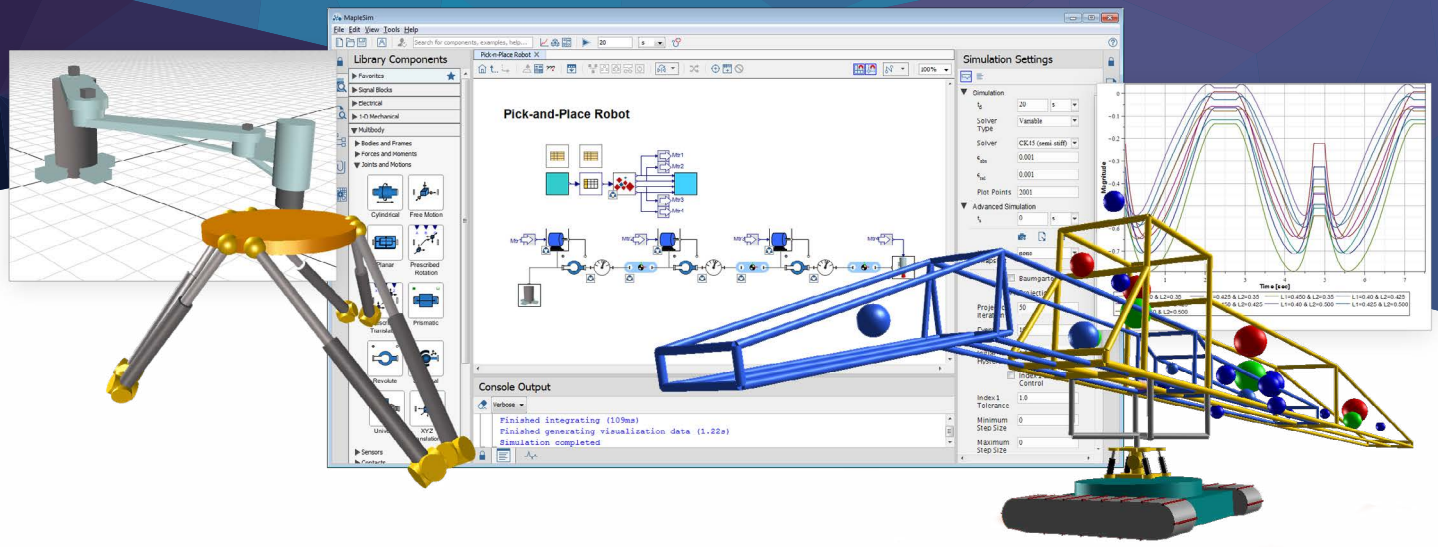
Advanced System-Level Modeling



MapleSim™

MapleSim

MapleSim™ is an advanced system-level modeling tool that enables innovation and reduces development risk, so you can create better products, faster.

- **Rapid creation and testing of initial concepts**
  By enabling quick prototyping and testing of design concepts, MapleSim allows you to try out more ideas in less time, getting you on track quickly and energizing the creative design process.

- **Natural environment for modeling multidomain systems**
  With MapleSim, you model your entire system inside a single environment, so you can track down design flaws arising from unexpected interactions between different domains, and even prevent these problems from occurring in the first place.

- **Computationally efficient models**
  MapleSim produces high fidelity, computationally efficient models suitable for in-the-loop simulations, controller design, and activities such as optimization, sensitivity analysis, and parameter sweeps, where many simulations are required to get results.

Why Choose MapleSim for your System-Level Modeling Projects?

System-level modeling is an extremely effective approach for engineering design projects that can help you reduce development time, uncover problems early in the development cycle, and improve overall designs. However, not every company that adopts this approach succeeds in achieving these benefits because they find it too difficult to translate their engineering expertise into their system-leveling modeling tool. **With MapleSim, you get an environment that helps you capture, preserve, and leverage your engineering knowledge so you can truly reap the rewards of system-level modeling and simulation, and create better products, faster**.

Capture Knowledge

The Challenge:

It's not always easy to tell your modeling software the things you already know about your system.

