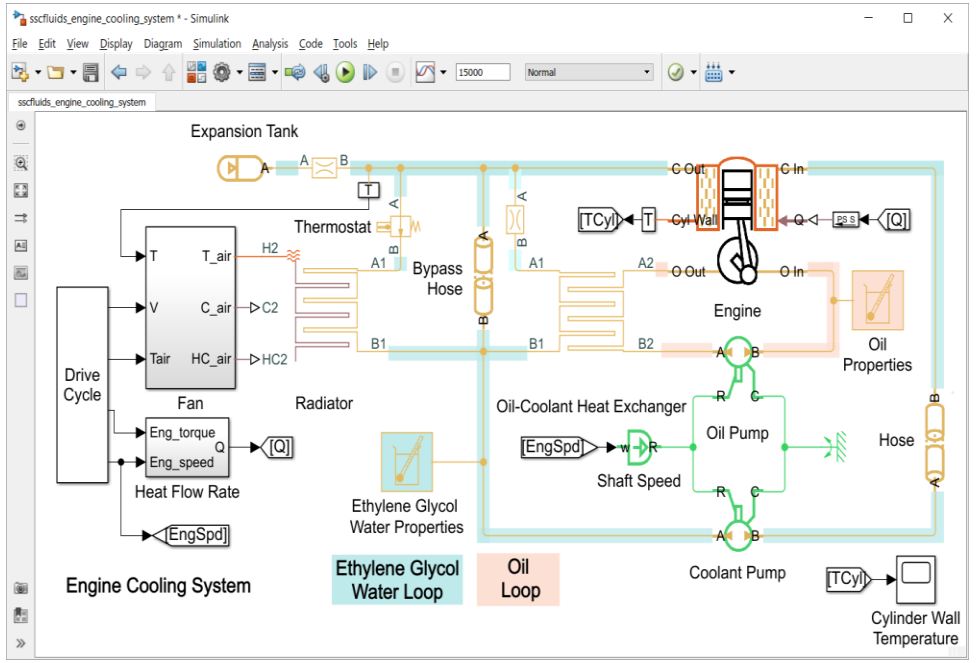
Heating and Cooling Systems Design with MATLAB & Simscape



Aldo Caraceto

Application Engineering Group - MathWorks

Johnson Controls Accelerates Industrial Controller Development for Magnetic-Bearing Centrifugal Liquid Chillers

Challenge

Develop an advanced controller to maximize the efficiency of magnetic centrifugal chillers

Solution

Use Simulink and Stateflow to model, simulate, optimize, and verify the control design, and use Embedded Coder to generate C code for PIL testing and production deployment

Results

- Design iterations reduced from months to days
- High-quality software delivered
- Development accelerated

The YORK Magnetic Centrifugal Chiller (YMC2) system from Johnson Controls

"Using our previous approach, we'd still be working on the controller. With Model-Based Design we not only shipped it sooner; we also delivered a much more stable product. The controller is so finely tuned that 99% of our customers run the default configuration with no adjustments."

- Curtis Crane, Johnson Controls

Link to user story

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- Simulink
- Stateflow
- Embedded Coder
- …

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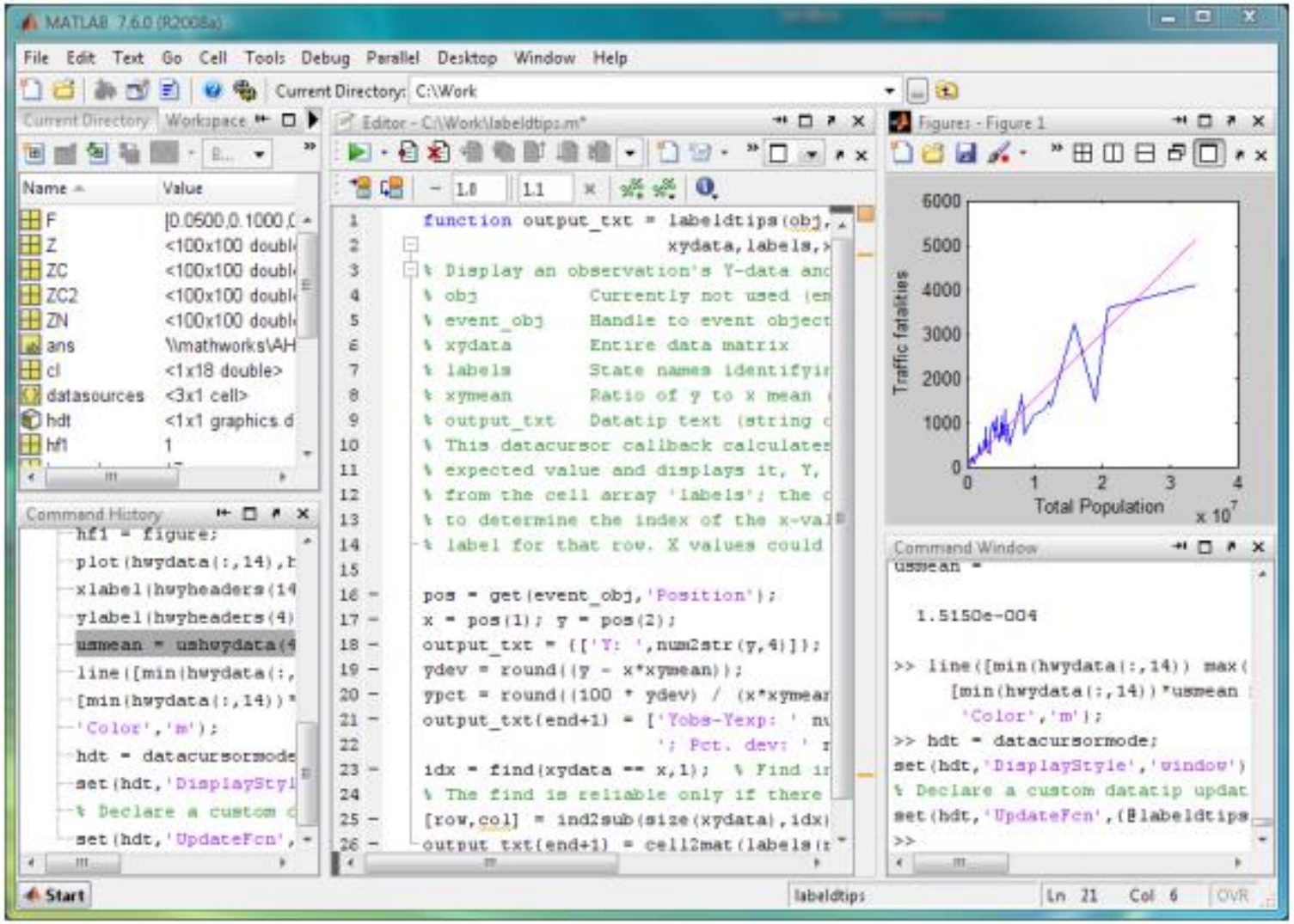
The team modeled the controller in Simulink, using Stateflow® to create a hierarchy of state machines for the major components. Linear control elements, including proportional integral derivative (PID) controls, were implemented in MATLAB and integrated into the Simulink model using MATLAB Function blocks.

