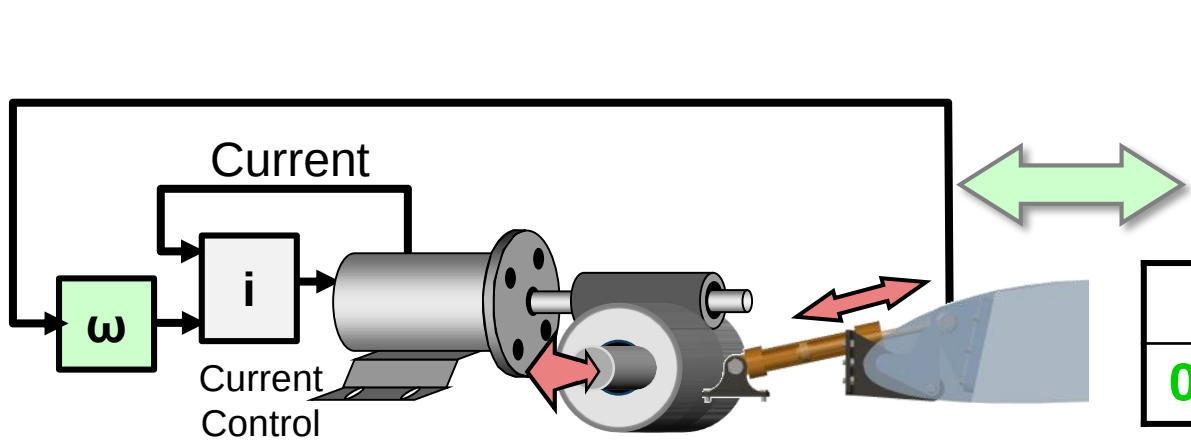
MATLAB EXPO 2018

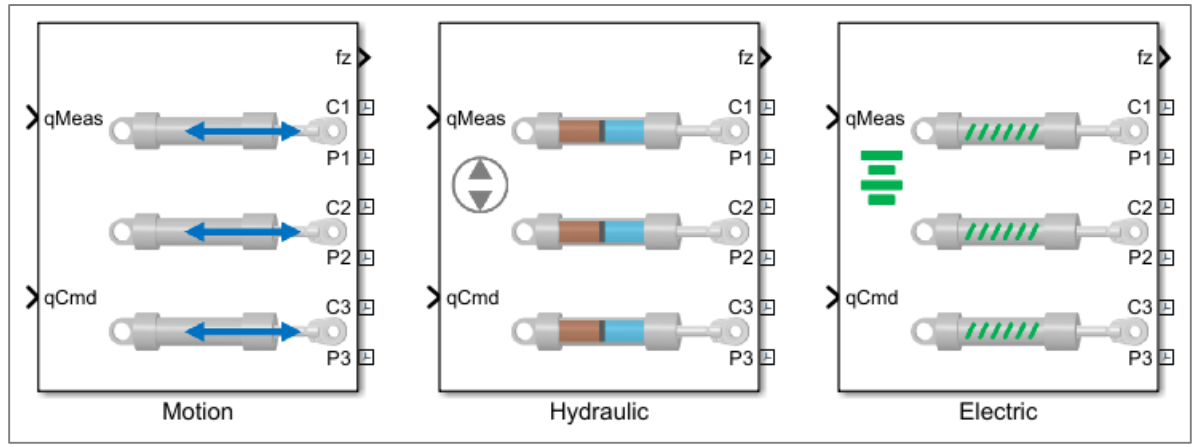
Progettazione meccatronica per sistemi avionici

Aldo Caraceto

Key Points

- Simulating the system in one environment enable to design higher quality controls
- Testing different actuator designs, having different levels of detail, in one environment saves time and encourages innovation
- Plant model supports the entire development process





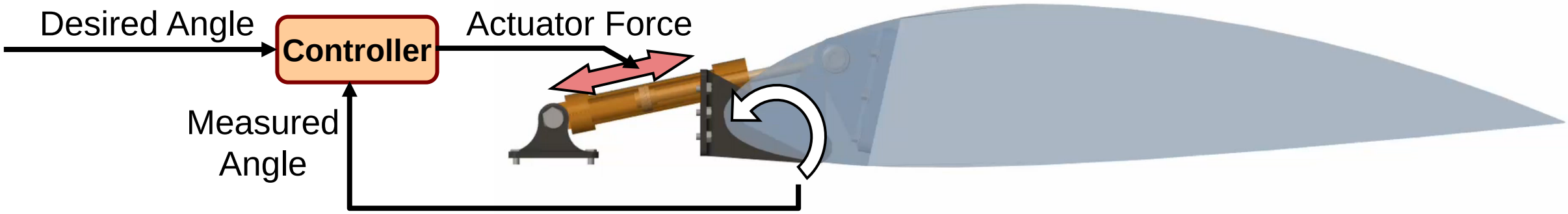
Configure Model → Real-Time Hardware → Generate C Code → Tune Parameter

Agenda

- Example: Flight actuation system
  - Benefits of Model-Based Design
- Actuator design
  - Link requirements and design
  - Modeling the mechanical system
  - Determining actuator requirements
  - Tradeoff studies
- Optimizing system performance
  - Tune controller automatically
- Model deployment
  - HIL testing
  - Protecting IP

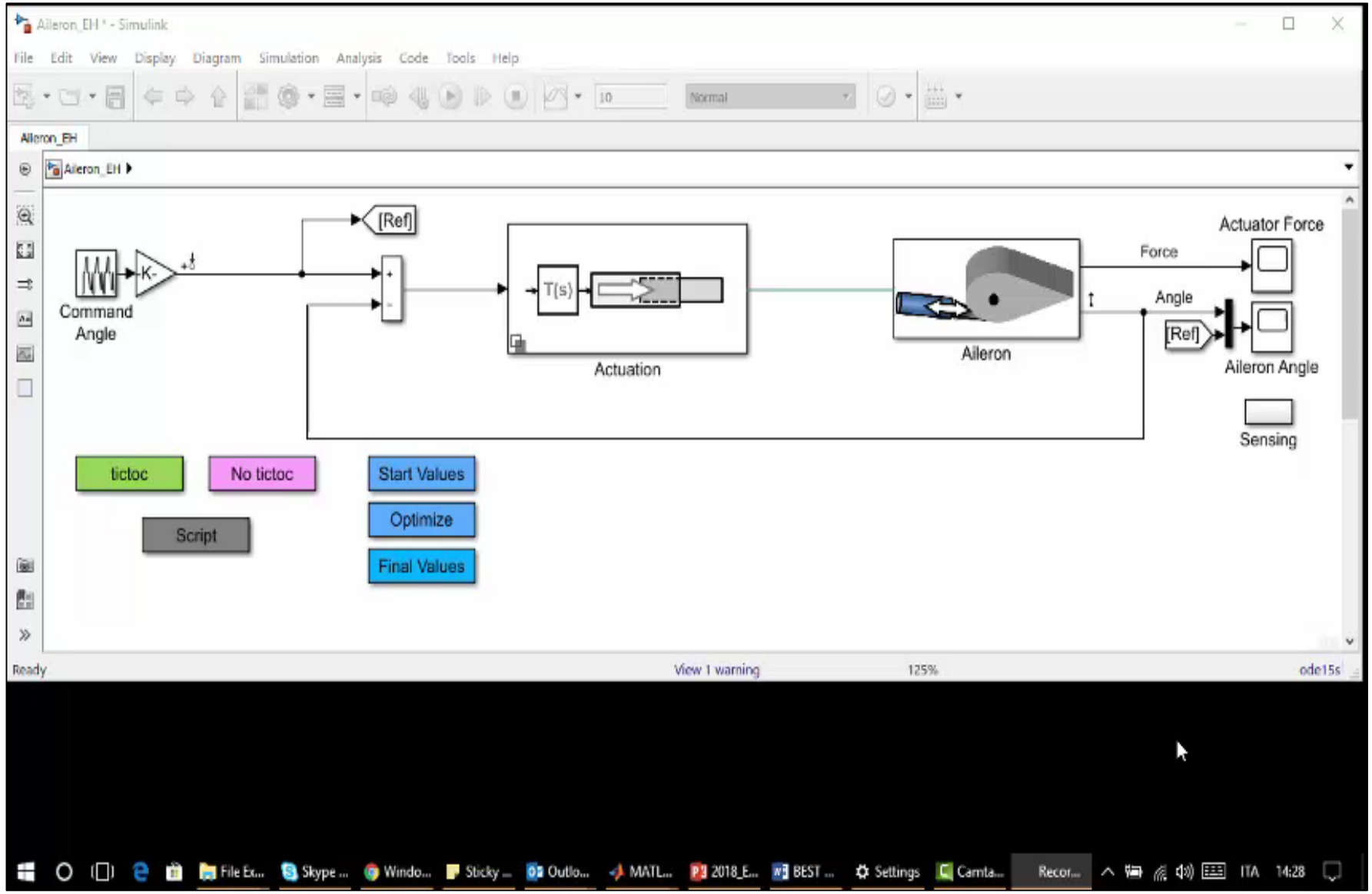
Example: Aileron Actuation System

- System

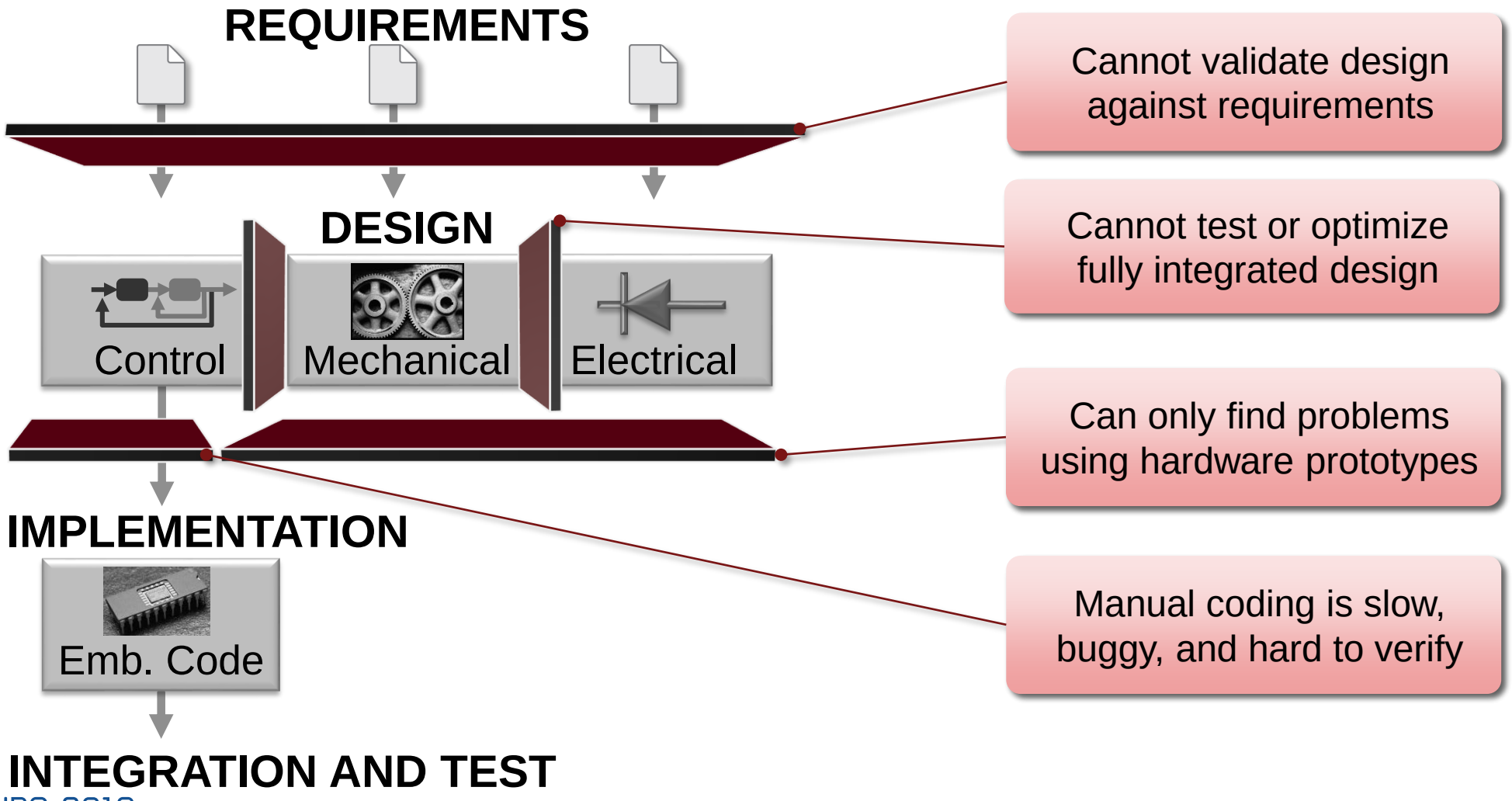


- Simulation goals
  1. Determine requirements for actuation system
  2. Test actuator designs
  3. Optimise system performance
  4. Run simulation on real-time hardware for HIL tests

