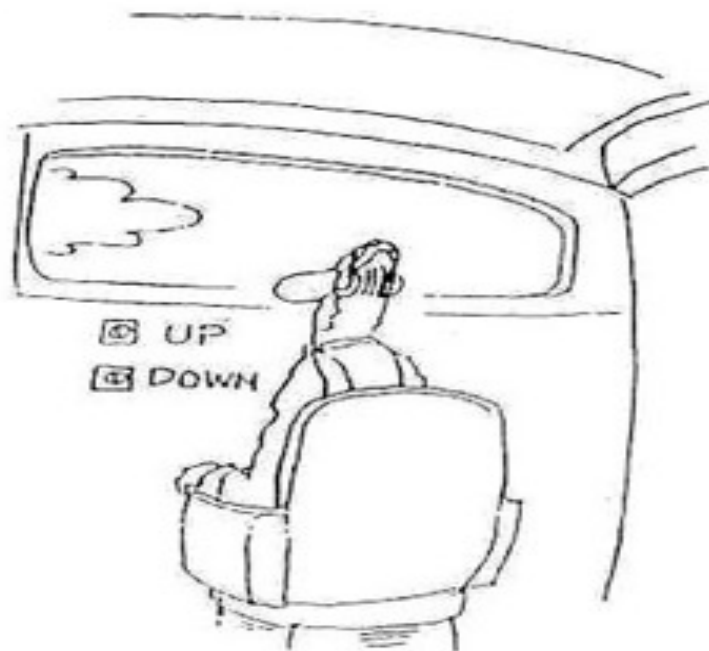
- “Smart” actuators: Introduction of local electronics, A350 “Flight Control Remote Module” , B787 “Remote Electronic Unit”
  - Airbus driver: Analog signals vulnerability to EMI when wiring installed in a composite fuselage
  - Principle: achieve the closed loop control locally and concentrate data for bidirectional exchanges with flight control computers through digital data buses
  - Generates weight saving
- Further reduction of the number of hydraulic systems
  - Driver: Bleedless aircraft electrical generation sized for the high power requirements of the Environment Control and Wing Ice Protection Systems, and able to power flight controls and other users with no significant over sizing, weight reliability and maintainability benefits
  - Issues to be solved: Jam free/tolerant landing gear actuation
- Introduction of Electromechanical Actuators EMA
  - Driver: simpler/lighter/cheaper than EHA
  - Issues to be solved: jamming and backlash
  - Spoiler EMA introduced on B787 for dissimilarity



