MATLAB CONFERENCE 2017

Simulink as Your Enterprise Simulation Platform

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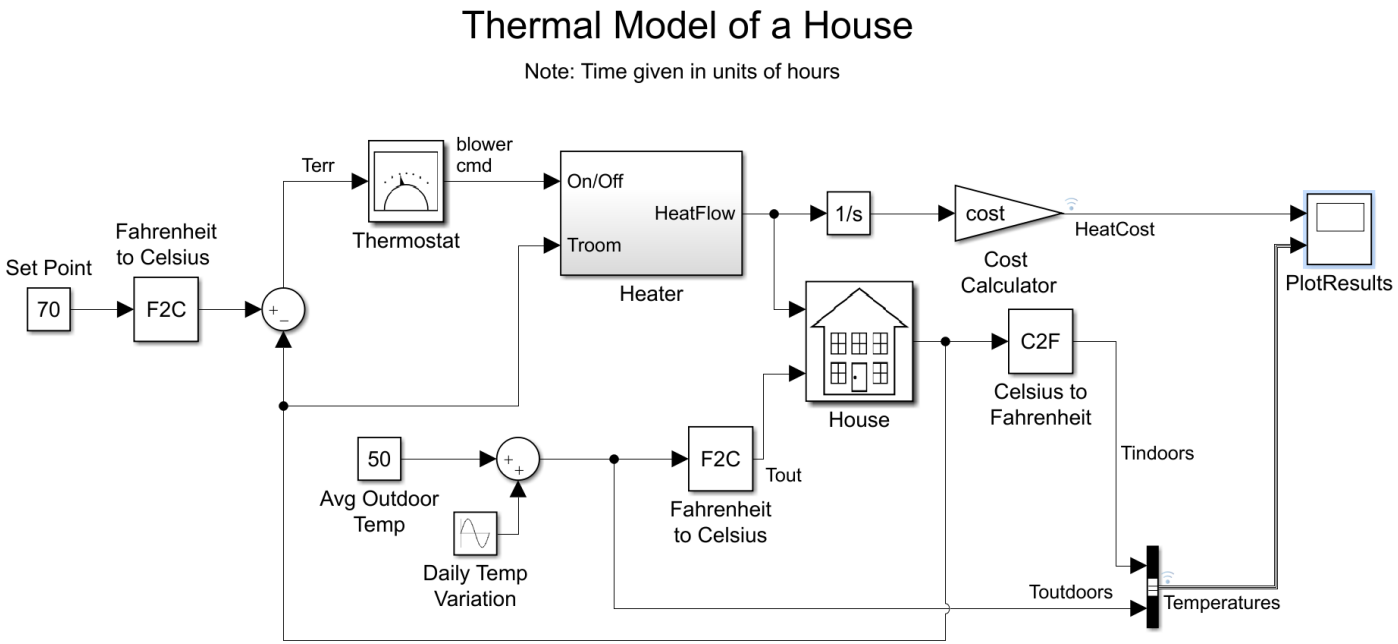
Applications Engineer
MathWorks Australia

What is an Enterprise Simulation Platform?

- Enterprise – Any size business or project. Small or large.
- Simulation – Evaluating system behavior through computation
- Platform – Scalable environment for multi-disciplinary collaboration

What is Simulink?

- A block diagram environment to **model** and **simulate** dynamic systems
- Block libraries are available to help you build your model



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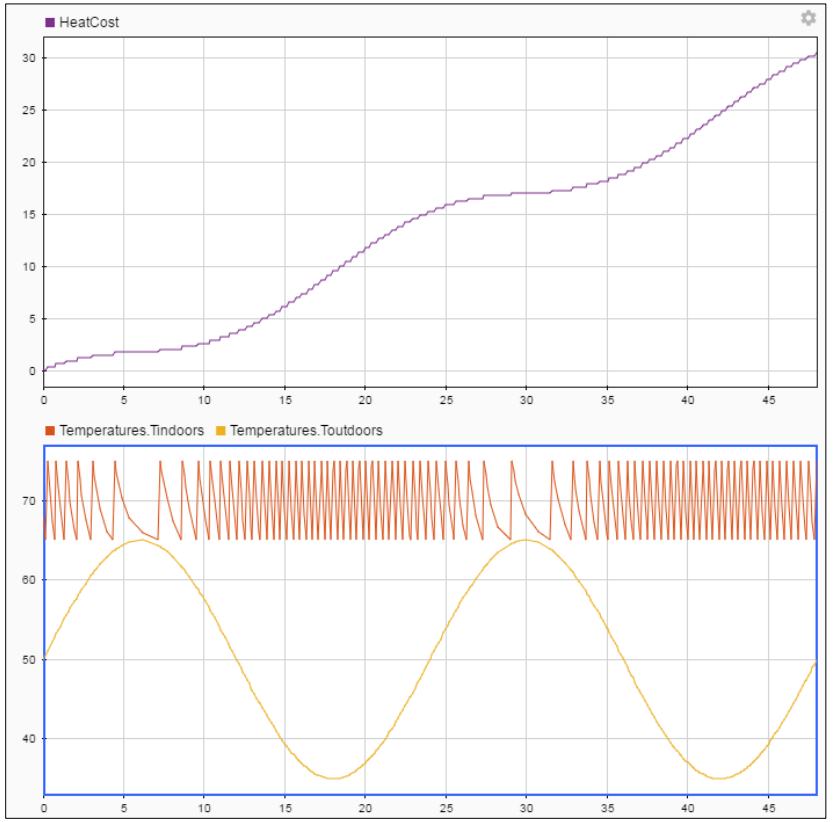


Simulink can be used as your Enterprise Simulation Platform

Carnegie Wave Energy

Designs and Builds the World's First Operating Wave Farm

Harness the power of ocean waves to generate electricity!

- Large submerged buoys (11m diameter)
- Buoy motion actuates pumps to pressurize water
- Water drives hydroelectric conversion devices

Challenges

- Multidomain problem: mechanical, hydraulic and electrical components
- Integrating a large multi faceted project for system level analysis
- Test under many different conditions

Solution

- Leverage Simulink as a simulation platform

Carnegie Wave Energy
Designs and Builds the World's First Operating Wave Farm

Crucial Design Insights Gained

"As engineering tools, MATLAB and Simulink provide significant value…they enable us to quickly test ideas that we would otherwise never try."

Jonathan Fiévez, CTO

"Simulink revealed system behaviours that we didn't anticipate."

Alex Pichard, Analysis Engineer

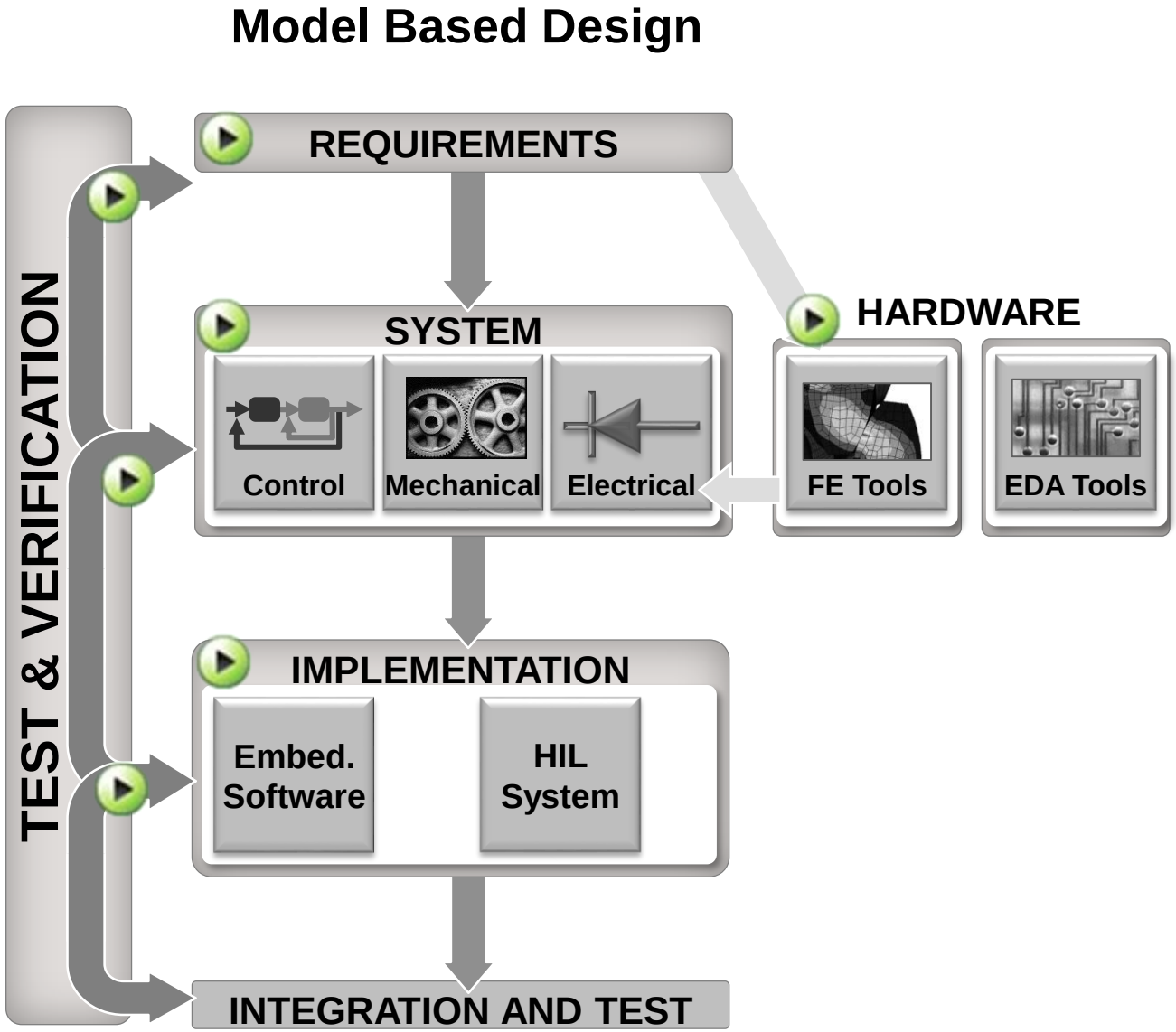
Sensitivity Studies Accelerated

" …we typically simulate 15 to 20 sea states for each parameter value we vary. With Parallel Computing Toolbox we can run simulations in parallel, and with a twelve-core computer we see an almost twelvefold increase in speed."

Jack Jorgensen, Analysis Engineer.

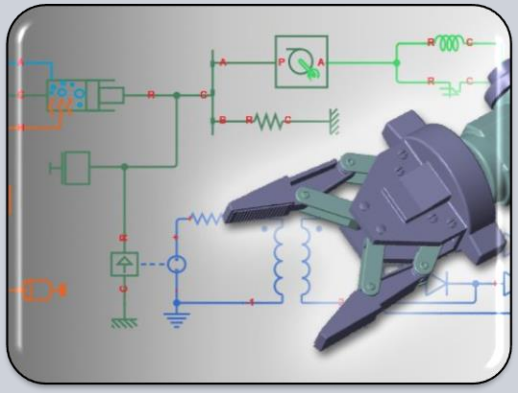
Enterprise Simulation Platform

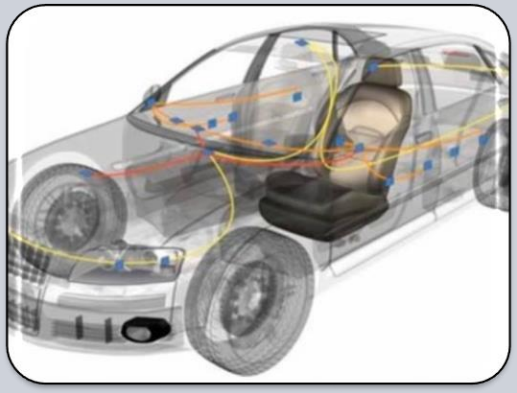
- Enterprise - Any size business or project
- Simulation – Evaluating system behavior through computation
- Platform – Scalable environment for multi-disciplinary collaboration