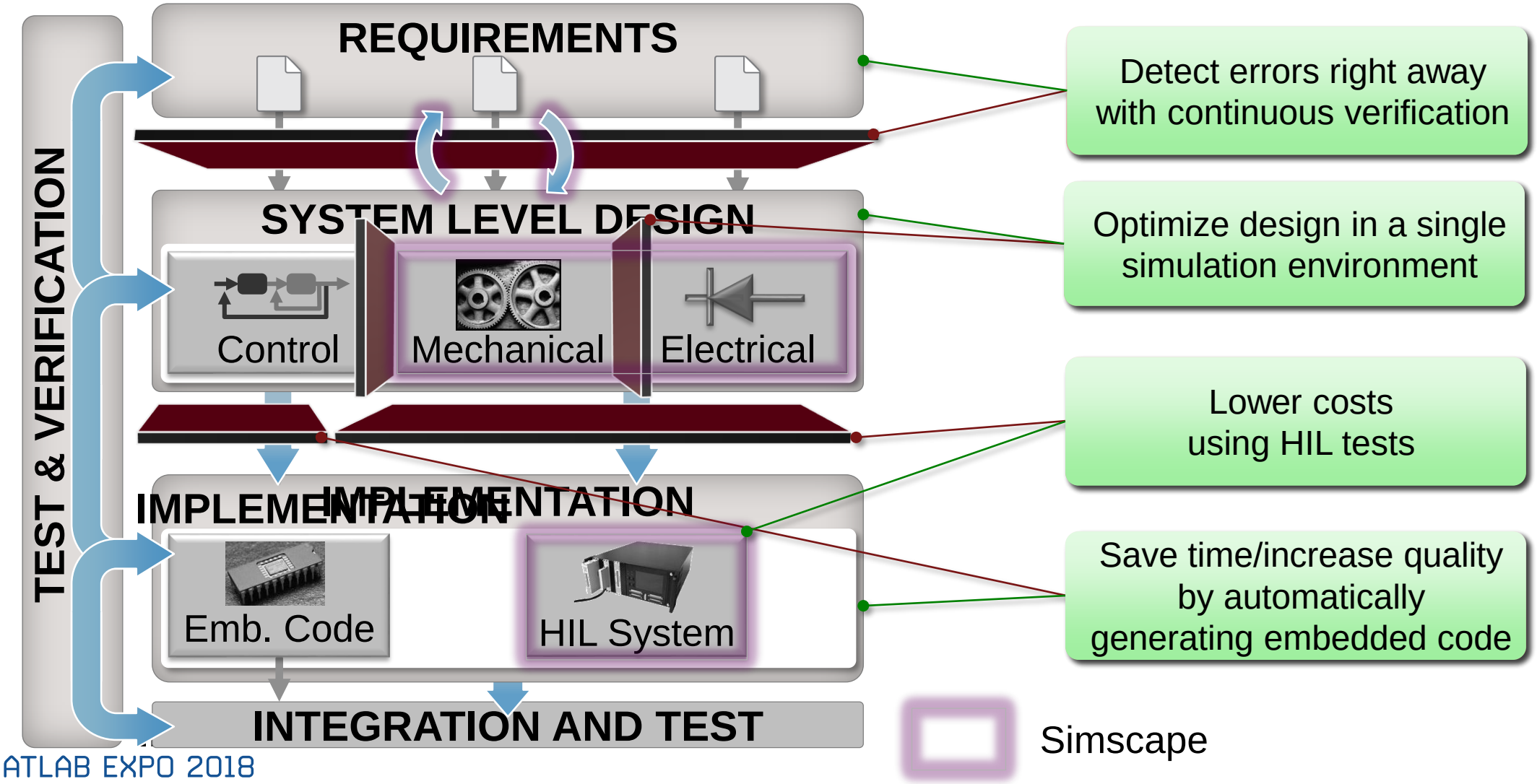
Aileron Actuation System – Simulink Model



Traditional Design Process



Model-Based Design



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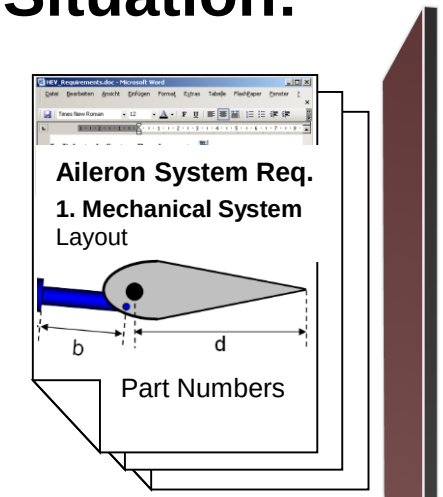
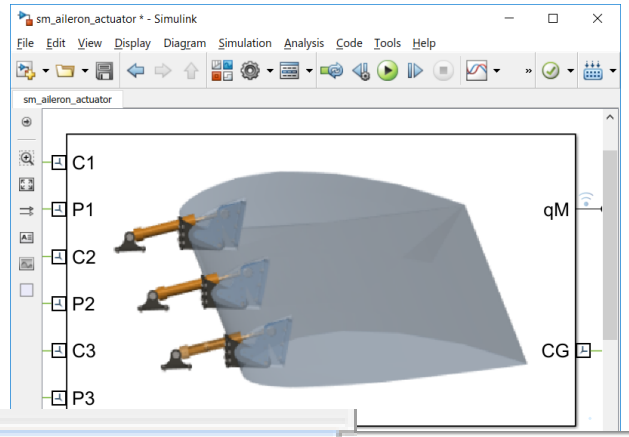
Link Specification and Design

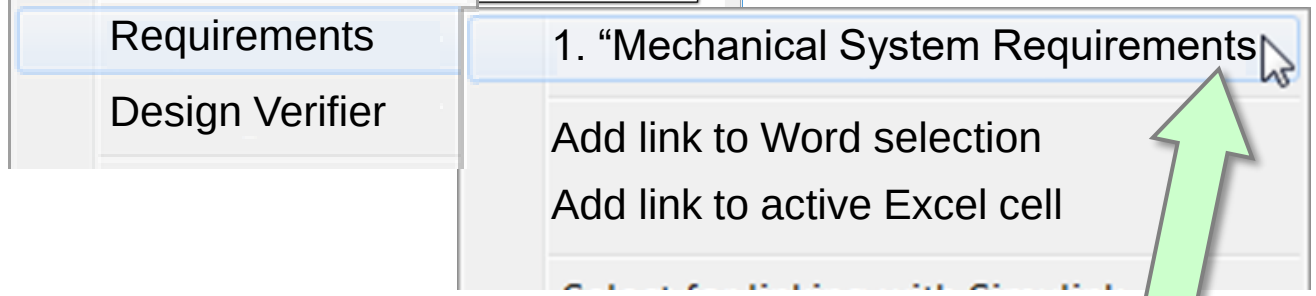
Situation:

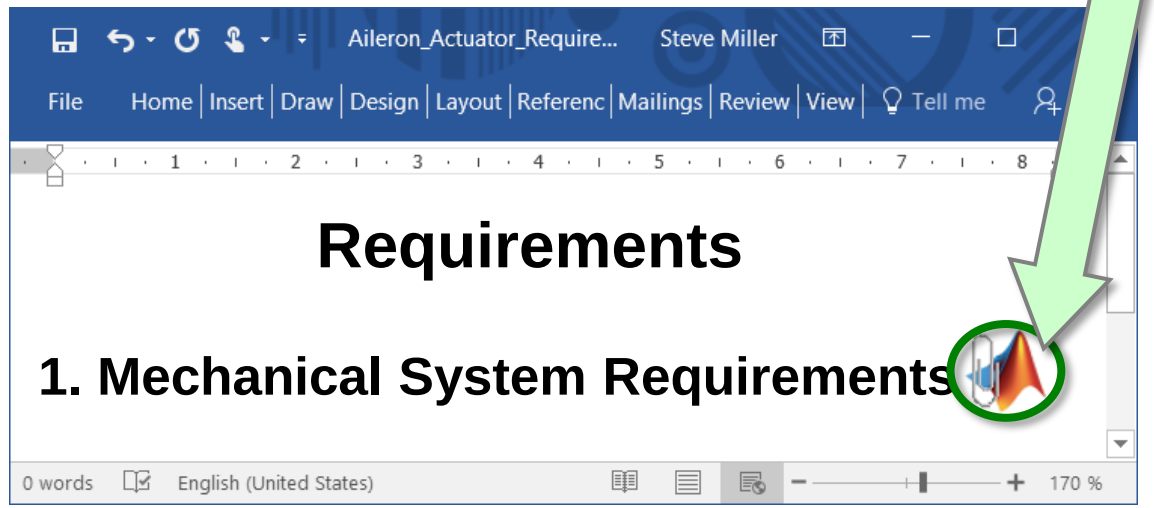


Problem: Difficult to check design against specification.

Solution: Link design and specification using Simulink Requirements







Modeling the Mechanical System

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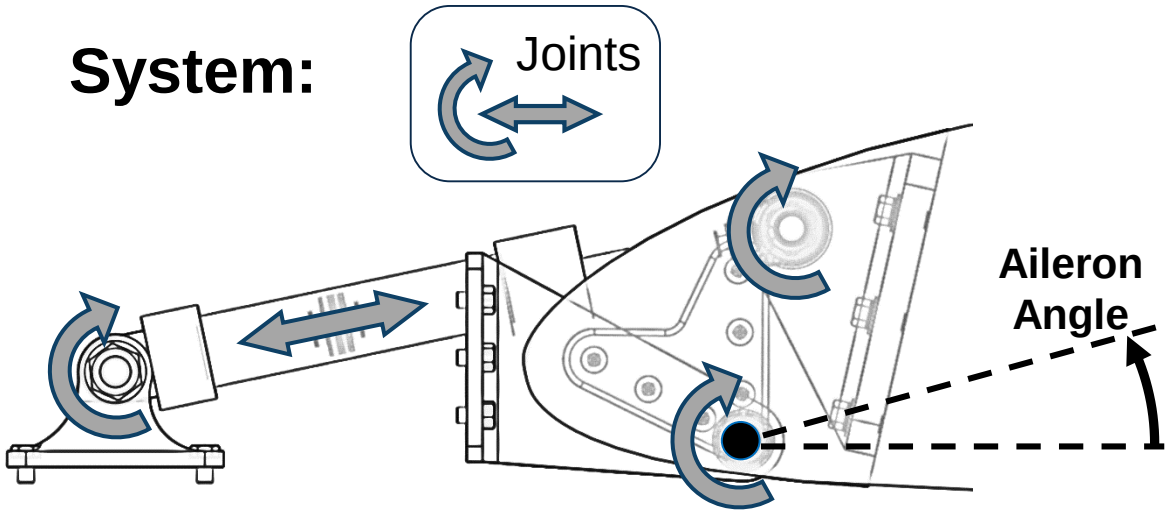
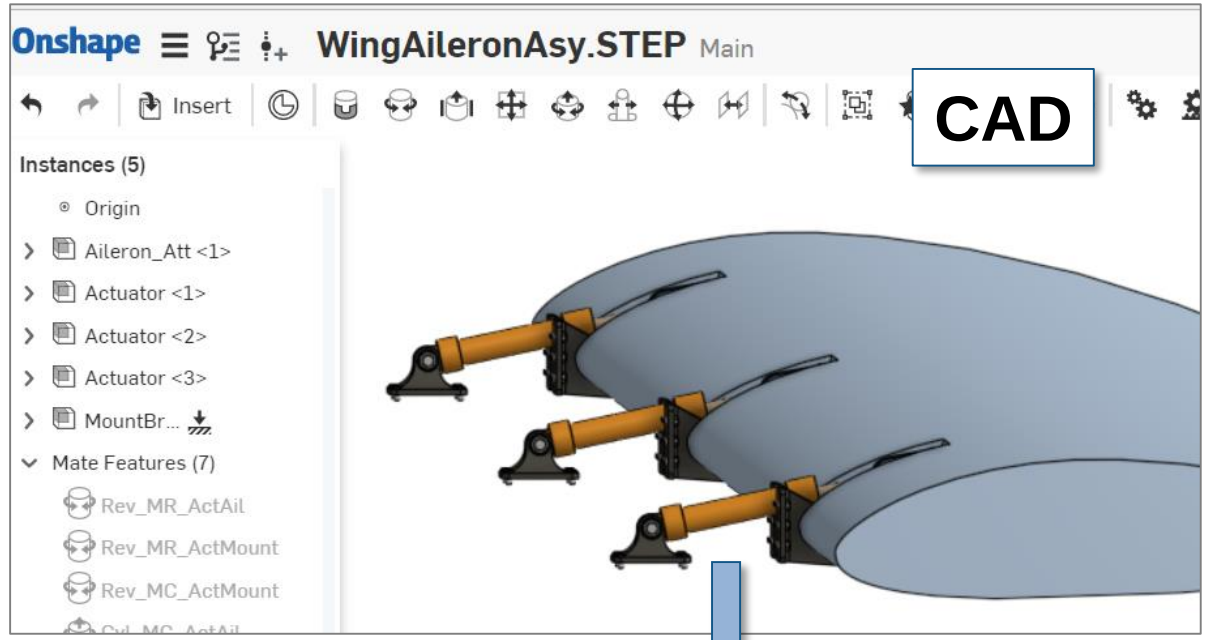
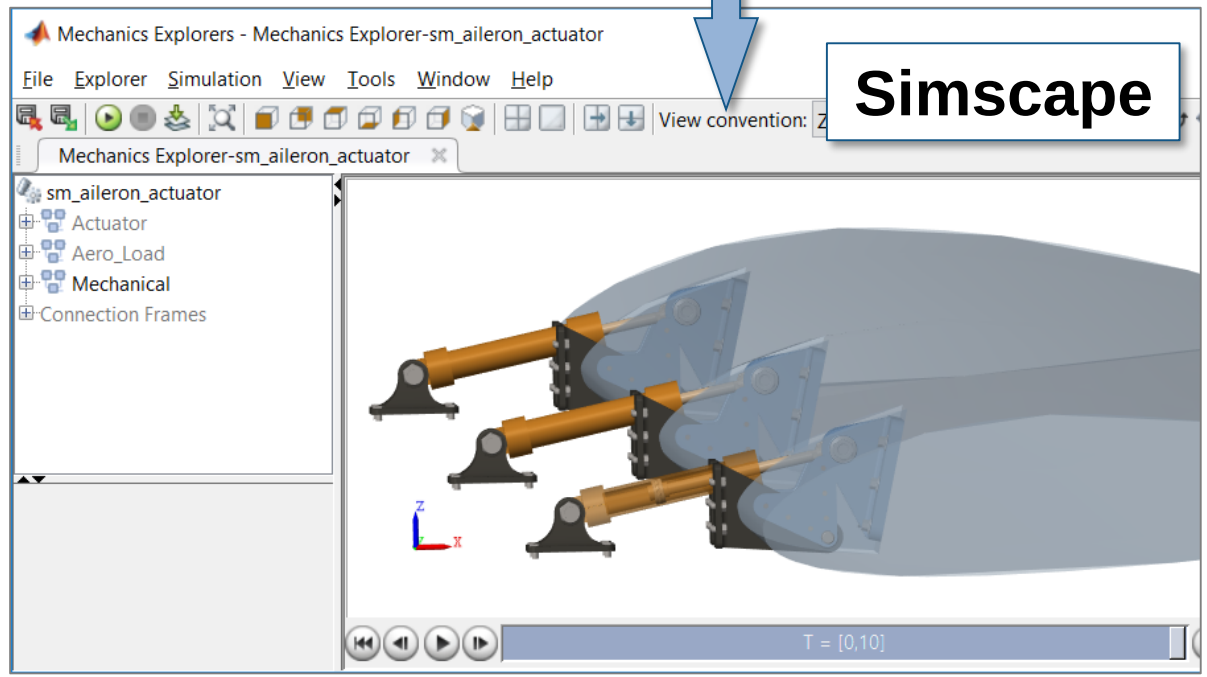
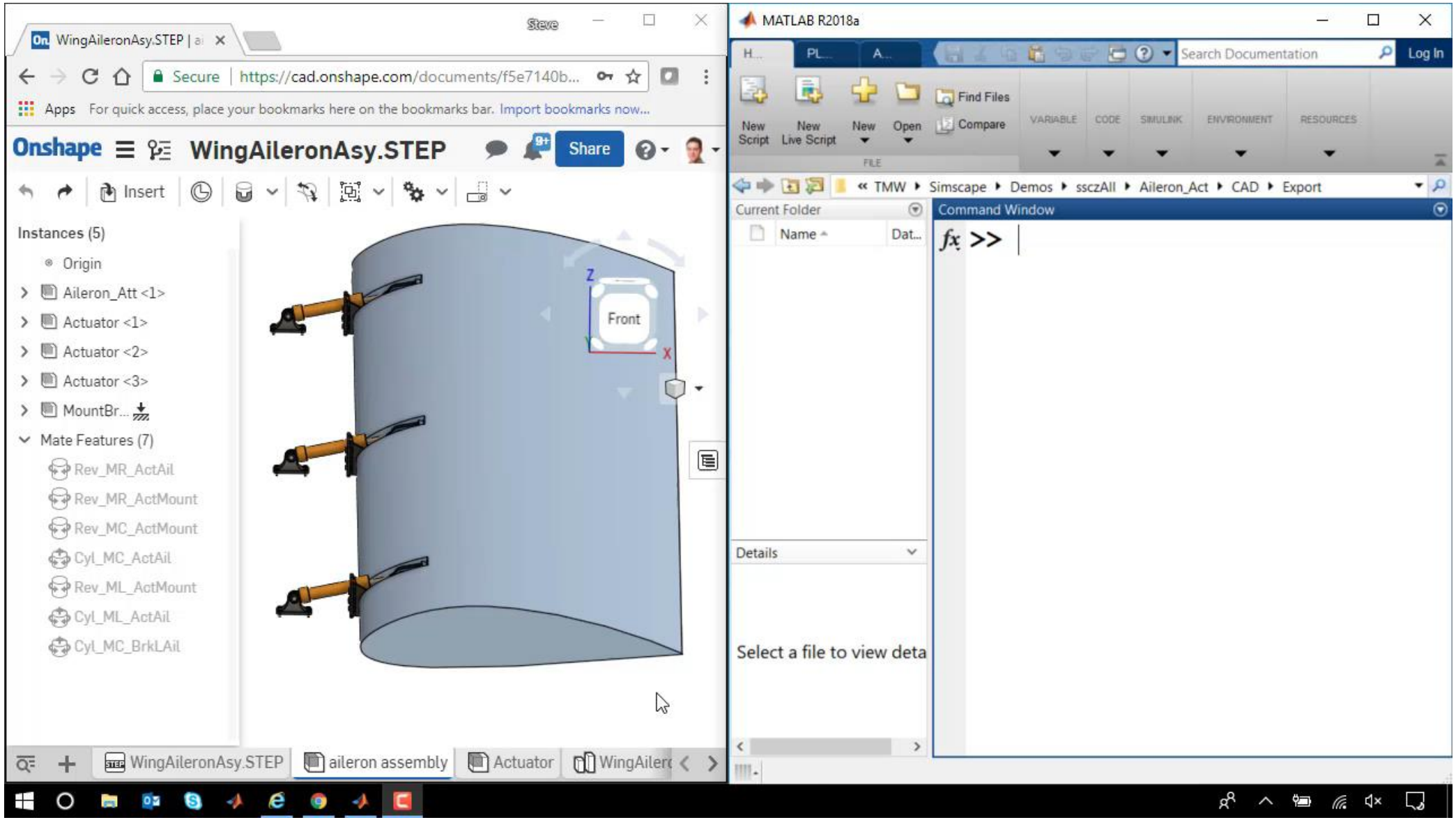