Component libraries rarely have the perfect assumptions for your project. Sometimes they offer too little fidelity, missing dynamics you need to capture. Sometimes they provide too much, forcing you to pick values for parameters you don't have or don't understand, so you end up with incorrect results because of parameters you don't care about.

The MapleSim Solution:

With MapleSim, you can easily map your engineering knowledge onto components and models.

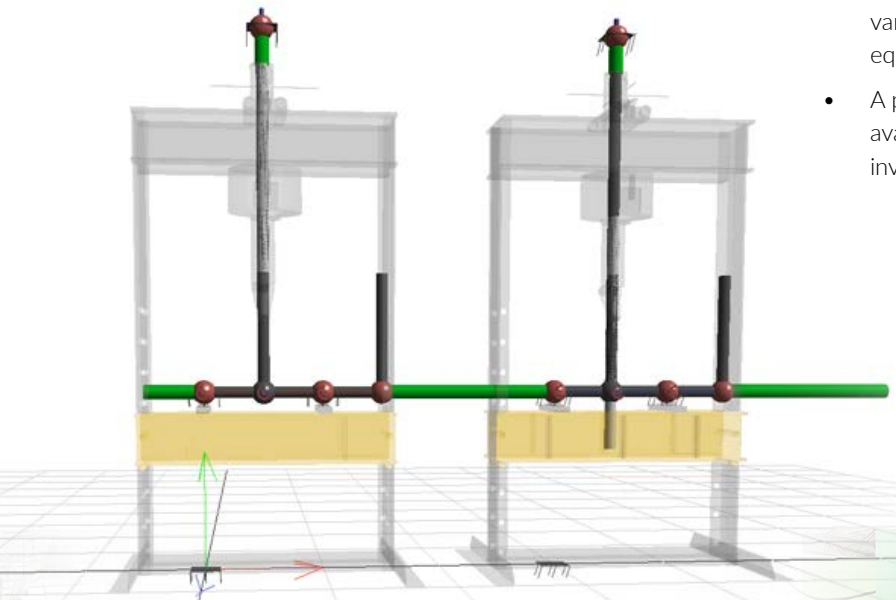
- Custom components are easily created by providing, or even deriving, the underlying mathematical equations that determine their behavior.
- The underlying equations that govern any component are accessible, so you can determine exactly how an unknown parameter is used.
- MapleSim does not force you to provide initial conditions for all parameters, it clearly communicates what happens when values are not specified, and it assists you with picking appropriate initial values.

Deepen Knowledge

The Challenge:

It can be difficult, or even impossible, to perform the analysis you want.

Modeling tools generally come with standard analysis tools, but if you want to move beyond the standard techniques, or even simply combine standard tools in an automated way, you will often find that your ability to increase your understanding of your system is limited not by your abilities, but by your tool.



The MapleSim Solution:

MapleSim provides both standard analysis tools and a flexible environment for customizing your analysis. You can explore your design as deeply as you wish to gain greater insight into system behavior and improve your design.

- Built-in tools make it easy to apply standard analysis techniques, such as sensitivity analysis, Monte Carlo simulation, parameter sweeps, and optimization.
- You can perform complicated operations at the click of a button or using a single command, including symbolic differentiation, symbolic integration, order reduction, variable isolation, and analytical solving of sets of equations.
- A powerful, math-aware programming language is available for developing customized analyses, such as inverse kinematics, vibration analysis, and much more.

Preserve Knowledge

The Challenge:

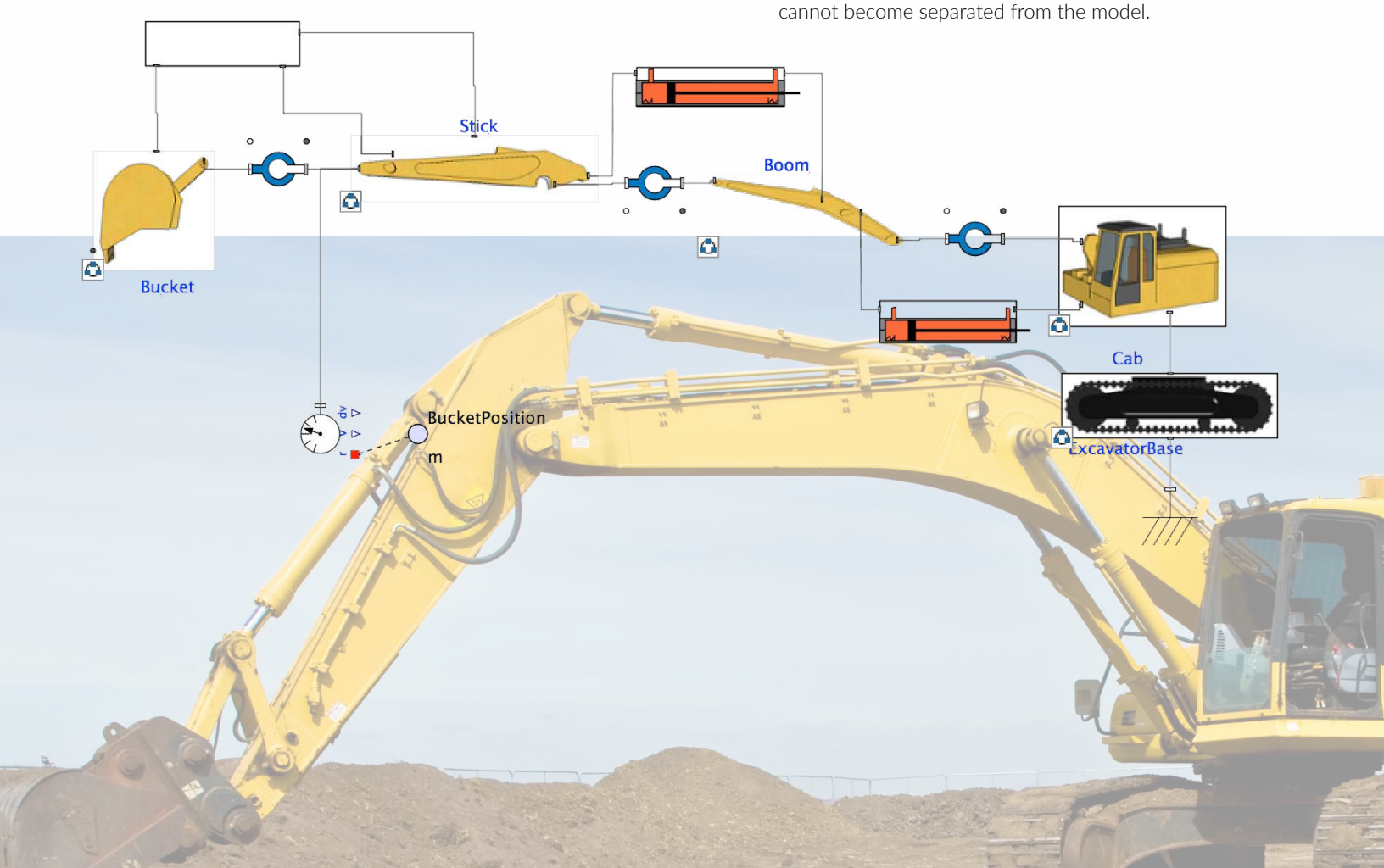
You don't just need the final model, you need the assumptions behind the model.

A lot of thinking goes into any engineering design, such as the reasoning behind certain decisions, and the assumptions the design is based on. Sometimes this knowledge is stored in a binder, sometimes it exists only in the engineer's brain. When the binder is misplaced or the engineer leaves the project, the person who takes over is left with a model, and no idea why it was built the way it was. Without that information, making changes to the model is difficult. What's worse, it's risky, since the changes could invalidate one of the underlying assumptions without anyone realizing it, and so produce a flawed design or incorrect results.

The MapleSim Solution:

The knowledge embedded in your MapleSim components and models is always accessible and comprehensible to other engineers, whether it's needed next week or next year.