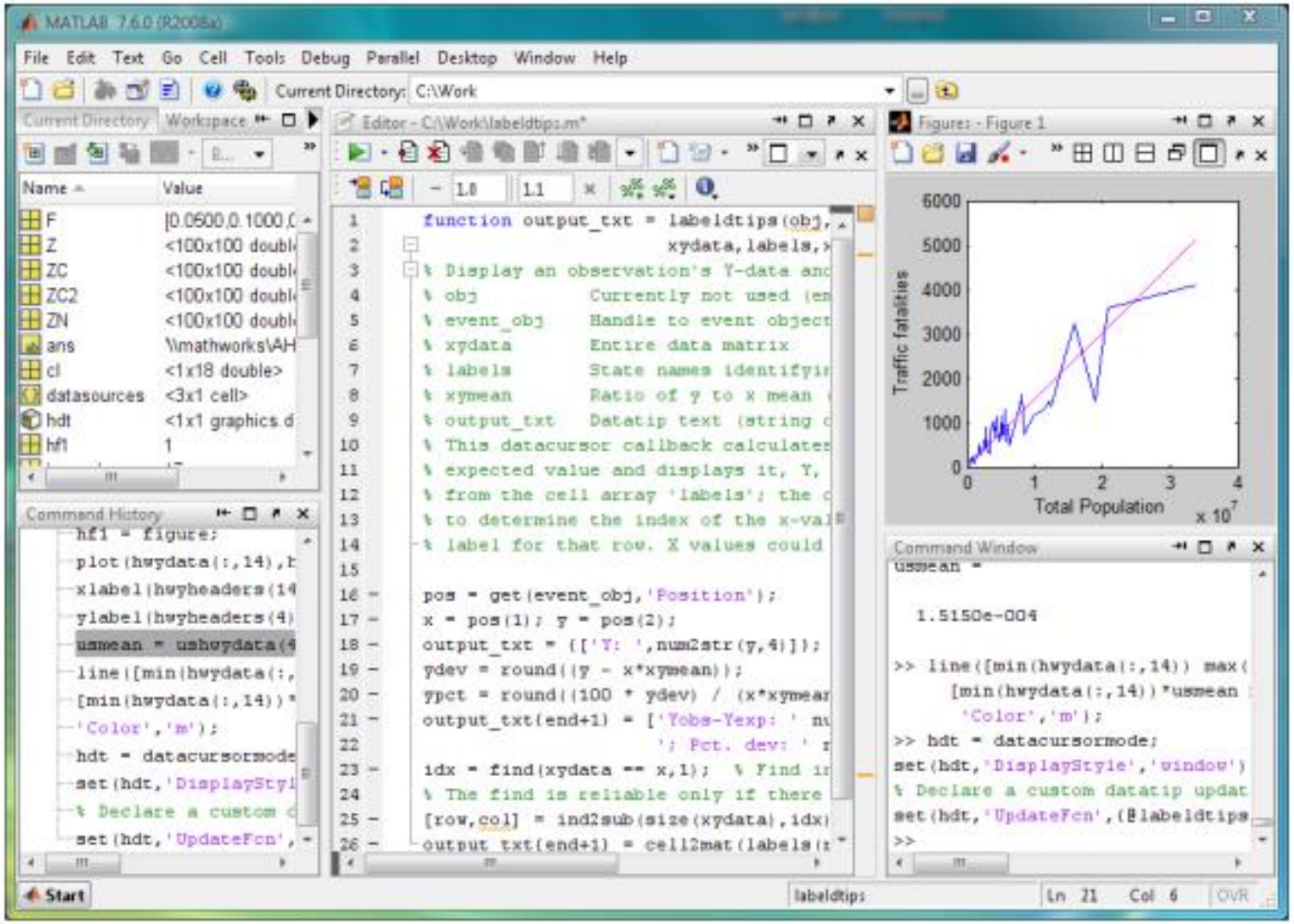
The team implemented a logging feature that records data from the control panel every 100 milliseconds, and generated multiple plots of this data in MATLAB to assist with debugging and troubleshooting.