Problem: Model the mechanical system within Simulink

Solution: Import the mechanical model from CAD into Simscape Multibody



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Steve
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Apps
For quick access, place your bookmarks here on the bookmarks bar. Import bookmarks now...
Onshape
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Actuator <1>
Actuator <2>
Actuator <3>
MountBr...
Mate Features (7)
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Rev_MR_ActMount
Rev_MC_ActMount
Cyl_MC_ActAil
Rev_ML_ActMount
Cyl_ML_ActAil
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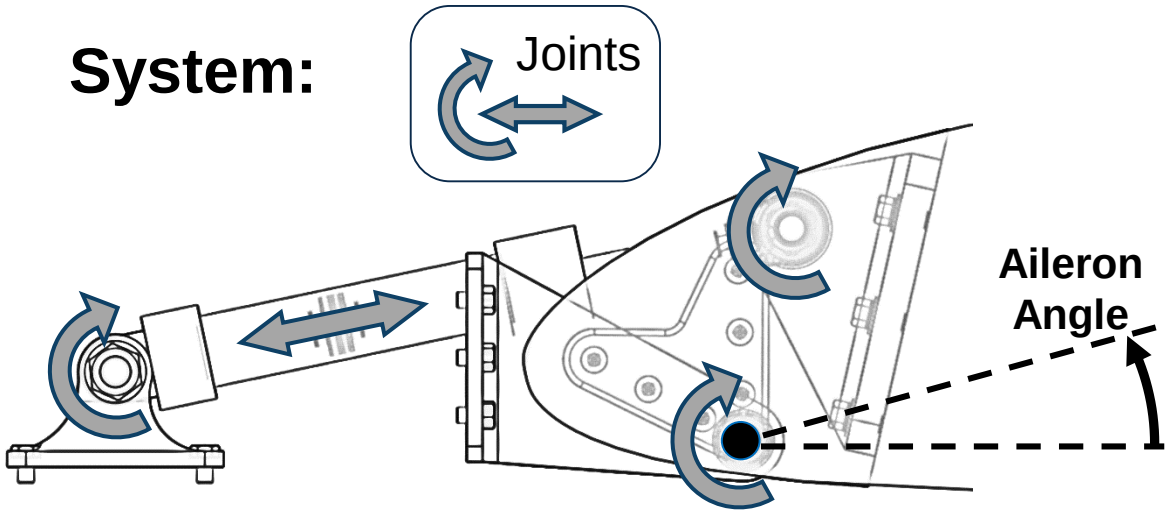

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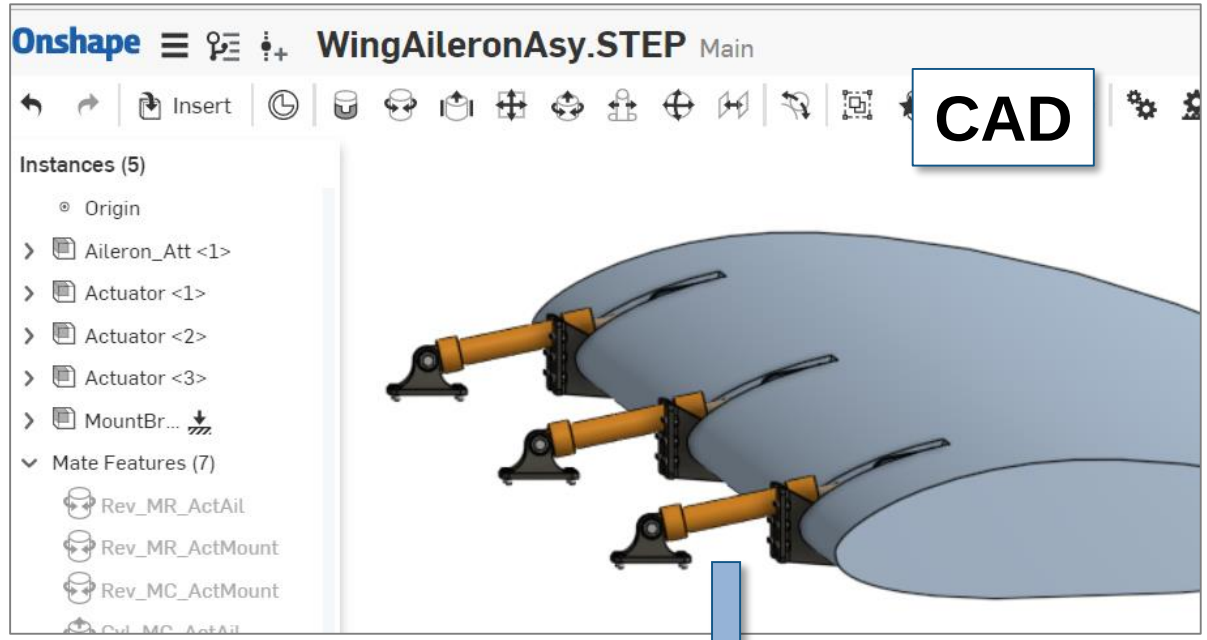
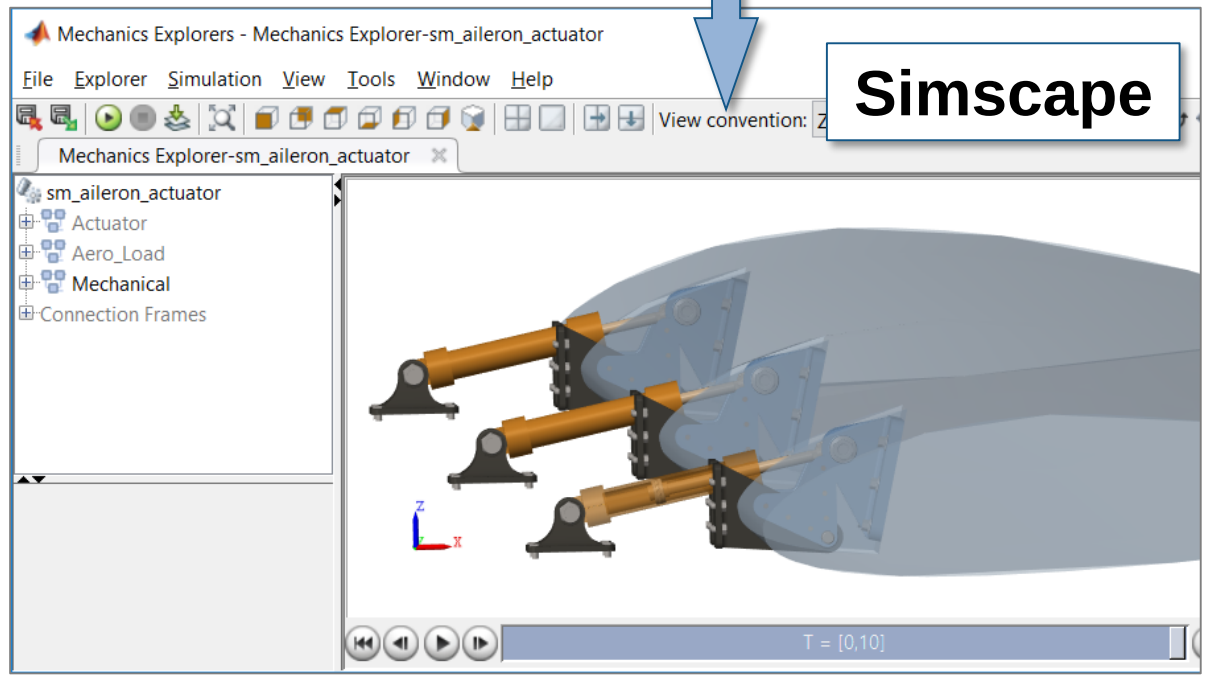
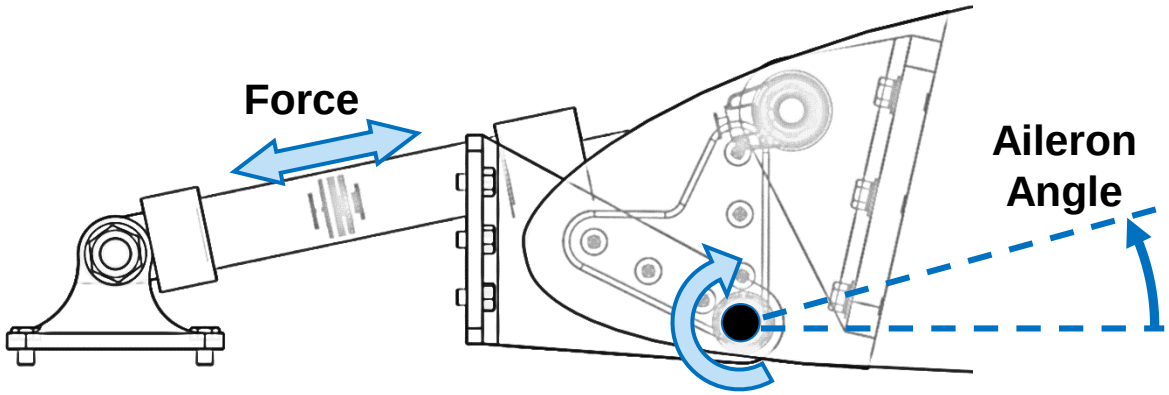
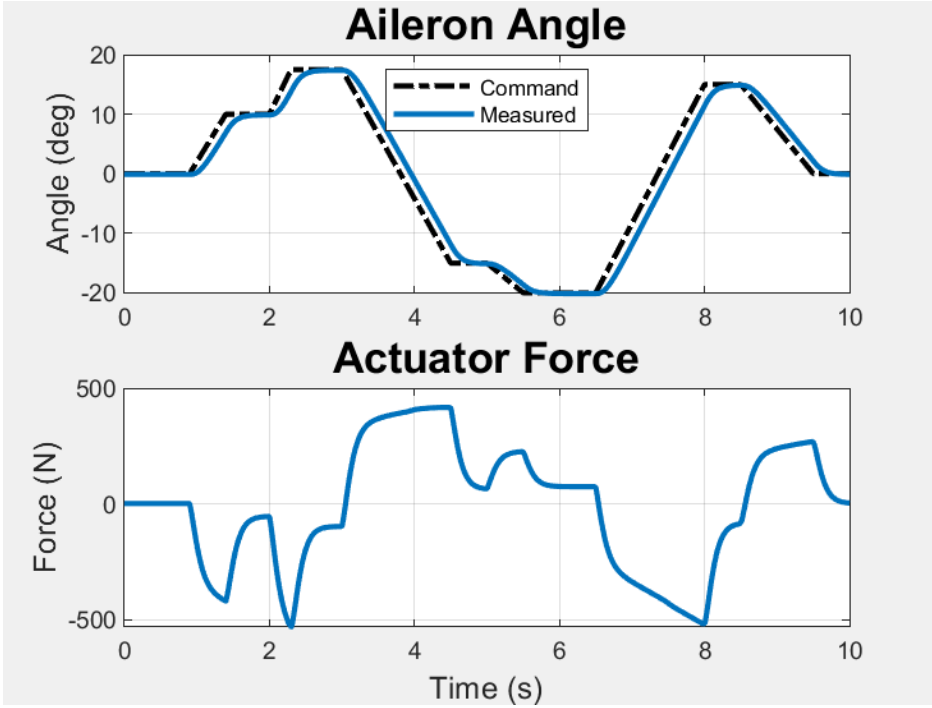




