Design and Control of the Digital Hydraulic Actuator for force-controlled flight control actuation

FT2019

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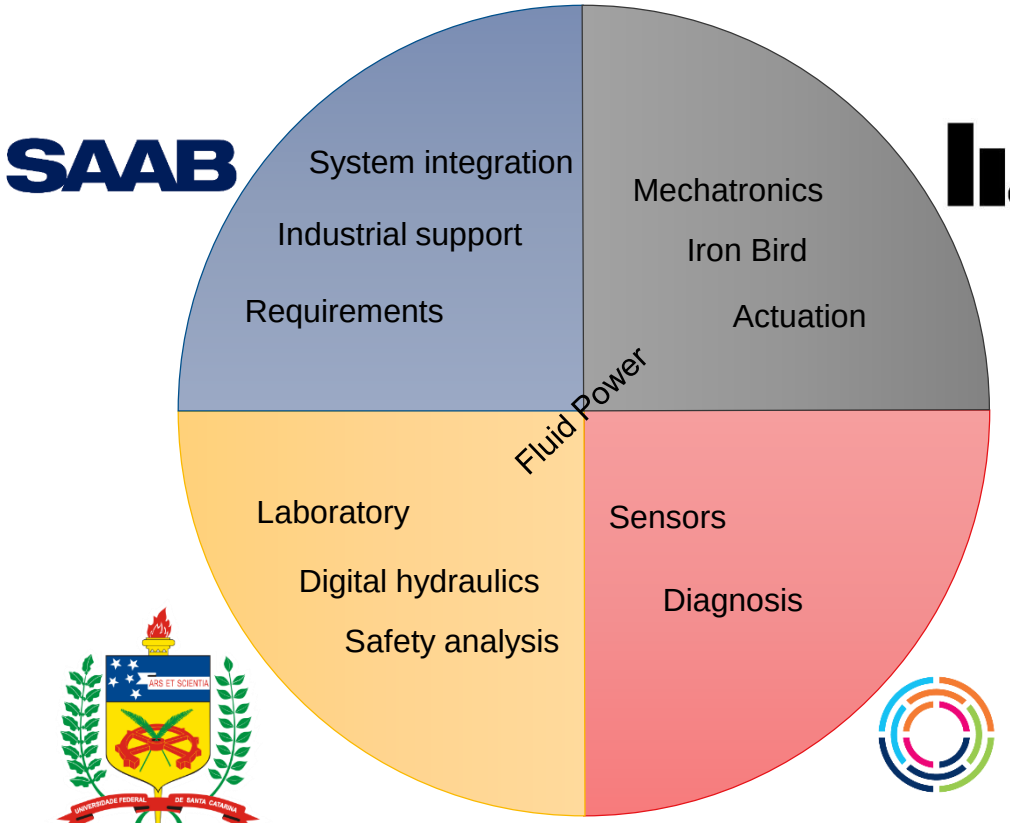
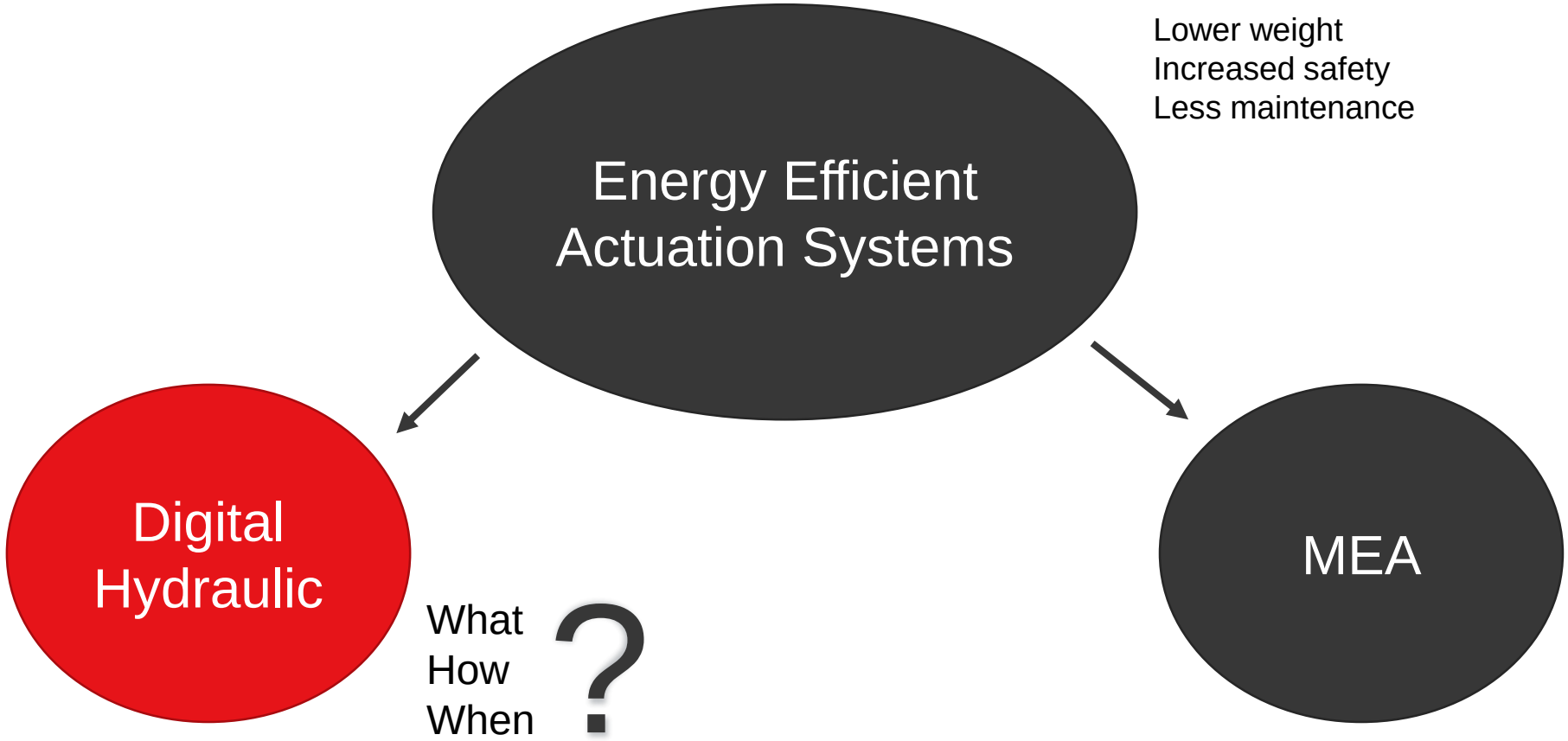
Background