What Is MATLAB



From [Tools on the Side](), [MATLAB Community]() blog, Posted by admin, June 9, 2008

What ~~is~~ Was MATLAB



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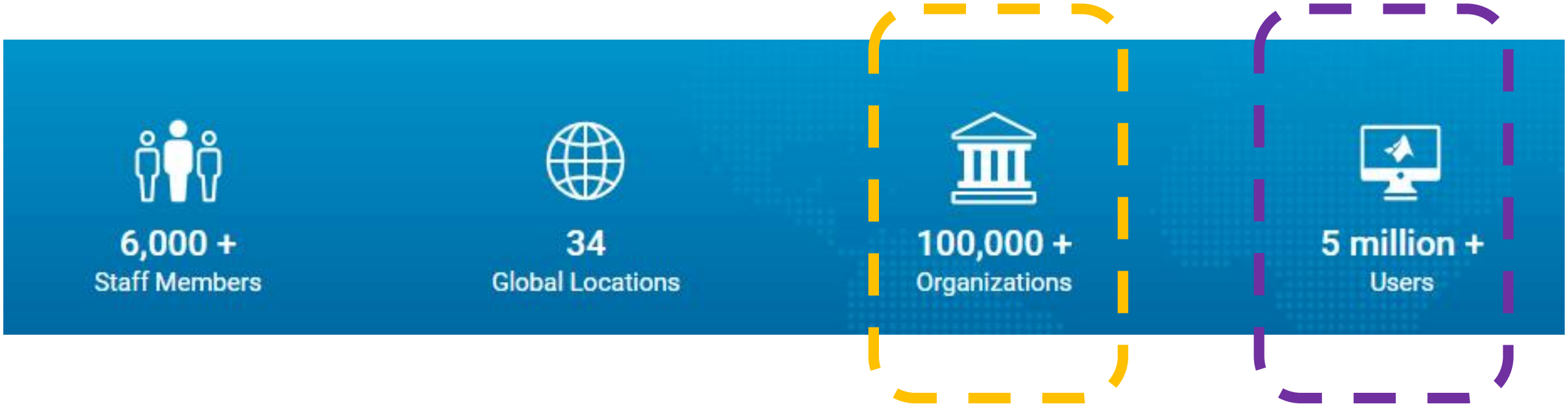
What Is MATLAB

…in 2023…

…after 30 releases…

Who Uses MATLAB



From «About MathWorks»

Why Using MATLAB - Applications

Automated Driving Systems

Design, simulate, and test automated driving systems

Computational Biology

Analyze, visualize, and model biological data and systems

Control Systems

Design, test, and implement control systems

Data Science

Explore data; build machine learning models; do predictive analytics

Deep Learning

Data preparation, design, simulation, and deployment for deep neural networks

Electrification

Develop electrical technology from components to systems

Embedded Systems

Design, code, and verify embedded systems

Enterprise and IT Systems

Use MATLAB with your IT systems

FPGA, ASIC, and SoC Development

Automate your workflow — from algorithm development to hardware design and verification

Image Processing and Computer Vision

Acquire, process, and analyze images and video for algorithm development and system design

Internet of Things

Connect embedded devices to the Internet and gain insight from your data

Machine Learning

Train models, tune parameters, and deploy to production or the edge

Mechatronics

Design, optimize, and verify mechatronic systems

Mixed-Signal Systems

Analyze, design, and verify analog and mixed-signal systems

Predictive Maintenance

Develop and deploy condition monitoring and predictive maintenance software

Robotics

Design, simulate, and verify robotics and autonomous systems

Signal Processing

Analyze signals and time-series data. Model, design, and simulate signal processing systems

