Morphing Wings Control using Infinite Linear Actuators

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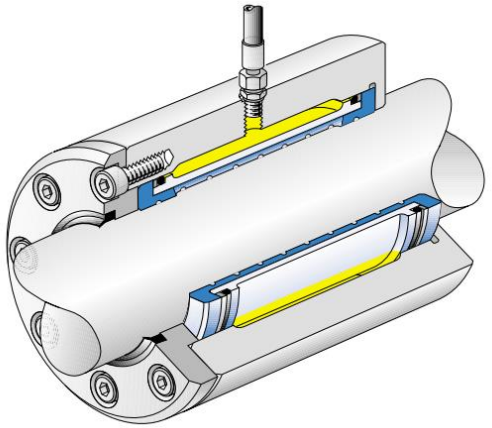
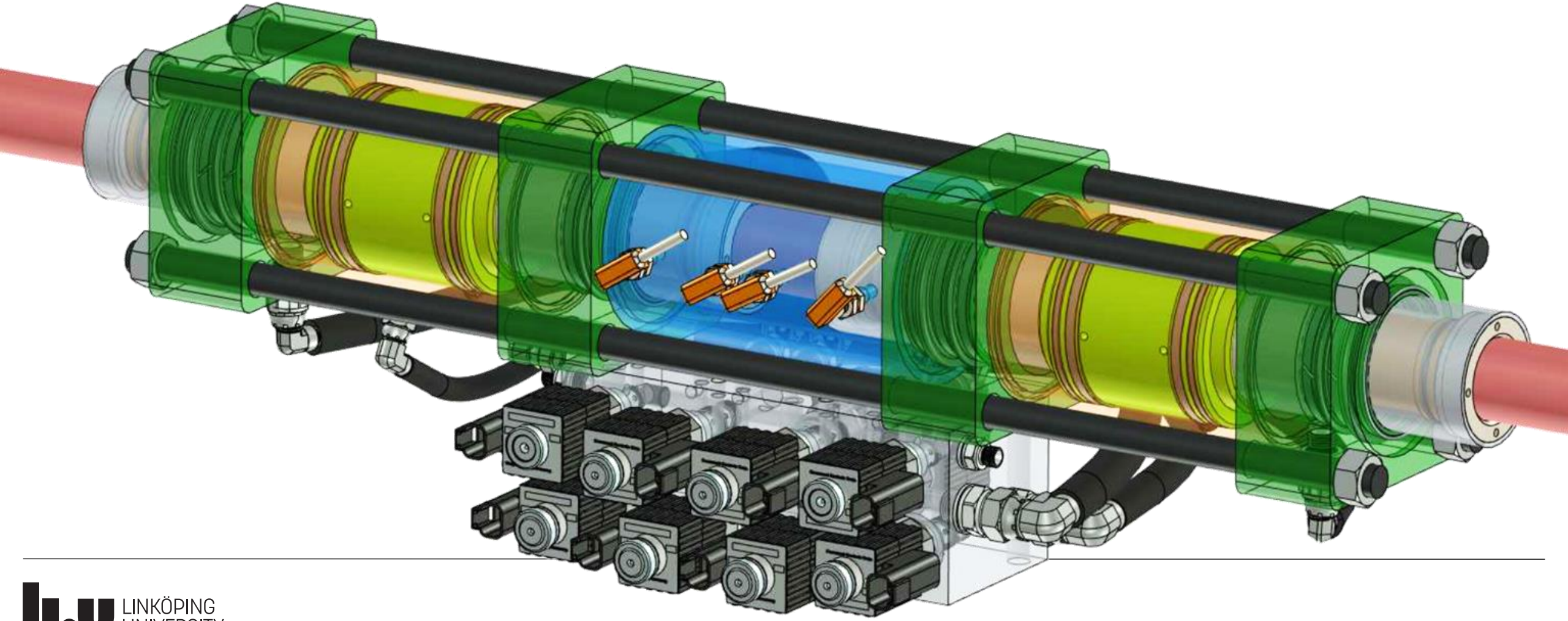
Hydraulic Clamping Mecanisms

- Good fatigue and sliding properties
- Low stick-slip effect
- Handles high axial forces
- Low pressure required for locking
- Good durability
- Fast clamping, ~ 20 ms

