

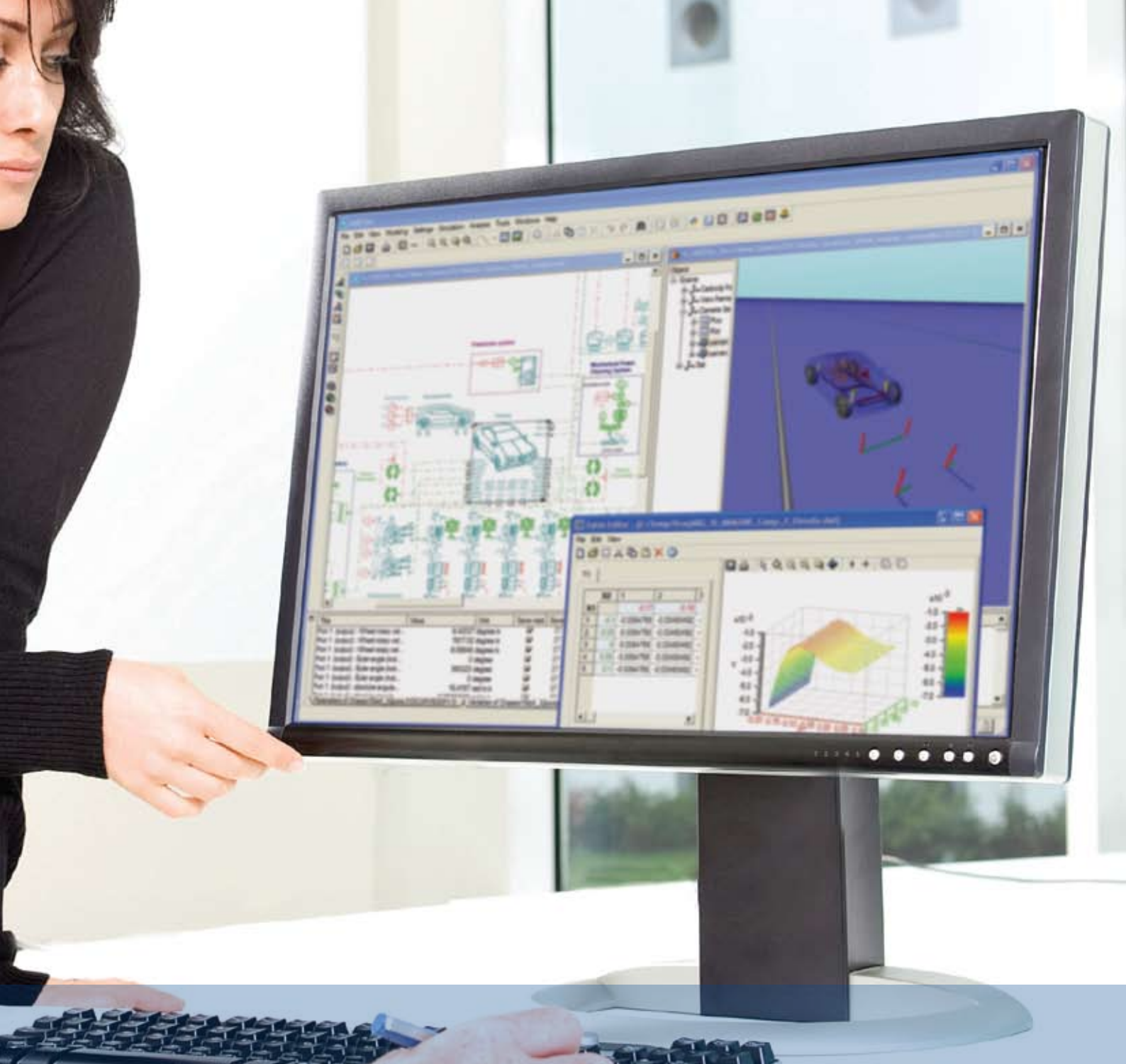
LMS Imagine.Lab AMESim Introduction





LMS Imagine.Lab AMESim

The integrated platform for 1D multi-domain system simulation



Enabling intelligent system simulation

Today intelligent system integration is driving improved product performance and delivering innovative designs in a variety of industries. Recent surveys show that approximately 80% of the next-generation systems and products will be derived from so-called intelligent systems. One of the most common examples is the advanced injection and control systems essential to clean-running and fuel-efficient car engines.