Test and Measurement

Acquire, analyze, and explore data and automate tests

Wireless Communications

Create, design, test, and verify wireless communications systems

From Solutions

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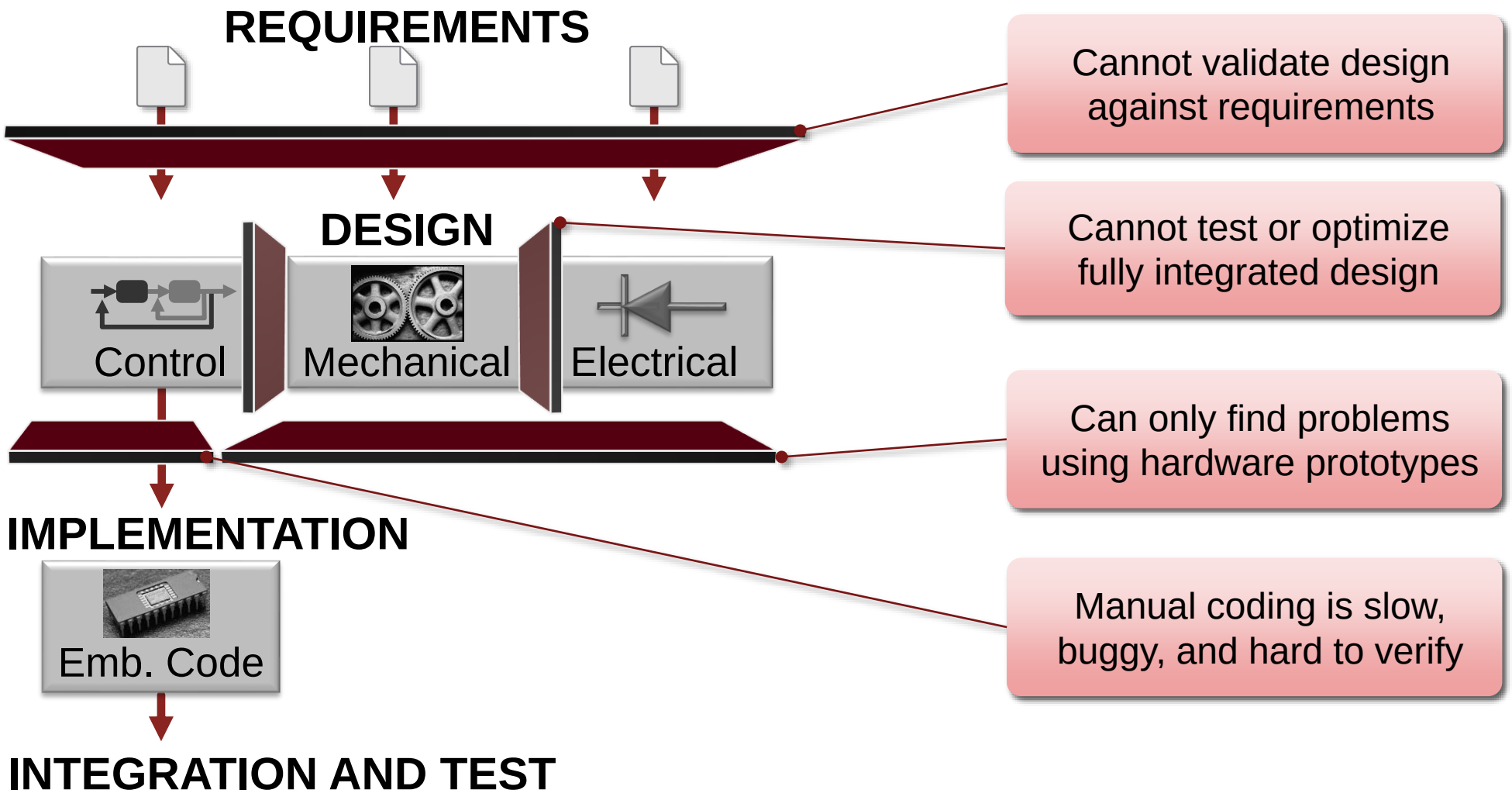
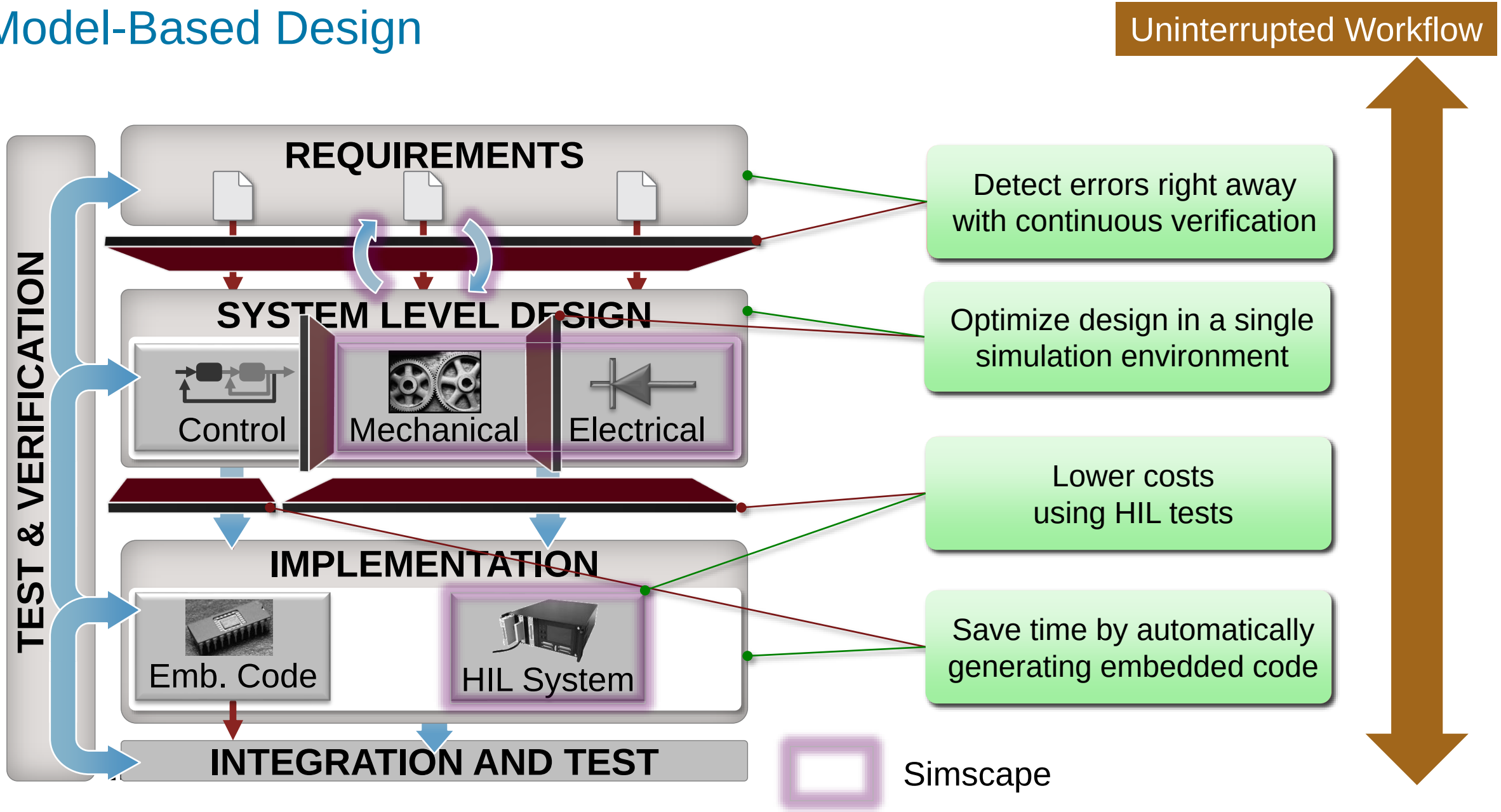
What Is Simulink