- All component definitions and model equations are accessible, for both built-in and custom created elements.
- When it is necessary to view a component's underlying code, intelligent tools help give you a complete view of the elements that define the component.
- Analyses, optimization investigations, and custom component definitions can include explanations, images, data files, and mathematical derivations. As a result, the thinking behind the component or model is always available, not just the final parameter value or plot.
- Models, simulation results, analysis, reports, custom component descriptions, animations, data files, and more are all kept in a single project file so the reasoning cannot become separated from the model.

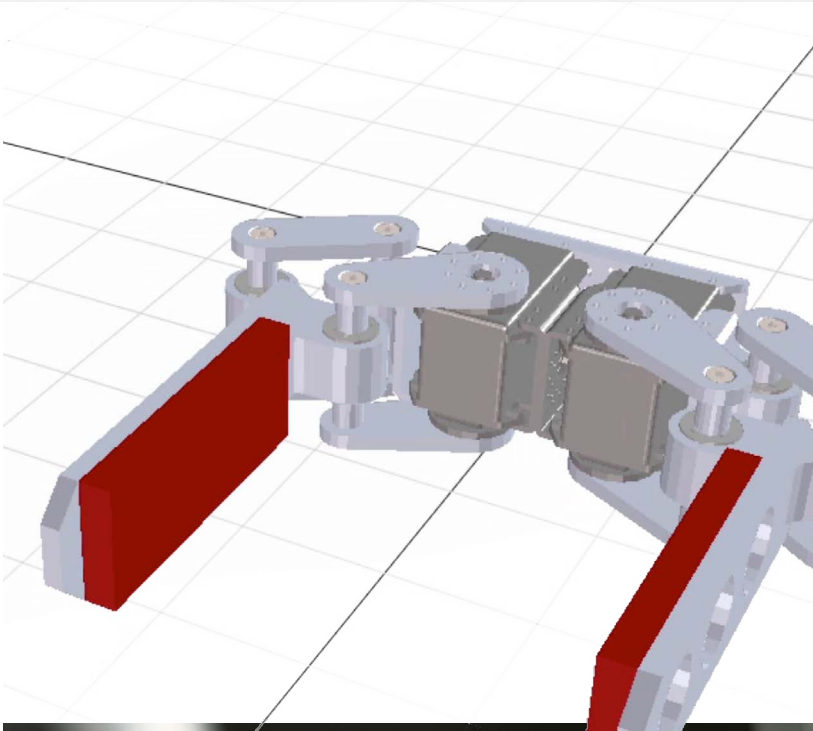


Leverage Knowledge

The Challenge:

Your model can provide answers to many questions, but those answers are often inaccessible.