But it is not only the automotive industry that is investing heavily in the intelligent system design trend to reach new targets for vital attributes like safety, comfort and, of course, driving pleasure. Active systems are running everything from key operating and safety mechanisms in the latest airplanes to “smart” packaging machines, hyper-speed printing presses, power-packing excavators and highly-efficient wind turbines. Intelligent systems clearly are essential when designing cost-efficient products with higher productivity levels and superior reliability.

LMS Imagine.Lab AMESim

The integrated platform for 1D multi-domain system simulation

Meeting strategically critical engineering challenges

How can an engineer pro-actively incorporate functional performance into an intelligent system? Especially a system with complex interaction between mechanical, hydraulic, pneumatic, thermal and electric/electronic components and subsystems?

This is exactly the beauty of LMS Imagine.Lab AMESim. This 1D simulation platform simplifies multi-domain integration using an easy-to-use simulation process. All engineers need to do is connect various validated components to simply and accurately predict multi-disciplinary intelligent system performance.

With extensive dedicated libraries totaling more 3,500 components, LMS Imagine.Lab AMESim actually saves enormous amounts of time by simply eliminating the need for extensive modeling. Thanks to its application-specific simulation capabilities, engineers can assess a variety of subsystems in multiple physical domains. This allows design and engineering teams to carefully balance product performance according to various brand attributes and achieve the best possible design way before committing to expensive and time-consuming prototype testing. Since LMS Imagine.Lab AMESim features intelligent system simulation early in the development cycle. It truly allows strategically critical design functionality to drive new product design.

LMS Imagine: your partner for intelligent system design

Thanks to over 20 years of experience with major industry actors worldwide, LMS Imagine can help customers solve their most critical design issues. Our expertise can make the difference between successful product launches and costly repairs, recalls or even product failures. Our innovative team's unique combination of skills, engineering experience and process know-how turns attribute engineering into a strategic competitive advantage.

LMS Imagine provides high-quality support services for all of its multi-domain solutions and software platform. Our customers benefit from the maximum return on their software investment. We are their partner when it comes to optimizing engineering productivity and maintaining up-to-date skills, competencies and systems that result in that essential competitive edge required for successful intelligent system design.

Function-driven design with LMS Imagine.Lab AMESim:

- Analyze intelligent system functionality right from the start
- Optimize mechanical, hydraulic, pneumatic, thermal and electric/electronic system interaction long before prototype testing
- Pro-actively engineer strategically critical design functionality for best overall product performance and quality
- Avoid design flaws, explore design alternatives and accelerate product development cycles

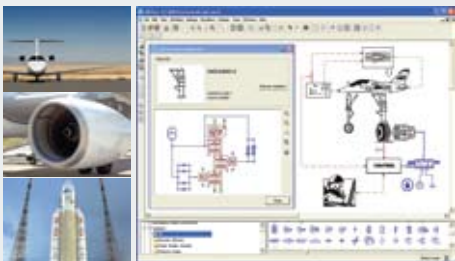


LMS Imagine.Lab AMESim solutions for:



Automotive and Ground Transportation

LMS Imagine.Lab AMESim offers dedicated solutions for all major vehicle subsystems: internal combustion engines, transmissions, vehicle thermal management systems, vehicle systems dynamics as well as fluid systems related to engines and electrical systems. Vehicle engineering teams can simulate system performance during the early design stage to optimally balance multiple functional requirements and brand attributes.