- Swedish – Brazilian collaboration
- Introduce Digital Hydraulics in Aircraft
- Digital Hydraulic Actuator, **DHA**



Technology Assessment

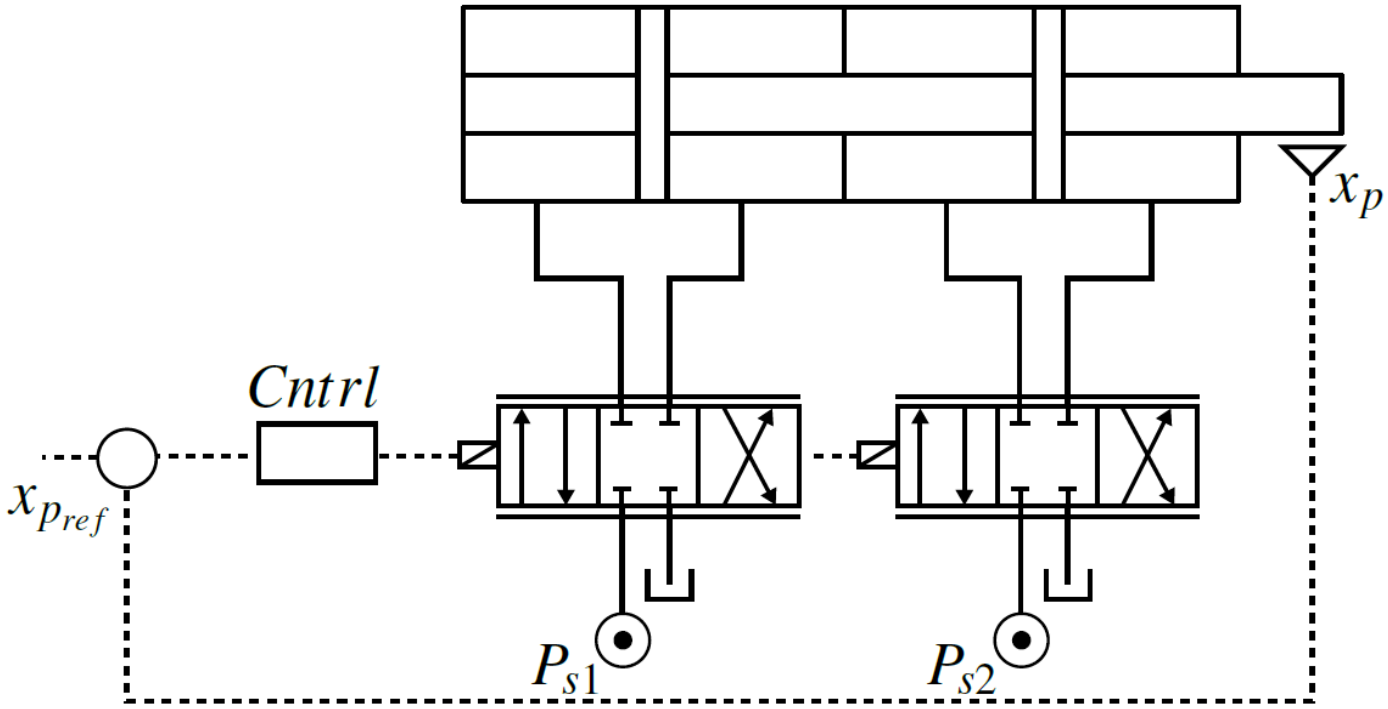


What is the problem?