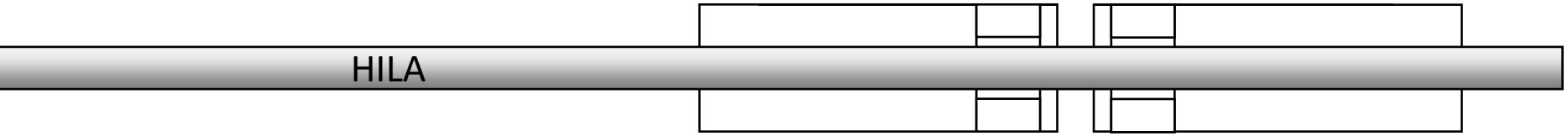


HILA – Hydraulic Infinite Linear Actuator

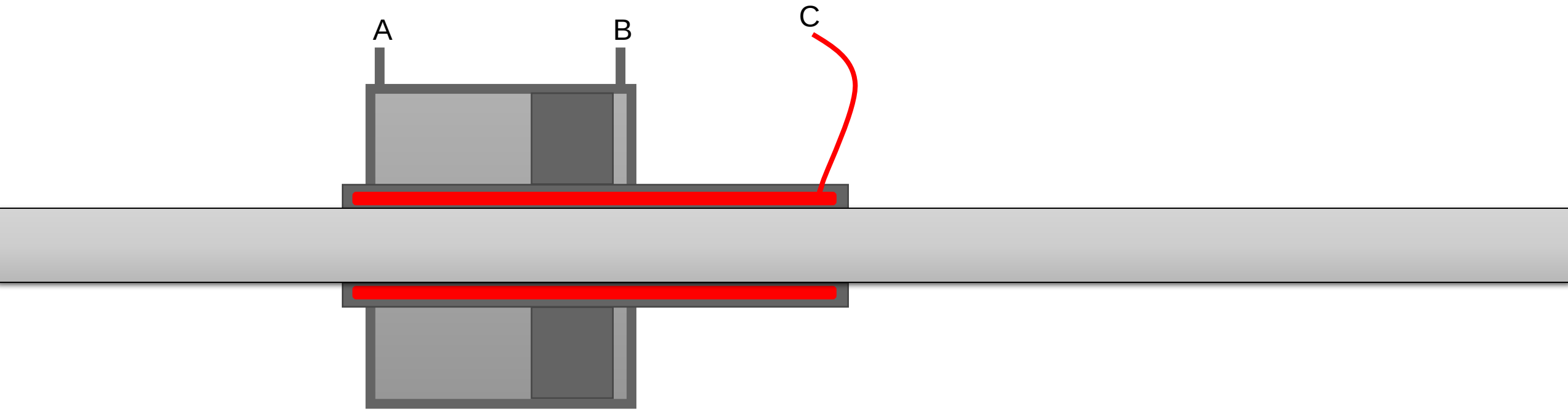


HILA- Three Modes of Operation

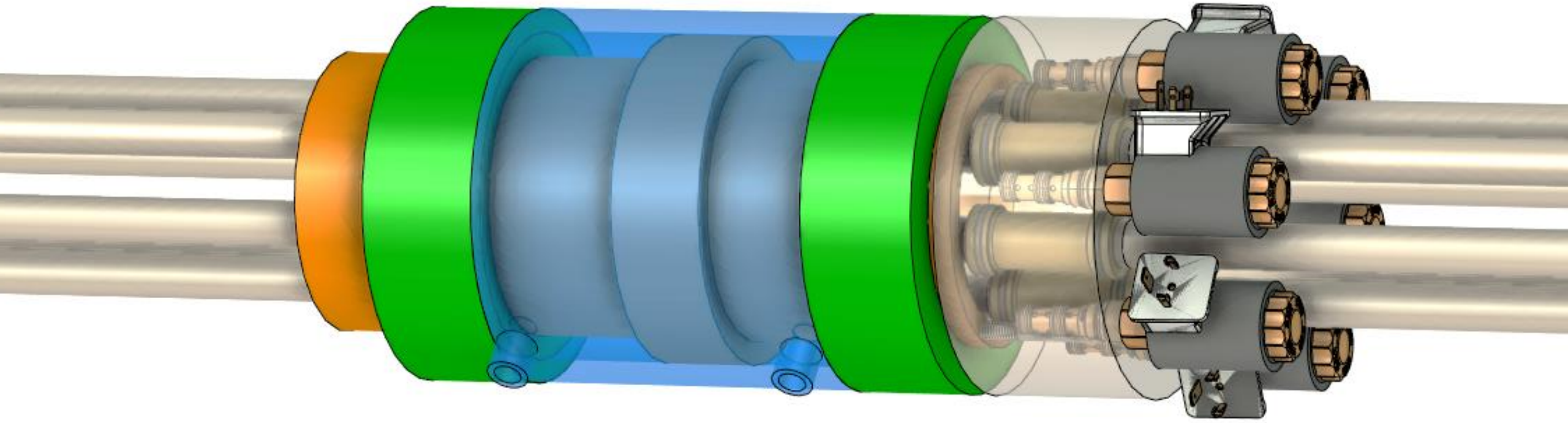
1. Normal operation – Like two hands hauling a rope with a load



Separate Clamping Pressurization

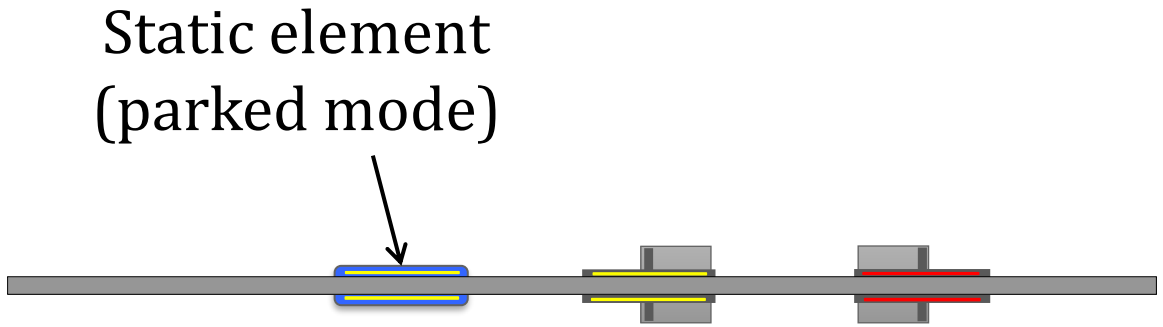


HILA Multi-Rod (MR)



Three Clamping Elements

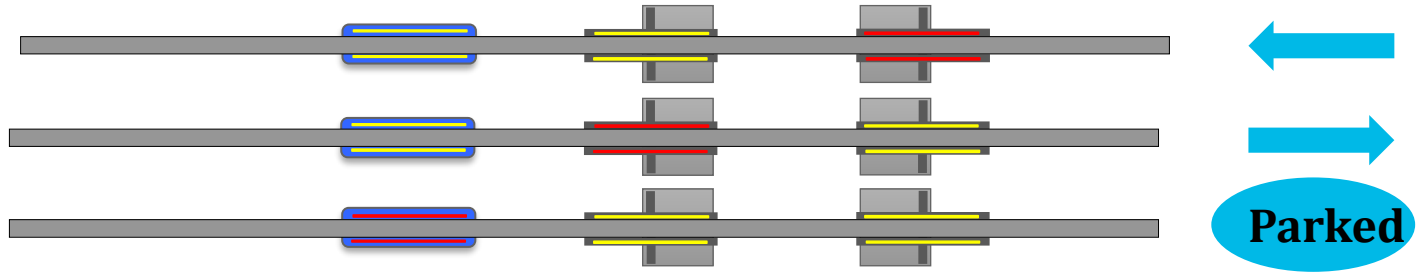
Two dynamic and three static HILA elements



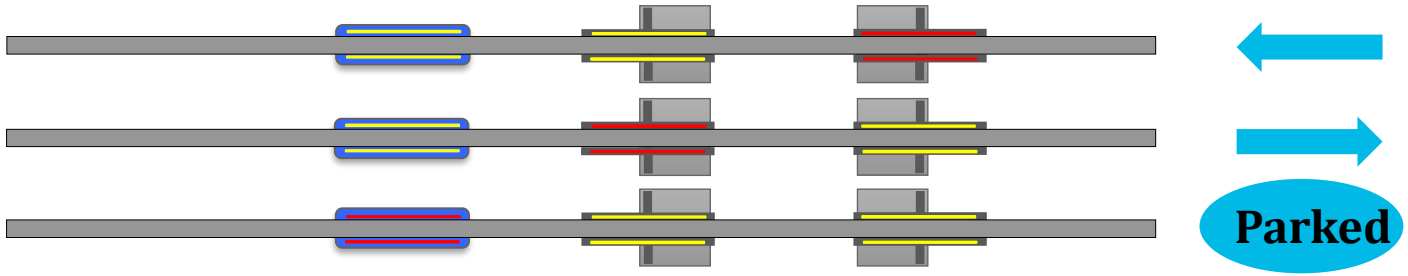
Red = pressurised clamping element
Yellow = unpressurised

Operating Modes – Left, Right and Static

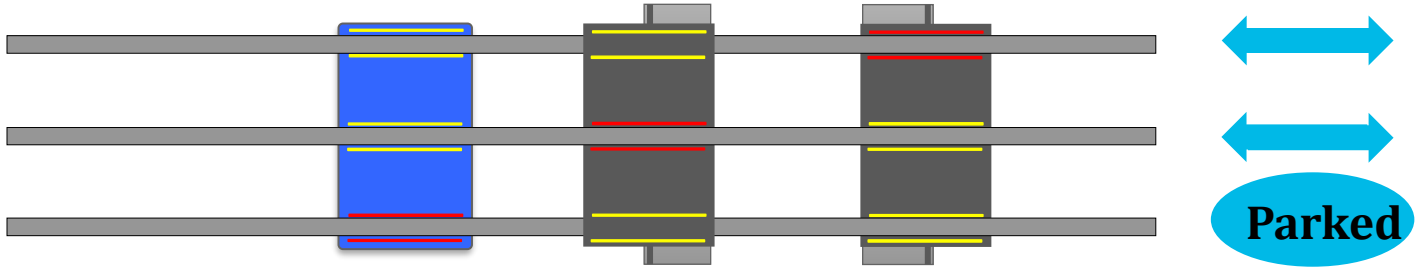
- Rod 1: Left Movement
- Rod 2: Right Movement
- Rod 3: Parked Mode