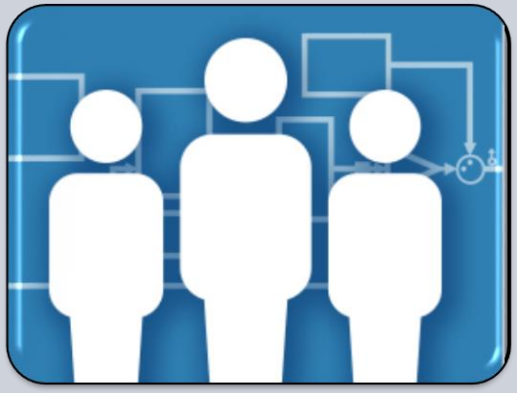


Simulation

Enterprise Simulation Platform Enablers





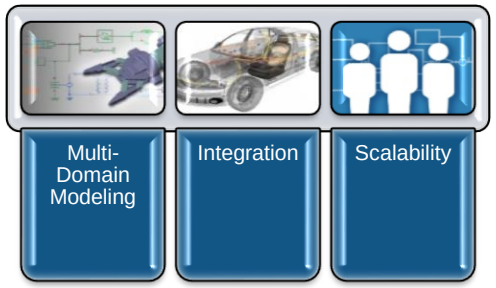


Multi-Domain Modeling

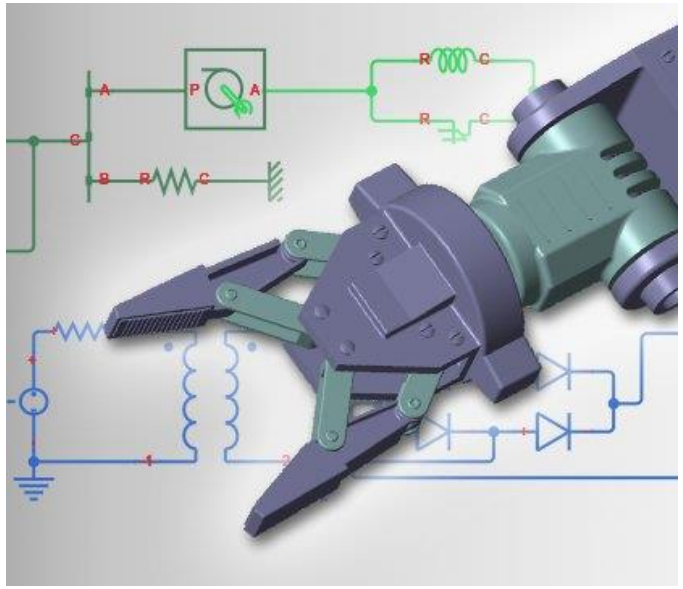
Integration

Scalability

Enterprise Simulation Platform Enablers



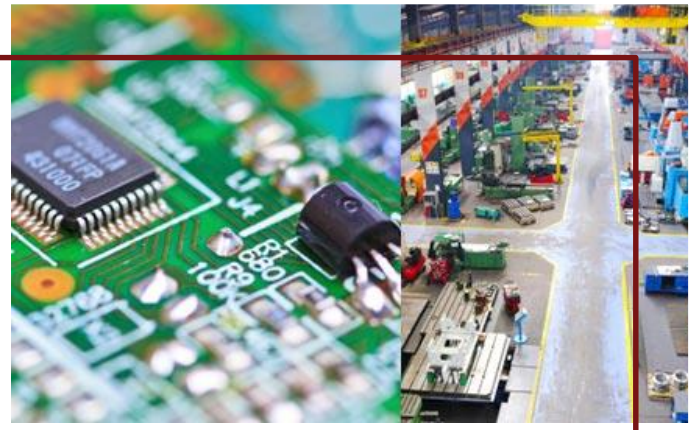
1. Multi-Domain Modeling



Multi-Domain Modeling in Simulink

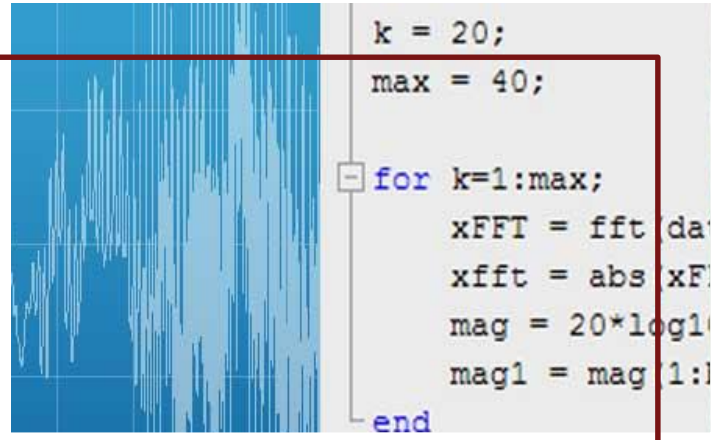
Dynamic Systems

State Machines



Discrete-Event Systems

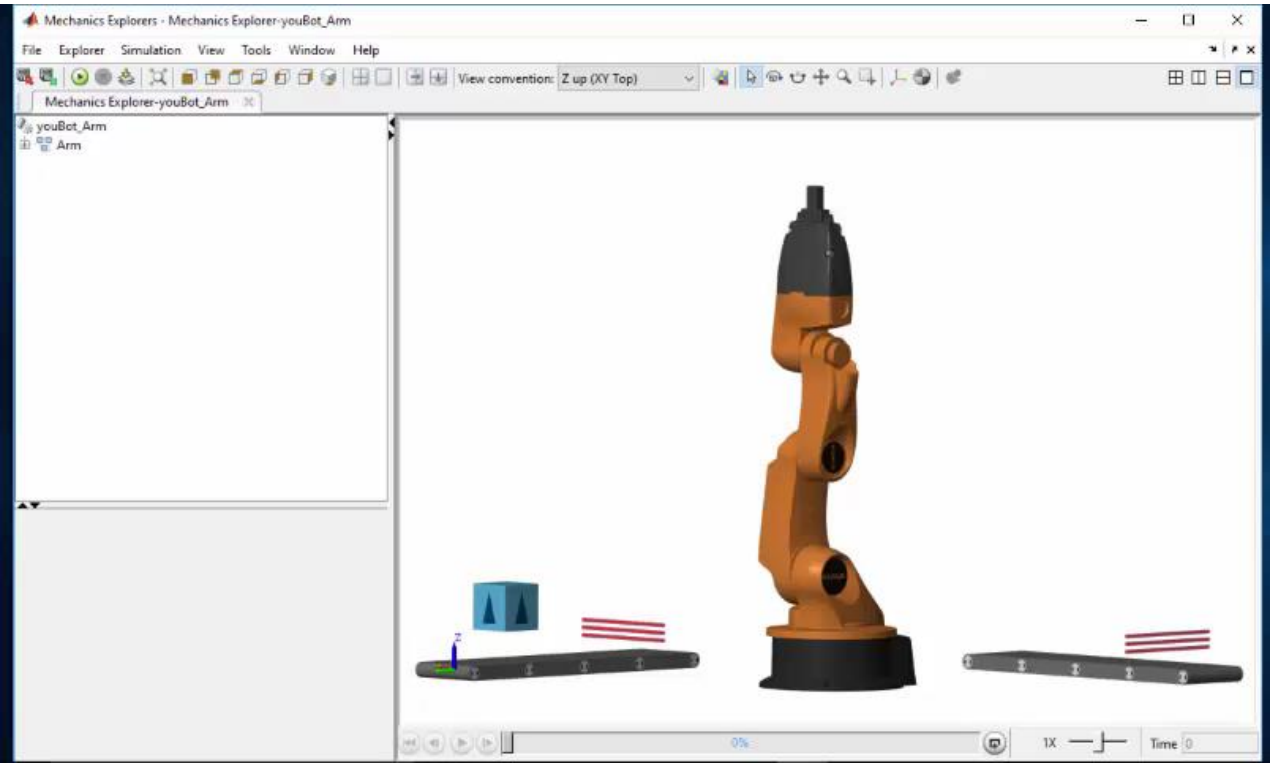
Physical Modeling



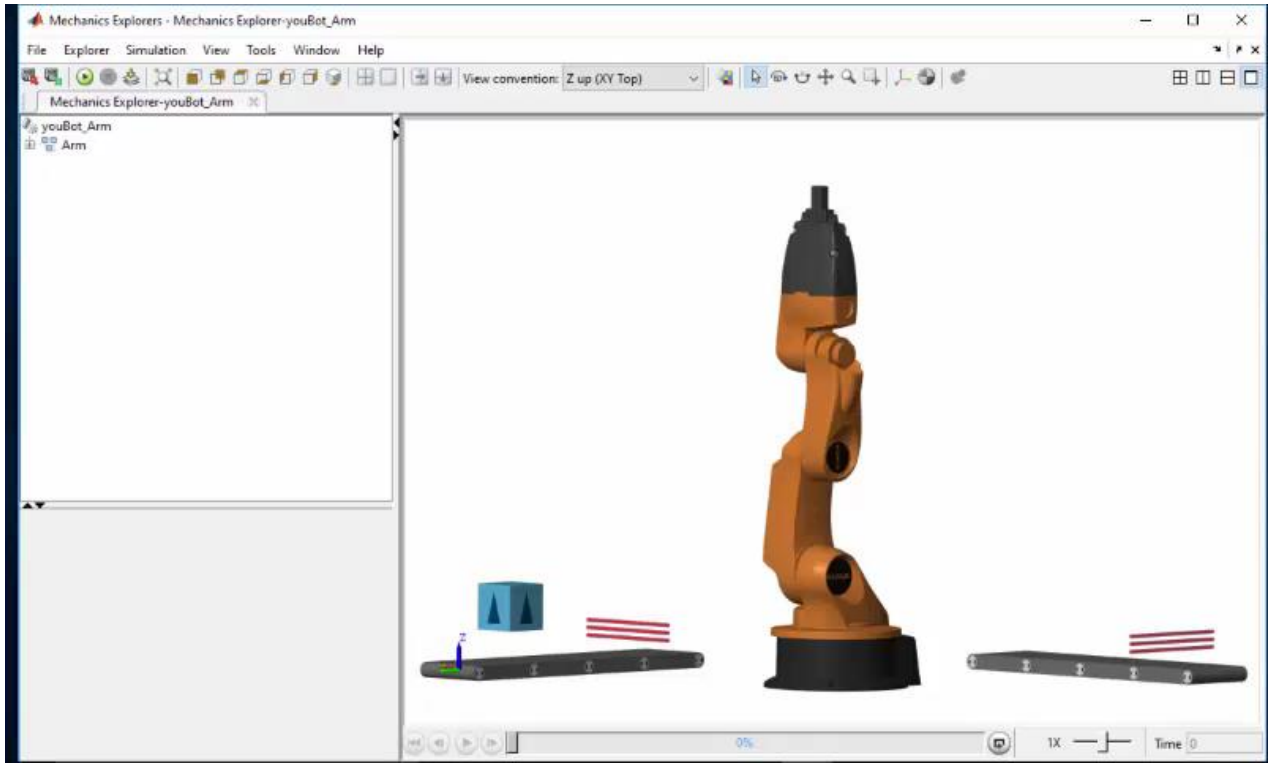
Code

Robot Arm Multi-Domain Simulation

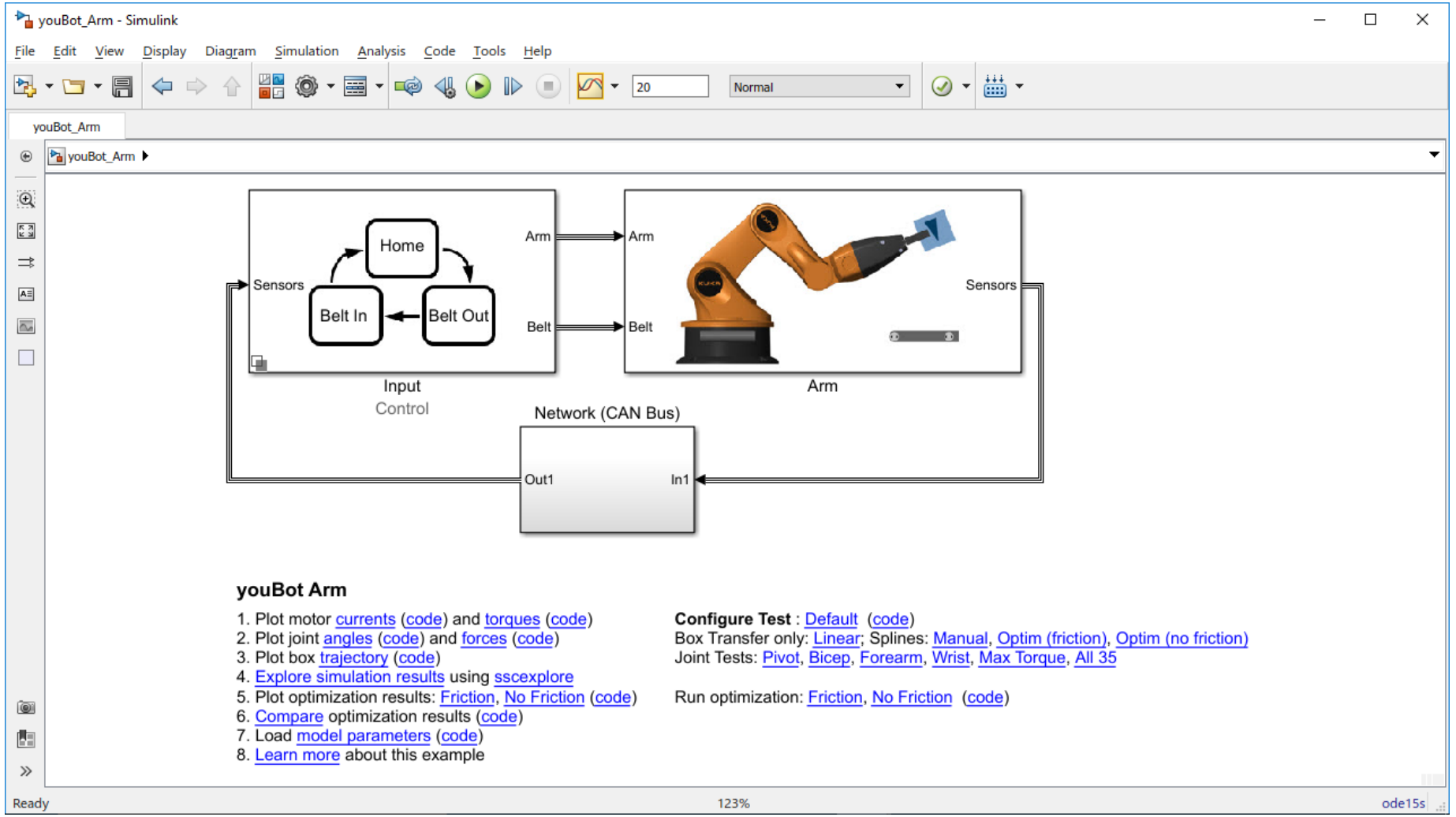
Without Network Model



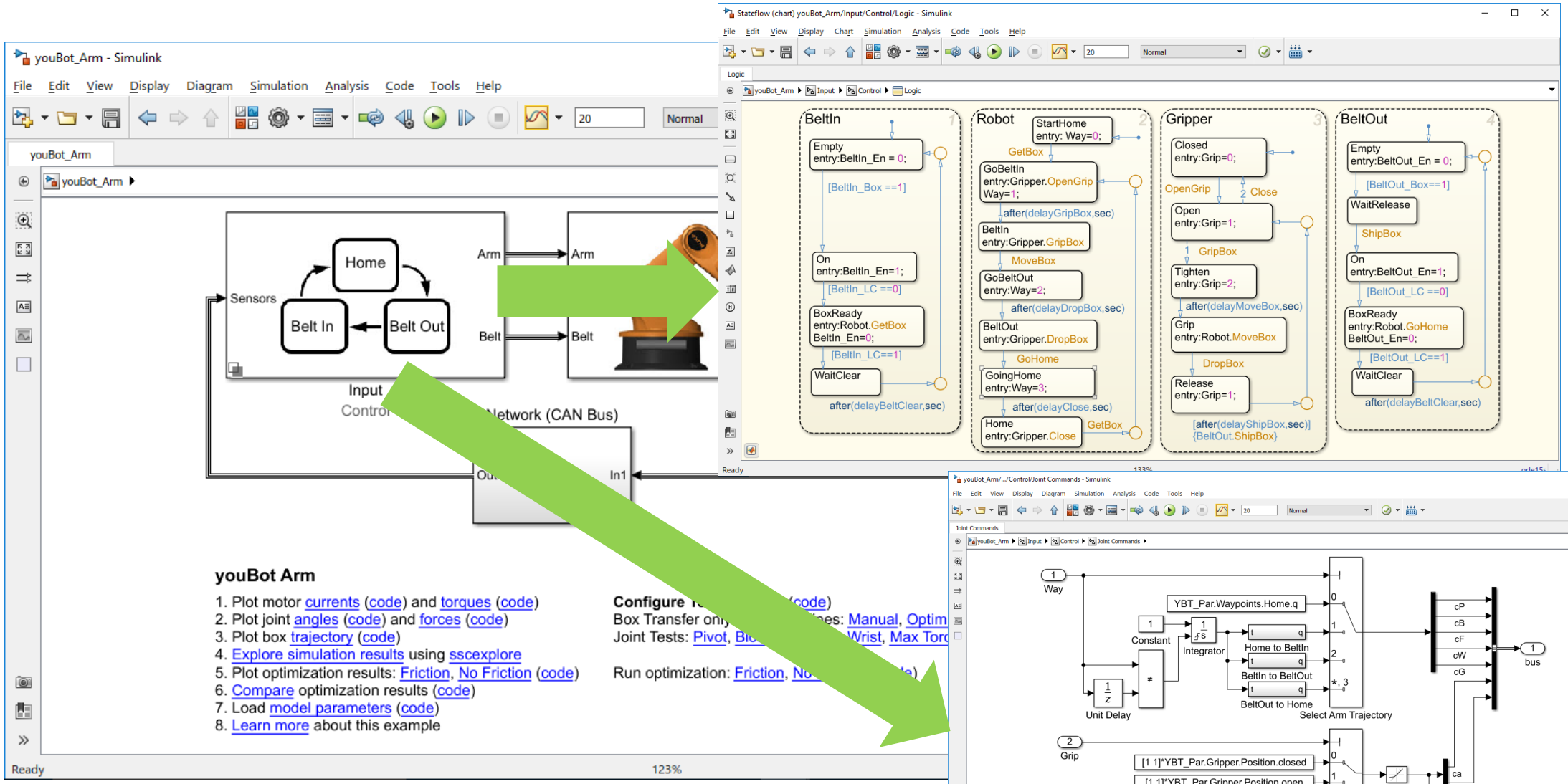
With Network Model



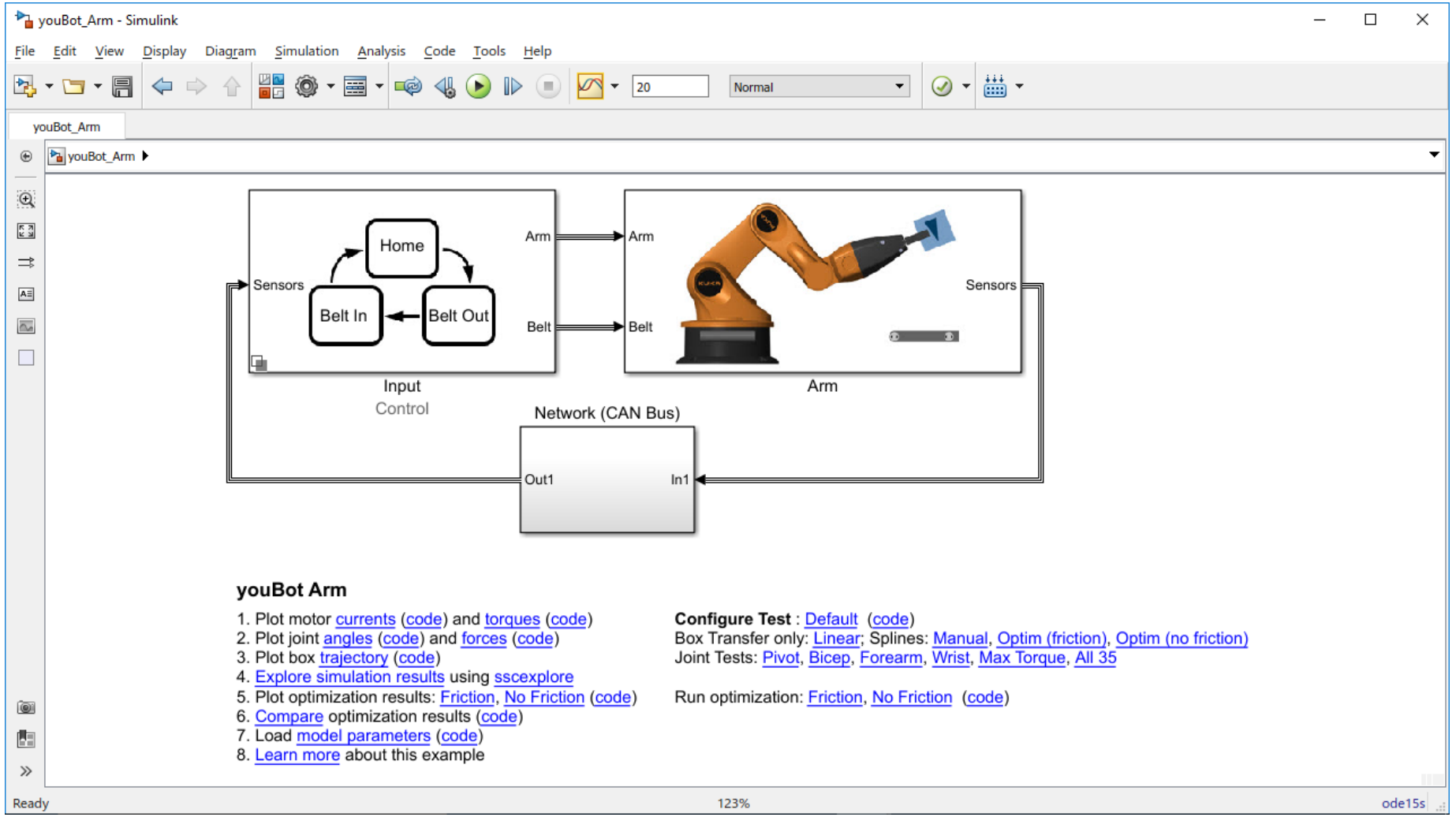
Multi-Domain Model



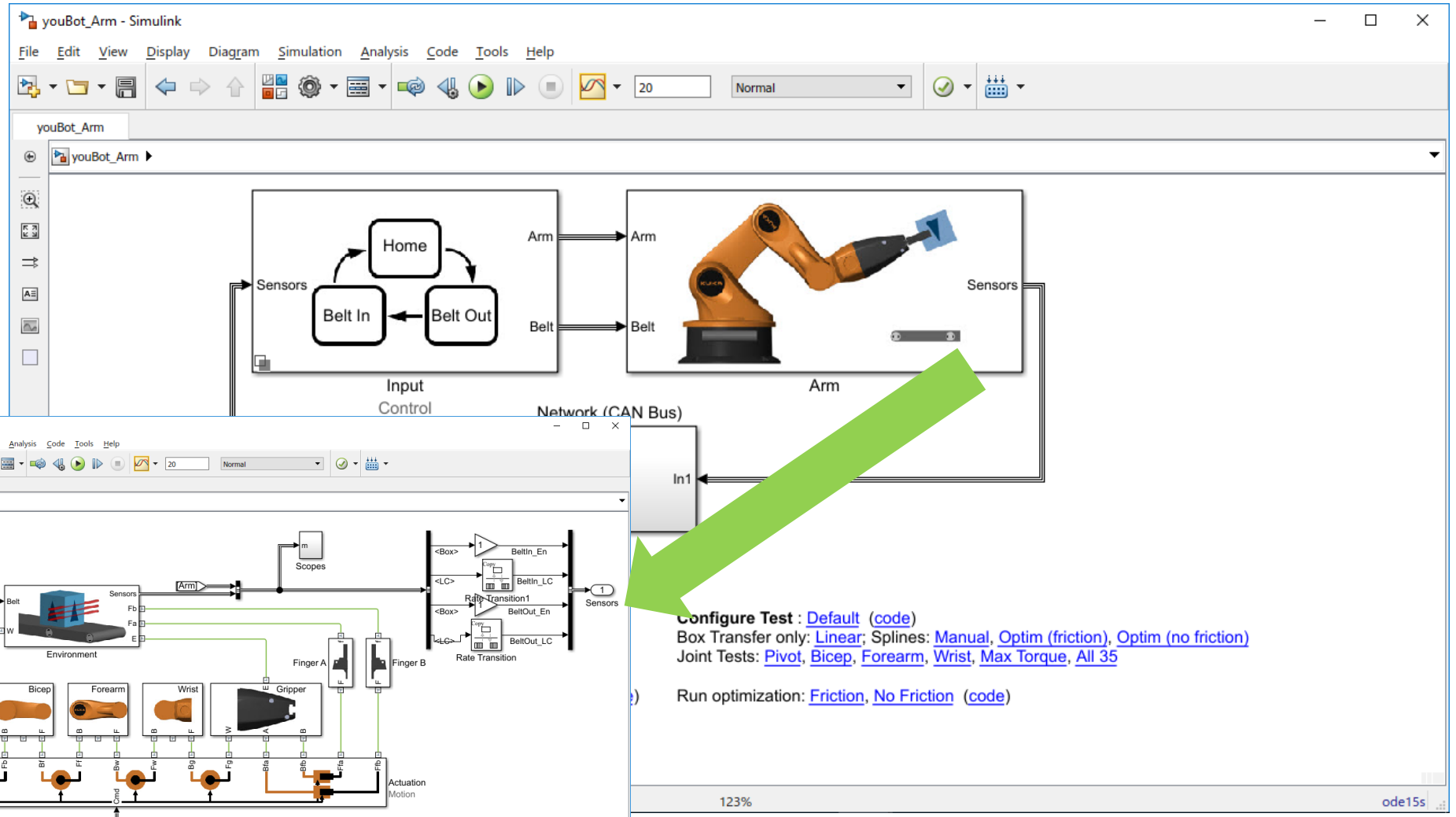
State Charts and System Dynamics



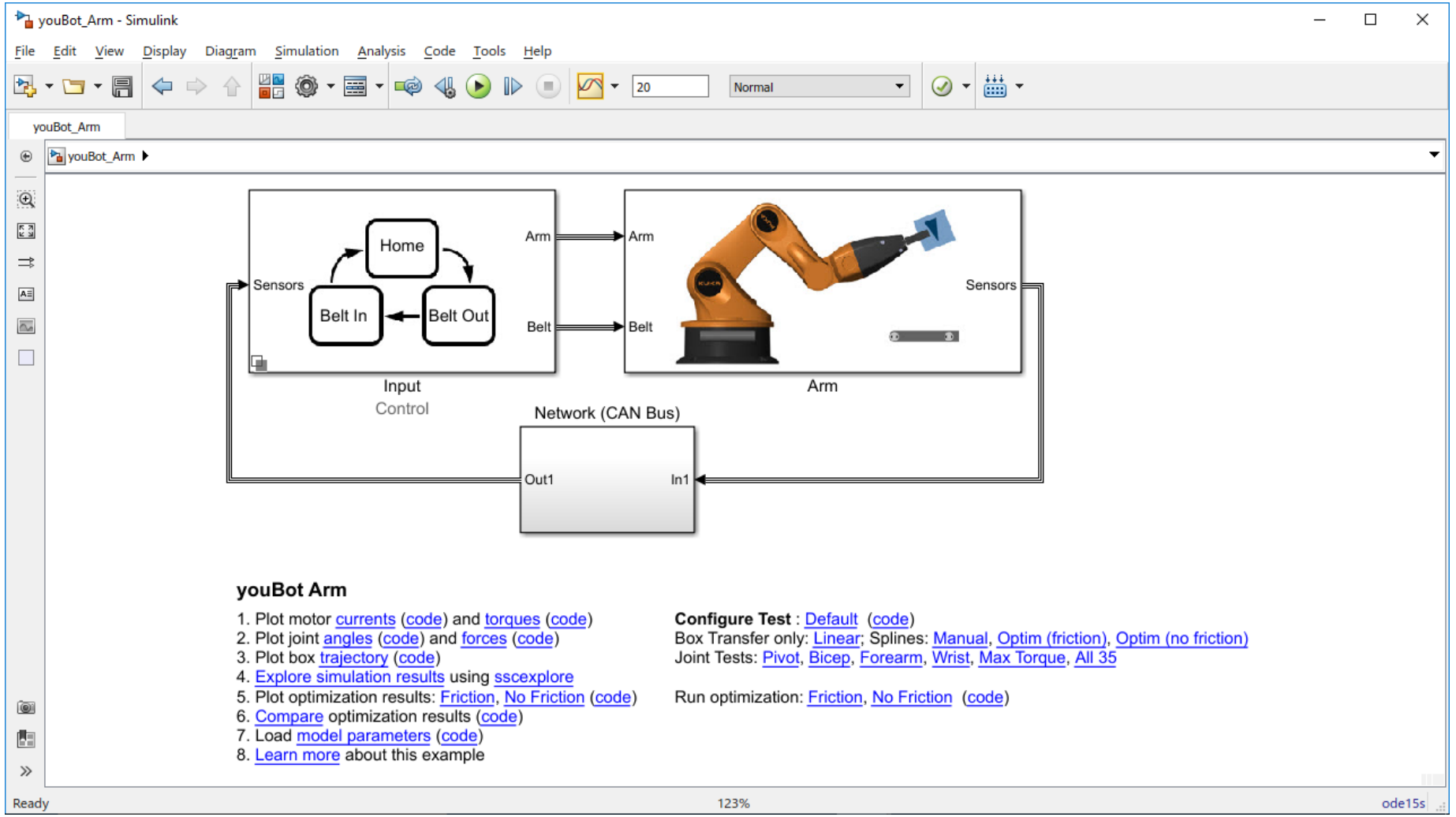
Multi-Domain Model



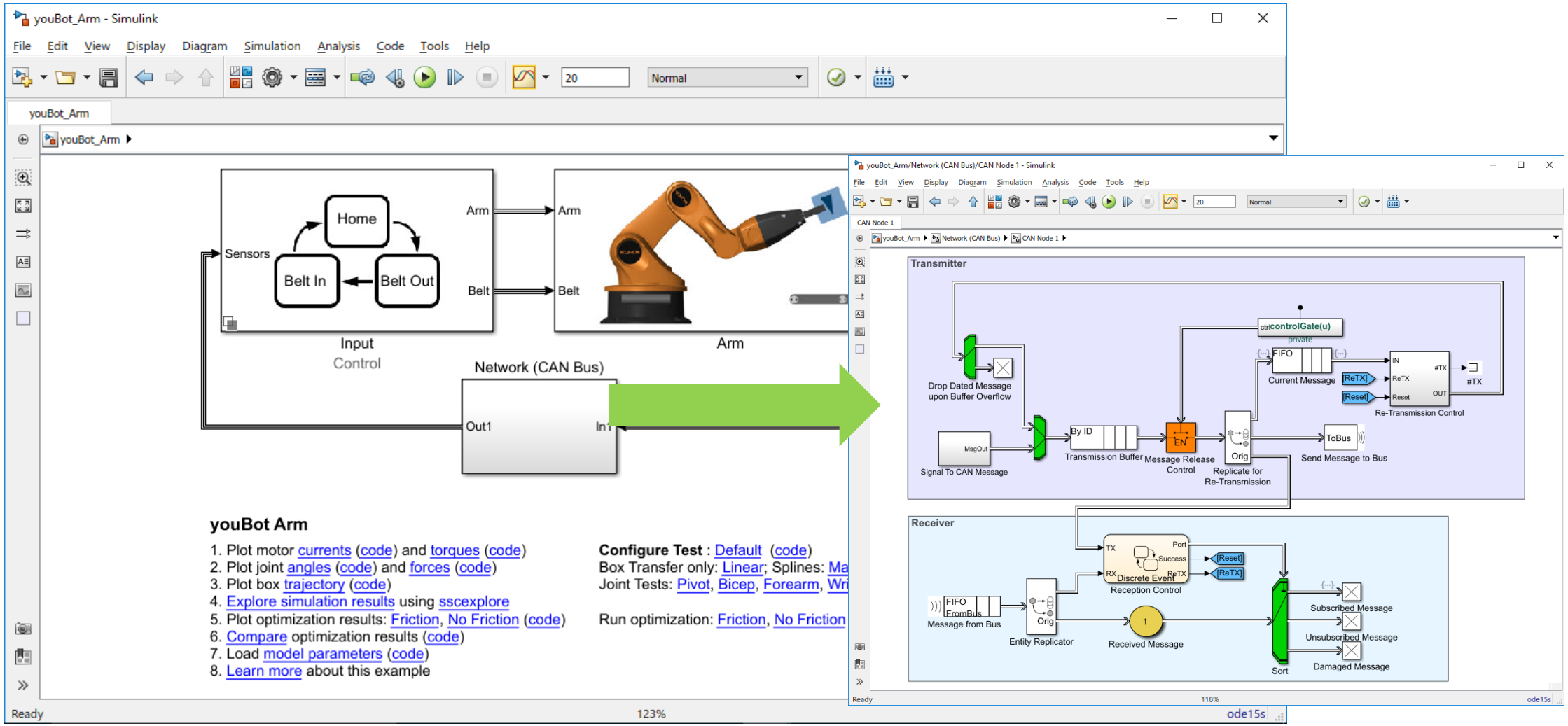
Physical Modeling



Multi-Domain Model

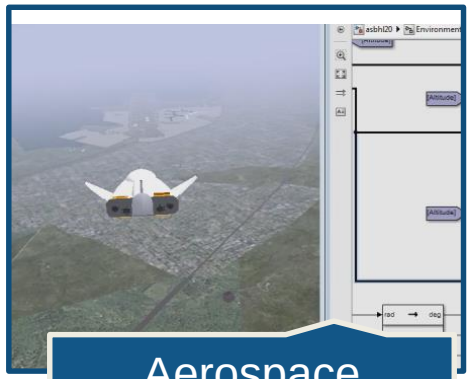


Discrete-Event Modeling