- **Throttle control**
- **Leakage**

} **Energy losses!**

- Distribution
- Fluid conditioning
- Aggressive oil

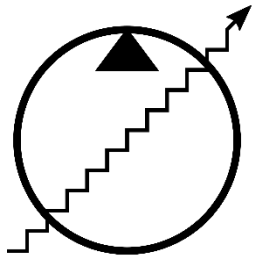


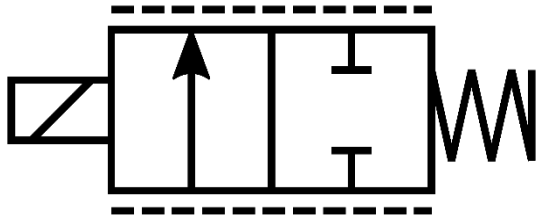
Why keep hydraulics?

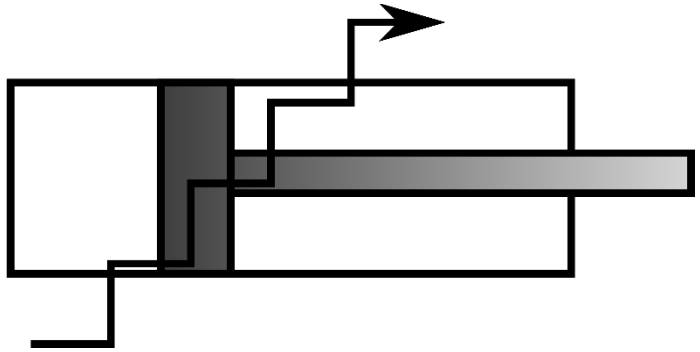
- High power density → We save weight
- Easy control
- High response → Good handling qualities
- High realiability → Easy to implement safety functions
- Dissipation of heat →

What is digital hydraulics

- Discretized hydraulic system
- Components
  - On/off valves
- Output
  - Flow
  - Force