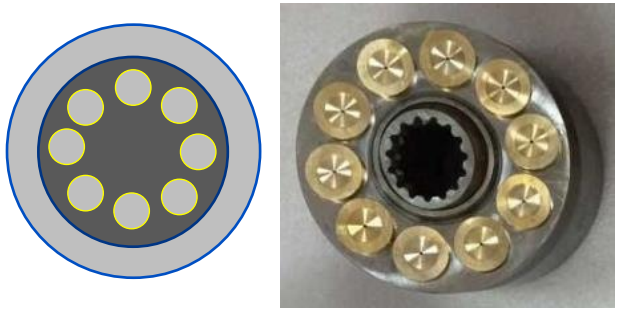


Independent Simultaneous Modes



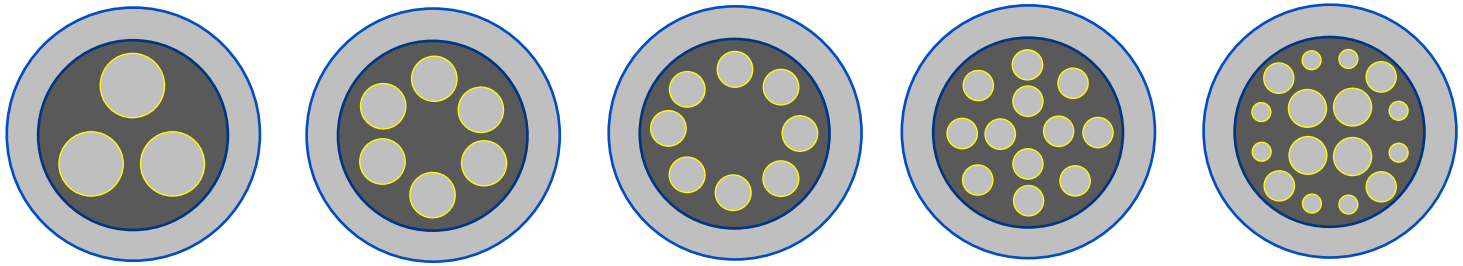
Rods Integrated in Common Pistons





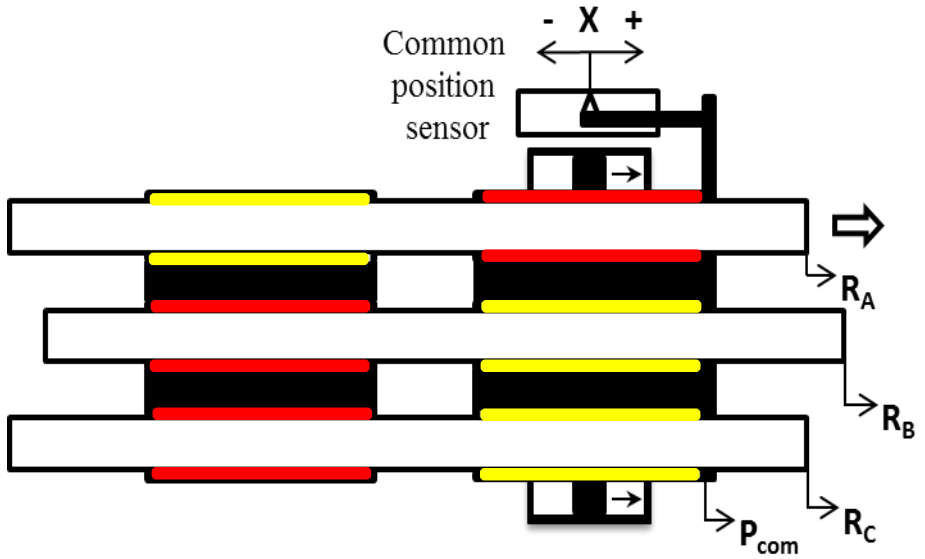
- Similarities with hydraulic axial piston machines
- Known techology

Different number of clamping elements and rods



Common Position Sensor for all Rods

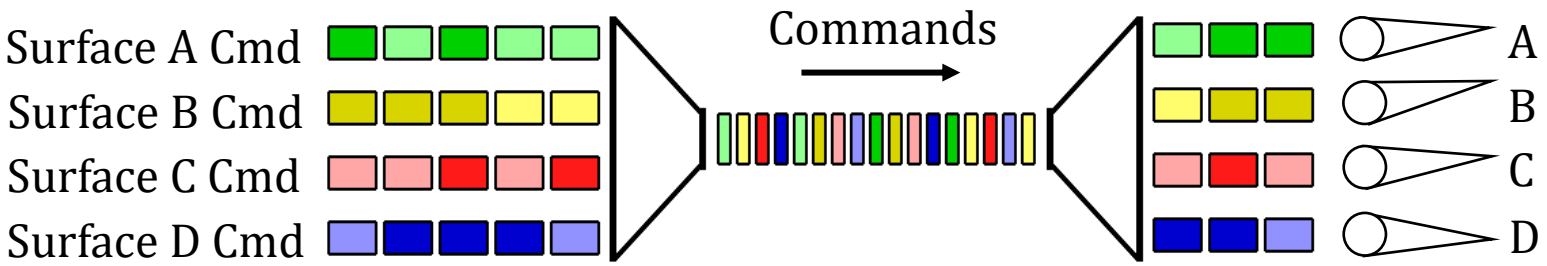
- Position sensor(s) in common piston for all piston rods positions
- Reduces number of sensors
- Saves volume, weight and cost
- Reducing bias: Additional inductive sensors as reference