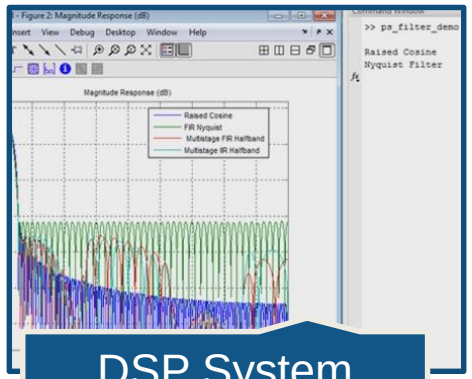
Domain-Specific Blocksets and Toolboxes

Simulink has numerous domain-specific tools, for example:

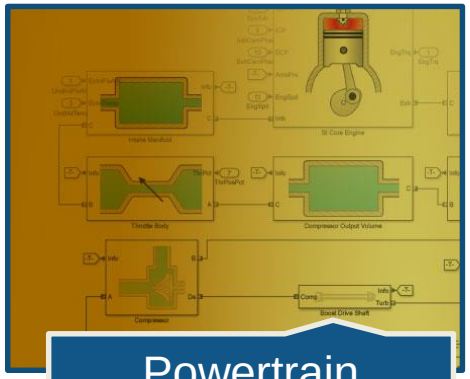


Aerospace Blockset

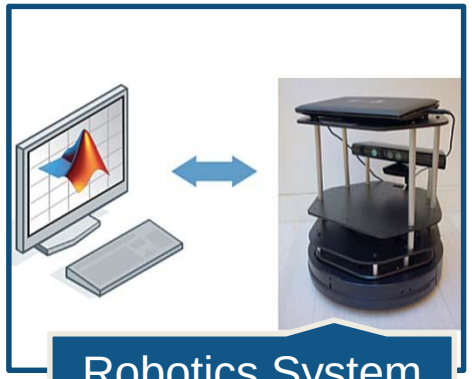
Computer Vision System Toolbox



DSP System Toolbox



Powertrain Blockset



Robotics System Toolbox

Customer Success in Multidomain Modeling

ABB, Deltamarin, and VTT Simulate and Optimize Energy Flows for large ships

Challenge

- Increase the energy efficiency of large vessels

Solution

- Use Simulink to model, simulate, and optimize ship energy flow
- Included mechanical, electrical, thermal, pneumatic, hydraulic and custom (e.g. steam) domains

Results

- Identified design improvements to save on cost and annual fuel usage
- Testing costs reduced by tens of thousands of euros

Customer Success in Multidomain Modeling

"While basic machinery can be modelled in spreadsheets, we could not achieve all our goals in Excel. **Simulink and Simscape enable us to run multidomain simulations** … and to **perform energy optimization** for today's ships and future ships."