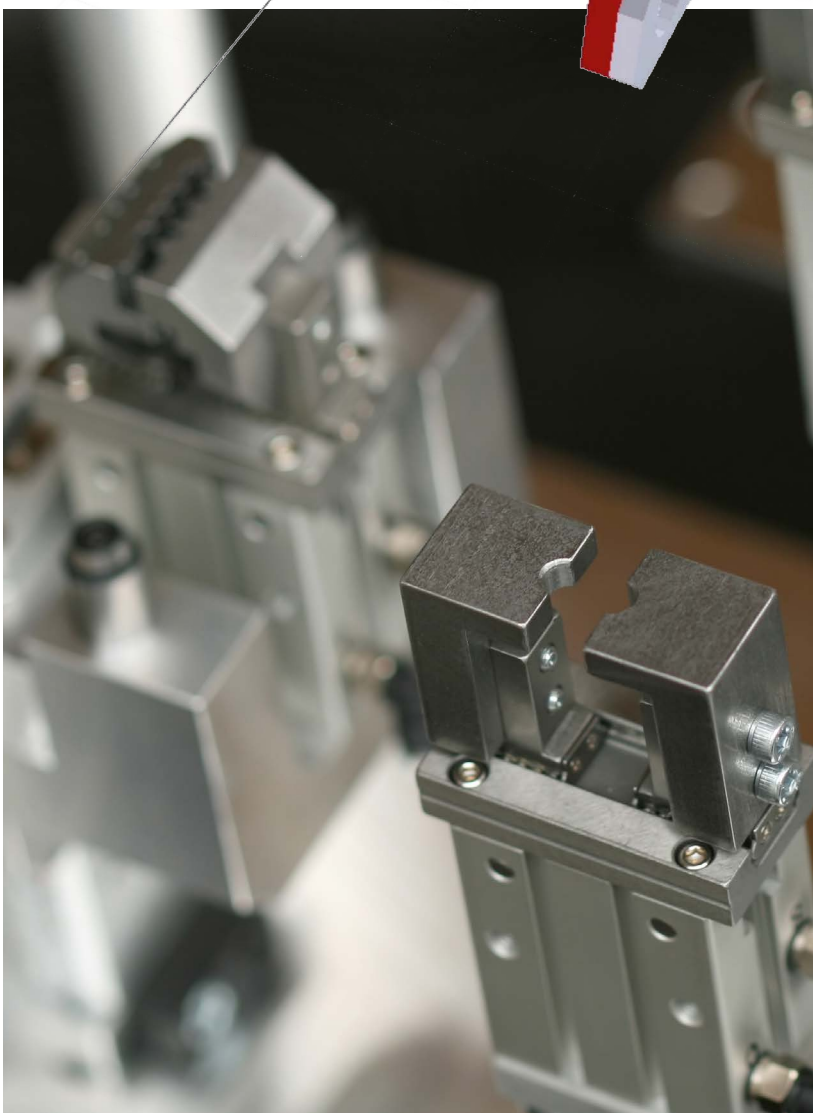
Usually it requires an expert in the use of the modeling tool to ask the questions. This can mean that fewer people get to ask questions, and the rest do without answers that could have been obtained from the model. Or it can mean that expensive engineers spend less time doing modeling because they are spending their time answering questions for other people. In addition, often the answers embedded in the model need to be provided to another tool in your toolchain, which can require additional work to move the knowledge from one tool to another.



The MapleSim Solution:

Whether you want to provide easy access to solutions derived from your MapleSim model throughout your organization, or integrate your model with the rest of your toolchain, MapleSim makes sure the results of your hard work are always accessible.

- You can create easy-to-use web applications that provide simplified interfaces to your MapleSim model, so people in your organization can get the answers they need, when they need them, using only a web browser.
- MapleSim provides easy connectivity to Simulink®, FMI-compliant modeling tools, CAD tools, and more.
- Royalty-free, callback-free code generation makes it simple and cost-effective to export your model to other tools.



Features

Block Library

MapleSim contains both physical component and signal-flow blocks. The physical component blocks include functionality for many domains:

- Electrical, including passive and active components, semiconductors, and electromechanical machines
- Thermal, including heat capacitors, conductors, convection, and radiation blocks
- Rotational and translational mechanics, including spring-mass dampers, gears, clutches, and bearings
- Multibody dynamics, including flexible beams, rigid bodies, and constraints
- Magnetics, including data for magnetic materials, electromagnetic fields, permanent magnets, field shapes, sensors, leakage, and flux and potential sources
- Thermal fluids, including boundary conditions, constraints, heat flow, heat transfer, and thermal sensors
- Hydraulics, including hydraulic cylinders and motors, orifices, and non-circular pipes

The signal-flow blocks include:

- Continuous and discrete blocks, such as filters, delays, and triggered samplers
- Logic and structural blocks, such as Boolean operators, switches, and mux/demux
- Arithmetic blocks, such as integrators, gains, vectors, and feedback

The block library can be extended by creating and sharing custom libraries, through specialized add-on products, and by importing third-party Modelica libraries.