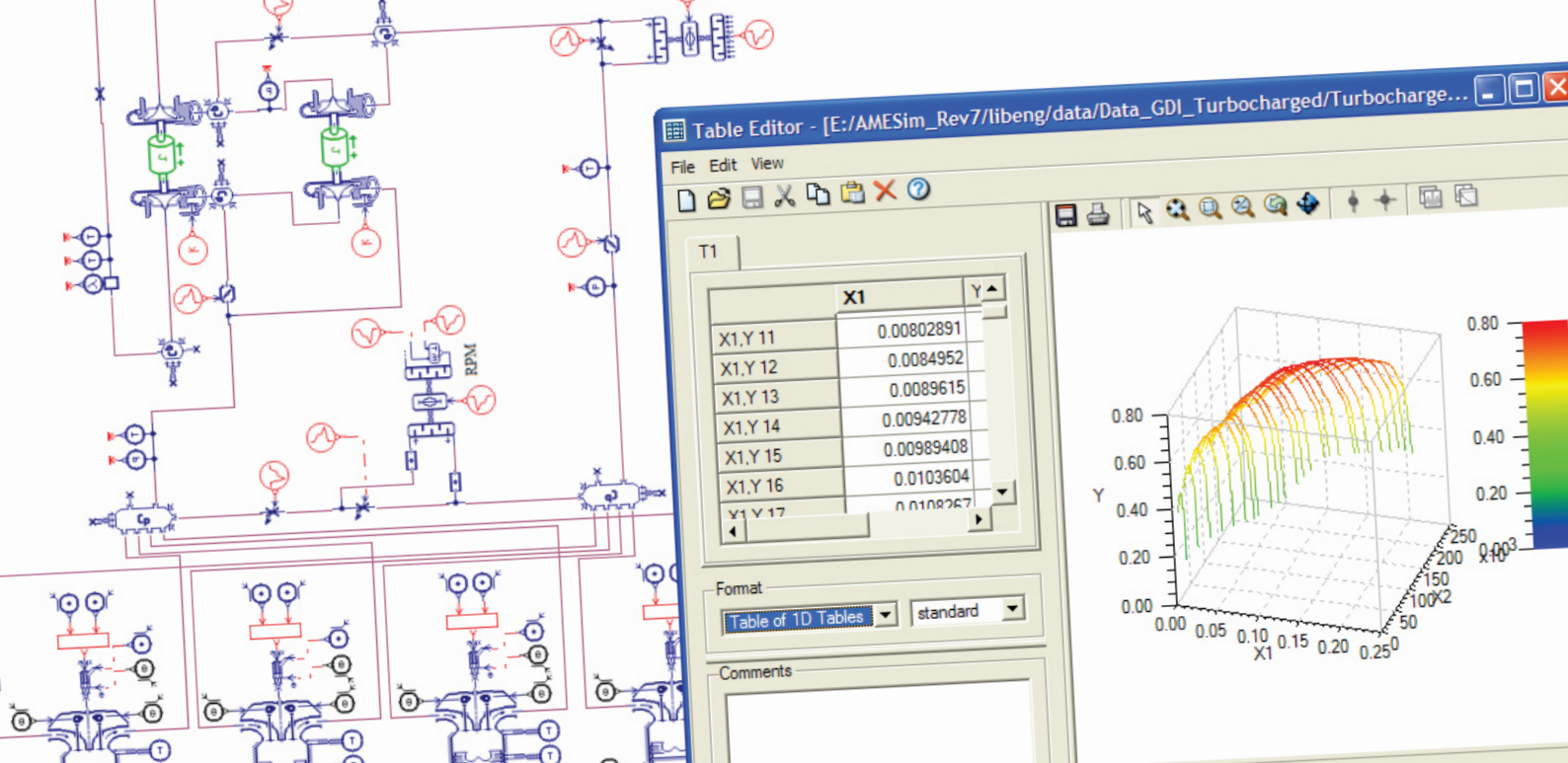
Aerospace

Aerospace manufacturers are challenged to design systems that are all encompassing: safe, reliable, efficient, comfortable and environmentally friendly. Thanks to its multi-domain system simulation capabilities, LMS Imagine.Lab AMESim meets these engineering challenges for a wide range of aeronautics and aerospace subsystems and components. The current portfolio includes solutions for aerospace engine equipment, environmental control systems, flight controls, ground loads and electromechanical components and numerous electrical systems.