Mia Elg, Deltamarin

Solution

- Use Simulink to model, simulate, and optimize ship energy flow
- Included mechanical, electrical, thermal, pneumatic, hydraulic and custom (e.g. steam) domains

Results

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Lockheed Martin Builds Discrete-Event Models to Predict F-35 Fleet Performance

F-35s ready for flight.

Challenge

Predict F-35 fleet performance to minimize life-cycle costs and maximize mission readiness

Solution

Build a discrete-event model of the fleet with Simulink and SimEvents, use MATLAB Distributed Computing Server to accelerate thousands of simulations, and interpolate the results with Neural Network Toolbox

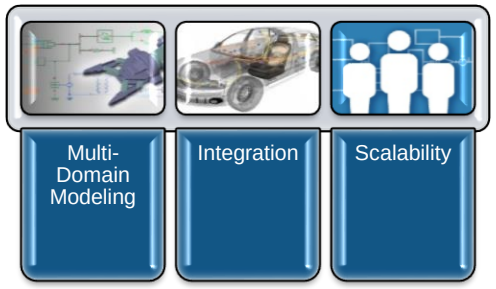
Results

- Simulation setup time reduced from months to hours
- Development effort lessened
- Simulation time cut by months

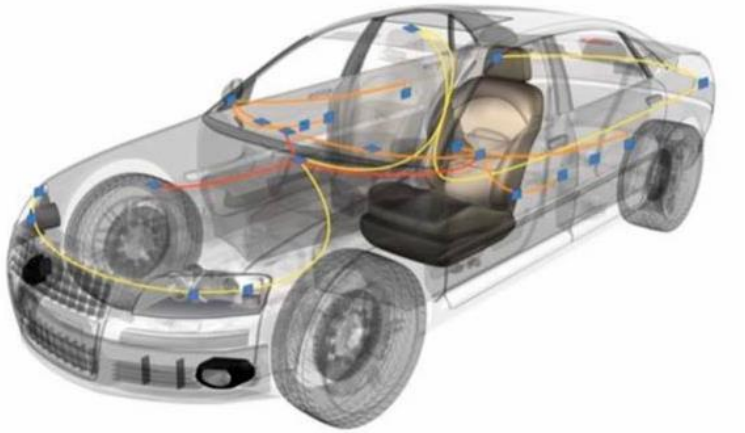
"By building a model with Simulink and SimEvents and running discrete-event simulations on a computer cluster, we rapidly identified many opportunities to maximize F-35 fleet performance while minimizing development and execution efforts."

