Simulink as Your Enterprise Simulation Platform

Daryl Ning
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
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
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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

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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

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Multi-Domain Model
Physical Modeling
Multi-Domain Model

youBot Arm
1. Plot motor currents (code) and torques (code)
2. Plot joint angles (code) and forces (code)
3. Plot box trajectory (code)
4. Explore simulation results with `ss2tf` and `tf2ss`
5. Plot optimization results: Friction, No Friction (code)
6. Compare optimization results (code)
7. Load model parameters (code)
8. Learn more about this example

Configure Test: Default (code)
Box Transfer only: Linear, Sines: Manual, Optim (friction), Optim (no friction)
Joint Tests: Pivot, Bicep, Forearm, Wrist, Max Torque, All 36
Run optimization: Friction, No Friction (code)
Discrete-Event Modeling
Simulink has numerous domain-specific tools, for example:
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

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

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

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%

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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

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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

Simulink projects help with

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

“It works on my computer, but not on someone else’s …”
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

Show model structure

List products required

Highlight issues

Team Workflows
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

Multi-Domain Modeling
Integration
Scalability
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