GEA Tianjin / 中国民航大学中欧航空工程师学院

## Future trends, more electric systems

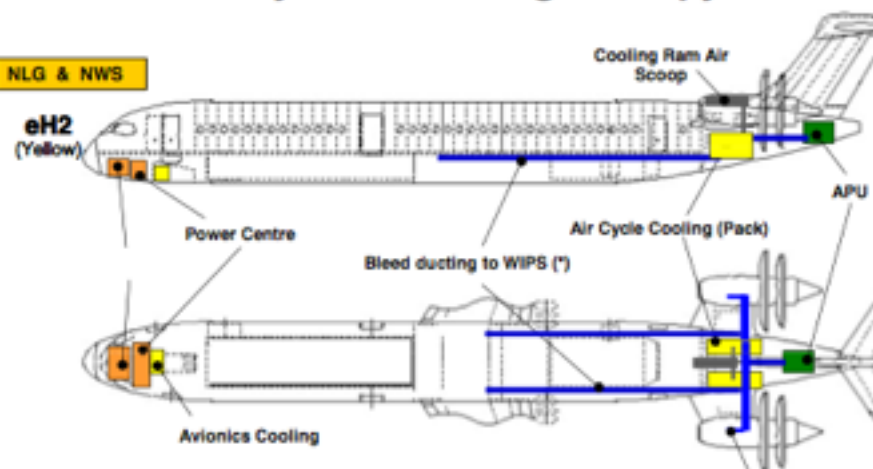
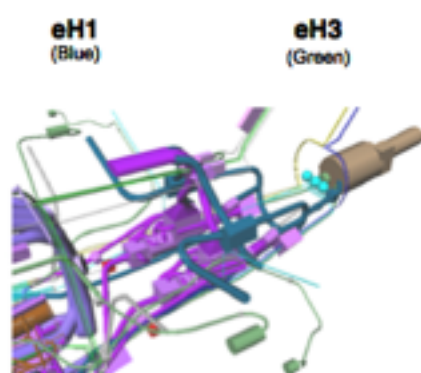
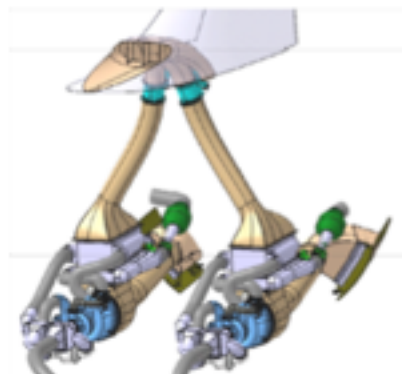
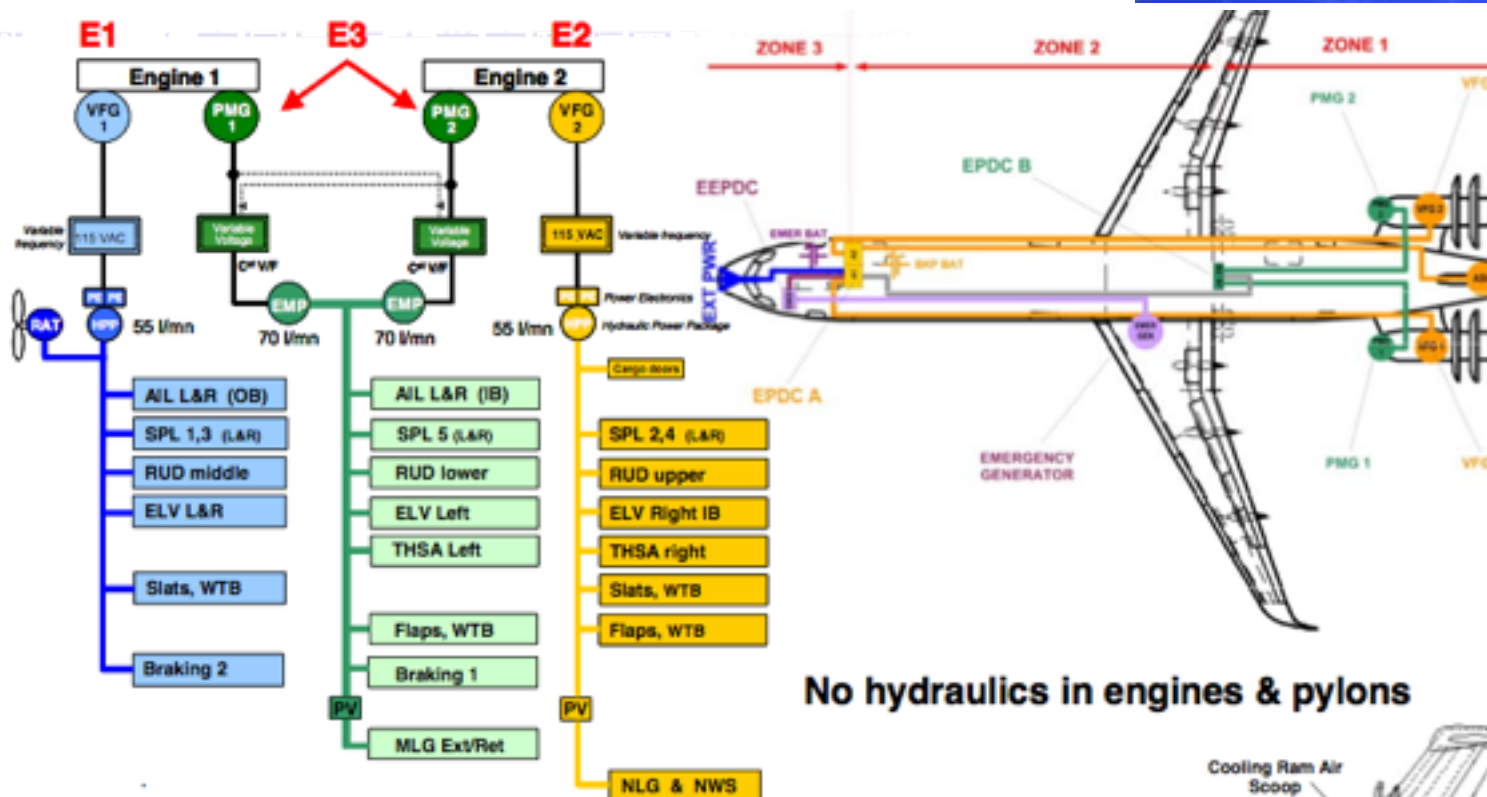
04.09.2015