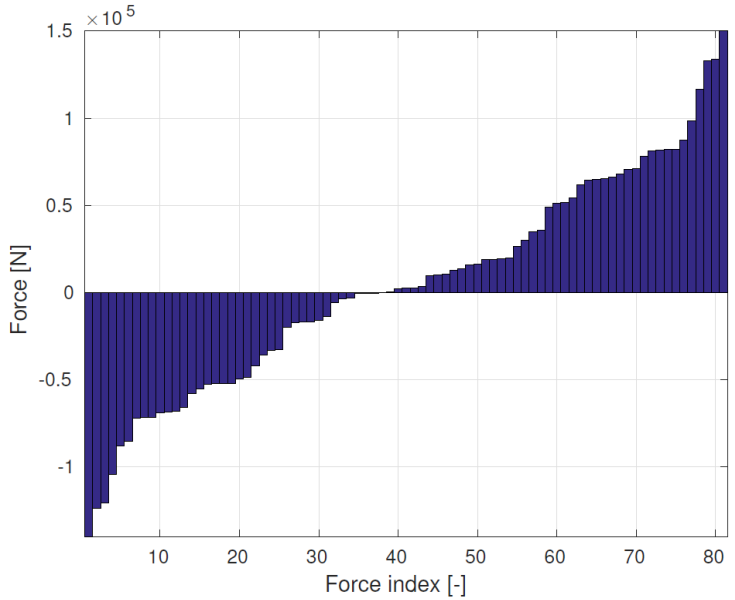


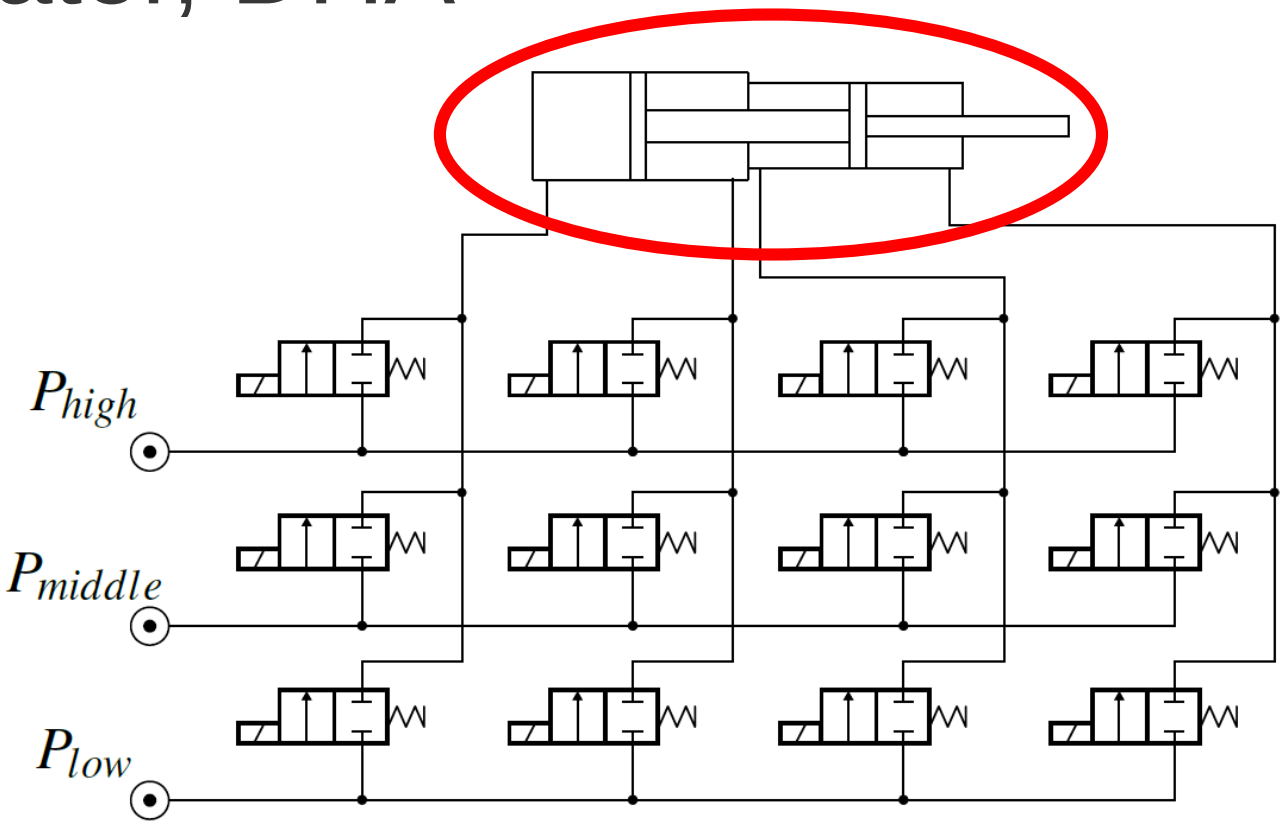




Digital Hydraulic Actuator, DHA

- Multi-chamber cylinder
- Several pressure lines
- On/off valves
- Force control