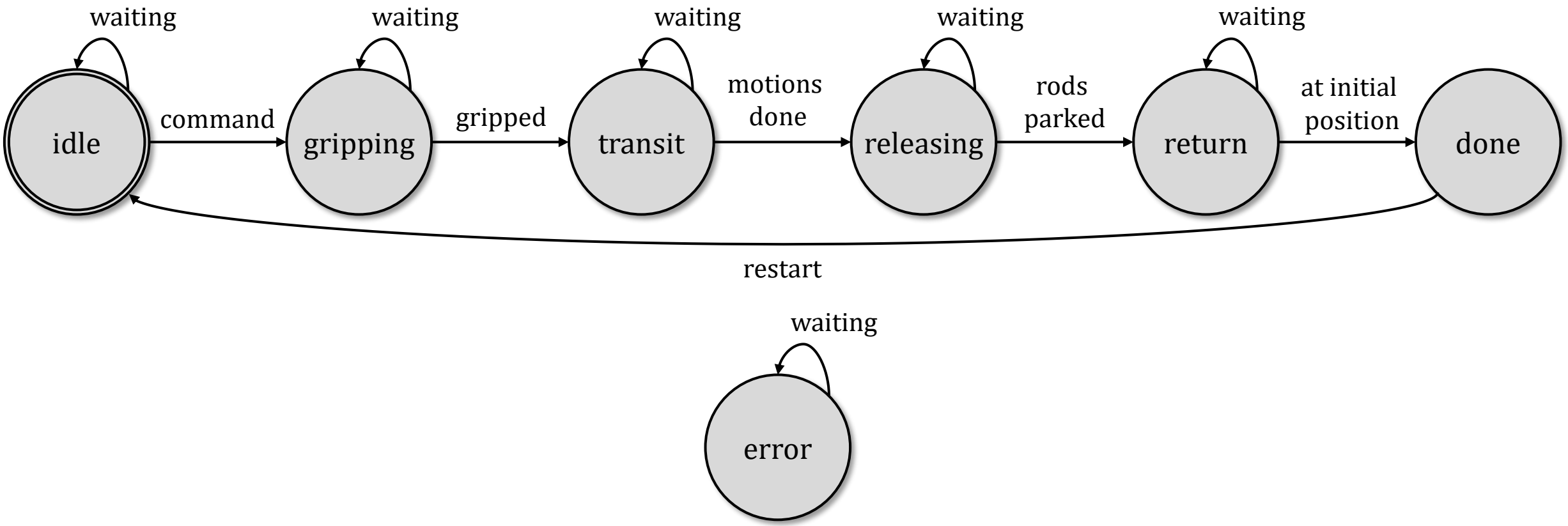
Time Multiplexing

A scheduler has to aim for several goals:

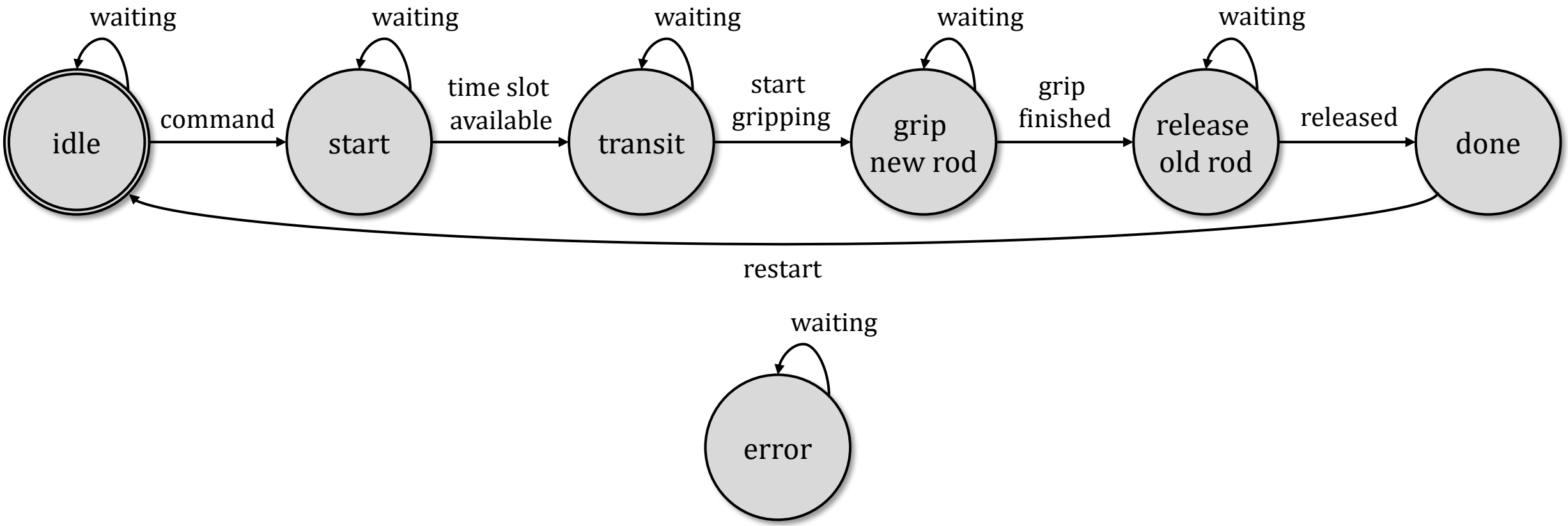
1. Maximizing throughput
2. Minimizing wait time
3. Minimizing response time



State Machine – Servo Mechanism



State Machine – Gripping Mechanism

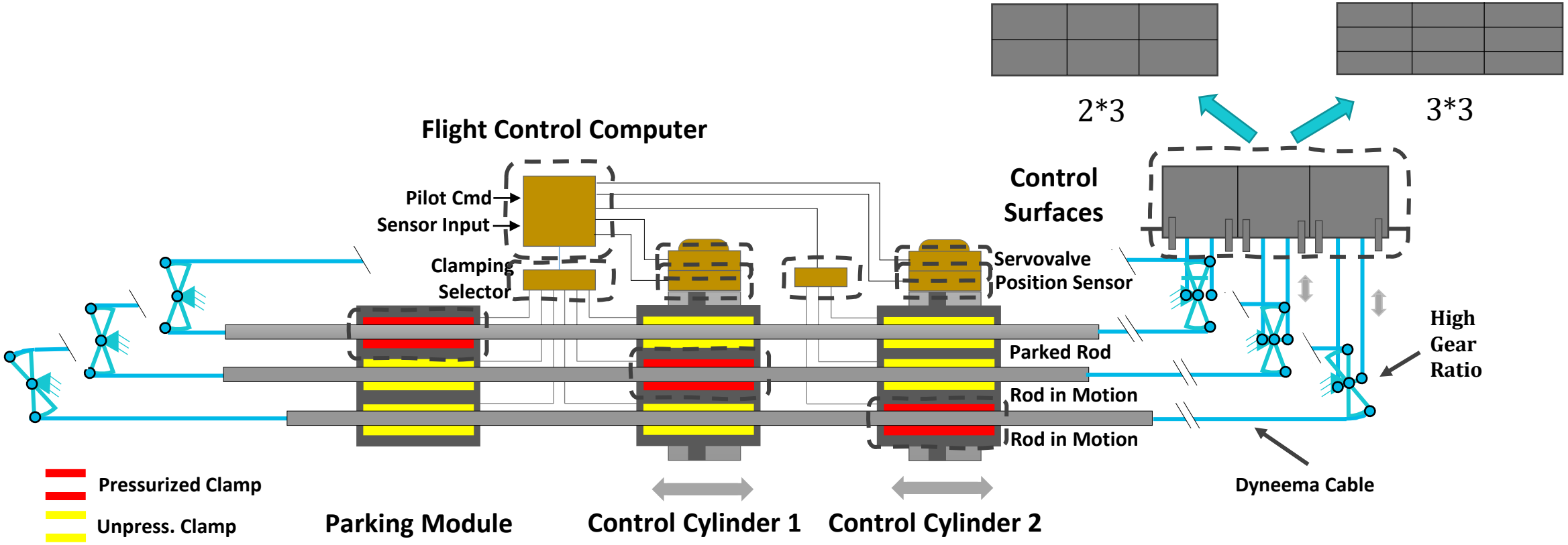


Morphing Wings

Why morphing wing?