- Ailerons
- Spoilers
- Rudder
- Elevators
- THSA
- Slats
- Flaps
- Braking

- MLG Ext/Ret
- NLG Ext/Ret and Steering





## GEA Tianjin / 中国民航大学中欧航空工程师学院

### Towards more electric aircraft

- For years engineers have dreamed of all-electric aircraft. They have envisioned a concept called "power-by-wire," in which electrical power moves aircraft flight surfaces.
- The goal of power-by-wire is to eliminate the hydraulic connection, and its associated risks.
- The transition to all-electric aircraft is still many years in the future.
- Aircraft engineers have tested electro hydrostatic actuators (EHAs), which combine electrical and hydraulic power: hence the evolutionary "more electric aircraft" idea.





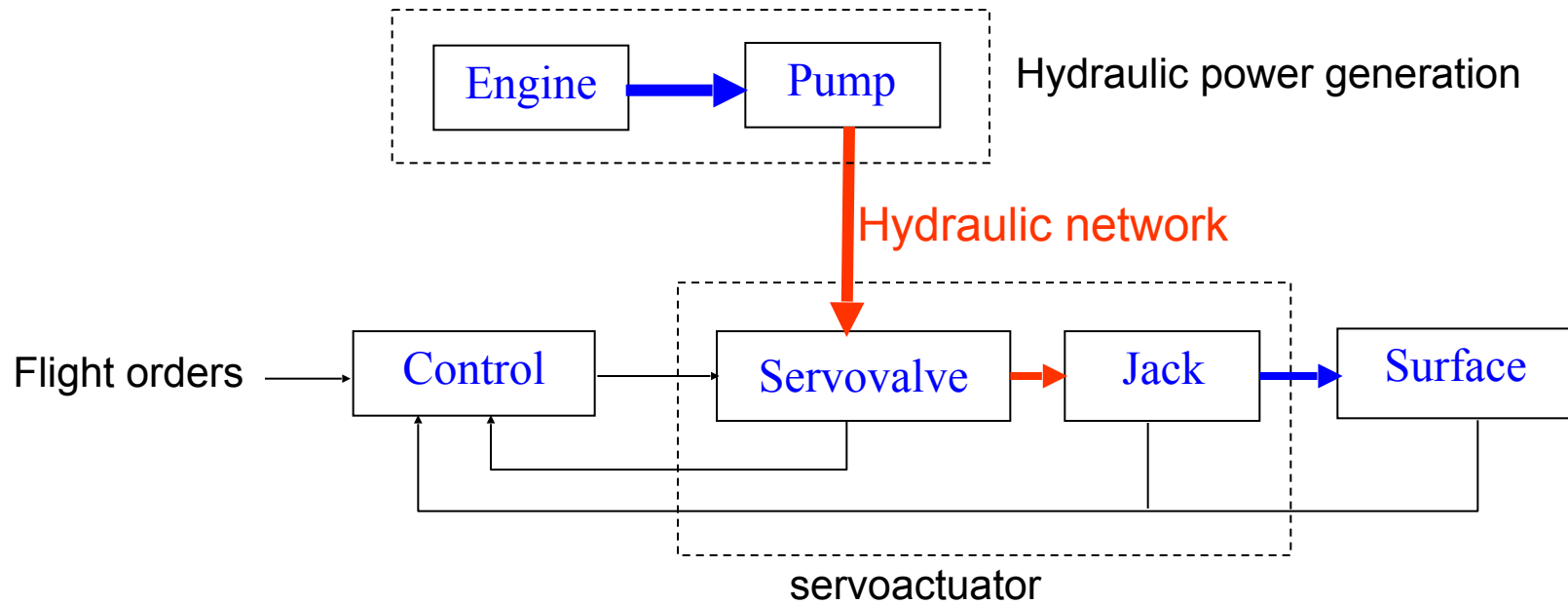
GEA Tianjin / 中国民航大学中欧航空工程师学院

## EHA Concept

- EHAs are electrically powered but use small hydraulic pumps and reservoirs that transform electrical power into hydraulic power.
- Airbus has worked with EHA flight control technologies for more than a decade. A320 and A340 flight test beds have operated since 1993-94 and 2000, respectively.
- The U.S. military's Joint Strike Fighter and C-141 Electric Starlifter programs have tested EHA systems, as well.

## GEA Tianjin / 中国民航大学中欧航空工程师学院

### Typical architecture of actuation system



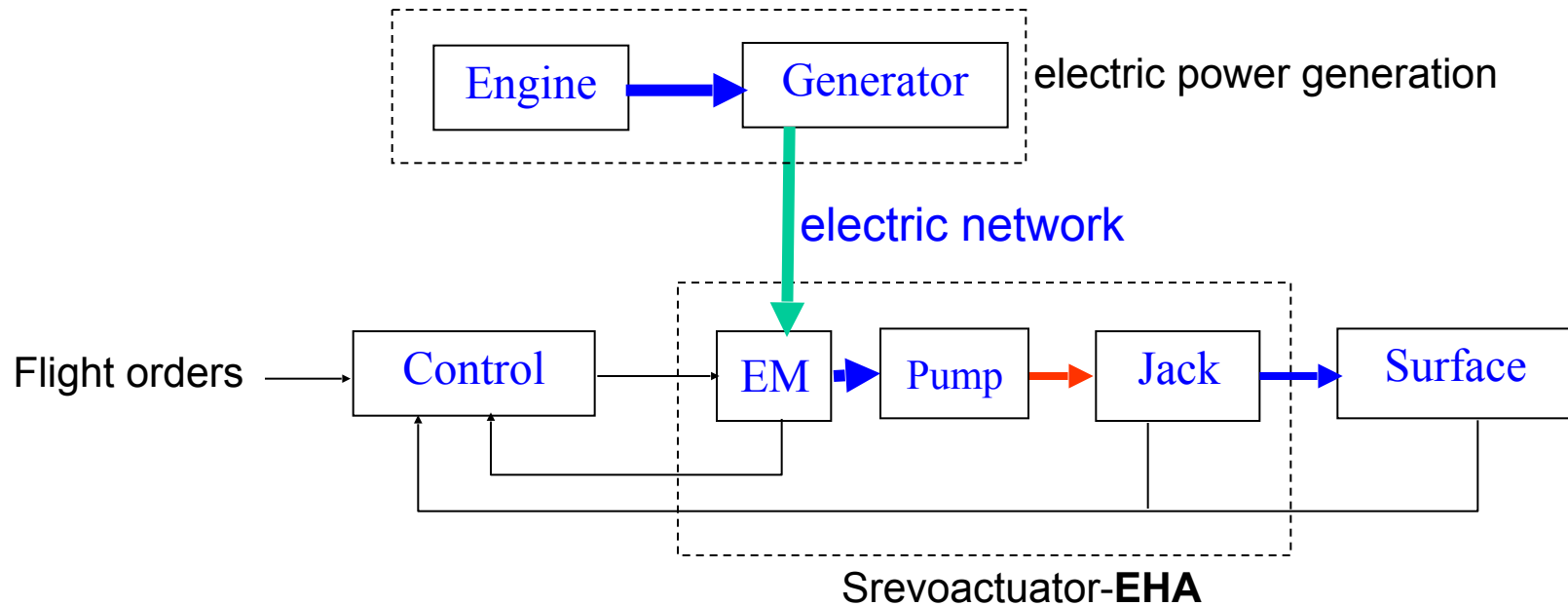
- Mass proportion:
 