Expectations with DHA

Opportunities

- No throttling
- Leak-free valves
- Energy recovery
- Force control

Challenges

- Requires fast valves
- Switching
- Discretized control

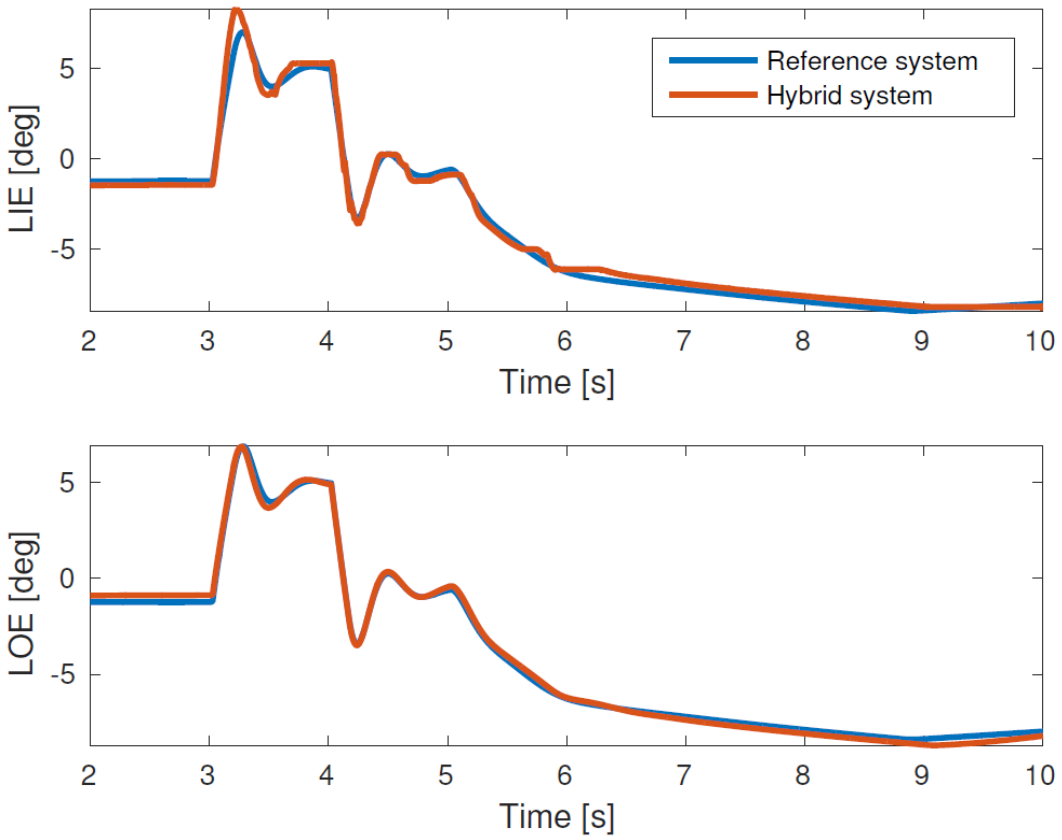
Collaborative work

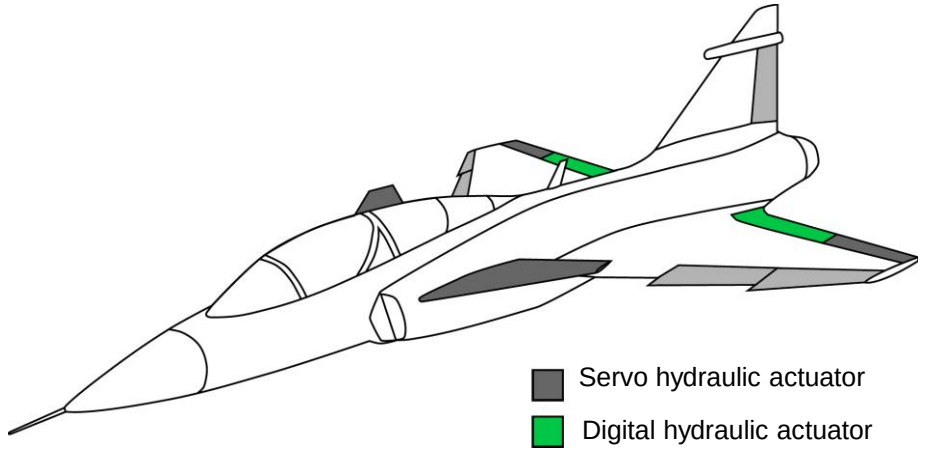
- Conceptual study on how to utilize Digital Hydraulics for aircraft applications
- Aircraft simulation with Digital Hydraulics
- Reference system and requirements
- Solutions assessment in full system simulations

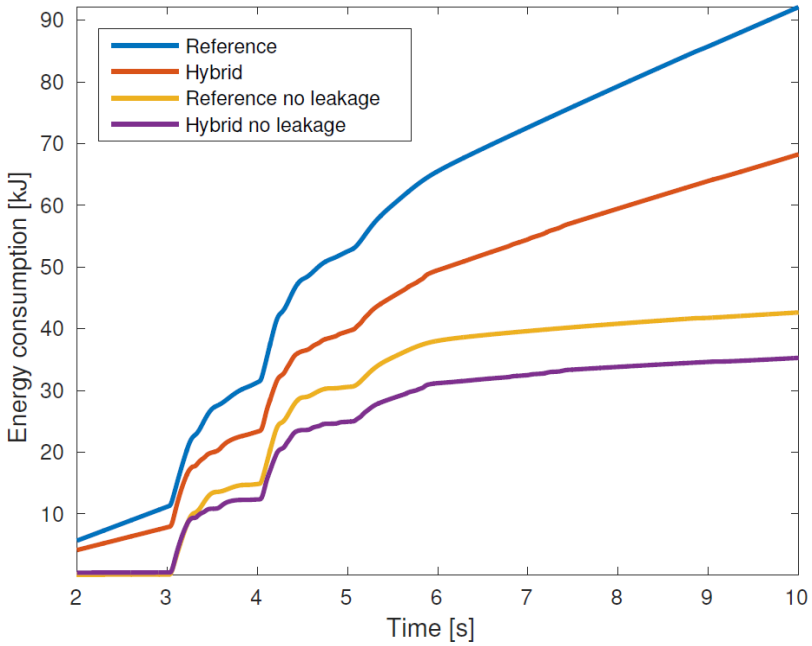
2 Master Theses at Saab

- Low-level control strategies
- Design and manufacturing of test bed
- Proof-of-concept
- Energy consumption study of the digital system
- Aircraft simulation with the DHA
- Safety and reliability analyses and comparison with conventional system