- Optimal cruise performance, gust alleviation and noise mitigation
- Needs many actuators, sensors and control surfaces
- A compromise between flexibility and load-carrying capacity
- High weight penalty due to the additional actuation systems
- Less complex solutions are desired!

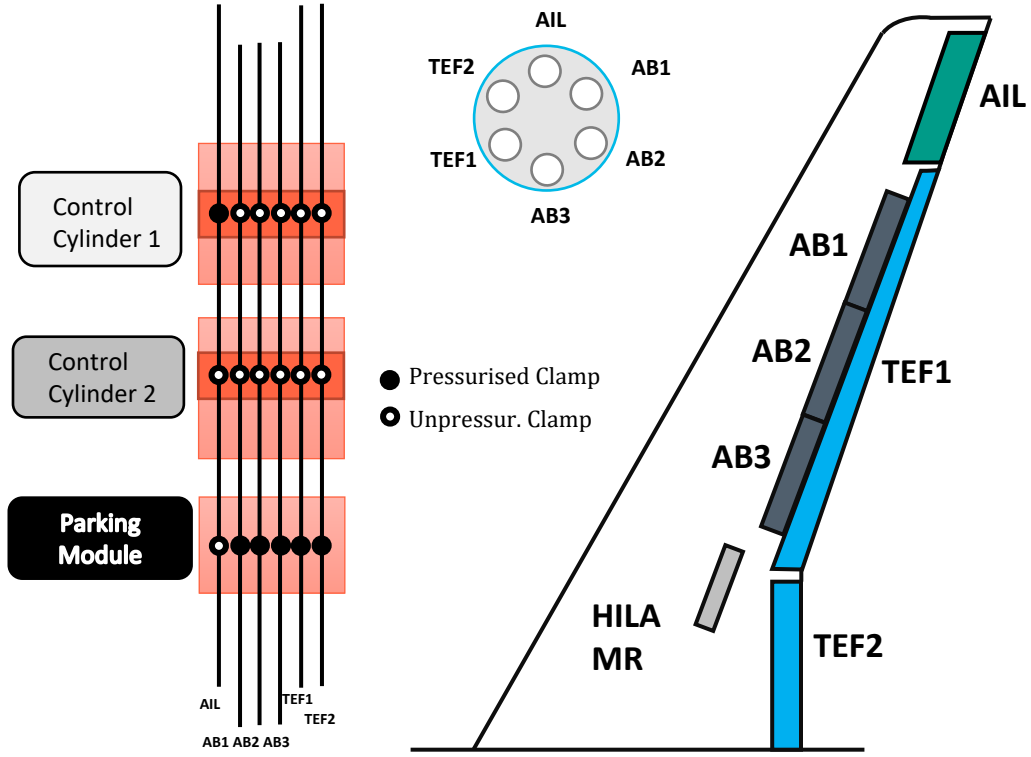
HILA MR for Morphing Wings

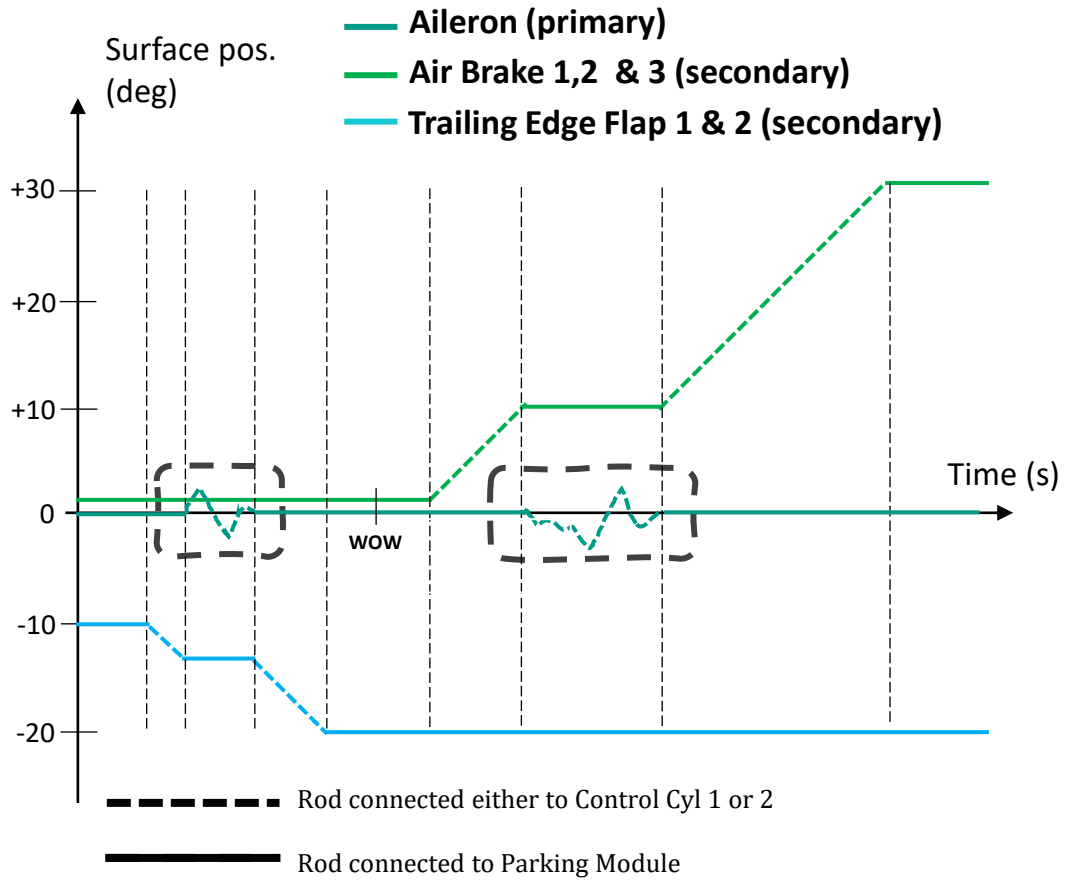


HILA MR in a Morphing Wing

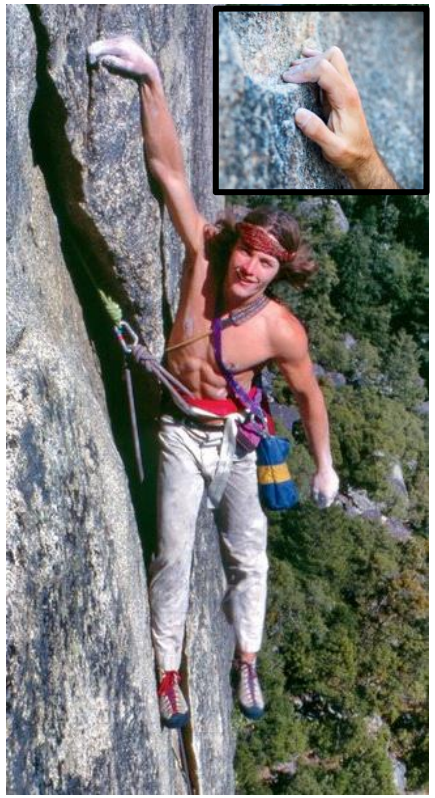
- One single actuator controls multiple surfaces
- Reduced mass and volume
- Enables a slender wing design
- Lower energy requirement
- Less expensive