tubing	fitting and attach	fluid	equipments
25%	15%	35%	25%



## GEA Tianjin / 中国民航大学中欧航空工程师学院

### Alternative actuation system



- Mass proportion:

**Wiring**

25%

fitting and attach

15%

fluid

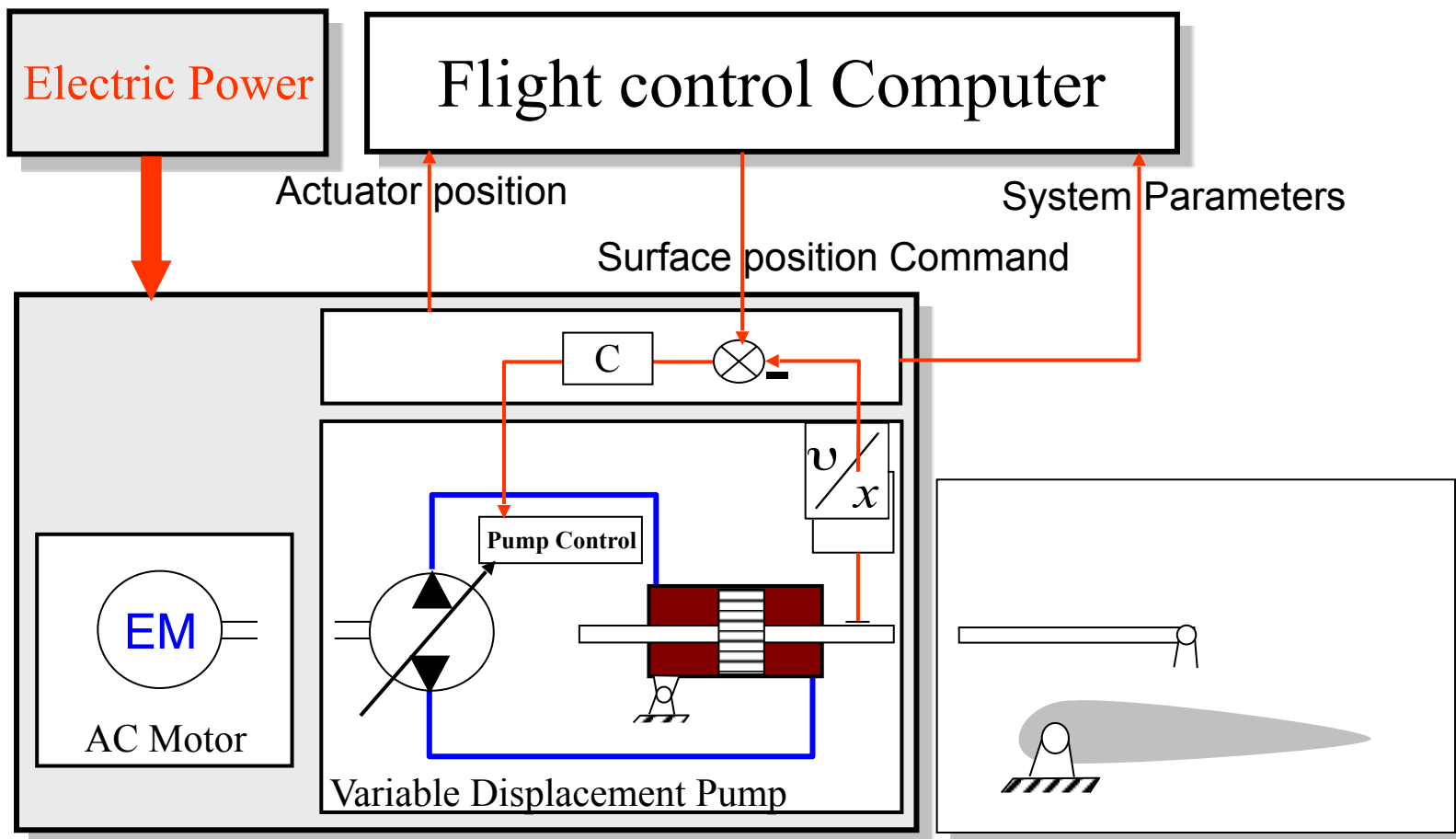
35%

equipments

25%

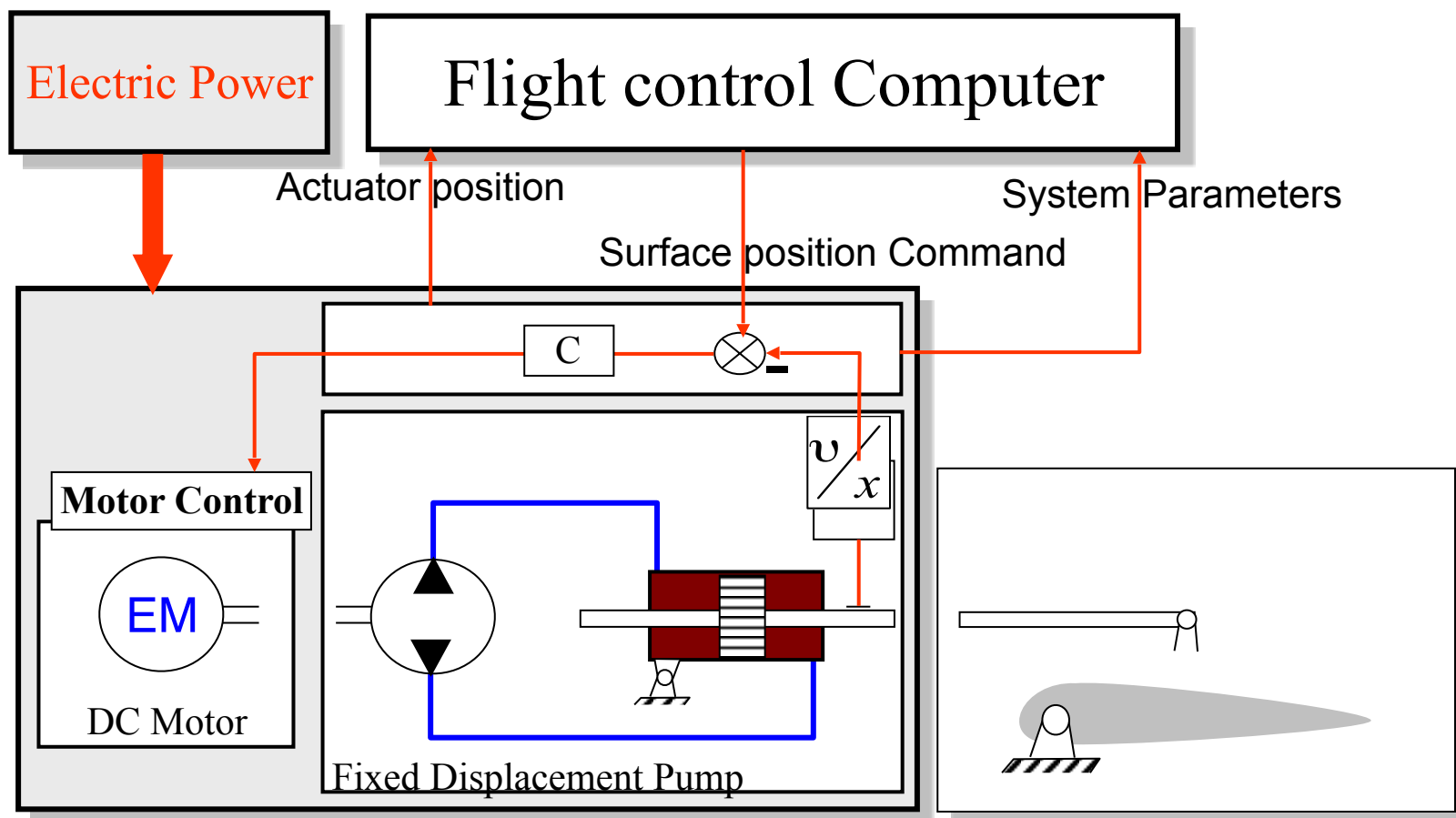
# GEA Tianjin / 中国民航大学中欧航空工程师学院

## Pump Control EHA

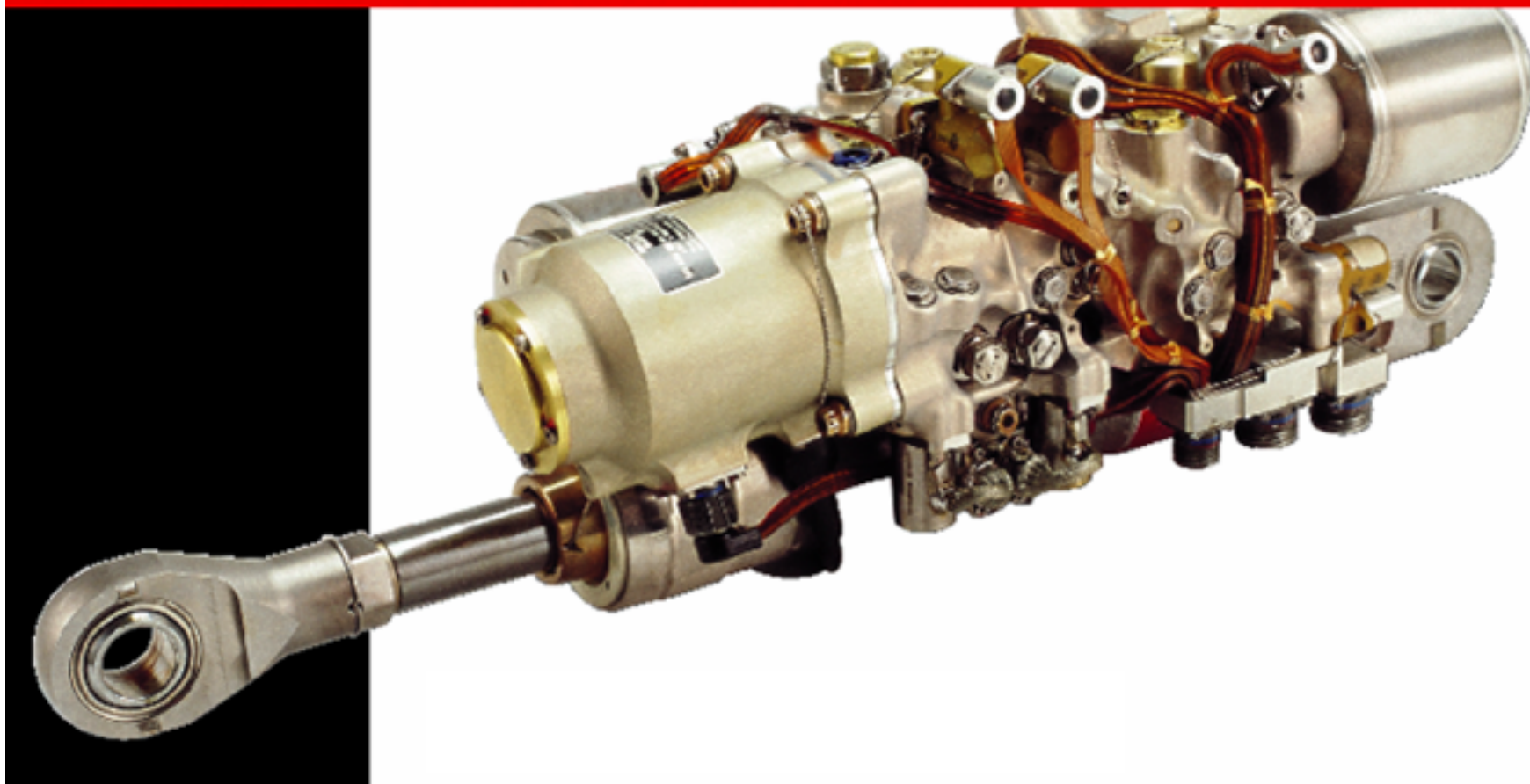


GEA Tianjin / 中国民航大学中欧航空工程师学院