Pure Digital Control





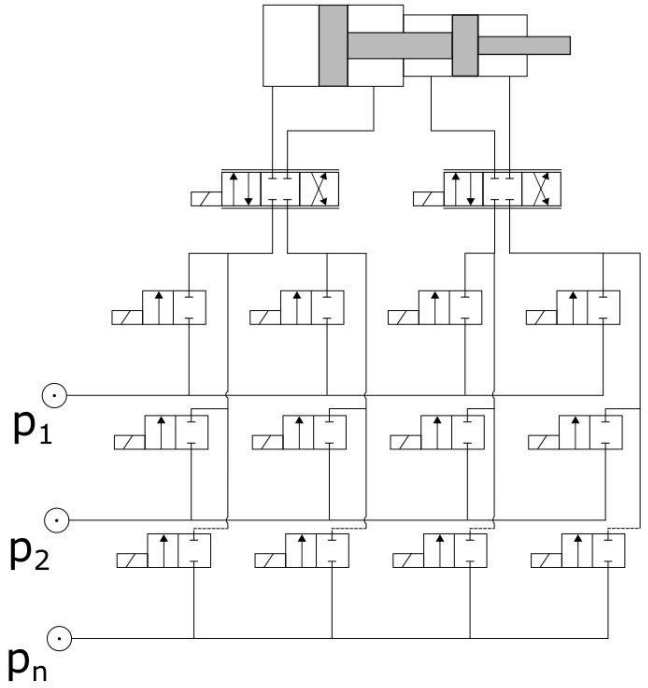


26 % less energy

New strategy

How to combine digital and restrictive control?

Conceptual study



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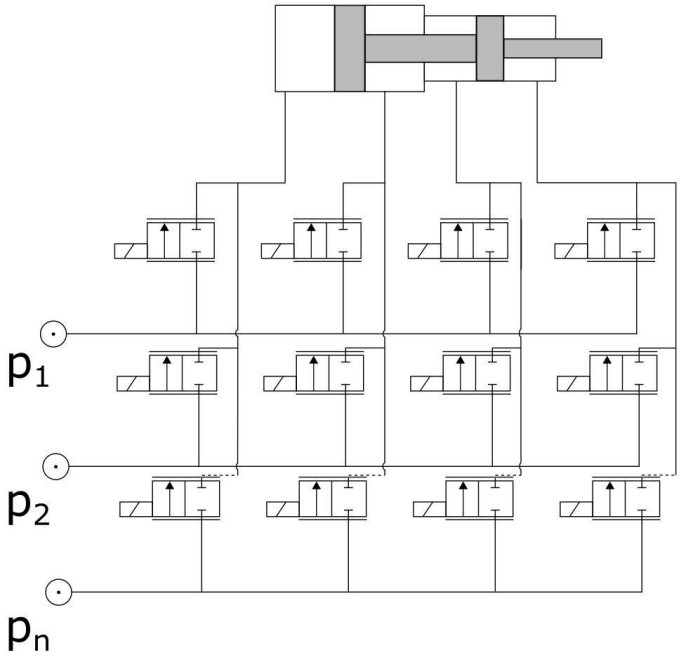

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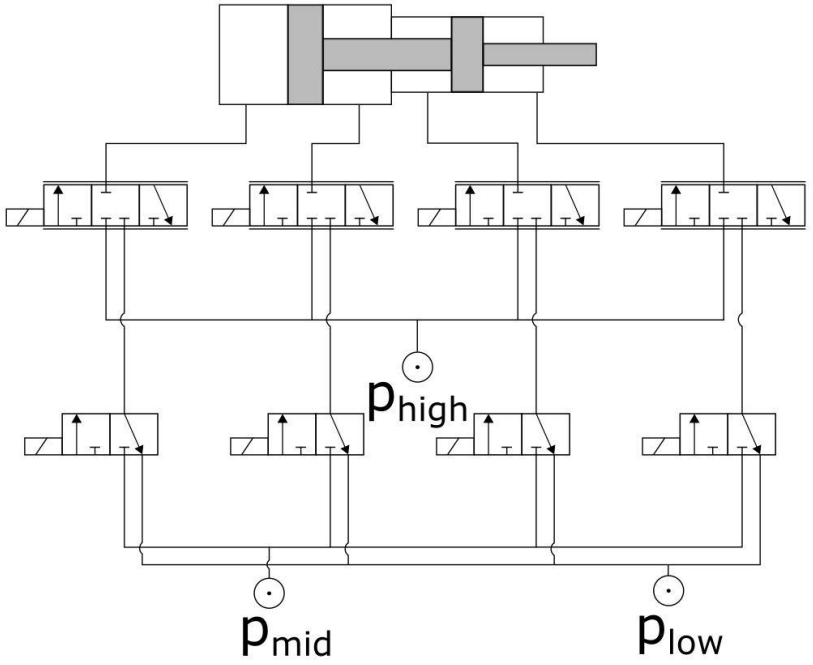