Determining Actuator Requirements

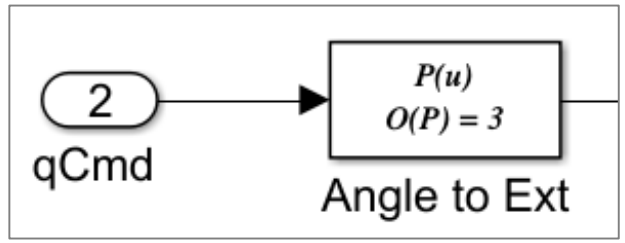
Model:

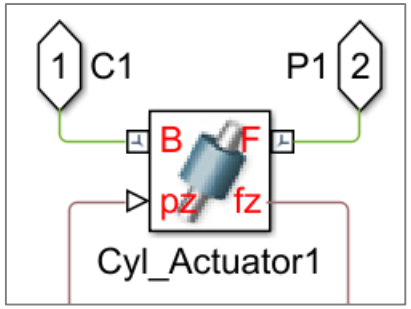




Problem: Determine the requirements for an aircraft aileron actuator

Solution: Use Simscape Multibody to model the aileron and use inverse dynamics to determine the required force





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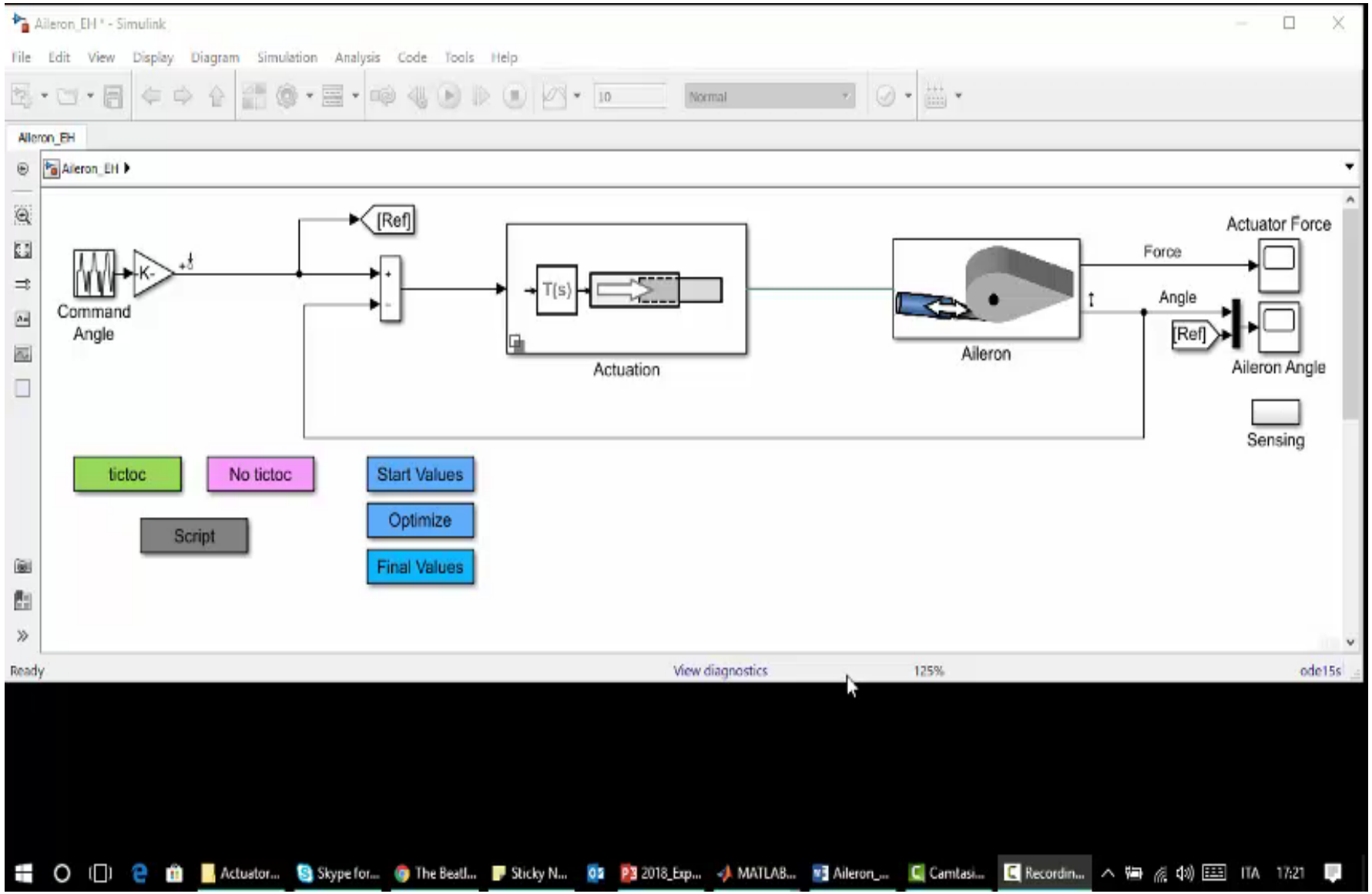

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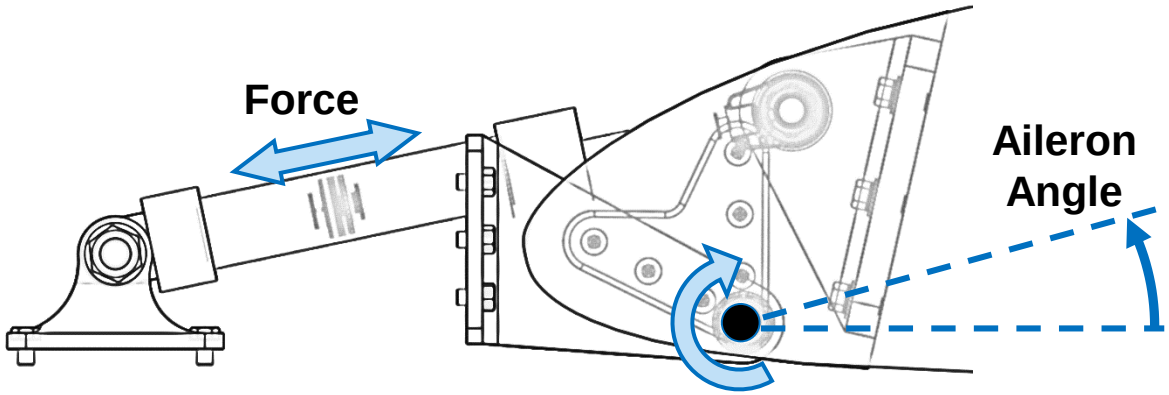

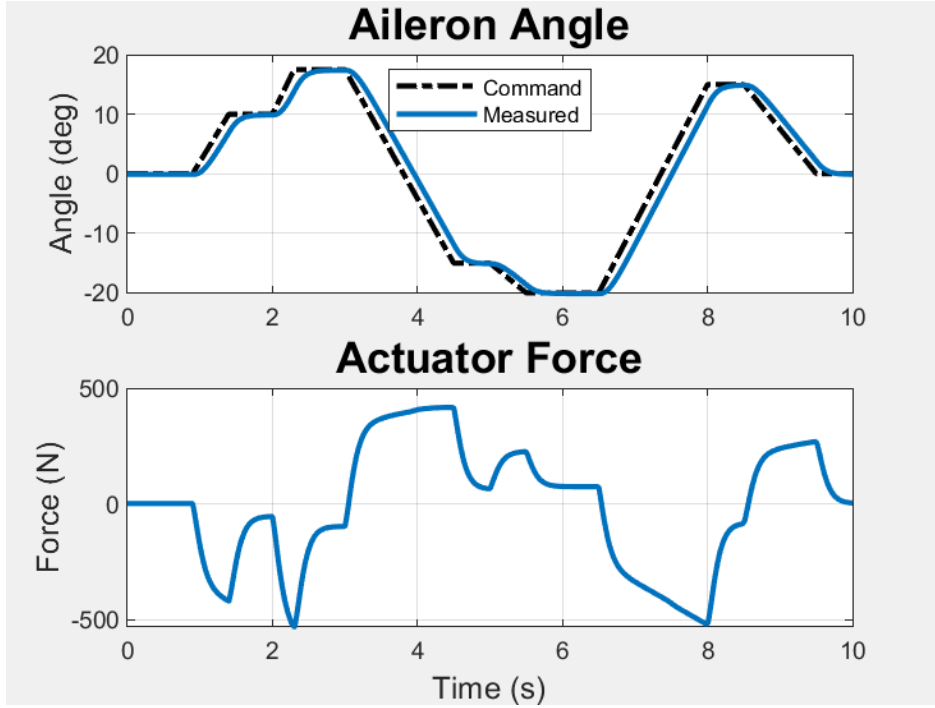

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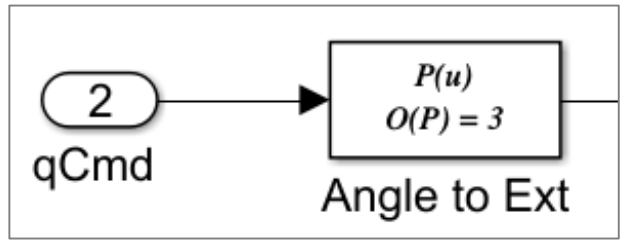
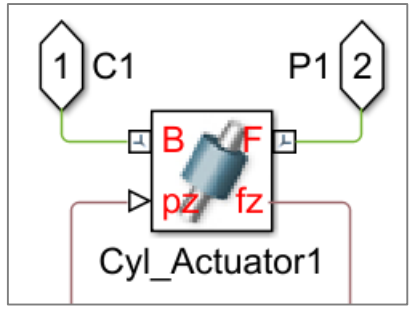
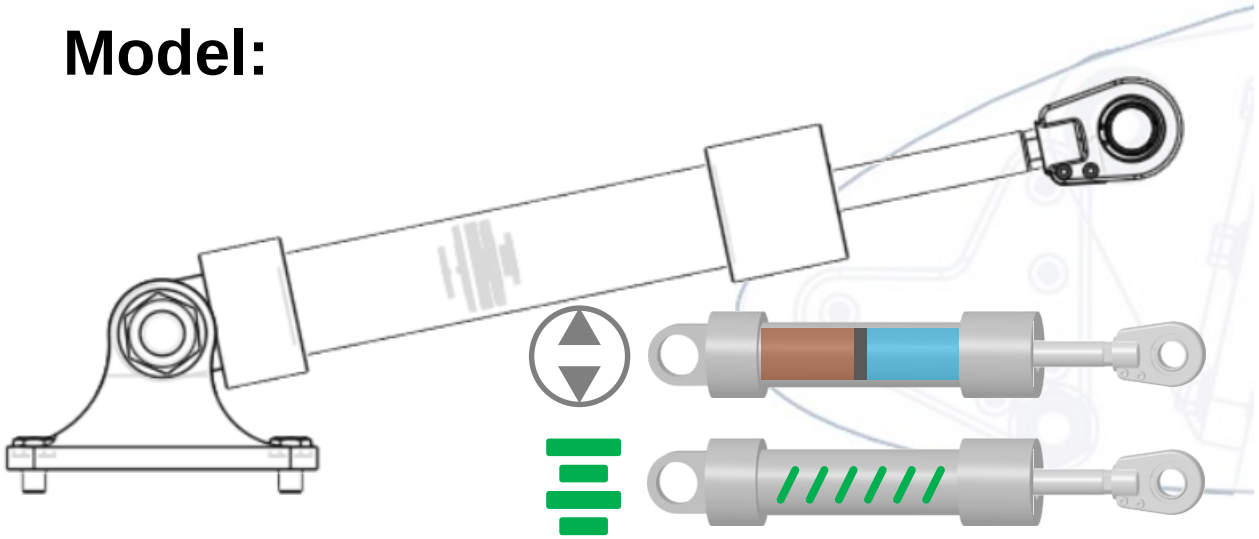
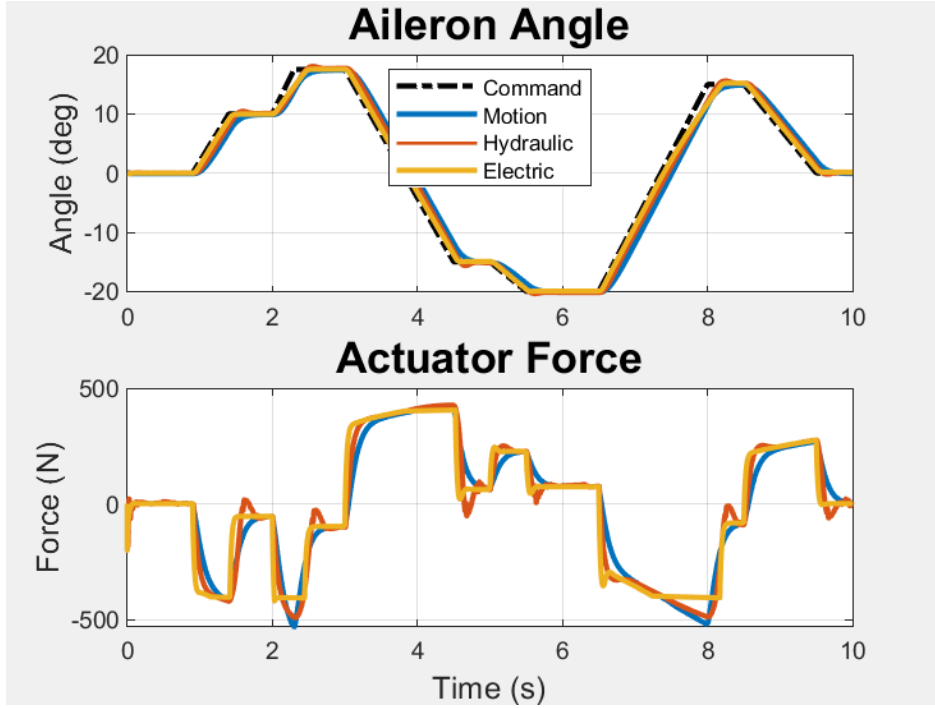