Industrial machinery

LMS Imagine.Lab AMESim helps heavy machinery and industrial equipment manufacturers develop innovative product designs that deliver higher throughput, more reliability, maximum efficiency and minimum downtime. The LMS Imagine.Lab AMESim platform covers fluid, thermal, hydraulic, mechanical, electro-mechanical and pneumatic domains. Application-specific solutions cover a wide range of industrial applications: machine tooling, robotics, hydraulic presses, test benches, cooling systems, air-conditioning systems, offshore oil platforms, pipelines, shipbuilding, power generators, railway and light rail solutions, construction equipment, agricultural machinery and packaging machinery.



LMS Imagine.Lab AMESim

The integrated platform for 1D multi-domain system simulation

LMS Imagine.Lab AMESim offers a complete 1D simulation suite to model and analyze multi-domain, intelligent systems and predict their multi-disciplinary performance. Model components are described using validated analytical models that represent the system's actual hydraulic, pneumatic, electric or mechanical behavior. To create a system simulation model, all the user has to do is use the various dedicated tools to access the required pre-defined components from validated libraries covering different physical domains. LMS Imagine.Lab AMESim can work with a variety of libraries to create a physics-based system model. Using libraries like the Hydraulic Component Design (HCD) and IFP-Engine, LMS Imagine.Lab AMESim software can accurately simulate intelligent system behavior long before detailed CAD geometry is available.

Validated components and dedicated libraries

An organic and innovative concept, LMS Imagine.Lab AMESim lets engineers develop and customize their own libraries by creating new models and sub-models. To facilitate model and library sharing with suppliers, customers or internal departments, LMS Imagine.Lab AMESim offers the capability to create and publish ready-to-use catalogs of component models, while still encrypting valuable corporate know-how. LMS Imagine.Lab AMESim offers a run-only version of the software, dedicated for users who simply want to run a packaged simulation model to analyze and visualize different design alternatives.

Dedicated application solutions accelerate engineering

LMS Imagine.Lab AMESim offers an extensive set of application-specific solutions to assess specific subsystem behavior. This way, experts can focus on the critical design and engineering issues without spending valuable time creating and validating models. In the engineering loop, outside suppliers can model, simulate and validate components early in the design process and provide their client, the original equipment manufacturer or OEM, with a virtual

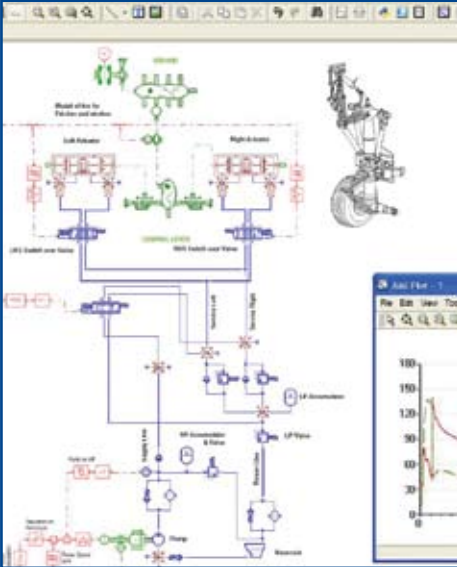
functional component or subsystem mock-up. In turn, OEMs can simulate components and subsystem integration to verify total performance levels and validate key design choices.

Easy and efficient interaction evaluation

Engineers really appreciate the fact that they can study each system independently, but the real added value of LMS Imagine.Lab AMESim is its truly unique capability to integrate and evaluate various subsystems in a single environment. For example, engineers working on an internal combustion engine can couple models of the transmission, the thermal management system and the electrical network to test new cabin heating strategies for obviously passenger comfort as well as the effect on fuel consumption and emissions. Another case found in aeronautics, users can couple all the vital landing gear elements, such as the suspension and the braking circuit, into one single simulation to test anti-skid strategies. Off-highway OEMs can estimate driving-cycle fuel consumption by coupling the internal combustion engine with all the pumps included in the hydraulic circuits to move the vehicle and actuate the different tools.