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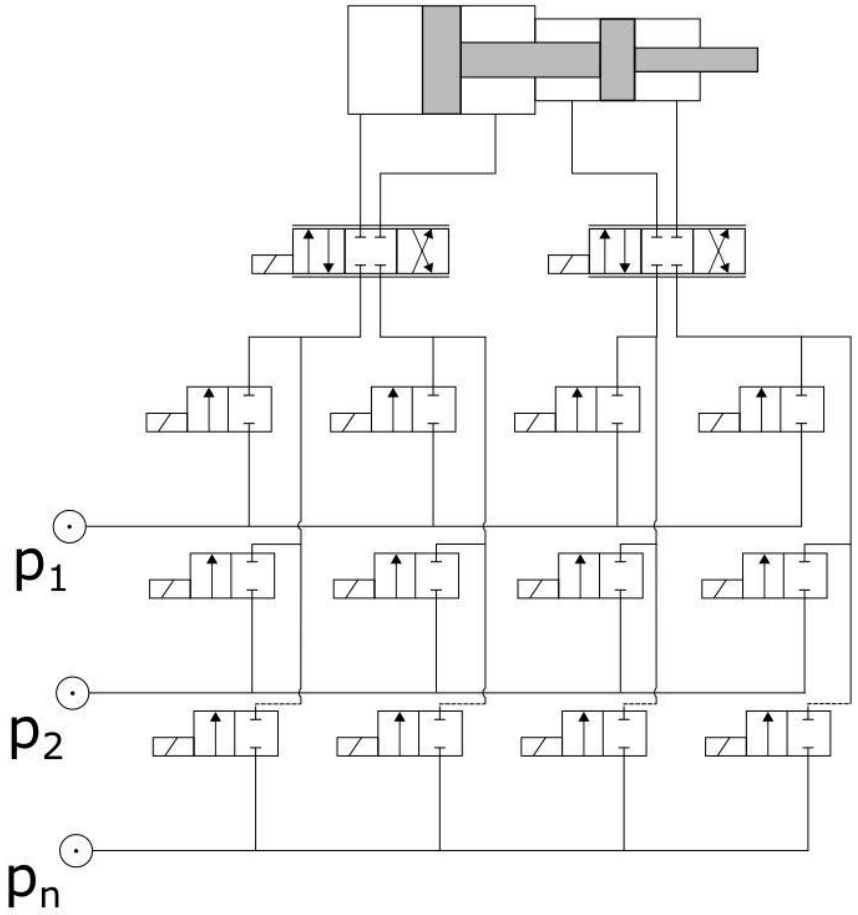
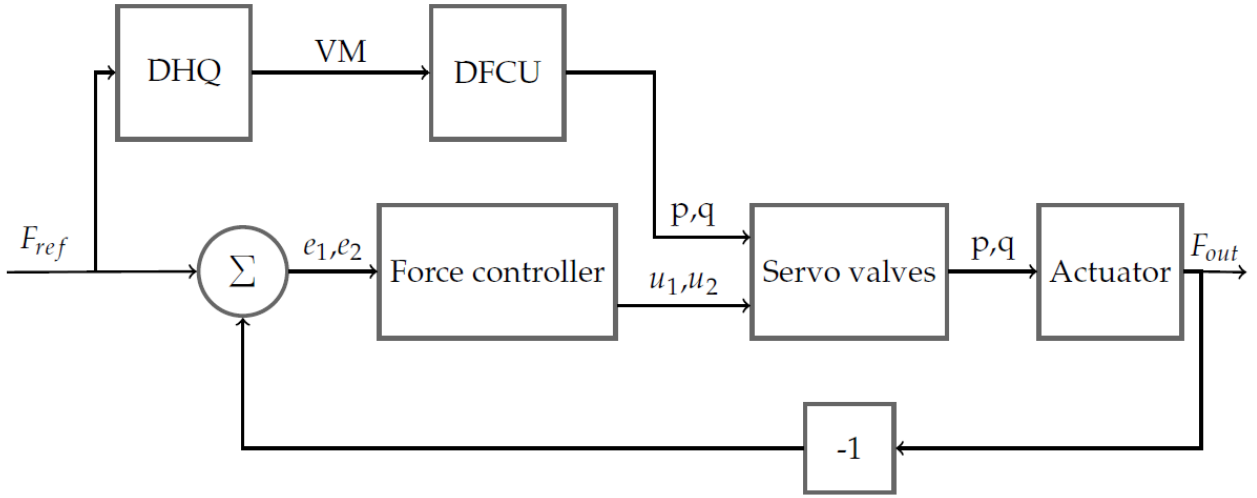
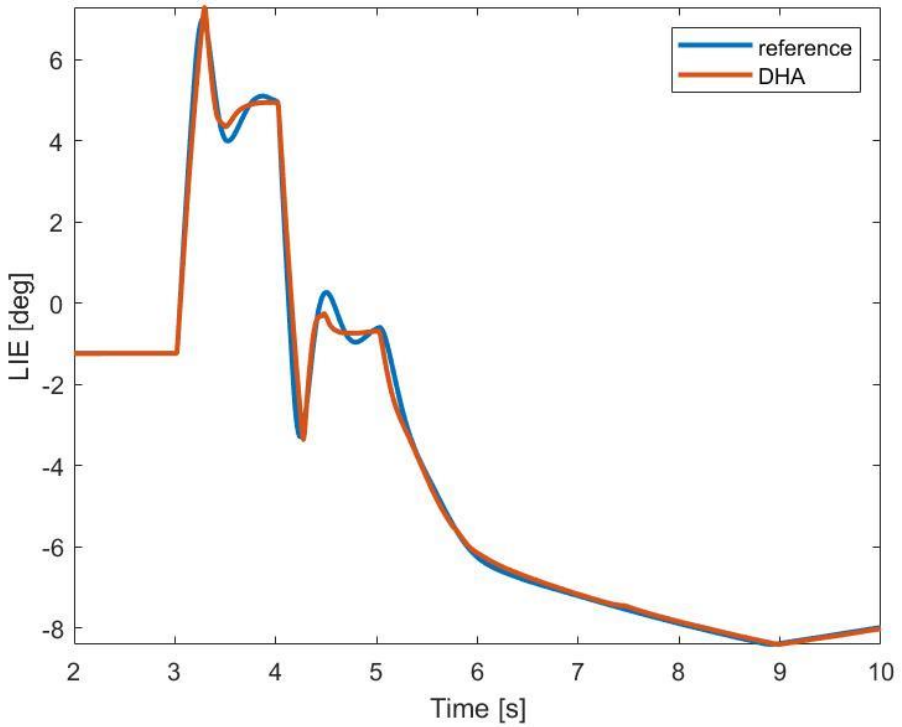
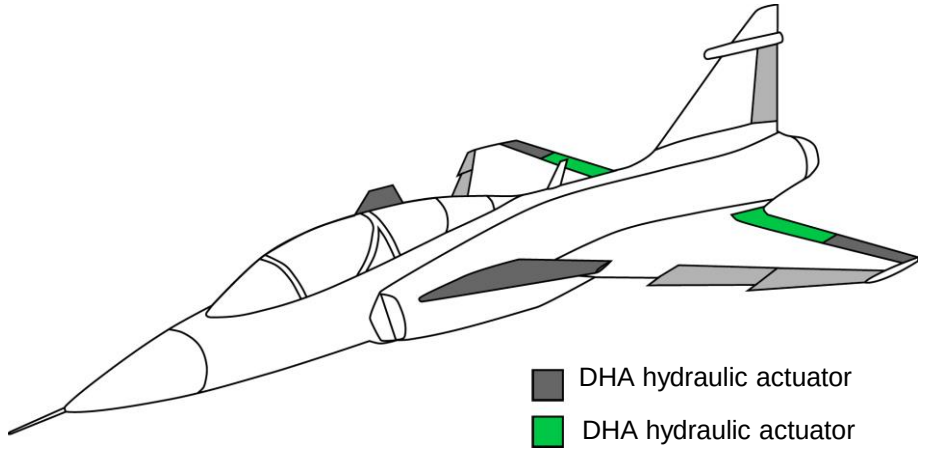
Digital and restrictive control