Traditional Design Process

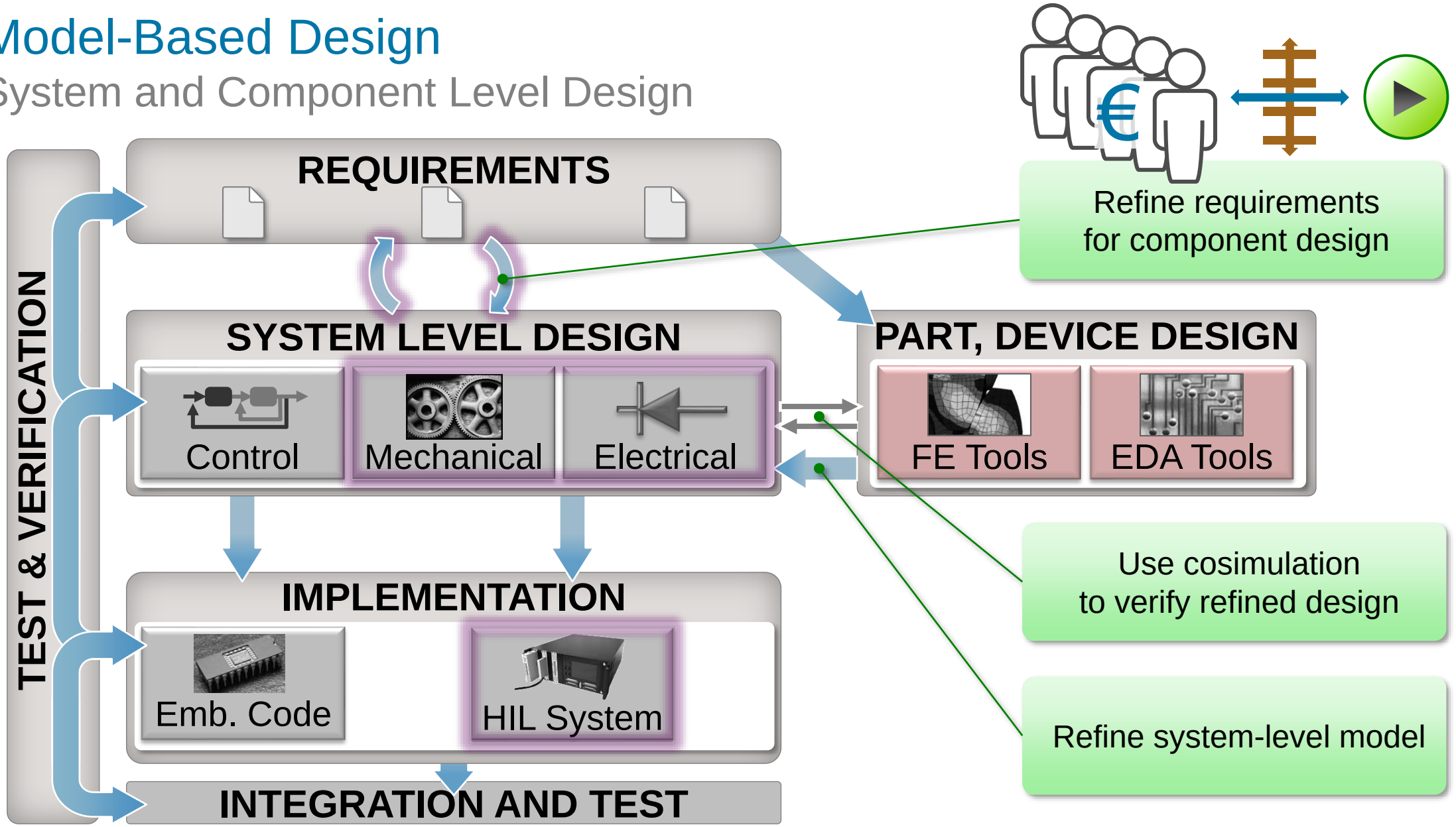


Model-Based Design



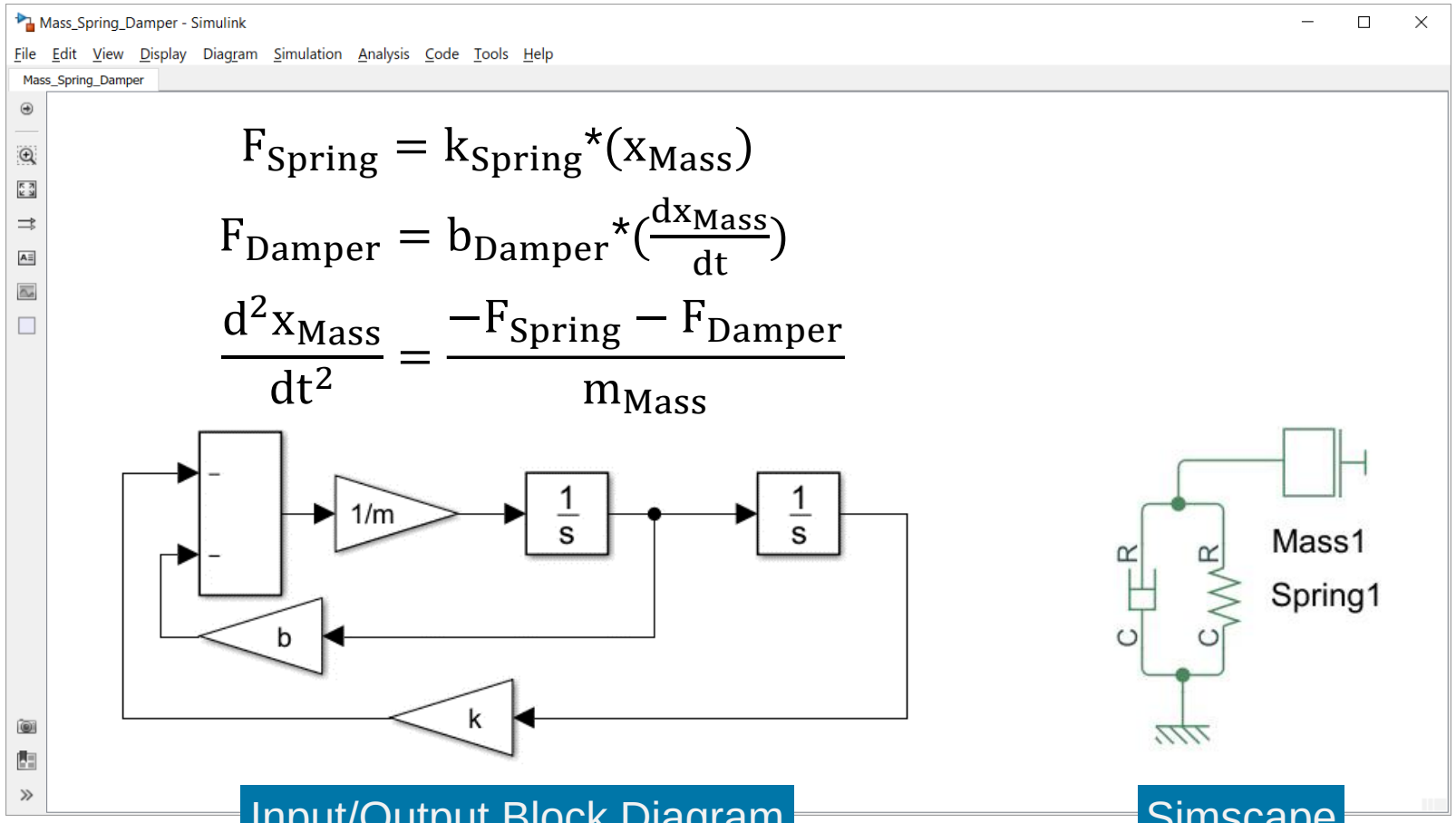
Model-Based Design

System and Component Level Design



Build Accurate Models Quickly

- Simply connect the components you need
- The more complex the system, the more value you get from Simscape
- Resulting model is intuitive, easy to modify, and easy for others to understand