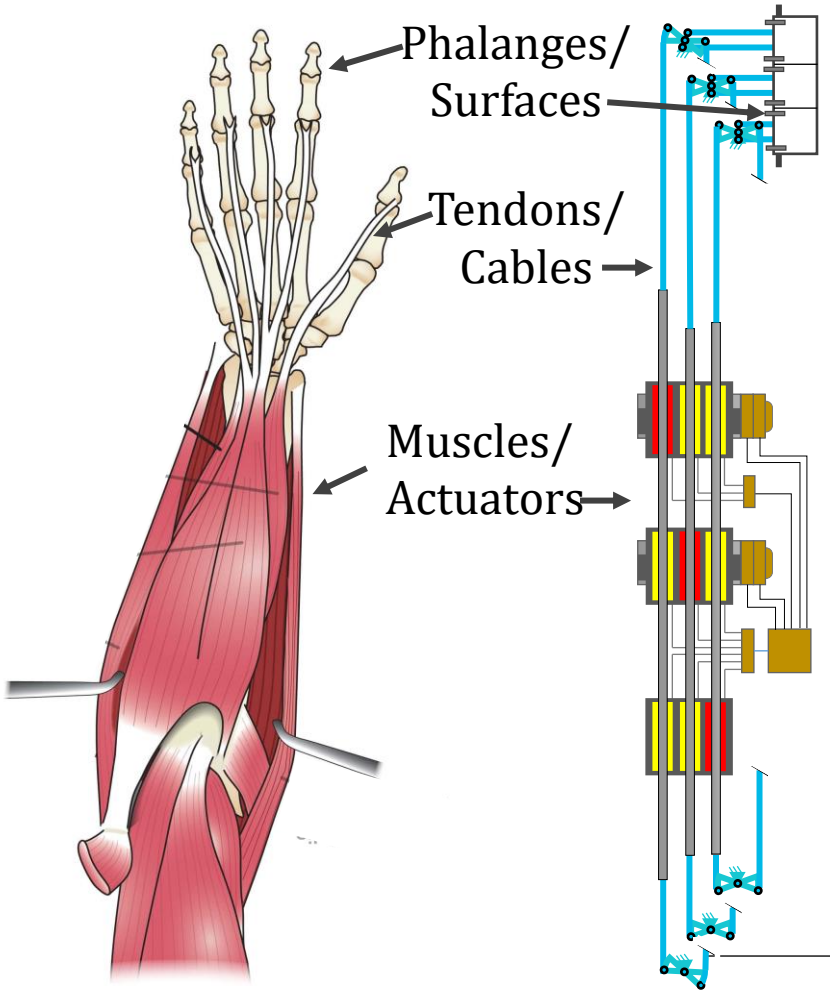
Example of Rudder Movements





Biomechanical Analogy





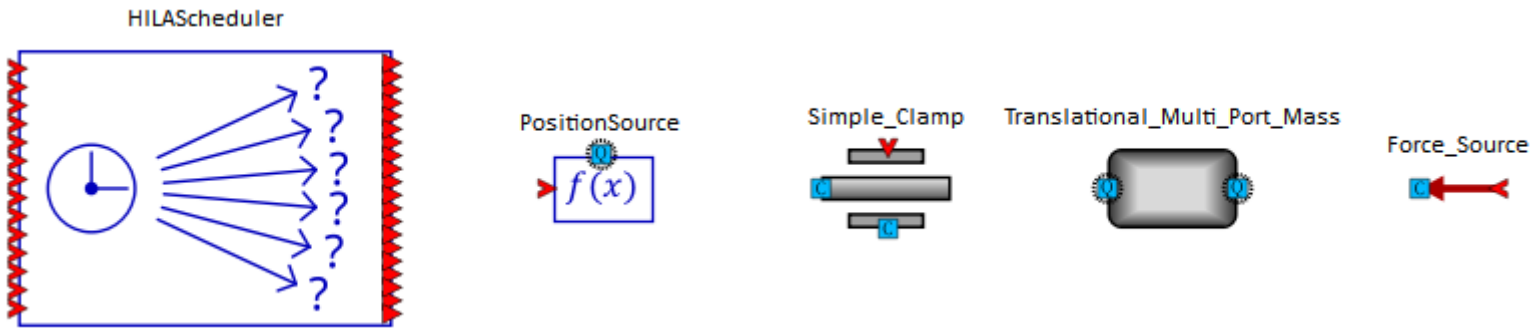
System Simulation

- Simulation models in Hopsan
  - Basic scheduling of six-rod HILA-MR
  - Aircraft control during flight mission
- 6 rods and 2 servos
- Distributed solvers
- Fixed step-size
- Works in real-time