Justin Beales
Lockheed Martin

Enterprise Simulation Platform Enablers

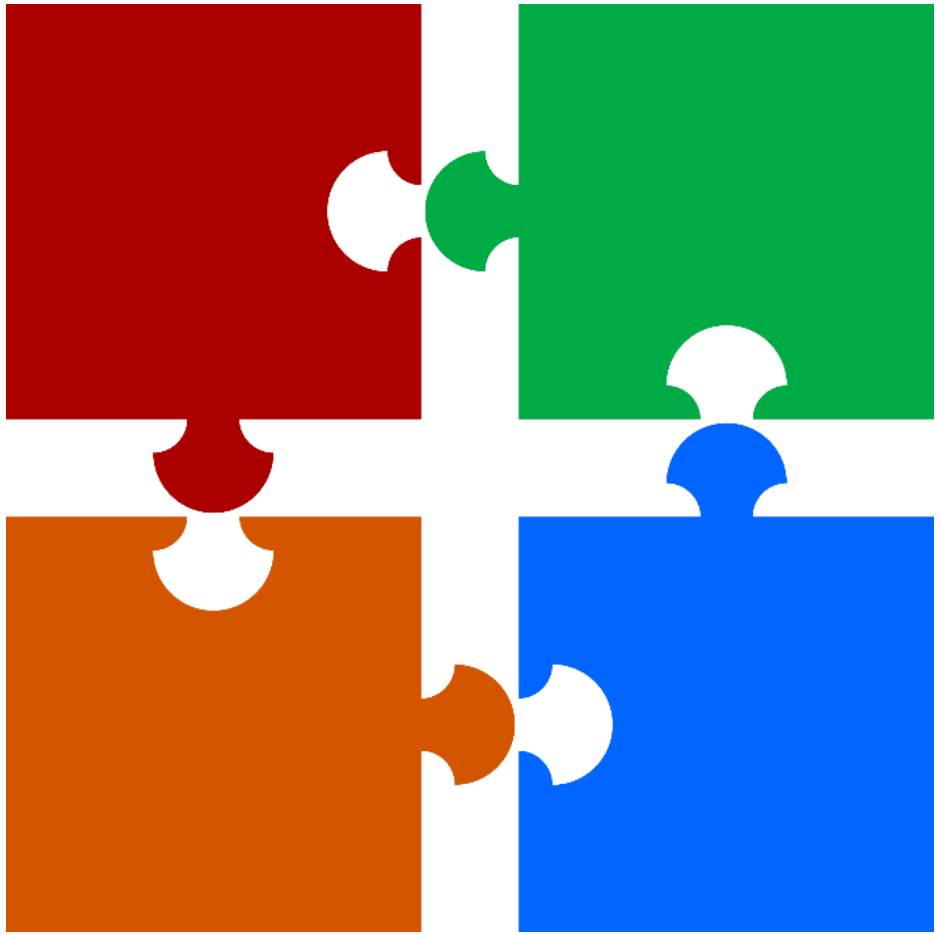


2. Simulation Integration



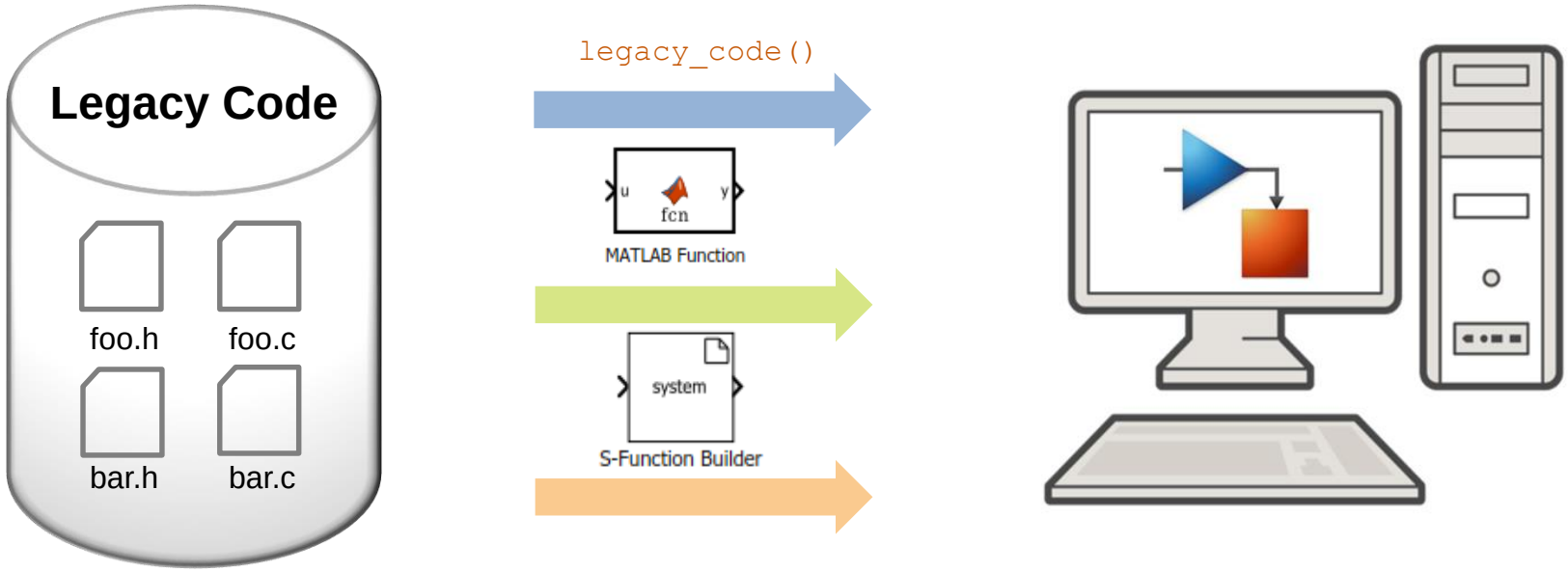
Disconnected Component Intellectual Property (IP)

Your IP exists in many forms and in many locations, making integration difficult

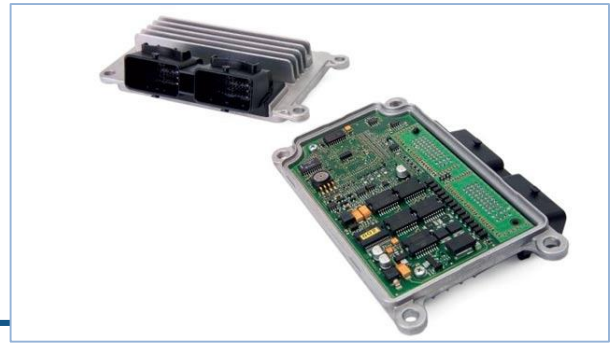


Integrating Your Code

Multiple ways to reuse your legacy code with Simulink



Lotus Engineering Develops Control Systems Software to Reduce Diesel Emissions



Emission control system

Challenge

To develop control systems that enable diesel engines to run cleaner and meet EPA standards for diesel emissions

Solution

Use MathWorks tools for Model-Based Design to model and simulate control systems for emission-reducing components, then generate fixed-point, production-intent code for on-track validation tests

Results

- Proof-of-concept delivered rapidly
- Development time reduced by 30%
- High-quality, production-intent code generated

"Using MathWorks tools to model our control systems has enabled us to manage the complexity of new emissions technologies. I integrated legacy code into the model so I knew I was simulating with the real algorithms"

Roger Tudor
Lotus Engineering

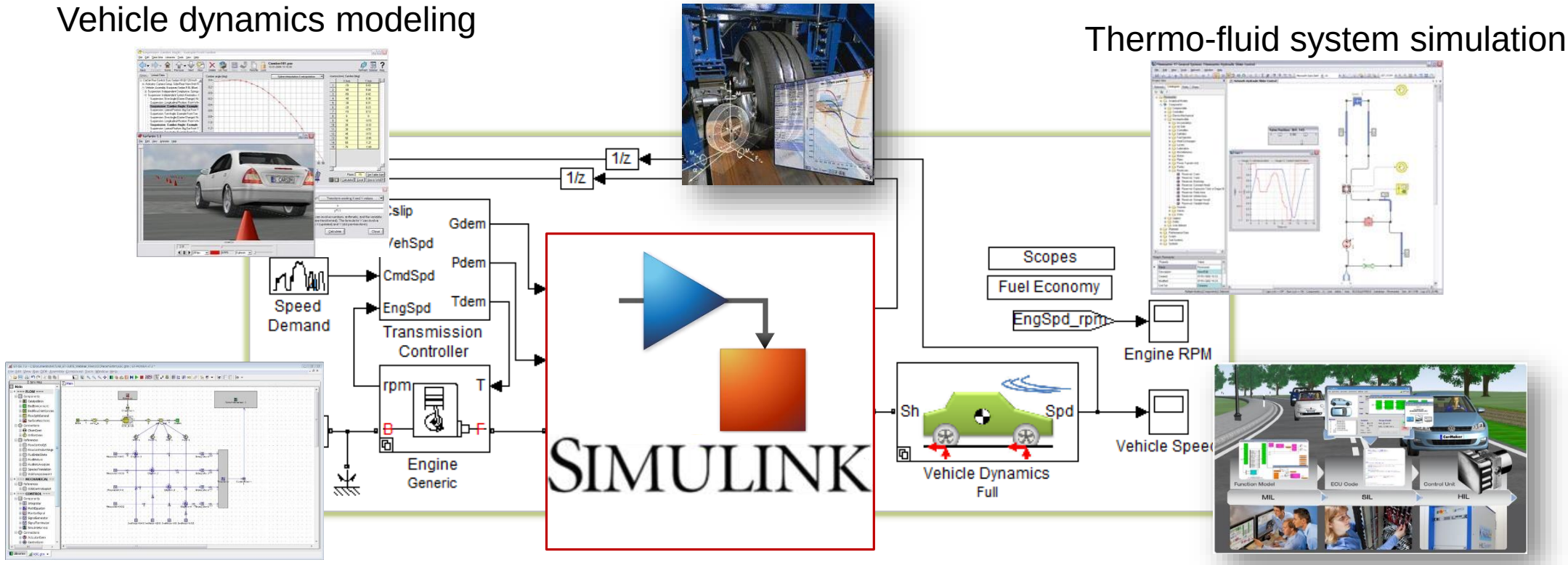
Integrating Third-Party Simulation Tools

- Mature and extensive APIs for third-party tool integration

Tire behavior assessment

Vehicle dynamics modeling

Thermo-fluid system simulation

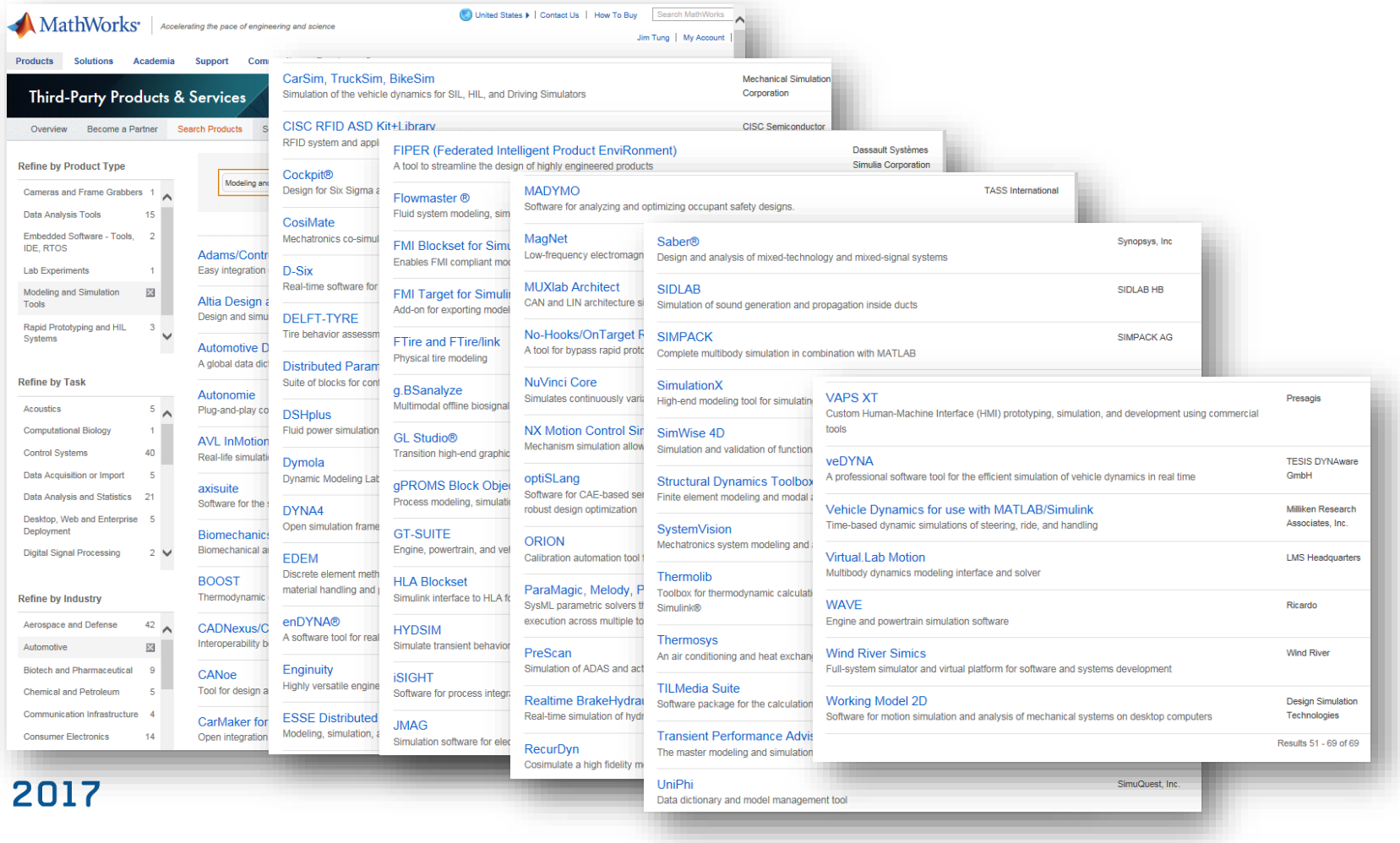


1D / 3D engine /exhaust simulation

Virtual test driving

Partner Ecosystem

Numerous partners provide interfaces to Simulink



Customer Success in Simulation Integration

Autoliv Develop Integrated Vehicle Safety Applications

Challenge

- Design and validate safety-critical control algorithms
- Integrate with several 3rd party domain specific tools

Solution

- Leverage Simulink as a platform by integrating third-party software

Results

- Industry first integration of stability control inertial sensor into airbag control unit
- Restraint control module software development time reduced by 30%

Customer Success in Simulation Integration

"**Seamless integration with third party software solutions enables rigorous development in a safe environment… it is very useful that you can export these complex third-party tool functionalities in the form of S-functions and run co-simulation.**"

Siddharth D'Silva, Autoliv

Solution

- Leverage Simulink as a platform by integrating third-party software

Results

- Industry first integration of stability control inertial sensor into airbag control unit
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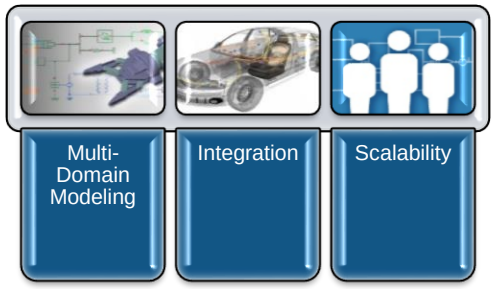
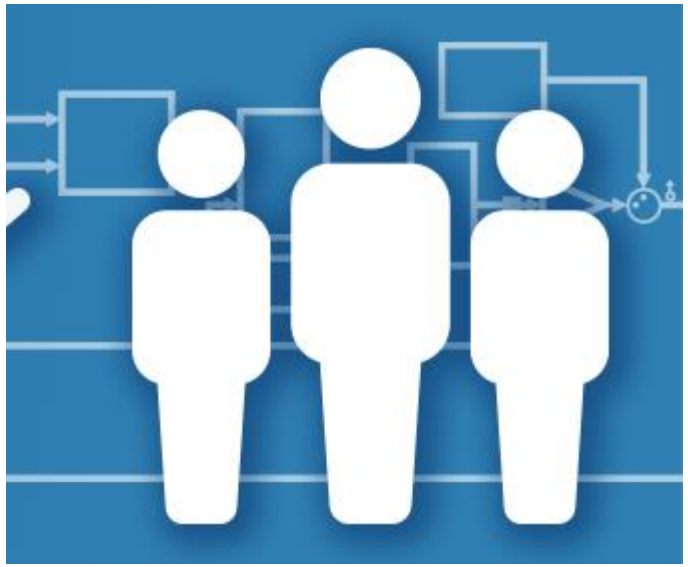
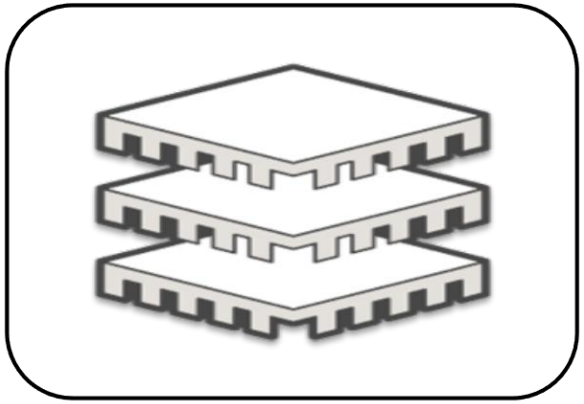
Enterprise Simulation Platform Enablers