Testing Electrical and Hydraulic Designs

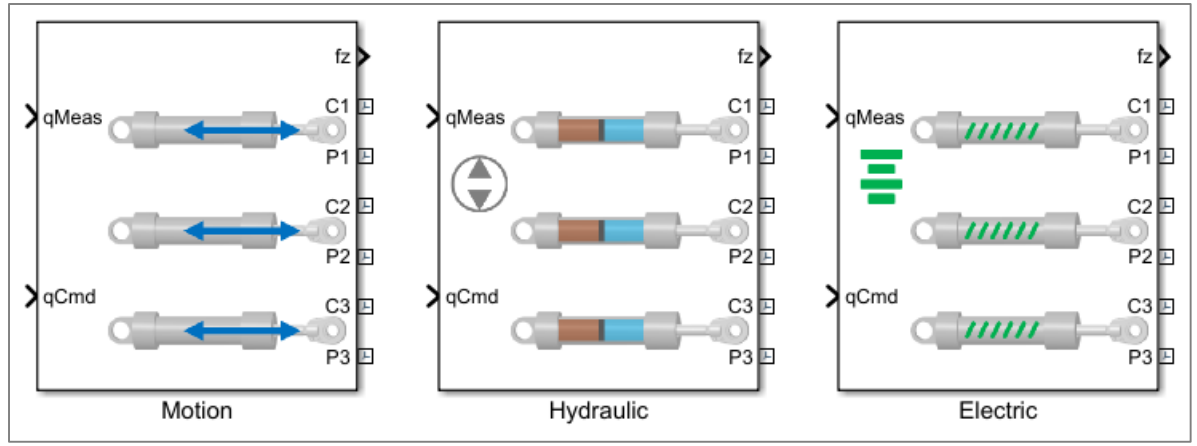
Model:





Problem: Select type of actuator based on system-level requirements

Solution: Use Simscape Fluids and Simscape Electronics to model the actuators, and variant subsystems to test them



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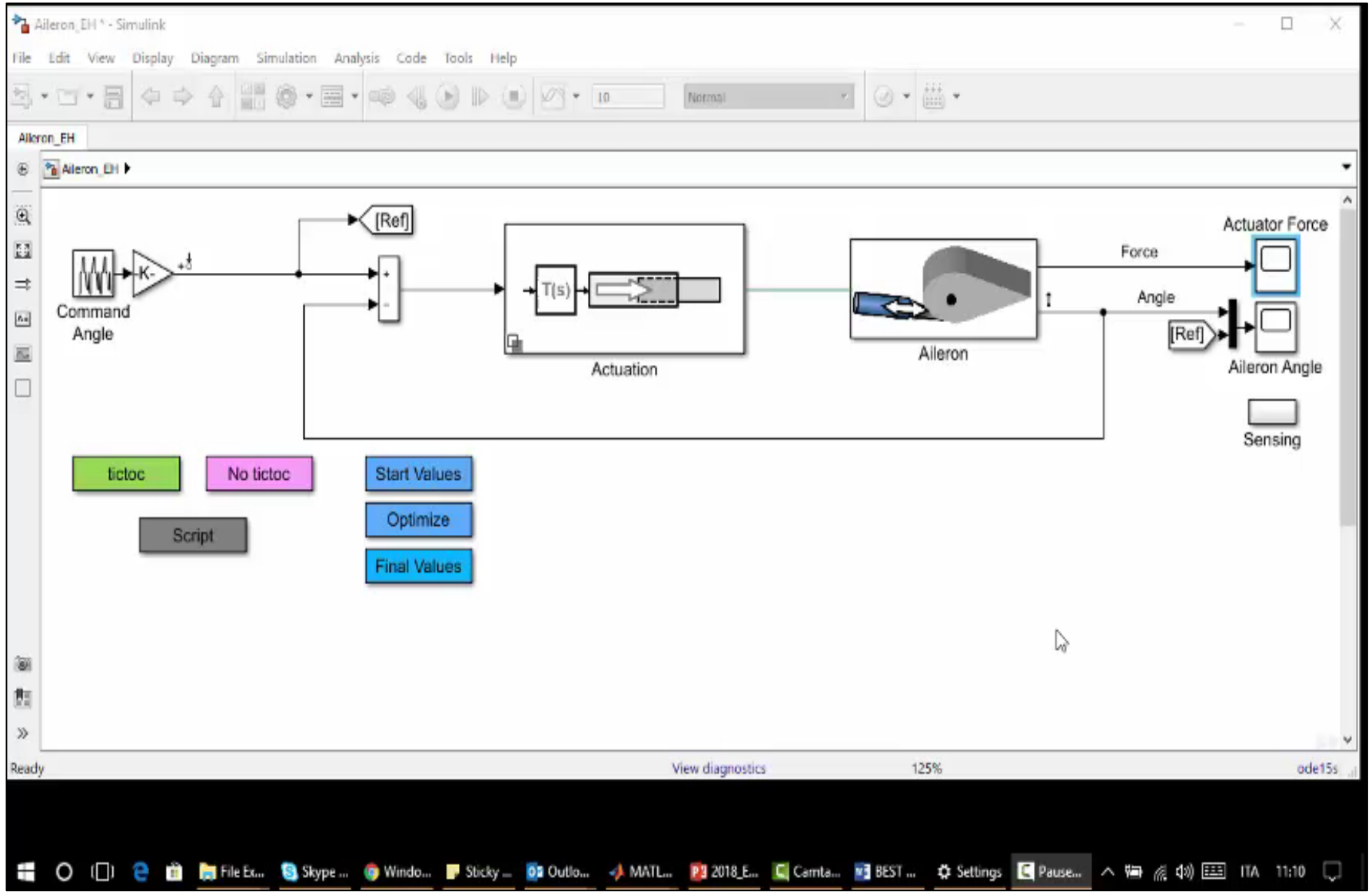

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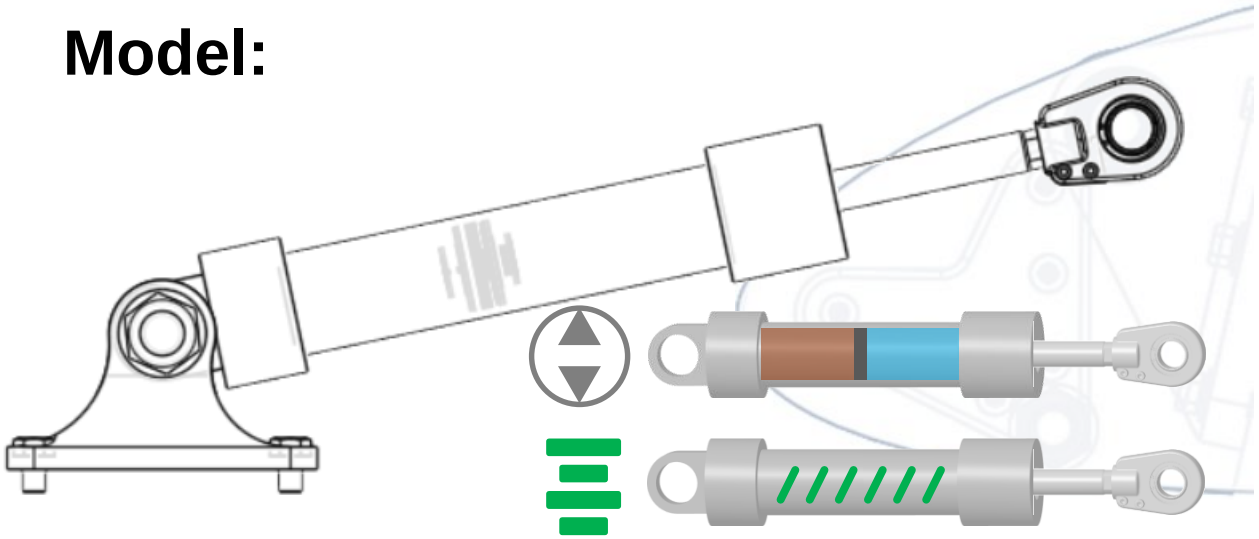

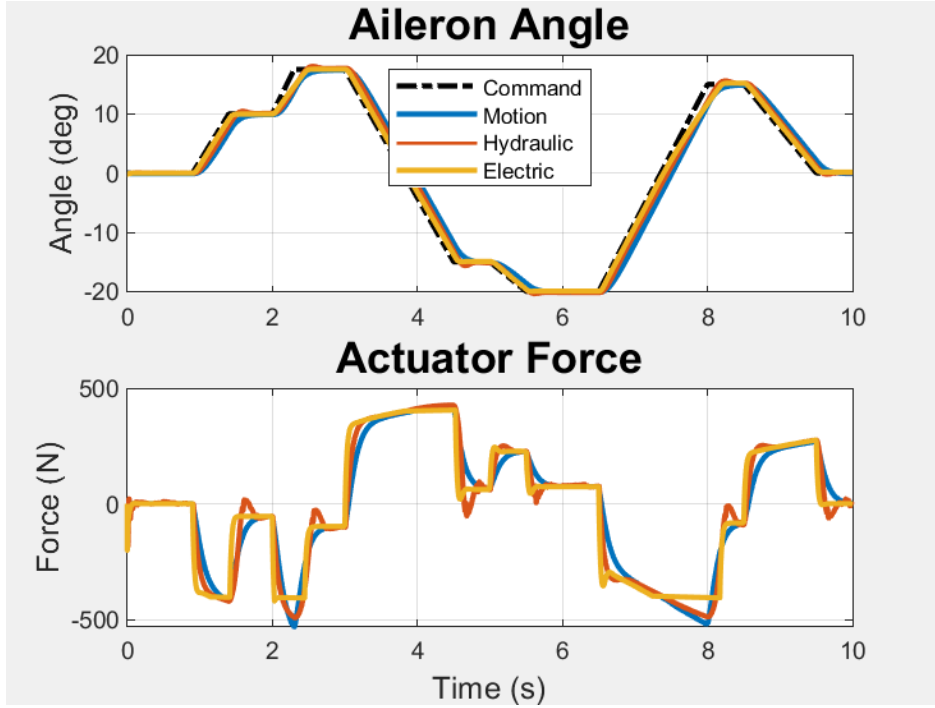

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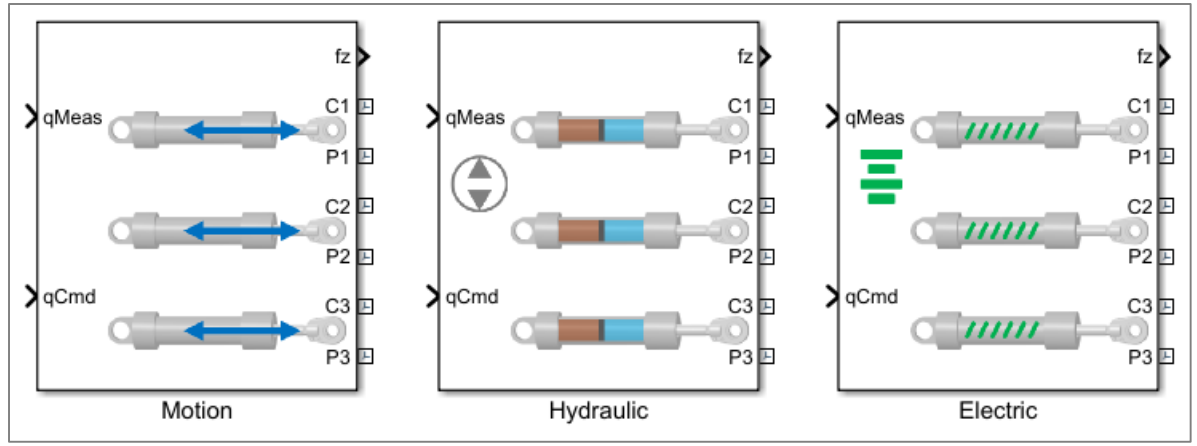
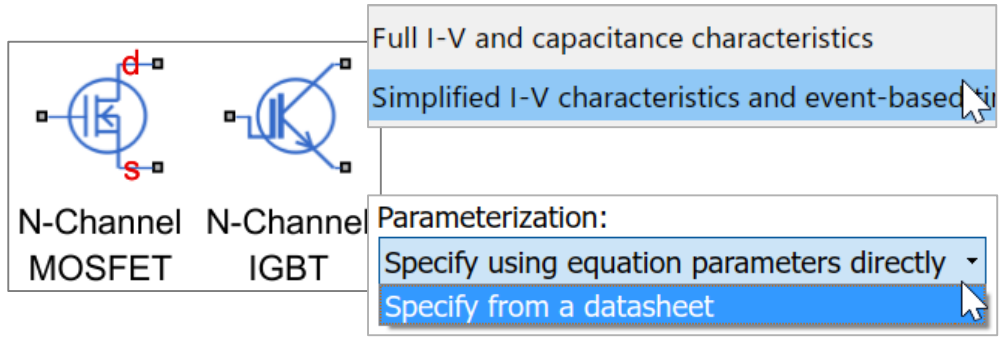
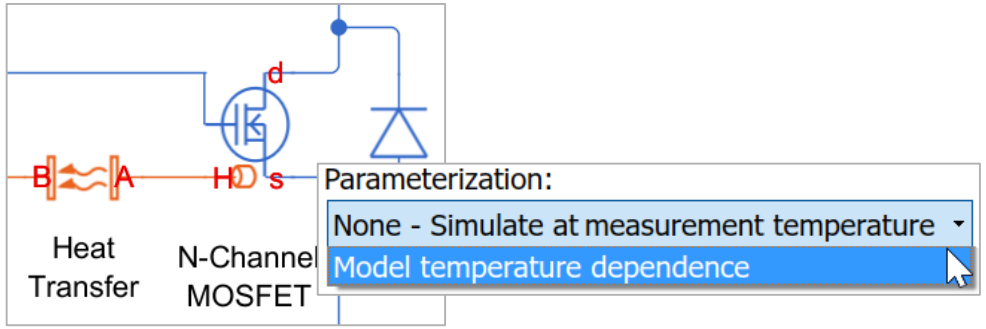


Adjusting Fidelity Using Simscape Electronics Components

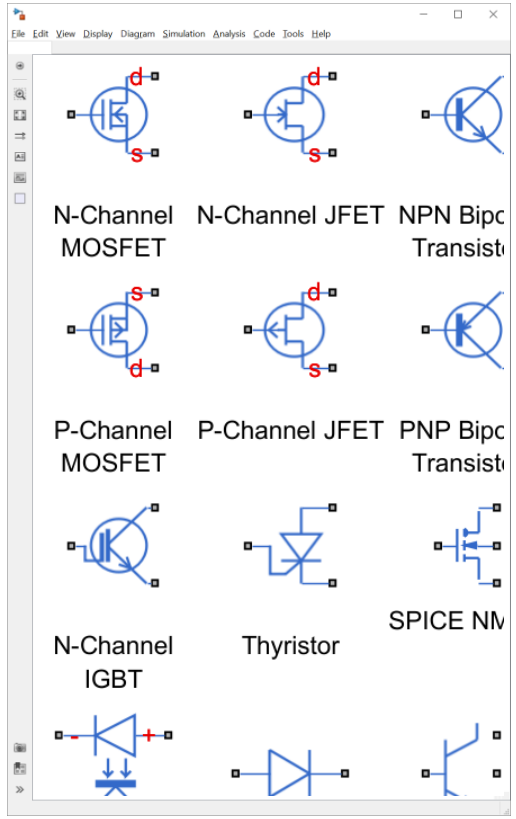
Semiconductors, Motors, Sensors, Op-Amps and Logic, Passive Devices