Interface and Modeling

- Drag-and-drop block diagram modeling environment
- Model diagram maps directly to the physical system
- System equations generated automatically from the diagram and simplified using lossless symbolic techniques
- Components from different domains are seamlessly combined in the same diagram
- Shareable custom block libraries
- Import of Modelica libraries and models based on the Modelica 3.x standard library
- Import of models created in other FMI-compatible software using FMI 2.0 Model Exchange and Co-Simulation
- Masked subsystems and scoped variables
- Control over parameters and initial conditions of a single instance of a shared component or subsystem
- Hierarchical model diagrams with easy model navigation
- User-defined variables for component parameters
- Block diagram and 3-D model construction of multibody systems
- Equation-based custom components, without scripting
- To/From blocks to facilitate clean routing
- Data import and export, and lookup tables
- Access to underlying Modelica code for any component or subsystem
- User-created favorites palette for commonly used blocks
- Units-aware, including SI, US, and Imperial
- Library of prebuilt models across multiple disciplines
- Revision control tools

Simulation

- Stiff/non-stiff/semi-stiff and fixed/adaptive numerical solvers (Rosenbrock, Cash-Karp, Runge-Kutta-Fehlberg, implicit Euler)
- Linear, nonlinear, continuous and discrete time, SISO, MIMO, and hybrid systems
- Lossless symbolic simplification of system equations produce efficient, high-fidelity models
- Index reduction method for high-index DAEs
- Analytic solution of algebraic loops without user intervention
- Detailed error analysis for model construction and simulation diagnosis
- Live, interruptible simulations that show results as the simulation progresses
- Compiled run-time mode for rapid execution
- Batch simulation, including the ability to run batch simulations and optimizations in parallel
- Parameter sets management tools
- Ability to call on external code as part of a simulation
- Snapshots for starting experiments at any time-step, even if the model was modified after the snapshot was taken
- Deployment of simulation models to other engineers with the MapleSim Explorer
- Efficient models and optimized C code generation for fast real-time execution, including hardware-in-the-loop (HIL) applications
- Deployment directly to popular platforms from MathWorks®, National Instruments™, B&R, dSPACE®, and more through connectivity add-ons

MapleSim Add-ons

- MapleSim Control Design Toolbox
- MapleSim CAD Toolbox
- MapleSim Battery Library
- MapleSim Driveline Library
- MapleSim Tire Library
- MapleSim Heat Transfer Library
- MapleSim Hydraulics Library® from Modelon
- MapleSim Pneumatics Library® from Modelon
- MapleSim Server
- MapleSim Explorer
- Connectivity add-ons for B&R, Simulink, FMI, and more
- MapleSim Engine Dynamics Library

Analysis and Documentation

- Extract, view, and manipulate the system equations for a model
- Parameter optimization and parameter sweeps
- Frequency domain and control analysis tools, including linear system analysis, parameter sweeps, sensitivity analysis, and Monte-Carlo simulation
- Data generation and signal generation tools
- Point-and-click access to powerful analysis and utility tools, for extracting both kinematic and dynamic equations from a multibody system, initialization diagnostics, motion profiles, vibration analysis, FMU generation, and more
- Full access to Maple for simulation analysis, visualization, and design documentation
- Scripting language for programmatic access to mathematical solvers, structures, and visualization tools for customized analysis
- API between MapleSim and Maple for programmatic analysis and testing
- Parameter management system for easily storing parameter sets, replacing groups of parameter values in a model, and comparing results
- Results management tools, including comparison of simulation runs on the same axes, instant plotting of both probed and unprobed variables, and easy creation of custom plots
- Live design documentation linked to model
- Include all related files in a MapleSim model for easy document management and sharing
- Natural math notation in analysis and design documents through Maple
- Supports development and deployment of easy-to-use custom applications based on the model, including web deployment using MapleSim Server

Visualization

- 3-D visualizations and animations of multibody systems
- Automatic ball-and-stick rendering–custom geometry (including springs, cylinders, boxes, force and torque arrows, and path traces) and imported STL shapes can be added for realistic rendering
- Full playback and camera control on 3-D visualizations and animations
- Export of 3-D visualizations for viewing outside MapleSim
- Customizable 2-D plots
- Multiple y-axes, and phase plots
- Log, semi-log, and linear axis scaling
- Pan, zoom and scale, point probe, and plot export
- Windows with multiple plots
- Drag-and-drop traces from one plot to another
- Full range of Maple plots available

MapleSim helps you **capture, deepen, preserve, and leverage your engineering knowledge** so you can make your system-level modeling projects a success.

Visit www.maplesim.com for product information, application stories, demo videos, a demo gallery, and more.

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