Input/Output Block Diagram

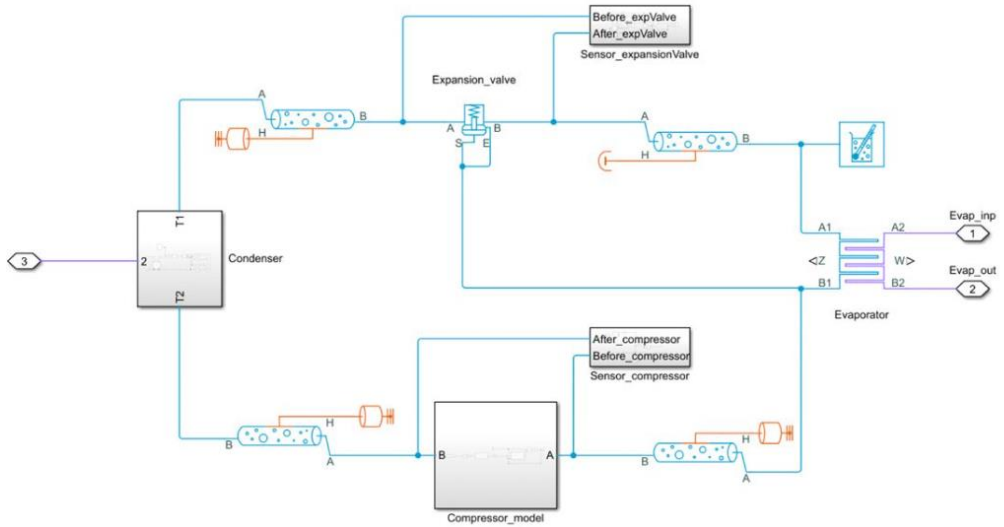
Simscape

Politecnico di Torino and EMA Global Develop a Multidomain Hypercar HVAC System Through Industry-Academia Collaboration

Using MATLAB and Simulink, EMA Global partnered closely with Politecnico di Torino to develop an HVAC system for a custom-built, multimillion dollar car

Results

- Developed detailed HVAC system modeled across six different physical domains using Simulink and Simscape
- Calibrated, optimized, and tested an accurate HVAC system controller without relying on hardware
- Shortened the overall development time for the controller using Model-Based Design



Model of the refrigerant cycle

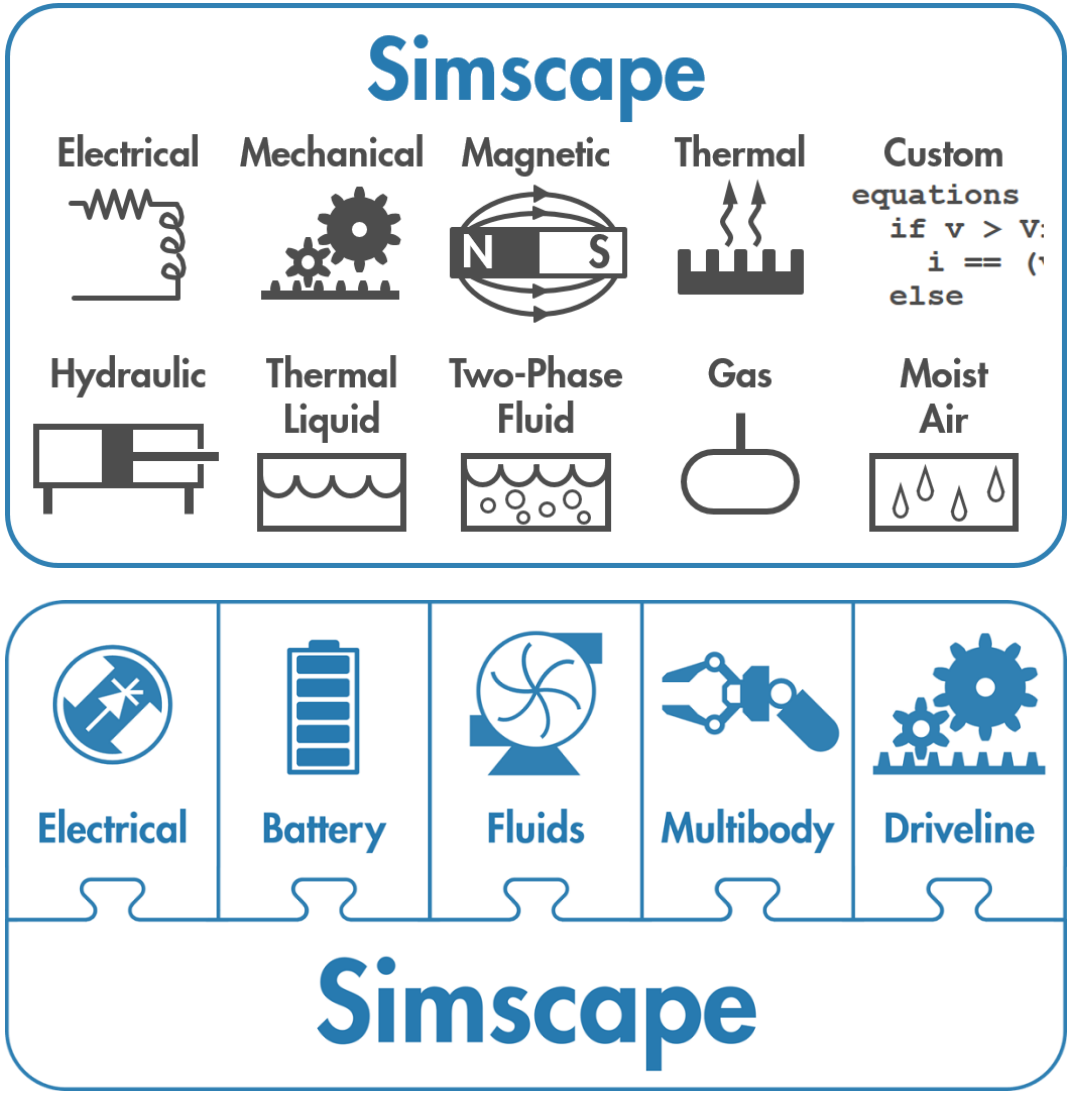
"This project was a great opportunity for EMA Global to collaborate with both MathWorks and Politecnico di Torino in applying a state-of-the-art automotive engineering approach that we can now continue to use moving forward."