System Simulation - Components

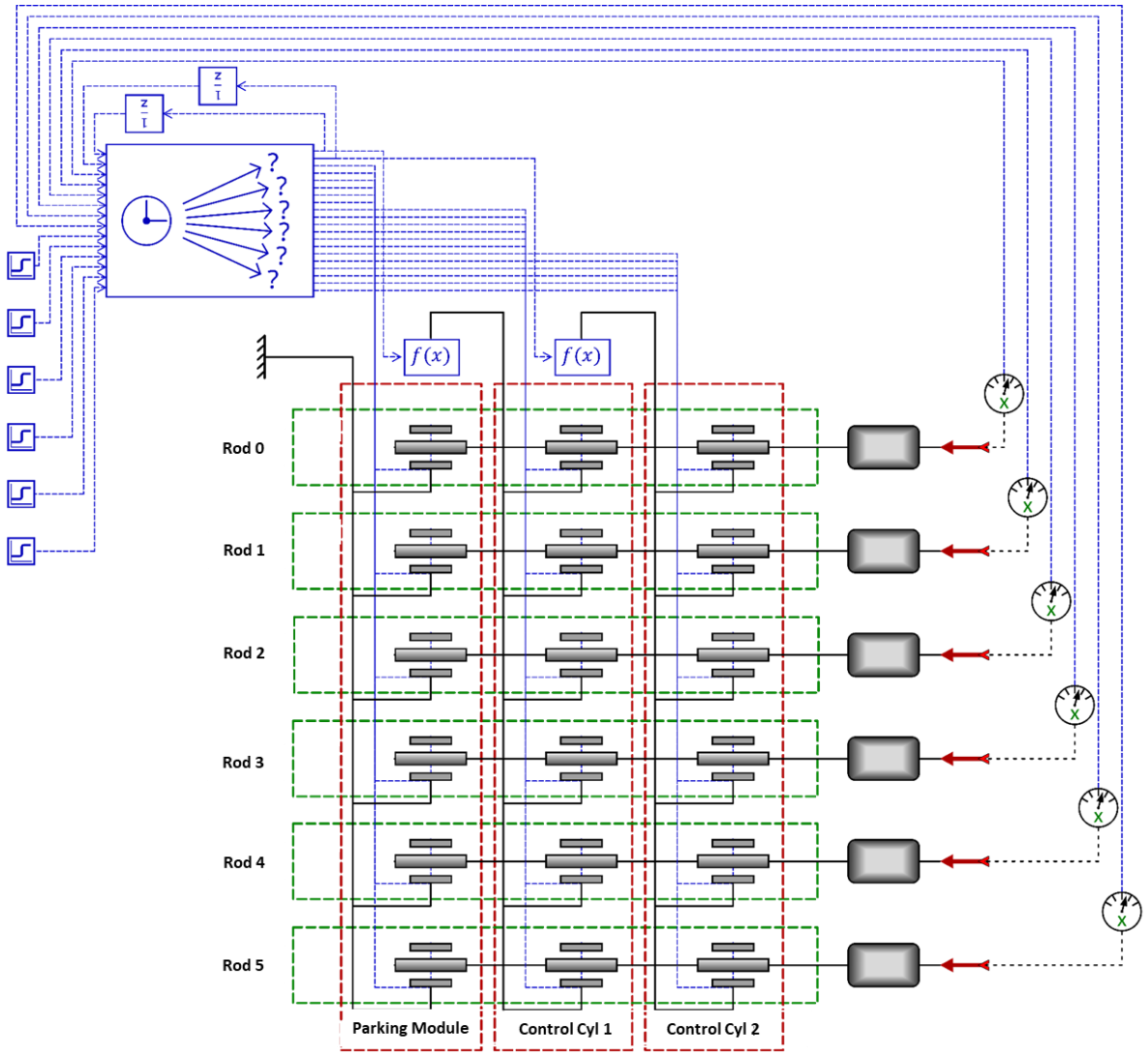
Autonomous precompiled components

– Each component solves its own local equations!

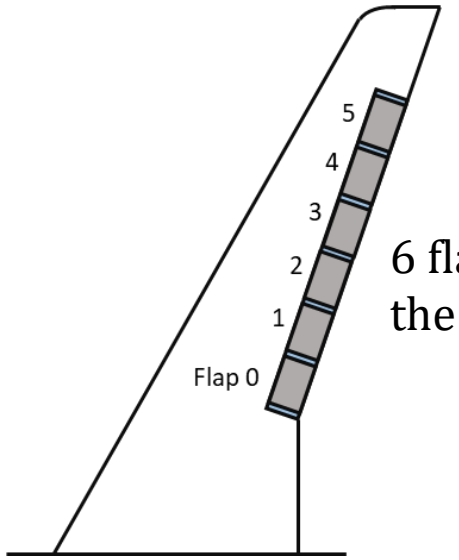


Scheduling Model

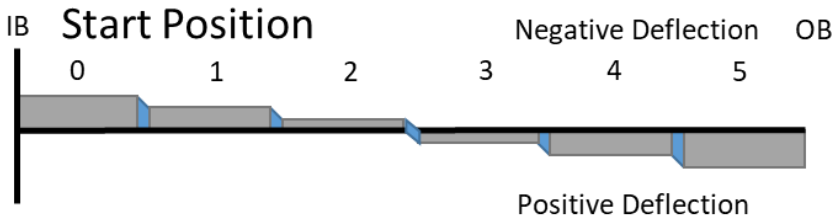
- Verification of scheduler
- Rods follow reference positions