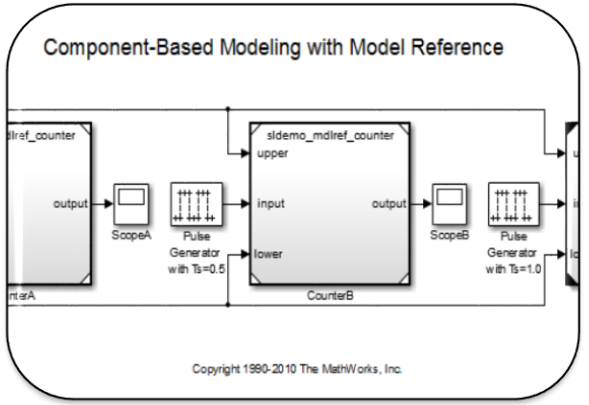
3. Scalability



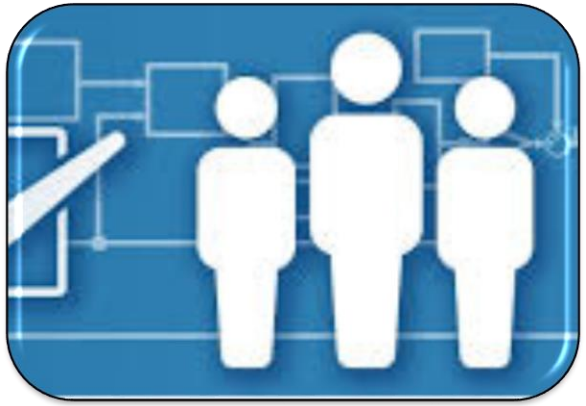
Scalability Challenges



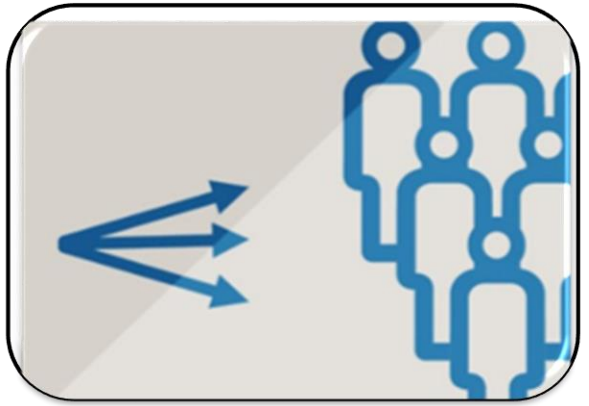
Performance



Componentization



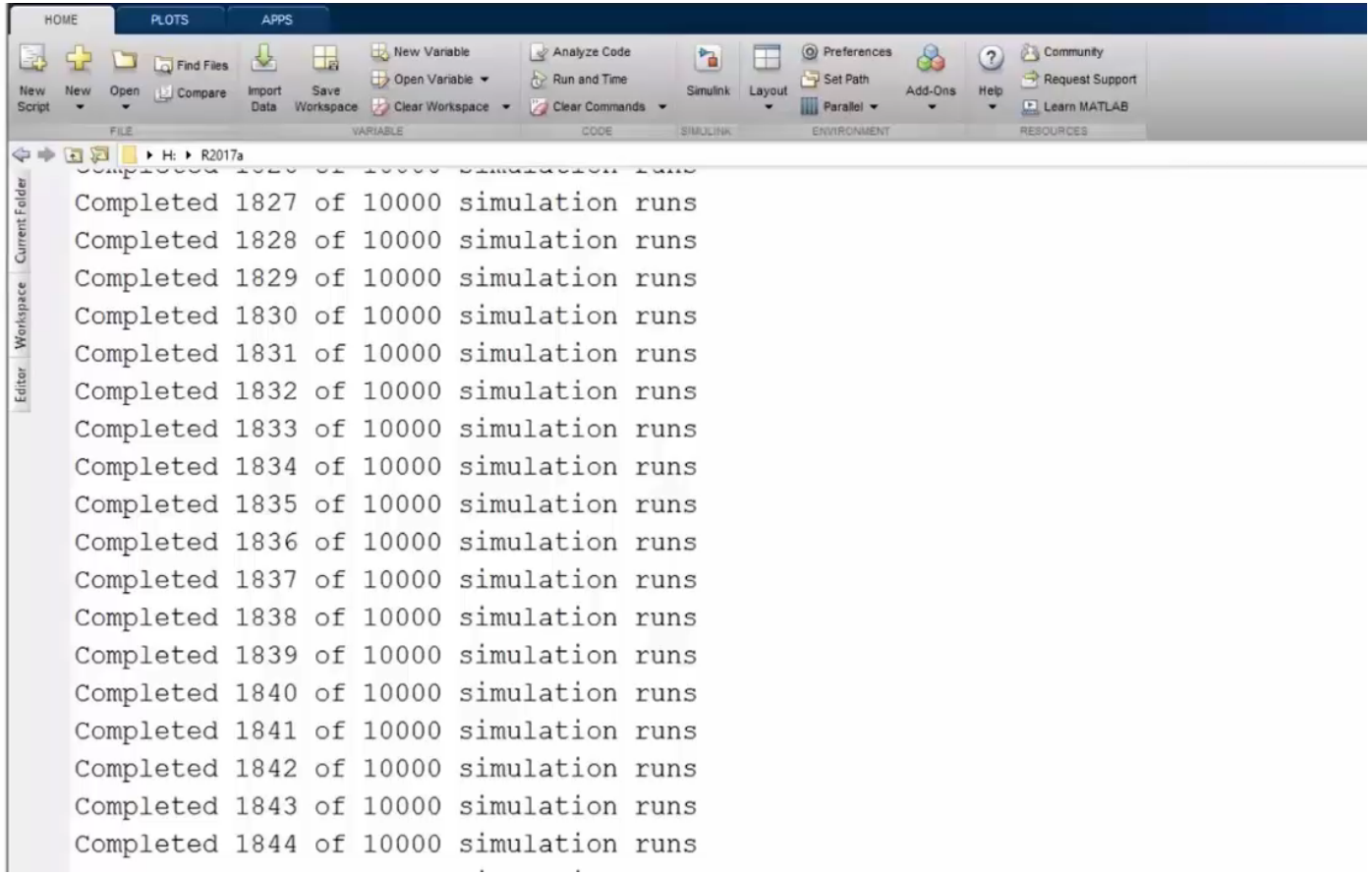
Team Workflows



Sharing

Performance Scalability

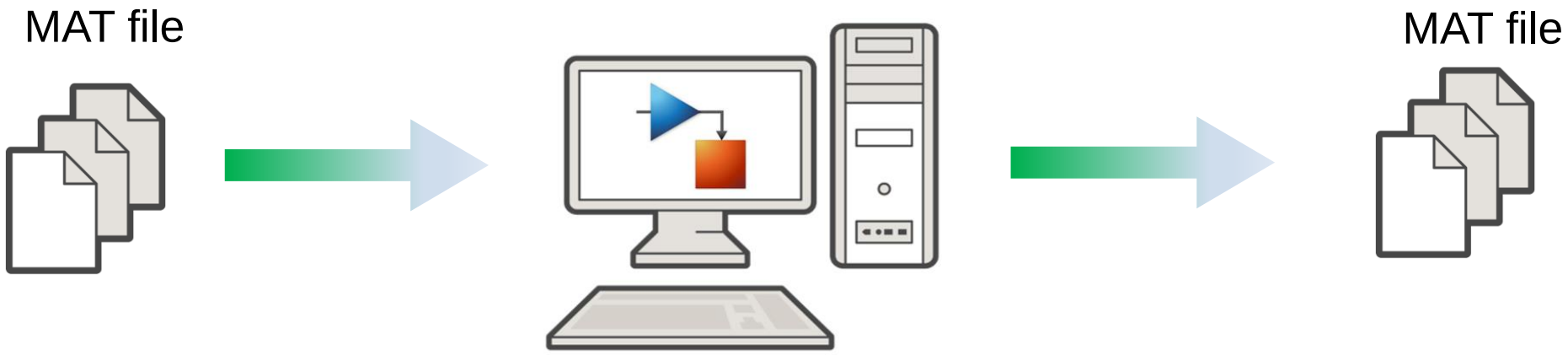
Easy scalability to multicore or cluster/cloud computation environment