- Mirko Zanotel, EMA Global Engineering

Link to article

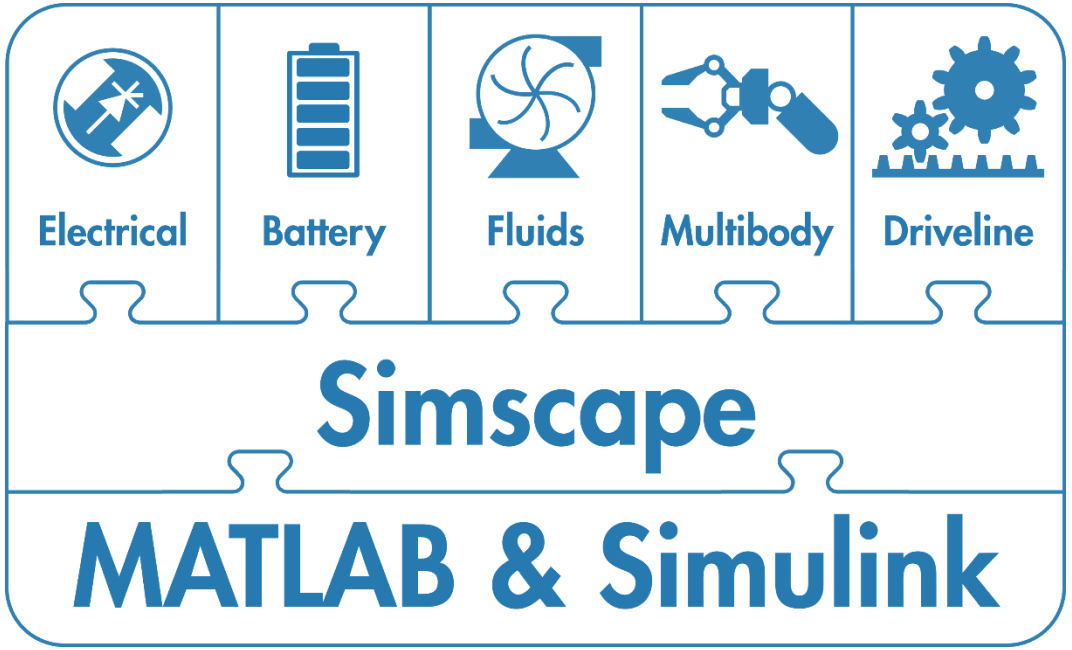
Simscape Products

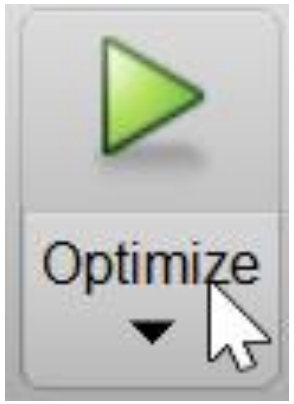
- Simscape platform
  - Foundation libraries in many domains
  - Language for defining custom blocks
    - Extension of MATLAB
  - Simulation engine and custom diagnostics
- Simscape add-on libraries
  - Extend foundation domains with components, effects, parameterizations
  - Multibody simulation
  - Editing Mode permits use of add-ons with Simscape license only
  - Models can be converted to C code

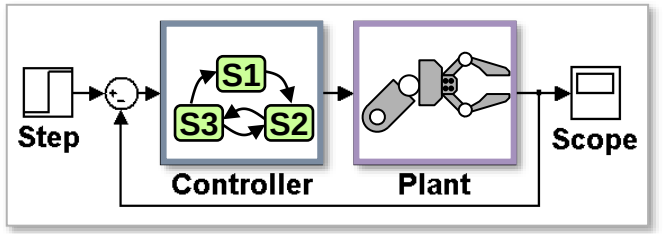


MATLAB, Simulink, & Simscape

- Get more value from your model of the physical system
- MATLAB
  - Automate any task (build, test, analyze)
  - Streamline testing (parallel computing)
- Simulink
  - Design and test algorithms
  - Test embedded software without hardware prototypes







Integrate and Test