Modeling and Simulation Made Easy with Simulink

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Questions covered in this presentation

1. Why do we do modeling and simulation?
2. Why use Simulink and Stateflow for modeling and simulation?
3. What is the process in transitioning from a code-based simulation framework to Simulink and Model-Based Design?
Why do we do modeling and simulation?

- To get a better understanding of the system’s:
  - Structure and interface connections
  - Robustness to environmental conditions
  - Response to user input

- And why is that important?
  - Find and fix bugs early
  - Test system under conditions difficult to replicate in the real world

- And why is that important?
  - Because early testing and fixing bugs early saves a lot of money down the road
Let’s check out Simulink
Fixing bugs late is very expensive

Errors introduced early but found late in the process are expensive to fix!

Relative cost to fix an error

- Errors introduced in:
  - coding phase
  - design phase
  - requirements phase

Project phase where error is fixed

Save money w/ early modeling and simulation

Model-Based Design Development Costs

$127,605

Traditional Development Costs

$380,805

Total Savings

$253,200

Percent Savings

66%
Breakdown of $253K saved

Thousands

$200

$150

$100

$50

$0

Requirements
Design
Coding
Testing
Example: NASA HL-20 Lifting Body
FDIR system

- HL-20 has an actuator system to control the left and right elevators
- Each system has a backup in case a failure occurs
- We’re going to test to see how well that backup system works.
OK Simulink can handle components. But what about VERY LARGE systems?

How large can a Simulink model be?
We have seen model structures that contain over 1 million blocks.

How does Simulink handle that large a scale?
With a number of capabilities design for large-scale modeling, including:

- Variants
- Libraries
- Bus signals
- Model blocks
Why is large-scale model performance faster with model referencing?

Faster simulations with Accelerator mode
Simulink automatically generates a MEX-file (MATLAB executable) that runs faster than the normal Simulink interpreted mode.

Faster system builds
Suppose your system contains 1000 Model blocks. You make a change to 1 Model block. Only that Model block gets rebuilt.

Faster system builds with parallel computing
Use parallel computing to speed up the time it takes to build the model reference hierarchy. Use either a multi-core computer or computer cluster.
Use the Performance Advisor to access these and other techniques to get more speed

Speed up your simulation and update diagram performance

- Performance Advisor analyzes your model for common performance bottlenecks
- Option to automatically apply the advice you receive
- Tool verifies whether its advice does indeed speed up your model
What about all the code I have now?

You can mix these different component types together within one system-level model in Simulink.

With the option of using more Simulink models later on.
How do I connect Simulink with my existing code-based simulation framework?
How do I connect Simulink with my existing code-based simulation framework?

- Generate code from Simulink. Integrate into CBSF. Simulate from CBSF.
- Cosimulate code from CBSF with Simulink model.
- Integrate code from CBSF into Simulink. Simulate from Simulink.
Simulink has been around for 20+ years

Aerospace & Defense customers include

- BAE Systems
- Boeing
- Cessna
- EADS
- Gulfstream
- Honeywell
- Lockheed Martin
- Los Alamos National Laboratory
- NASA
- Sandia National Laboratories
- United States Air Force

An Eagle 150 unmanned aerial vehicle flight.
(Image courtesy of Composites Technology Research Malaysia.)
BAE Systems Surface Ships Develops On-Board Trainer Plant Simulation for Royal Navy Using MathWorks Tools

Challenge
Develop an on-board training system for the Royal Navy’s Type 45 destroyer

Solution
Use MathWorks tools to model and simulate the ship’s physical systems and generate production C code for the training system

Results
- Efficient production code generated
- Development effort cut in half
- Early feedback on system specification provided to Type 45 project

“The simulation engineers produced a high-level, tested description of the C code—the Simulink model—which the software engineers used to generate the code for the application. Without MathWorks tools I don’t think we could have completed the trainer with as few resources as we did.”

Peter Worthington
BAE Systems Surface Ships

Link to user story

The Royal Navy’s HMS Daring on sea trials.
Gulfstream Aerospace Develops Pilot-in-the-Loop Aircraft Simulator with MathWorks Tools

**Challenge**
Develop a pilot-in-the-loop aircraft simulation facility for real-time evaluation of control law designs and flight displays

**Solution**
Use Simulink, Aerospace Blockset, and Simulink Coder to model and simulate the digital flight-control system and aircraft dynamics in real time

**Results**
- Successful first flight
- Accelerated development
- Realistic flight-test preparation environment

“On a tight schedule, we developed a pilot-in-the-loop simulation lab in which we can easily evaluate various control systems and rapidly adjust the feedforward path of the control laws if needed. Without MathWorks tools we would not have met our deadline.”

Nomaan Saeed
Gulfstream Aerospace

Cockpit of Gulfstream’s aircraft simulator.

Link to user story
Lockheed Martin Space Systems Uses SimMechanics with a Real-Time Simulator to Automate Mars Reconnaissance Orbiter Development

Challenge
Develop the guidance, navigation, and control system for the Mars Reconnaissance Orbiter

Solution
Use MathWorks tools to accelerate control design and automate the development of accurate, real-time spacecraft simulations

Results
- Spacecraft pointing simulation modeled in days
- Interorganization communication improved
- Efficient code generated automatically

“Simulink, SimMechanics, and Simulink Coder enabled us to autonomously go from an accurate CAD model of the MRO vehicle into C code that runs in real time.”

Jim Chapel
Lockheed Martin Space Systems

Artist’s rendition of Mars Reconnaissance Orbiter. (Image courtesy of NASA.)
Key takeaways

- Simulink provides a multi-domain modeling and simulation platform that is designed for engineers and scientists
  - Model and simulate controls, signal processing, mechanical, electrical, and logical systems in a domain that is natural for engineers and scientists to understand.

- With Simulink, testing is done earlier so that bugs can be found and eliminated as early as possible
  - Simulink includes a simulation engine for early testing and debugging

- Simulink can be used in combination with your existing simulation environment
  - Generate code from the Simulink model into your simulation environment or bring the code into Simulink
Where can I find out more?

- Overview webinars of main products:
  - Introduction to Simulink
  - Control Logic Design Made Easy with Stateflow
  - Best Practices for Verification and Validation

- Details on connecting Simulink with simulation frameworks:
  - MathWorks AIAA Paper “Integrating Simulink with Other Simulation Environments”
  - Webinar “Connecting Simulink with Other Simulation Frameworks”

- Contact your account rep for additional resources