Performance Scalability

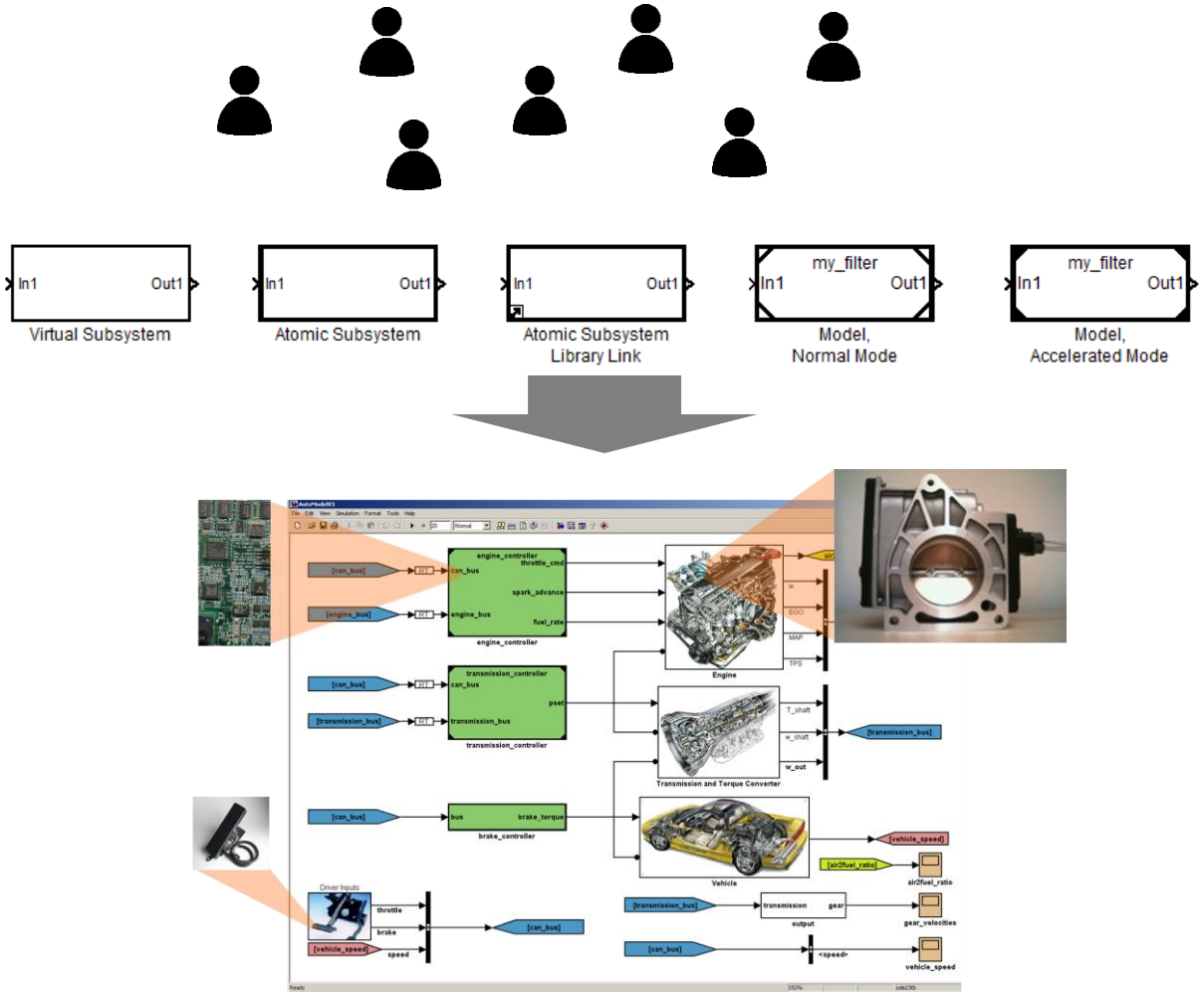
Big data workflow

- Processing large amount of simulation inputs / outputs



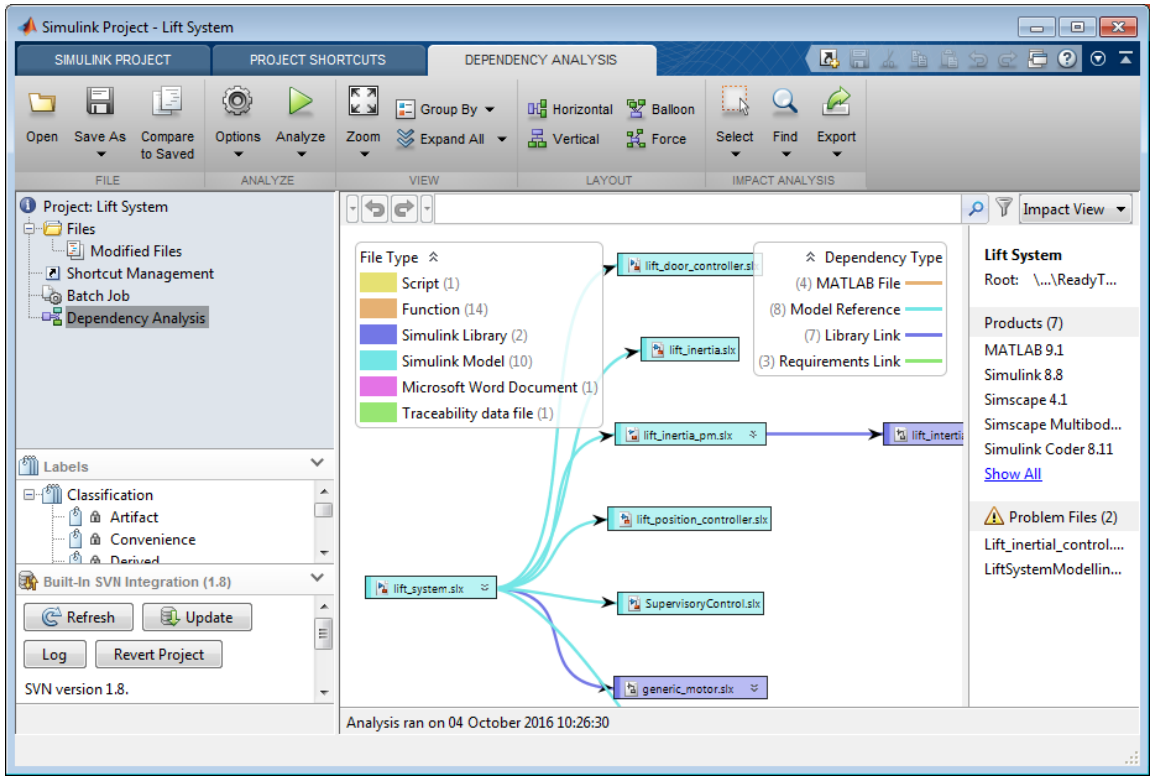
Complex Design Development through Componentization

- Supporting team workflows
  - Faster modular development
  - More effective verification
  - Increased reusability
- Improving performance
  - Incremental loading and code generation
  - Simulation speed
  - Memory usage

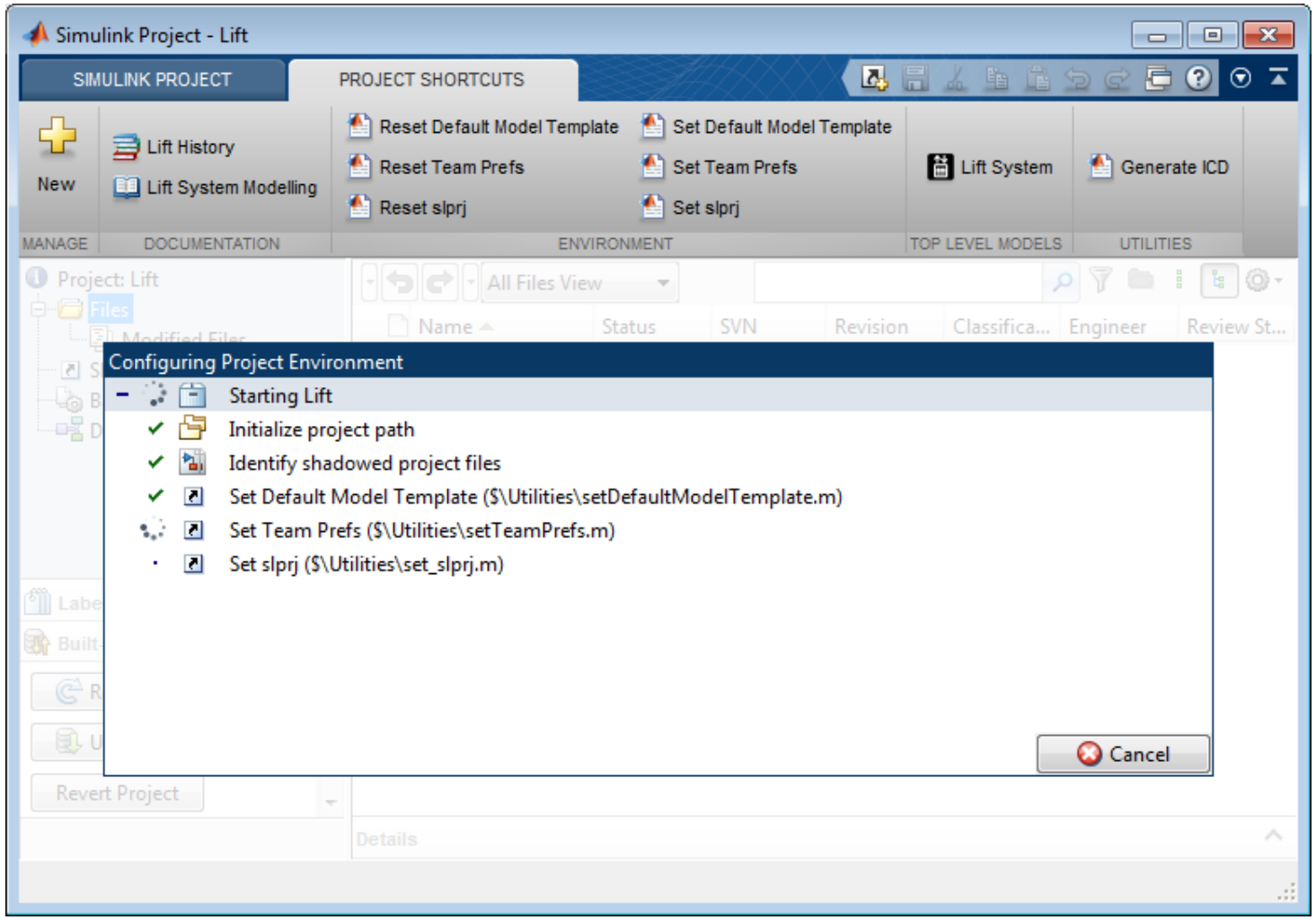


Capabilities Enabling Team Workflows

- Simulink Projects
- Source control
- Design comparison and merging
- Dependency analysis



Manage team development with Simulink Projects



"It works on my computer, but not on someone else's …"

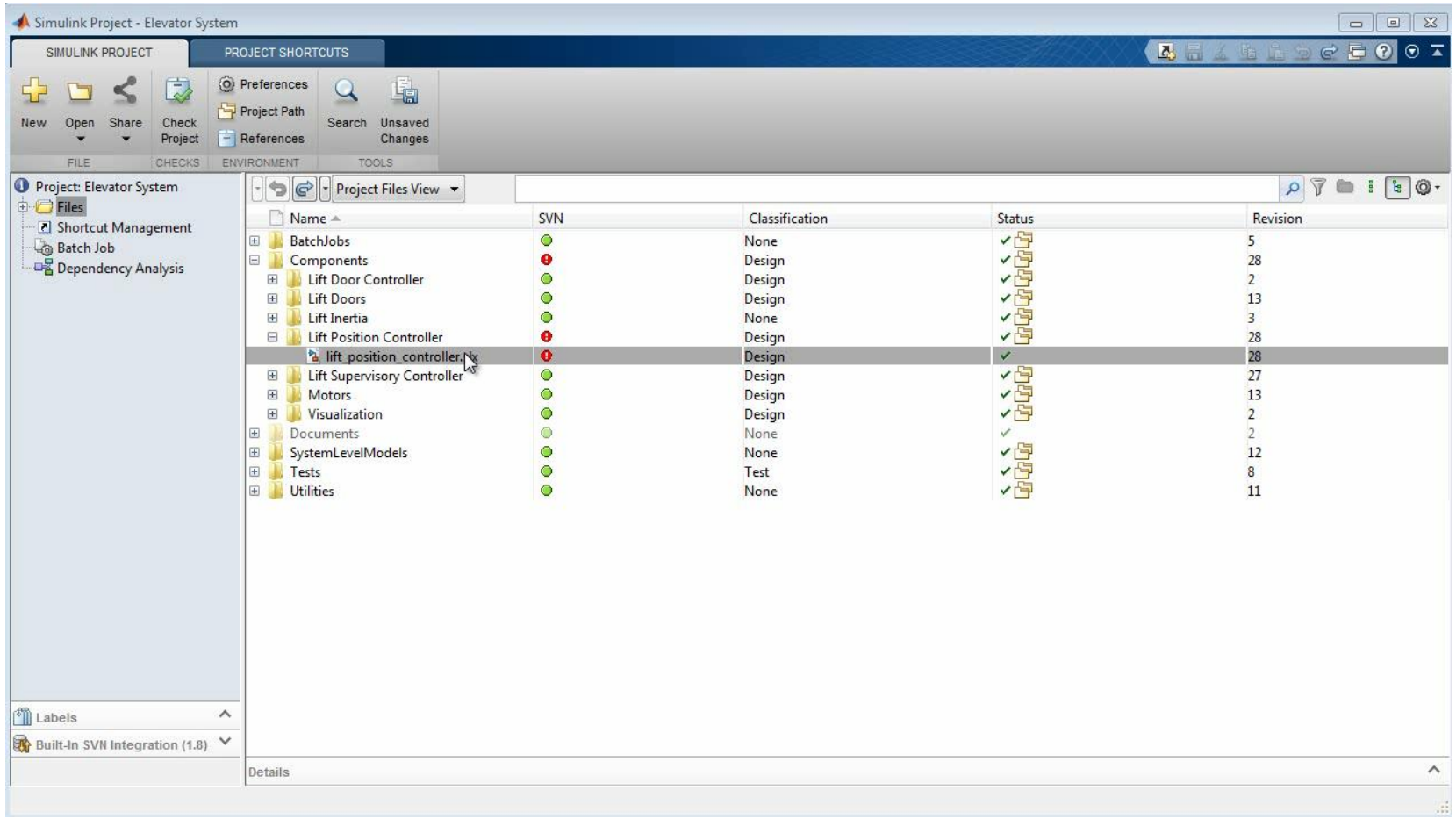
Simulink projects help with

- File management
- Paths
- Startup/Shutdown scripts
- Source control interaction
- Simulink customisation

Source Control Integrations

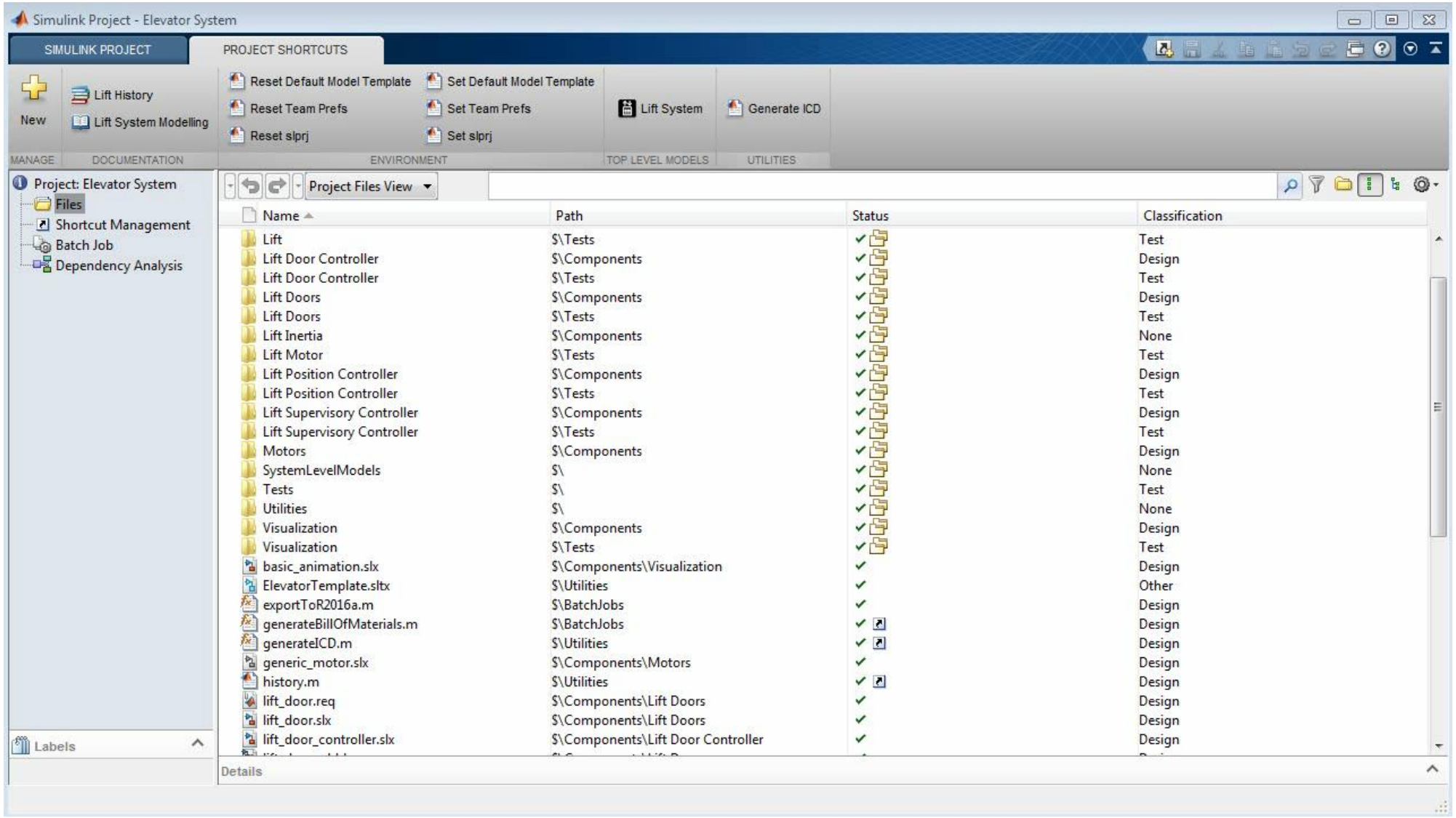
Microsoft Team Foundation Server (TFS) integration available now from MathWorks File Exchange