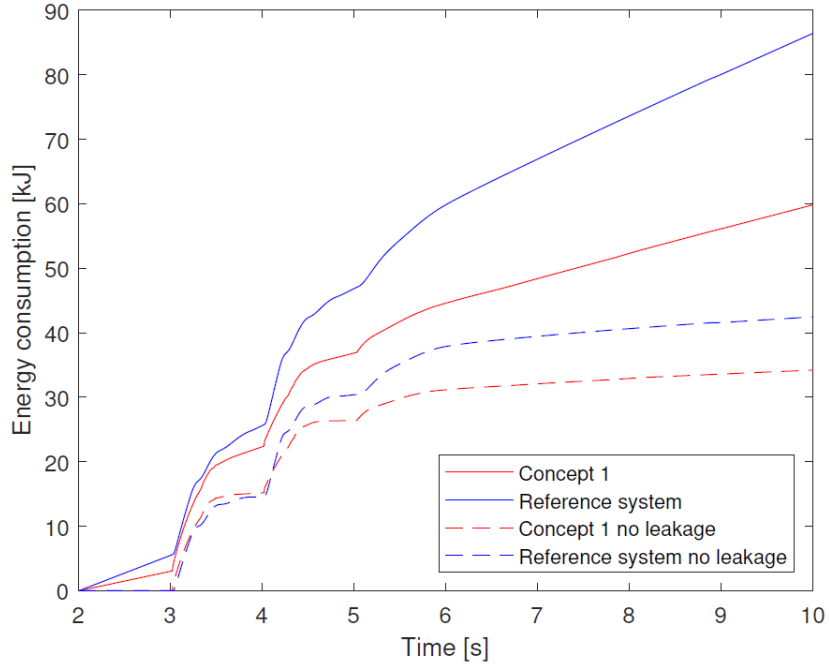




Evaluation







~30 % less energy

Some thoughts…

- More advanced controllers needed
- Synchronizing of switching
- New switching strategies
- Leakage has a big influence

- Sizing of the concept
- Full mission simulations
- Energy analysis
  - Switching losses
  - Throttling losses
  - Energy recuperation
- Force control vs position control

Technology Assessment