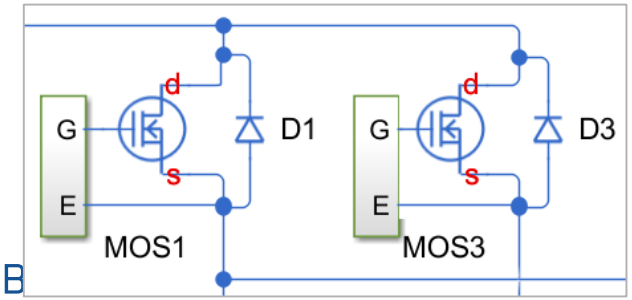
- Switching and signal amplification
  - Parameterize with data sheets
  - Simple and detailed variants
- Thermal effects
  - Effect on behavior
  - Heat transfer to environment
- Measure power losses





Subset of libraries



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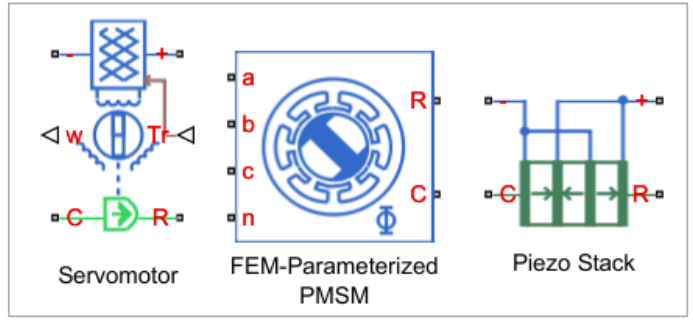
            LoggingNode                    Power
    ____________________________________    _______