Manage Concurrent Design Conflicts – 3 Way Merge

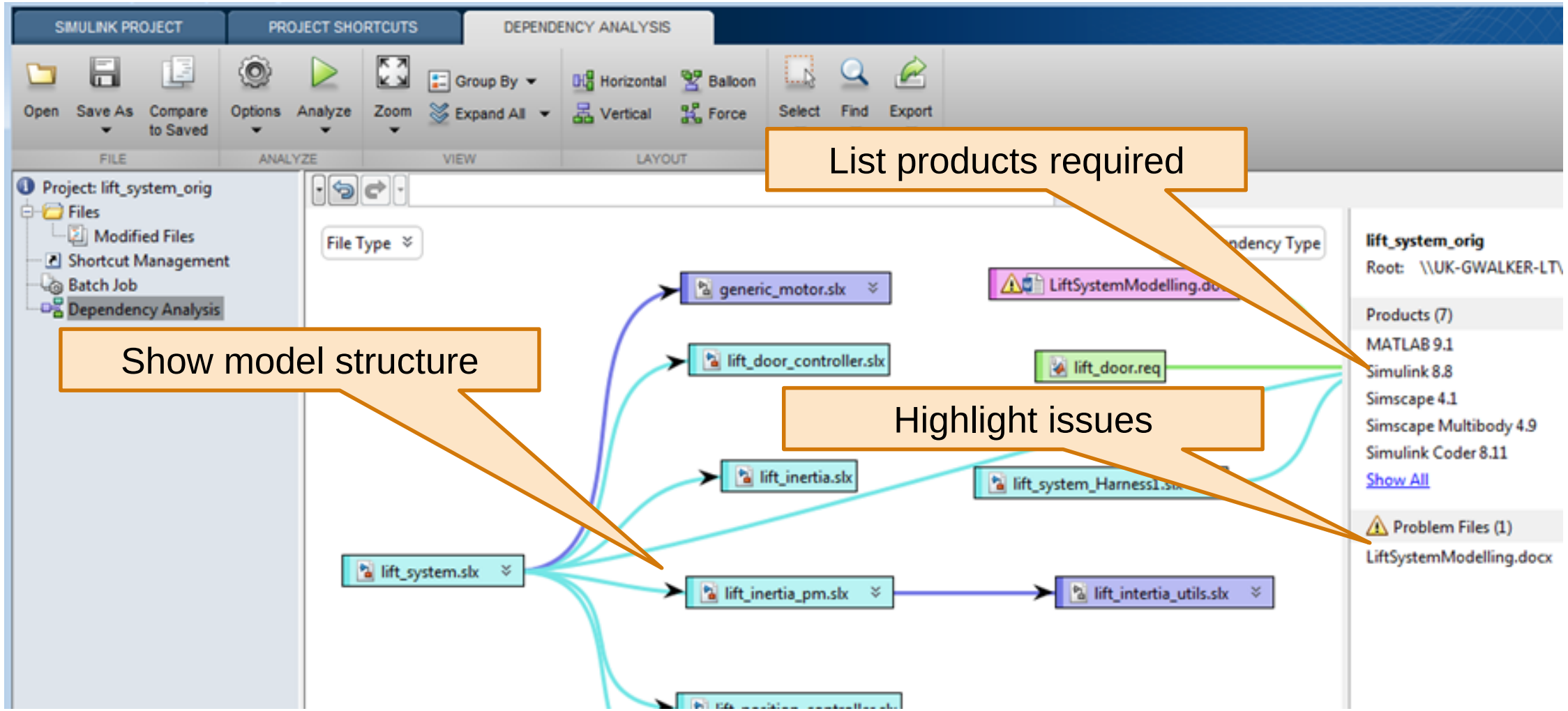


- Supports concurrent engineering
- Identify conflicts in design
- Automatically merge changes

Dependency Analysis – Modular Development

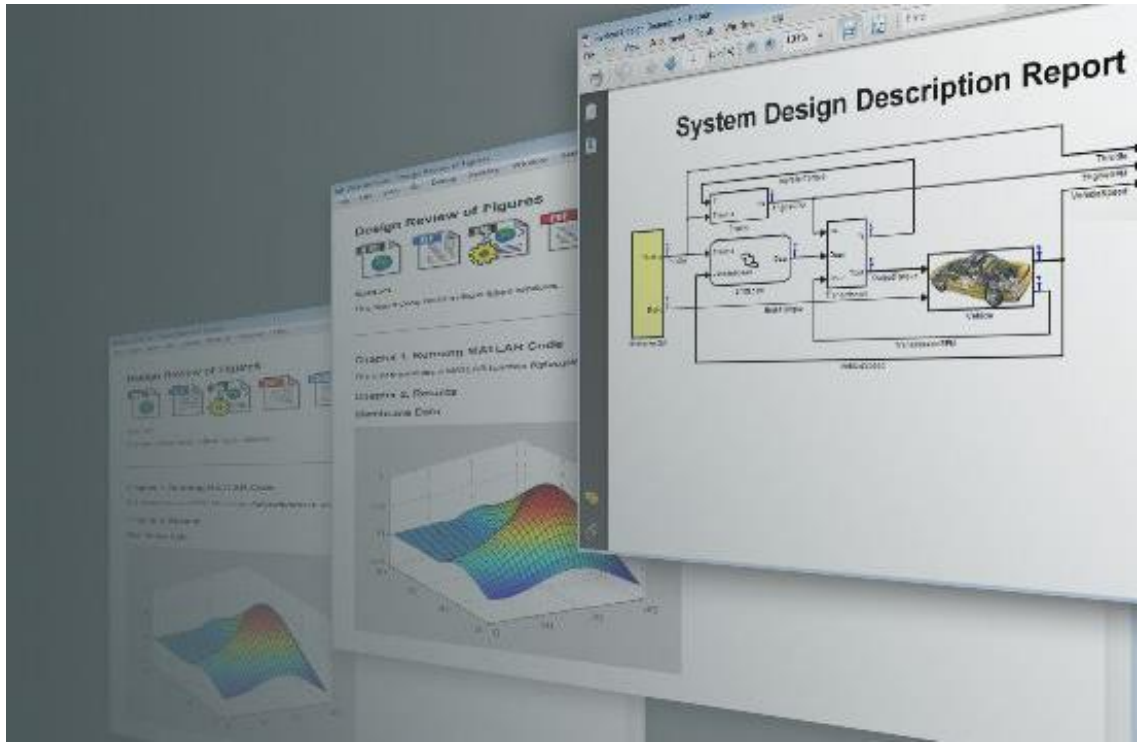


Dependency Analysis – Modular Development



Sharing Outside Your Team

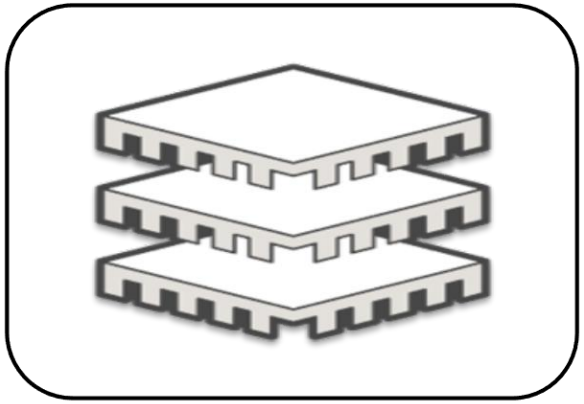
- Quick File Packaging
- Model Protection (IP Management)
- Reporting and Documentation



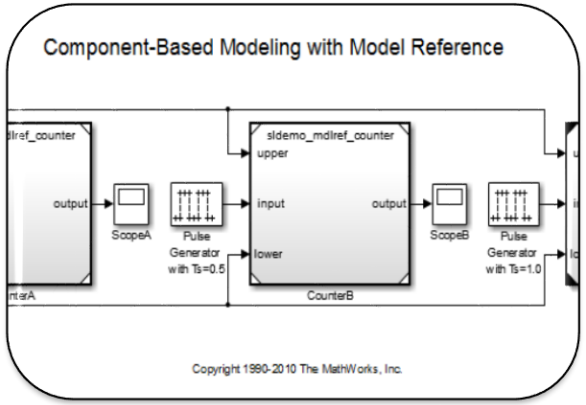
Simulink Addresses Scalability Challenges

Parallel Simulations

Big Data



Performance



Componentization

Modular design

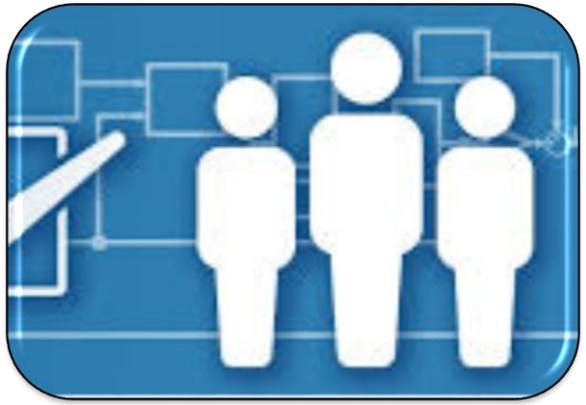
Performance Improvements

Simulink Projects

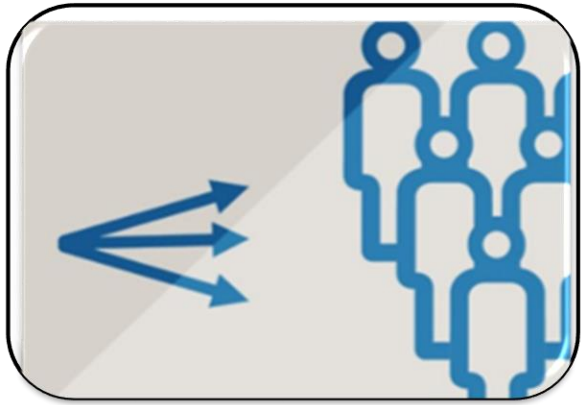
Source Control

3 Way Merge

Dependency Analysis



Team Workflows



Sharing

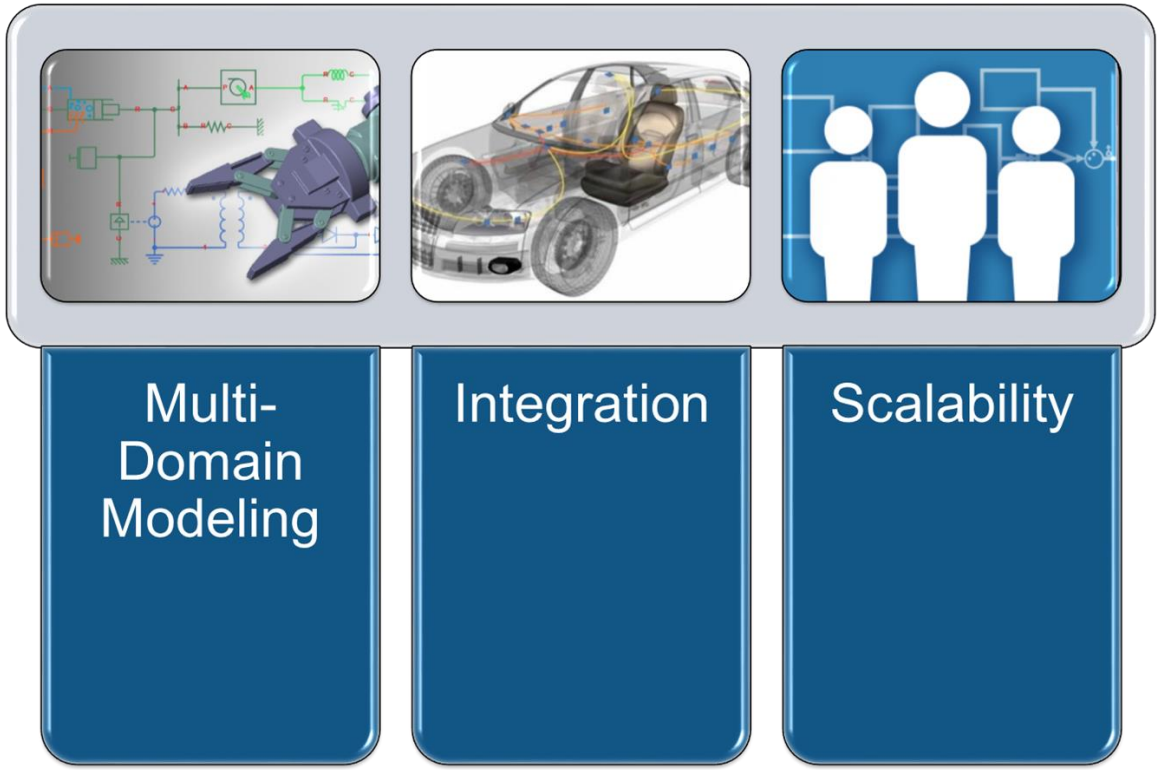
Simulink Projects

IP Protection

Reports

Web Views

Simulink can be used as your Enterprise Simulation Platform



Simulink as Enterprise Simulation Platform

"It would be horrendously complex to build a scale model of our full system for all the different variants we considered in the design phase.

*"**With Simulink** … **we built virtual prototypes that enable us to predict system performance** under various sea conditions, simulate failure cases, and analyze loads **so we can select the best design and accurately specify component requirements** to our suppliers."*

Jonathan Fiévez, CTO
Carnegie Wave Energy