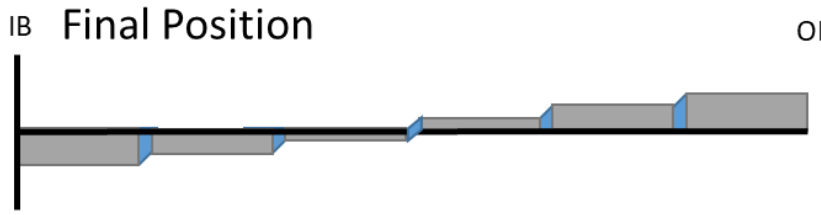


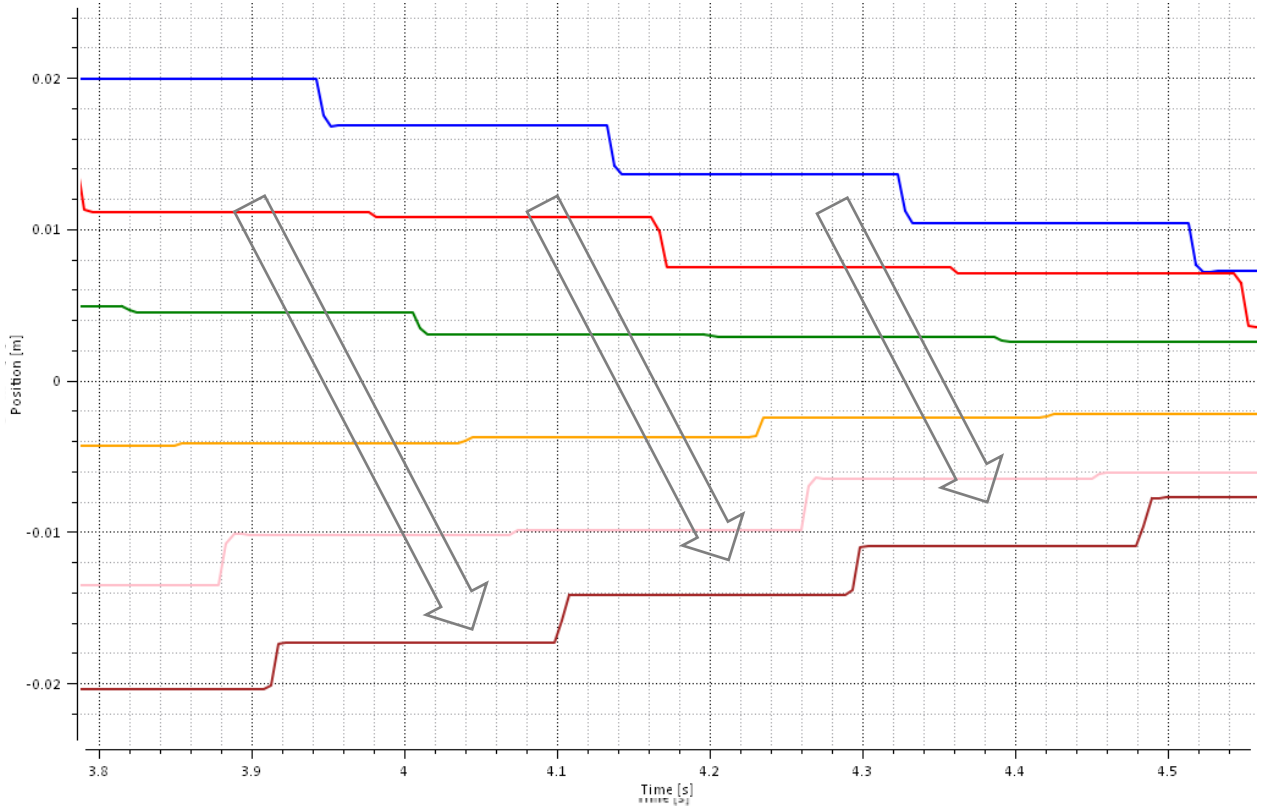
Simulation Results



6 flaps along
the trailing edge

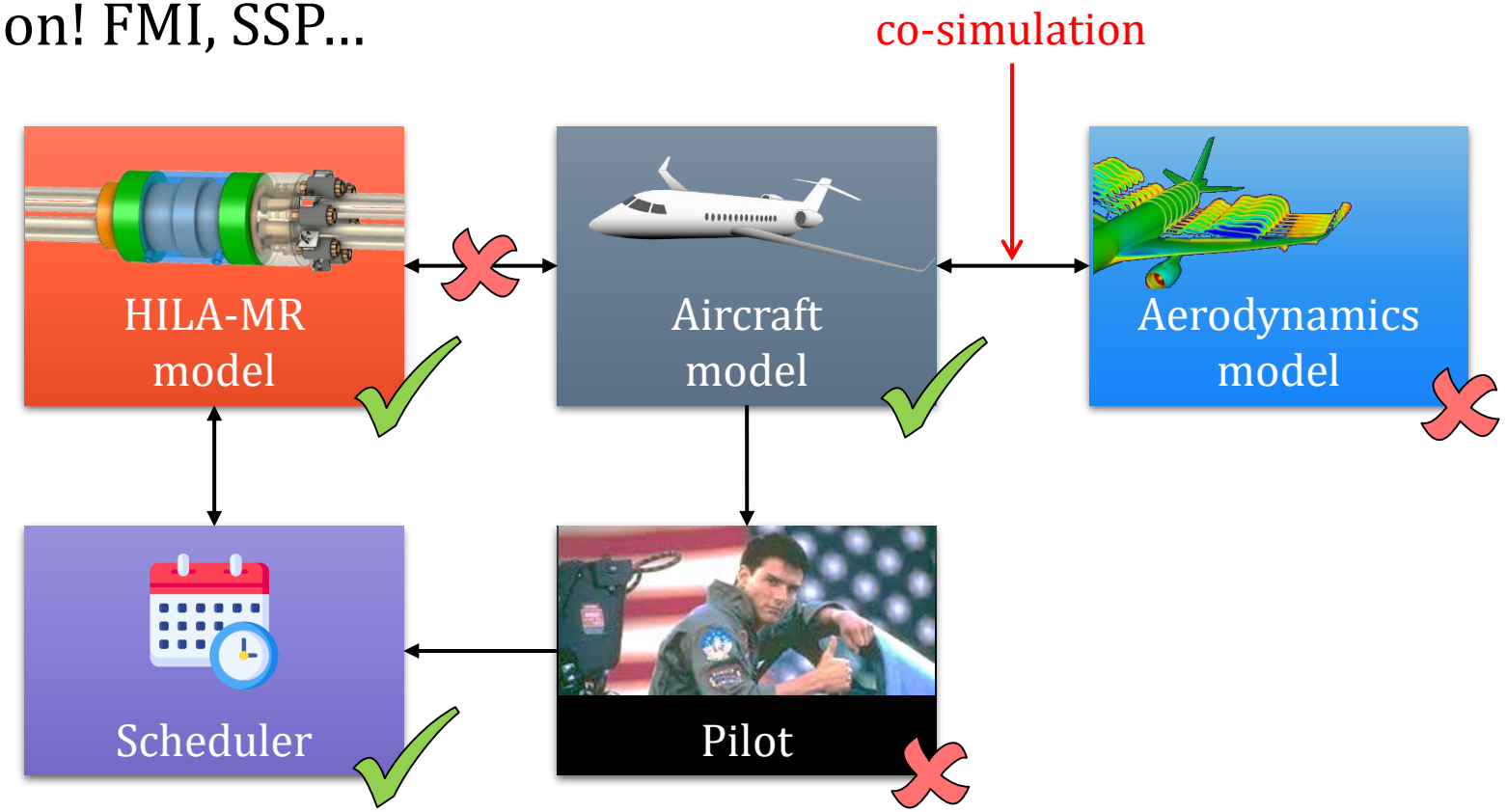






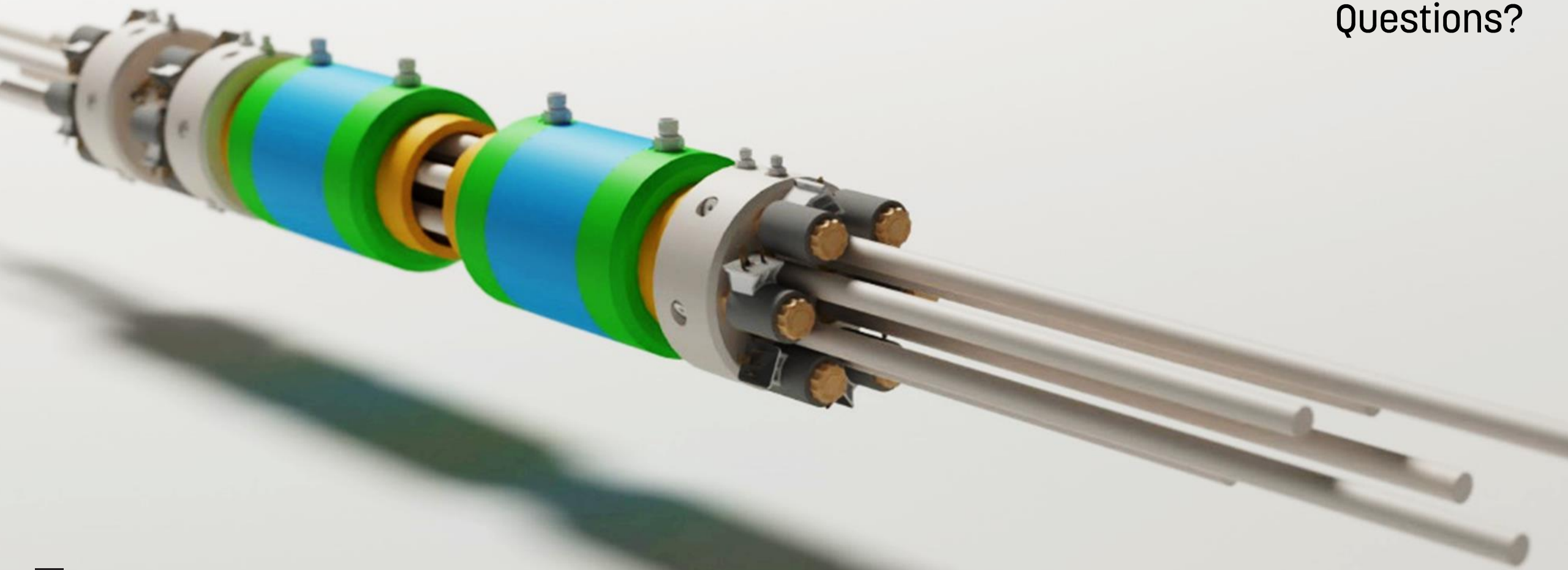
Research Outlook

Co-simulation! FMI, SSP…



Thank you!

Questions?



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