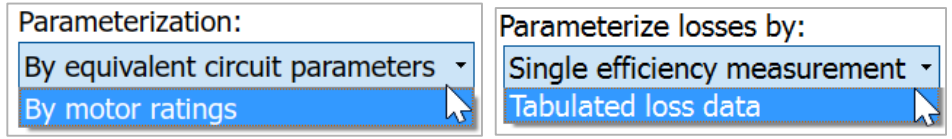
    'elec_solar_converter.D1'              0.96137
    'elec_solar_converter.MOS1'             16.173
```

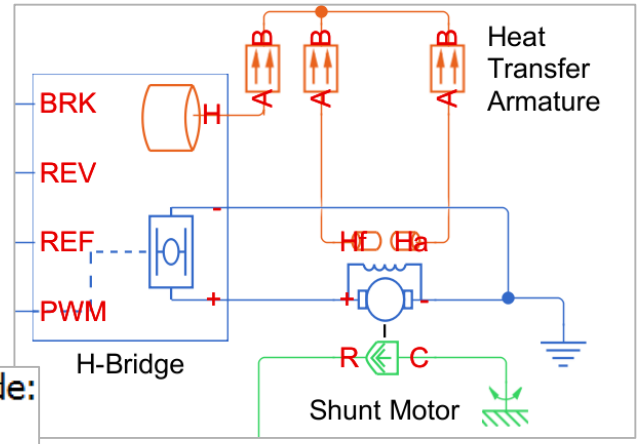
Adjusting Fidelity Using Simscape Electronics Components

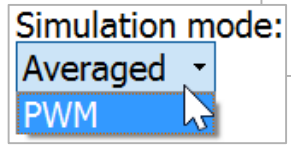
Semiconductors, **Motors**, Sensors, Op-Amps and Logic, Passive Devices

- Translational and rotational actuators
  - Parameterize with data sheets or with data from FEM software
  - Specify electrical losses
- Thermal effects
  - Temperature dependent behavior
  - Heat transfer to environment
- Include or neglect switching effects

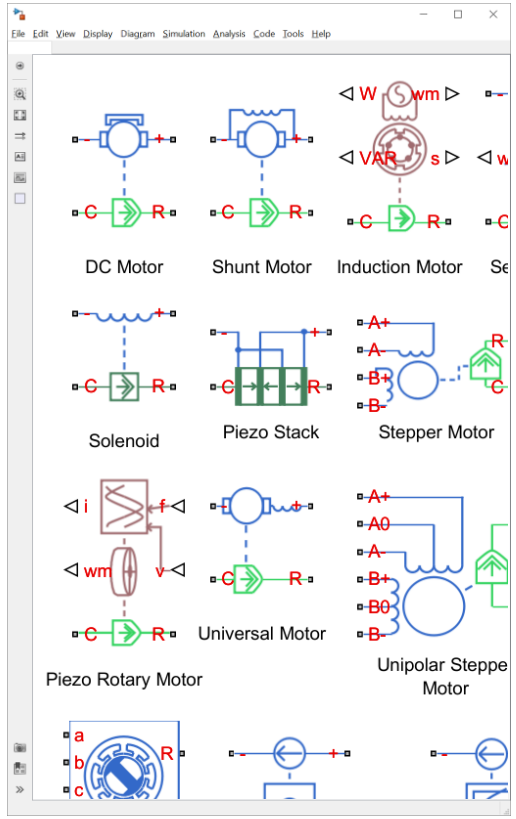








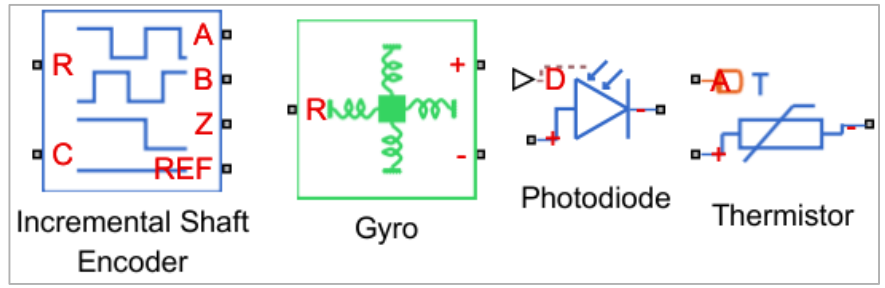
Subset of libraries

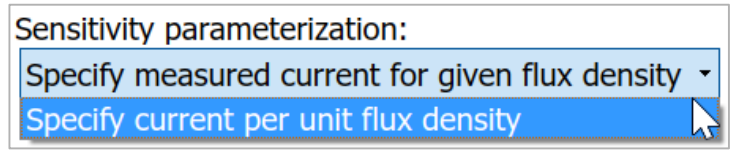


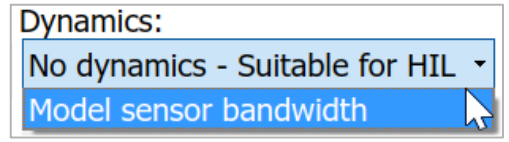
Adjusting Fidelity Using Simscape Electronics Components

Semiconductors, Motors, **Sensors**, Op-Amps and Logic, Passive Devices

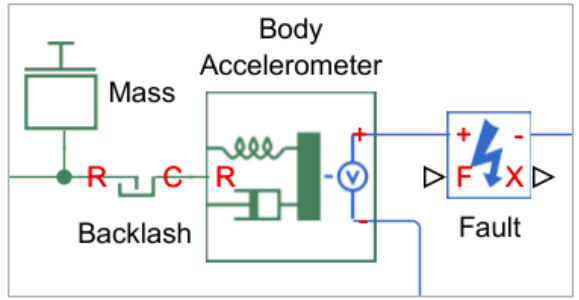
- Includes electronic, thermal, and mechanical sensors
  - Analog and digital
  - Parameterization options
  - Include or neglect sensor bandwidth

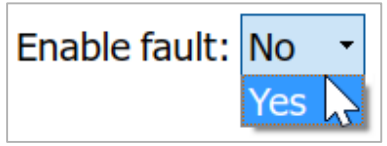






- Test effects of sensor damage or failure on system performance





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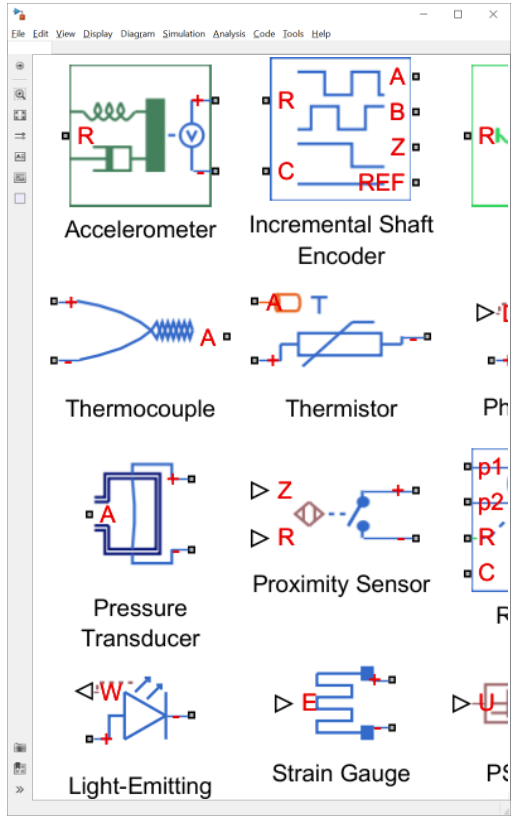
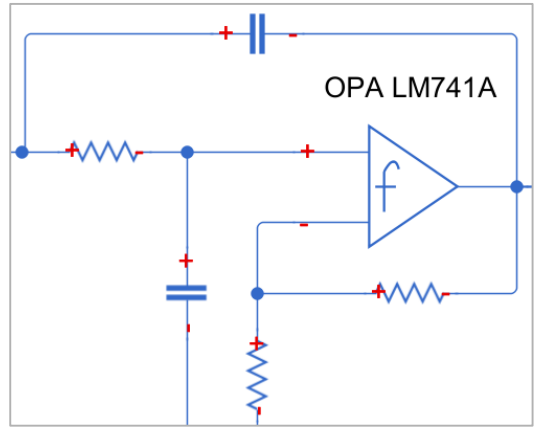
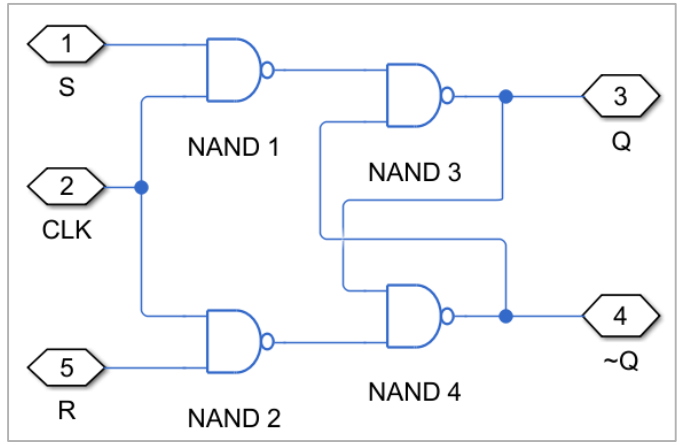


Adjusting Fidelity Using Simscape Electronics Components

Semiconductors, Motors, Sensors, **Op-Amps and Logic**, Passive Devices

- Behavioral models for fast simulation
  - Similar behavior to models with transistor implementation
  - Enables testing of larger circuits in less time
- Use models to perform high-level design
  - Avoid nonlinear effects during normal circuit operation





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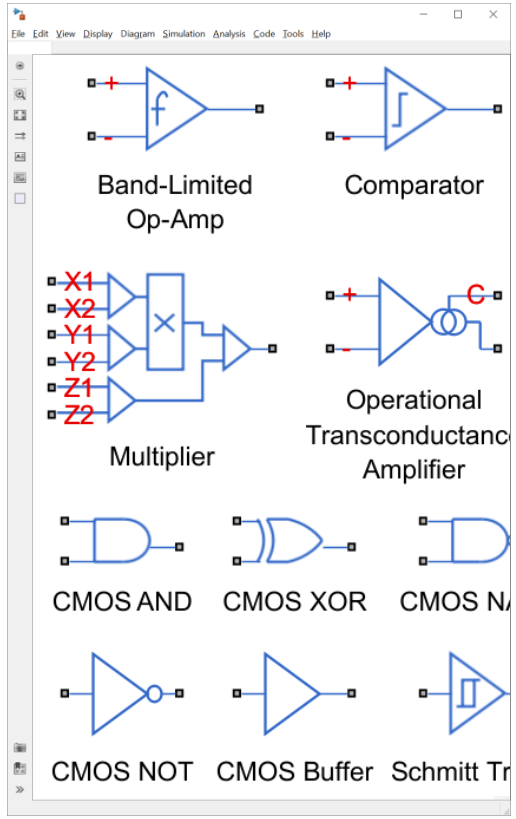
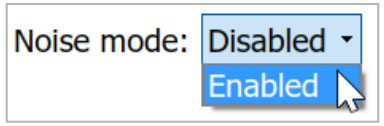
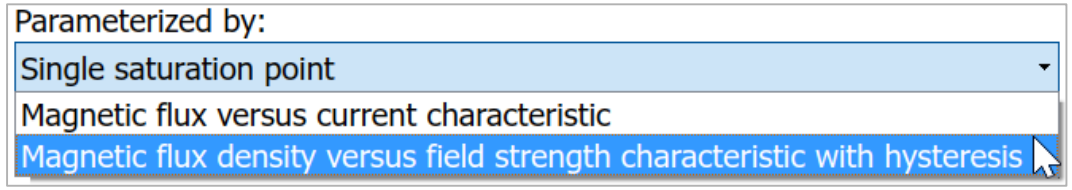


Adjusting Fidelity Using Simscape Electronics Components

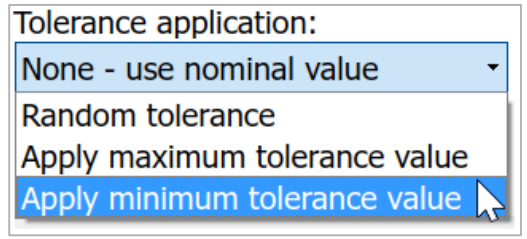
Semiconductors, Motors, Sensors, Op-Amps and Logic, **Passive Devices**

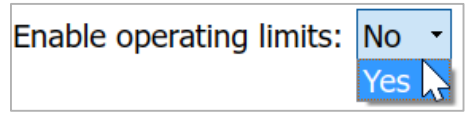
- Linear and nonlinear devices
  - Enable physical effects



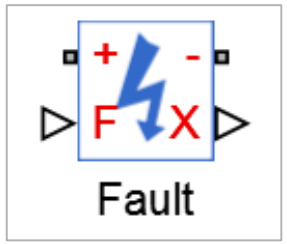


- Specify operating limits and tolerances
  - Model realistic behavior

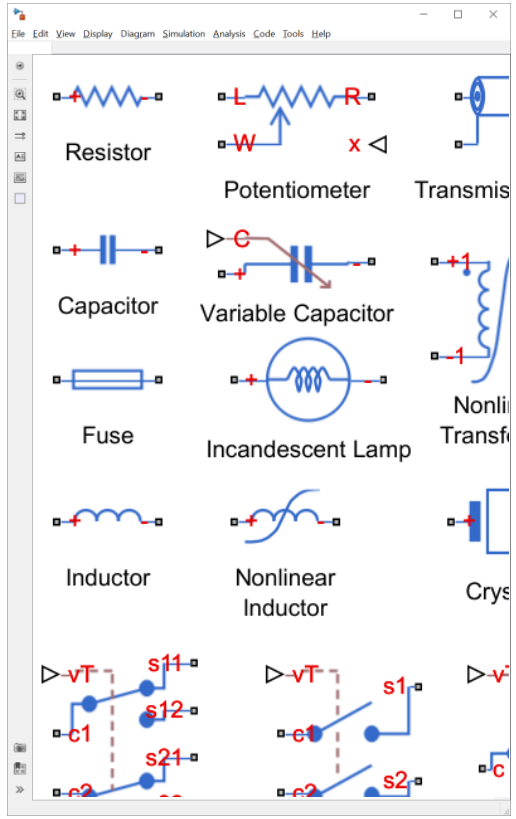




- Test effects of component failure on system level performance
  - Fault modeling