## Motor Control EHA



# Electrohydrostatic Actuator



For : JSF ( Joint Strike Fighter )

Designed by: Parker Aerospace Control Systems Division Military



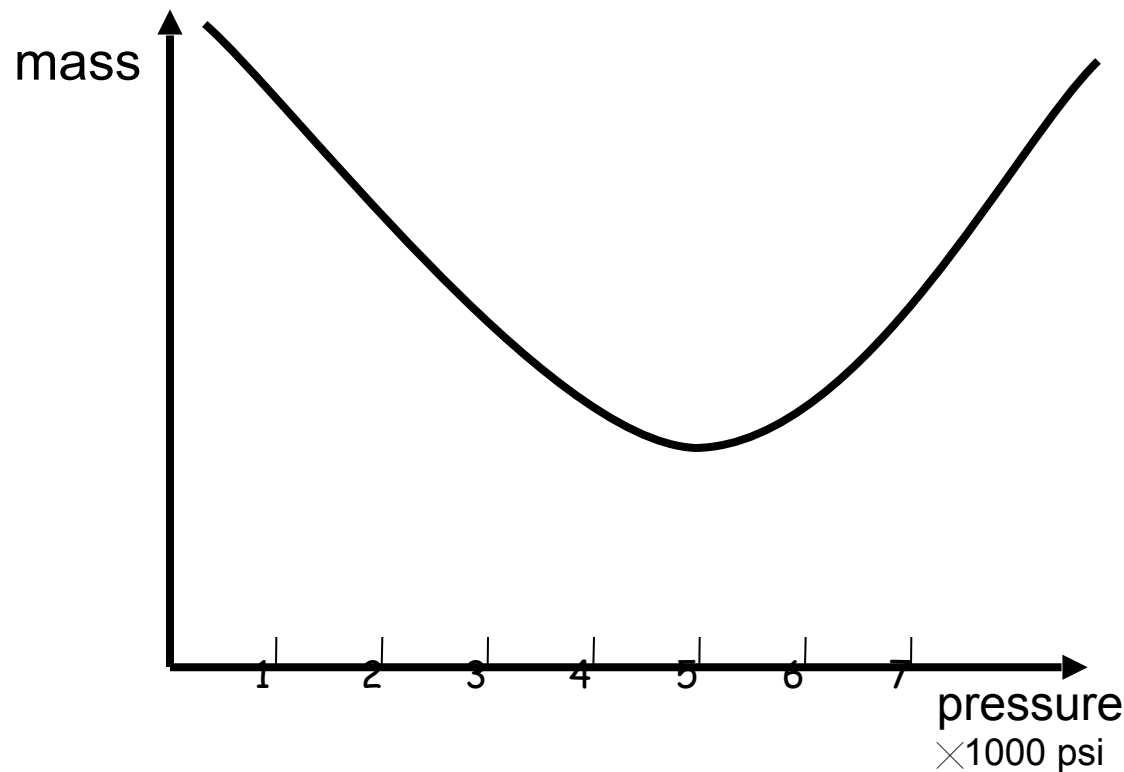
GEA Tianjin / 中国民航大学中欧航空工程师学院

## Future of hydraulics

## GEA Tianjin / 中国民航大学中欧航空工程师学院

## 6.1 High pressure circuits

System pressure VS. system mass



The higher the pressure, the thinner the pipe, the thicker the pipe wall!