Subset of libraries

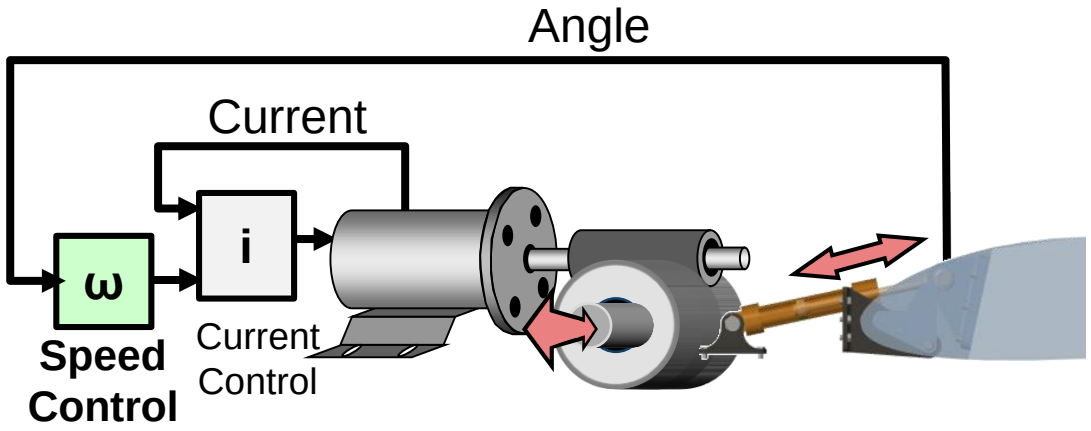


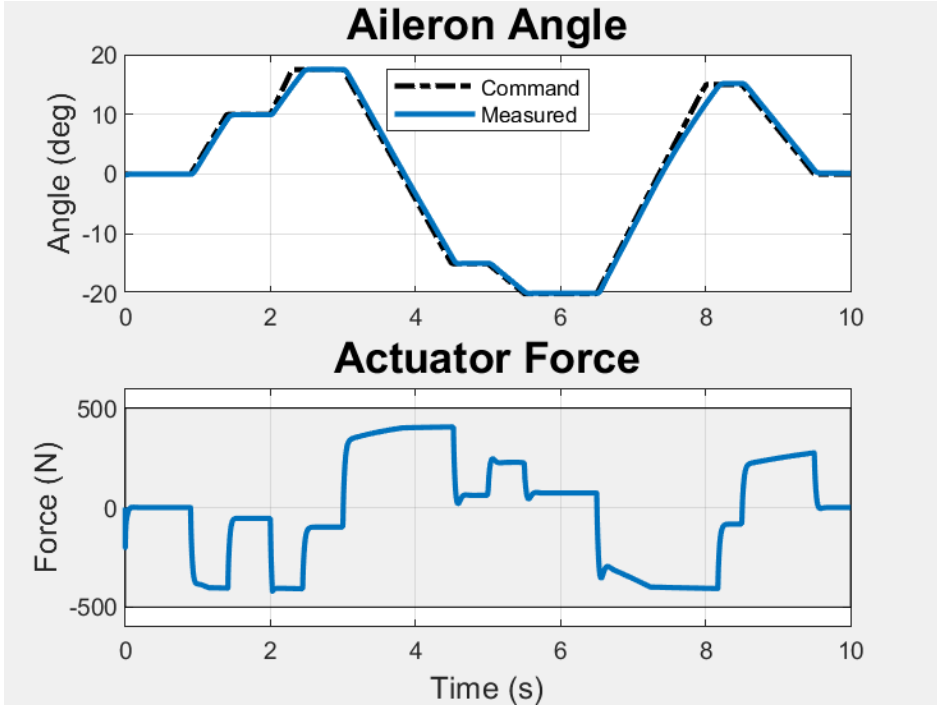
Agenda

- Example: Flight actuation system
  - Benefits of Model-Based Design
- Actuator design
  - Link requirements and design
  - Modeling the mechanical system
  - Determining actuator requirements
  - Tradeoff studies
- Optimizing system performance
  - Tune controller automatically
- Model deployment
  - HIL testing
  - Protecting IP

Optimizing System Performance

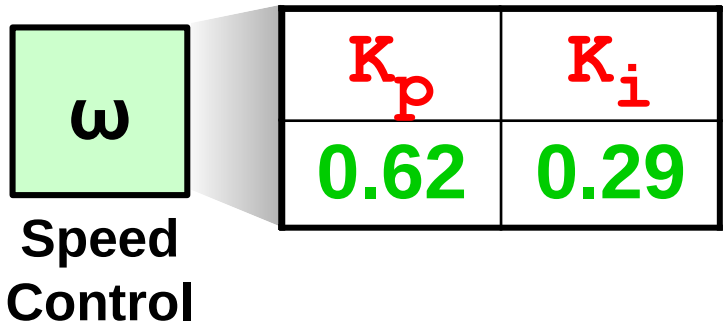
Model:



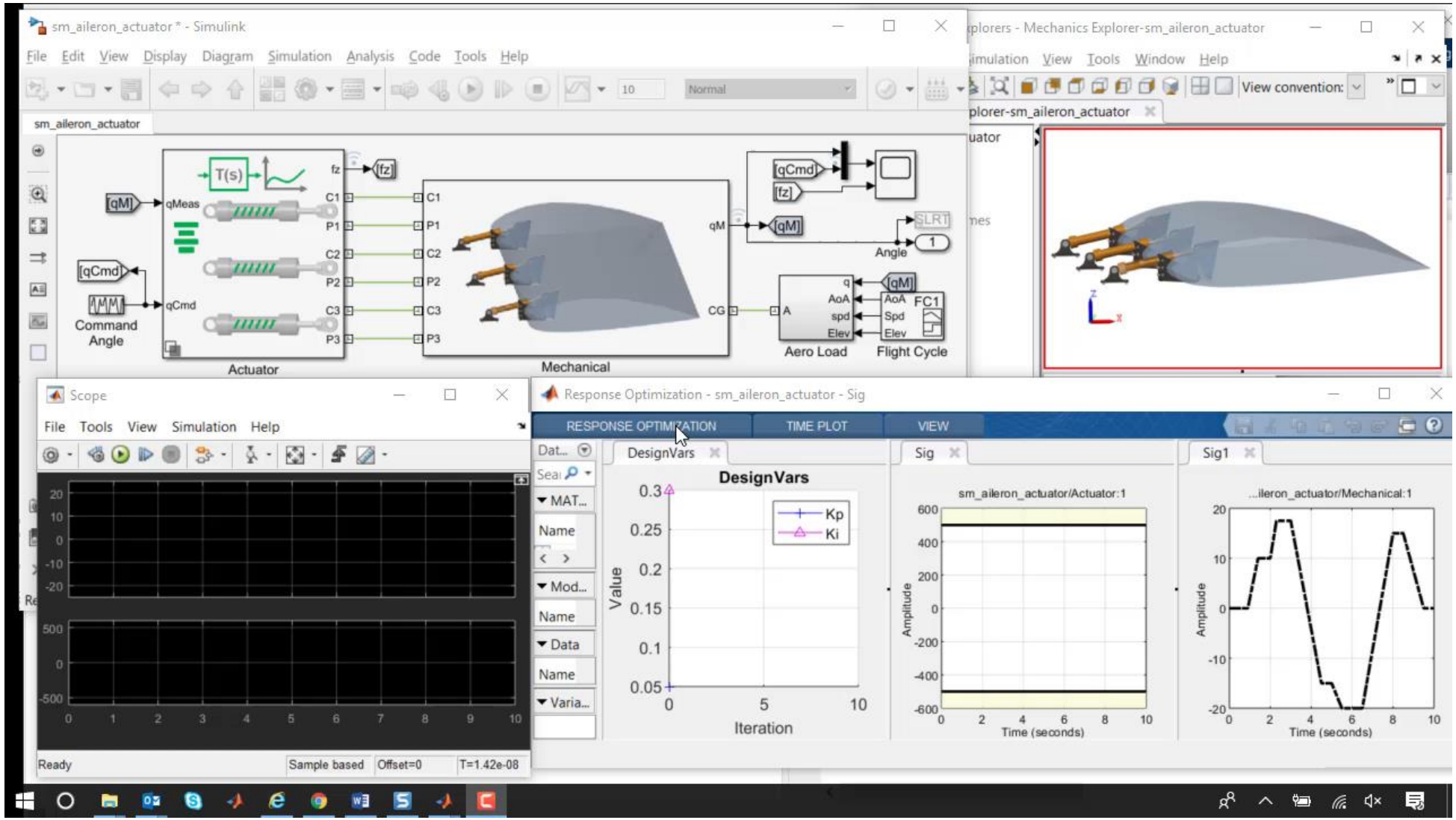


Problem: Optimize the speed controller to meet system requirements

Solution: Tune controller parameters with Simulink Design Optimization

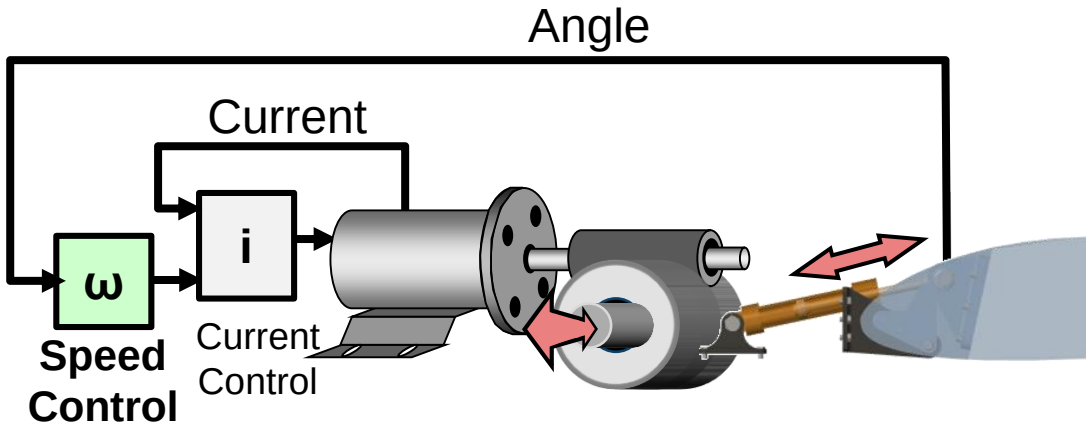


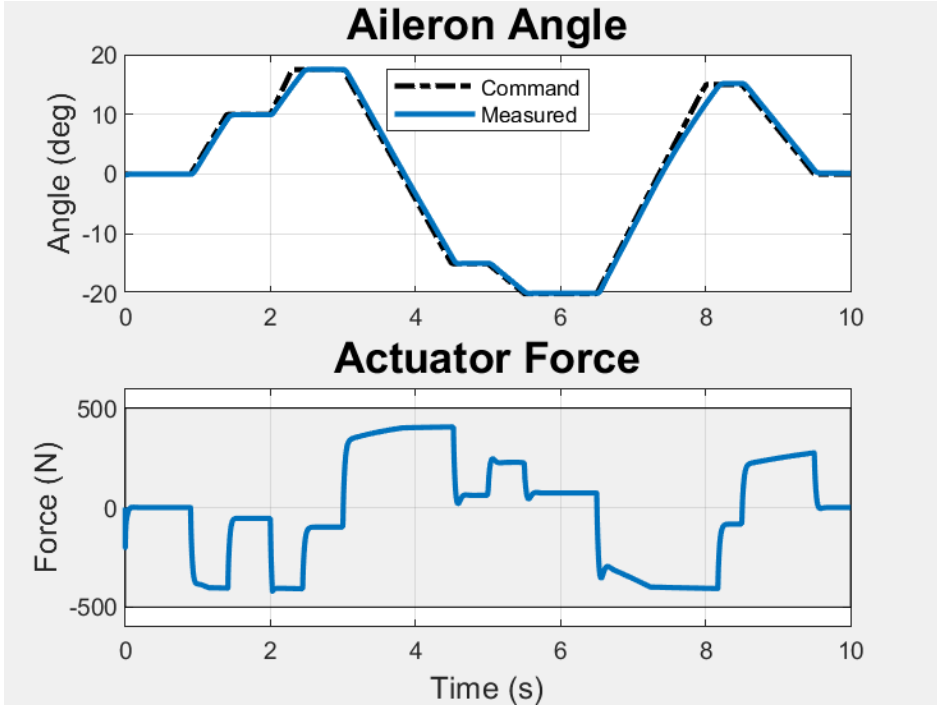
Optimizing System Performance



Optimizing System Performance

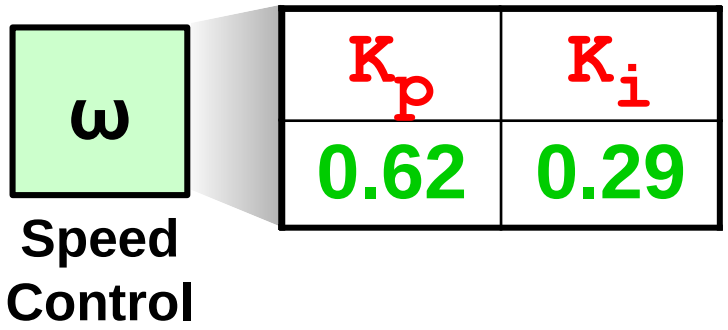
Model:





Problem: Optimize the speed controller to meet system requirements

Solution: Tune PID parameters with Simulink Control Design



Agenda

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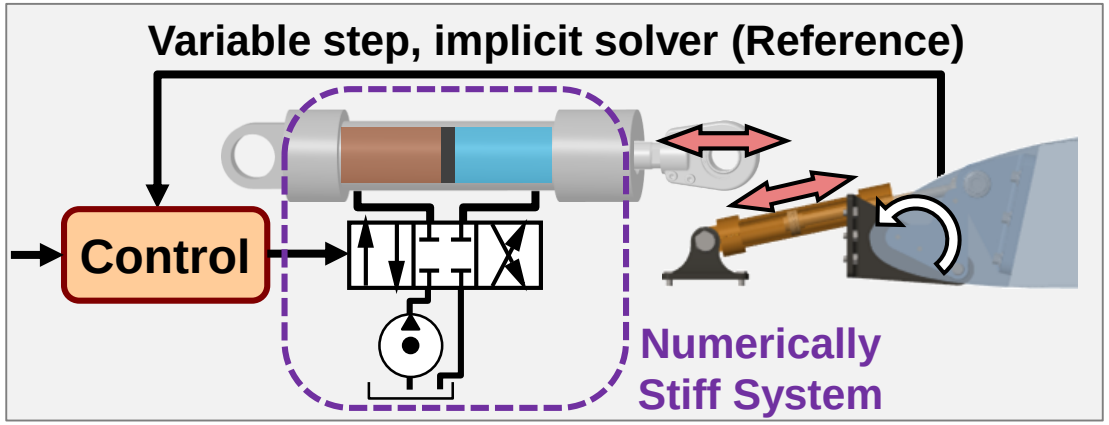
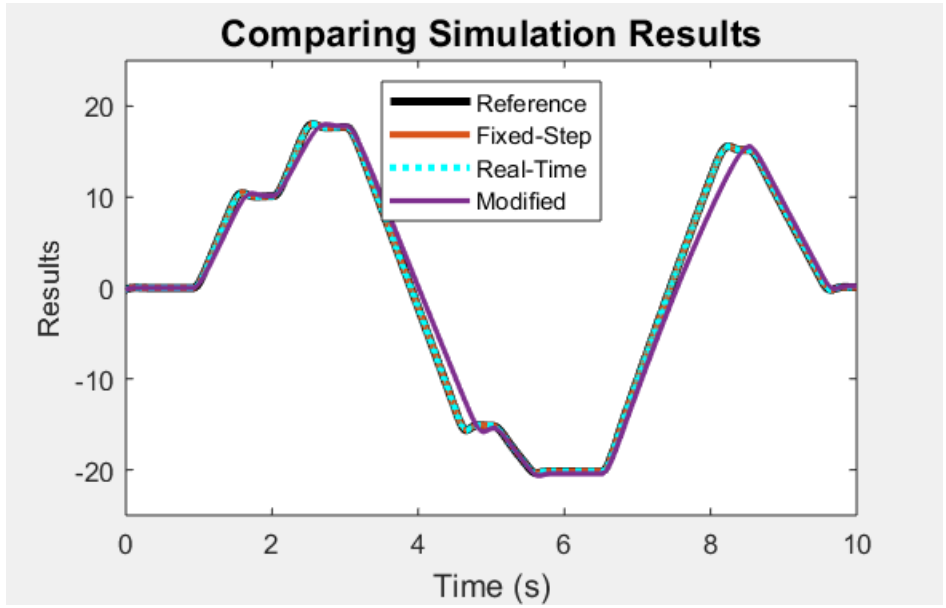
Configuring a Hydraulic Actuator for HIL Testing

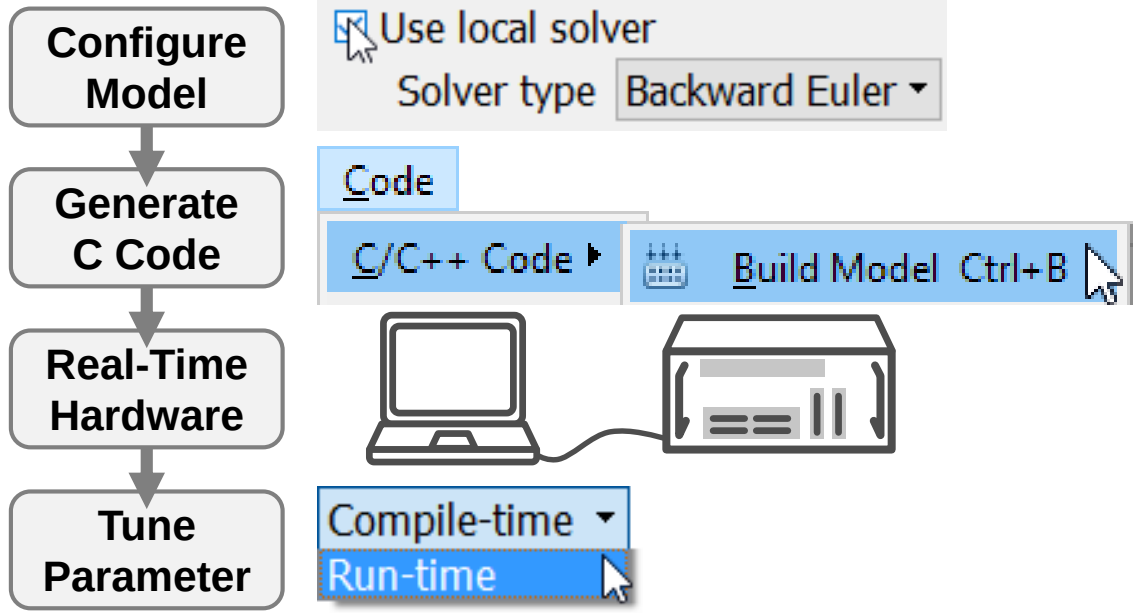
Model:





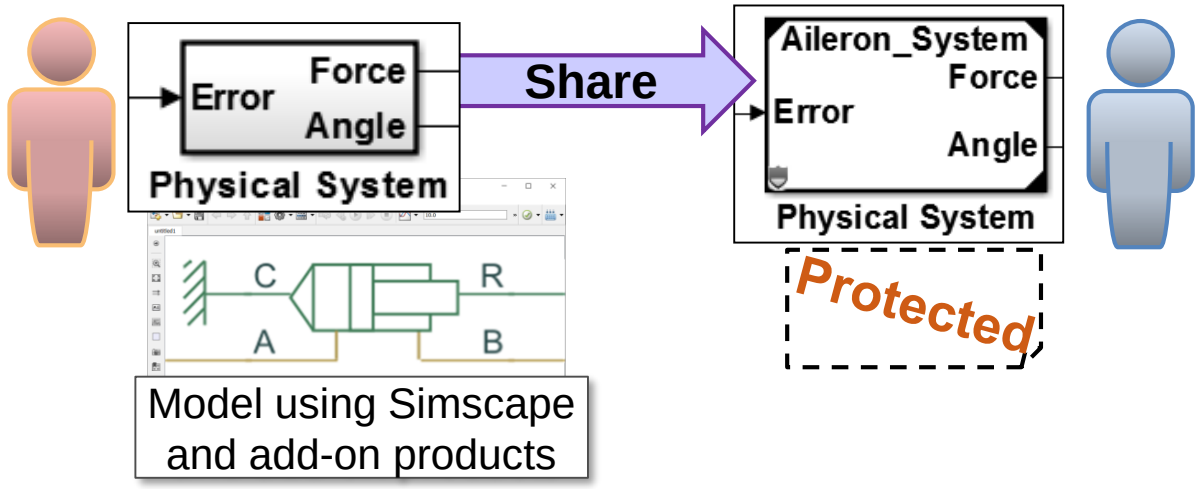
Problem: Configure solvers to minimize computations and convert to C code for real-time simulation

Solution: Use Simscape local solvers on stiff physical networks and Simulink Coder™ to generate C code



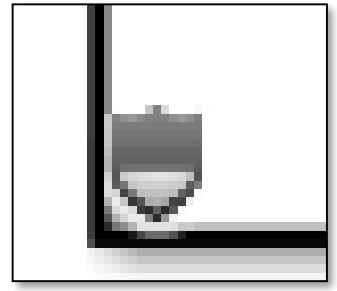
Sharing Models and Protecting Intellectual Property

Situation:

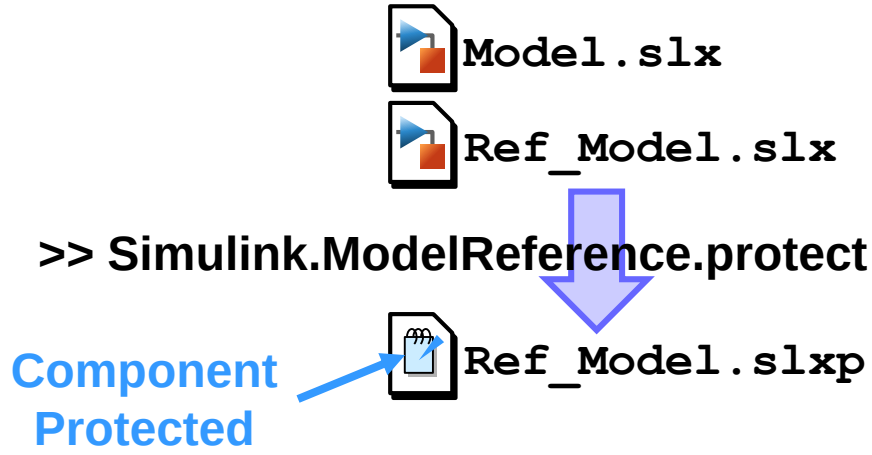


Problem: Share a component or library with others that does not expose the source code.

Solution: Use the Model Reference Protected Mode from Simulink to protect intellectual property

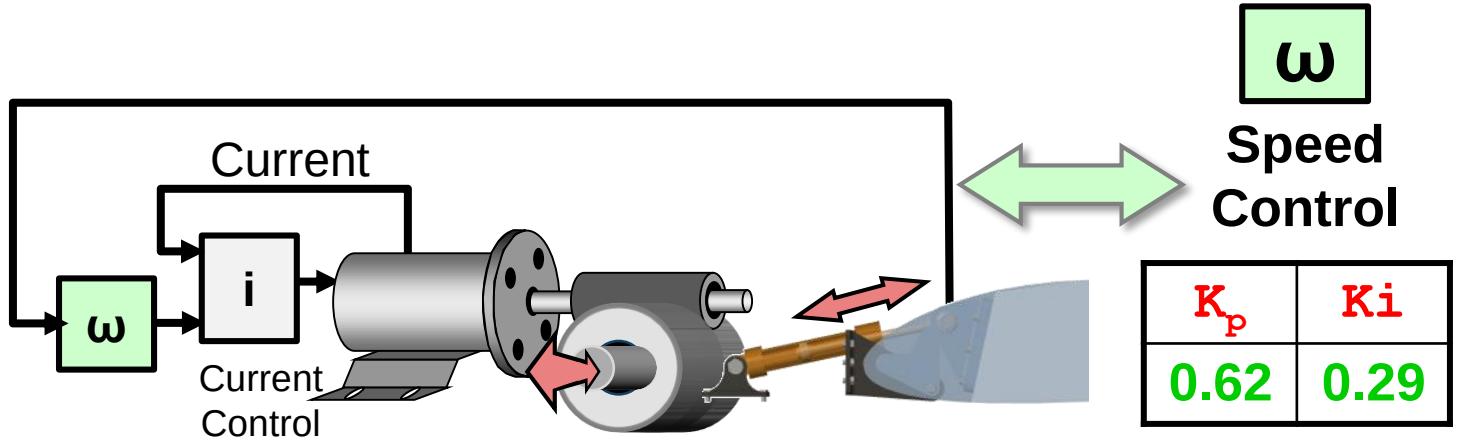


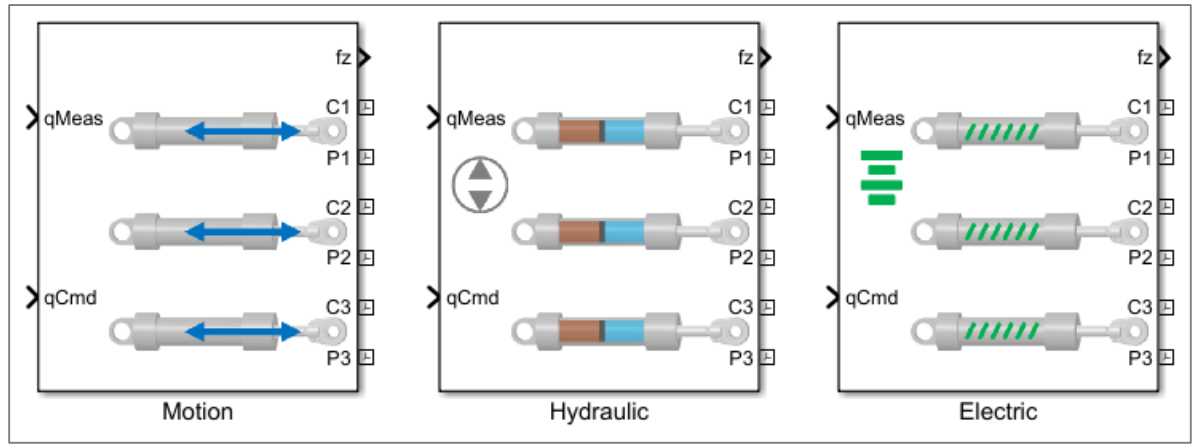
- ✓Simulate
- ✓Change parameter values
- ✓Does not require licenses for Simscape add-on products
- ✓Source code protected



Key Points

- Simulating the system in one environment enable to design higher quality controls
- Testing different actuator designs, having different levels of detail, in one environment saves time and encourages innovation
- Plant model supports the entire development process





Configure Model → Real-Time Hardware → Generate C Code → Tune Parameter

MATLAB EXPO 2018

Progettazione meccatronica per sistemi avionici

Aldo Caraceto