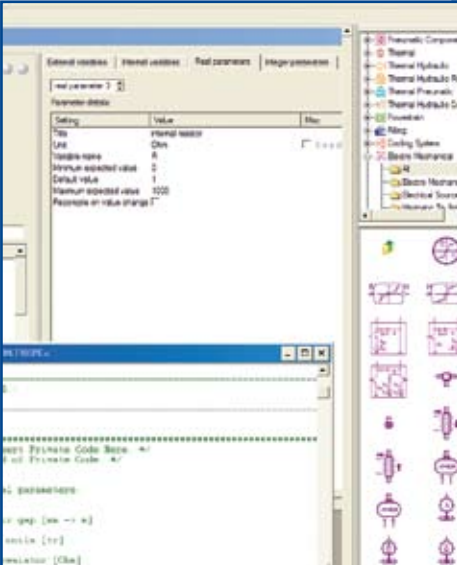
Develop, validate and share system models

The LMS Imagine.Lab AMESim platform contains all the core design and simulation products that engineers need to get started. According to the application, the platform can be easily augmented with task-specific interfaces, tools and dedicated libraries. The easy interactive graphical interface lets LMS Imagine.Lab AMESim users to quickly build complex, multi-domain system models by simply connecting various validated and pre-defined components. This results in an actual working 'rough sketch' of the desired model. A logical 1D representation, it is easy to understand and investigate design possibilities.



LMS Imagine.Lab Solutions

Powertrain Transmission	Internal Combustion Engine	Vehicle System Dynamics	Ground Loads and Flight Controls	Vehicle Thermal Management	Fluids Systems	Electromechanical	Energy
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LMS Imagine.Lab AMESim Suite

Packages				Options				
AMESim Base	AMESim Advanced	AMESim Expert	AMERun	Analysis Tools	Numerical Tools	Pre/Post Processing Tools	Interfaces	Libraries

LMS Imagine.Lab AMESim Packages

The LMS Imagine.Lab AMESim suite comes with dedicated packages tailored to our customers' precise needs. Customers can choose from four different packages: AMESim Advanced, the core package; AMESim Expert and Base, two variations on the core package; and a runtime version, AMERun. A flexible and thorough solution, all packages of the LMS Imagine.Lab AMESim software suite are easily enhanced with specific tools and dedicated, validated libraries to satisfy various customer requests.

AMESim Advanced: **Customize and share multi-disciplinary system models**

AMESim Advanced is designed to develop and analyze multi-disciplinary system models. It is the ideal version for users who need to share models with other departments or with outside partners.

Via the easy and interactive graphical interface, AMESim Advanced users can build complex multi-domain system models in minutes by simply combining validated components from various libraries covering different physical domains. The result is a straightforward system model representation which is easy to understand and investigate. Users create models by connecting physics-based building blocks. This innovative concept avoids cumbersome numerical model creation and code writing. Users are plunged directly into the critical aspects of design like analysis and optimization.

Based on the most advanced numerical techniques, the AMESim Advanced solver supports ordinary differential equation (ODE) and differential algebraic equations (DAE). The solver automatically and dynamically selects the best-adapted calculation method from 17 algorithms, depending on the system dynamics.

In addition to the core platform, AMESim Advanced features AMECustom. This practical customization tool lets users tailor the software to specific applications or internal or external processes. It even allows users to compile company-specific model databases with customized user interfaces and parameter sets. For security purposes, sensitive information can be protected via encryption before supplying models to third parties.

A design exploration tool for exploring the design space, LMS Imagine.Lab OPTIMUS is a design optimization software application that captures and manages LMS Imagine.Lab AMESim engineering simulations. AMESim Advanced users can quickly and efficiently explore the design space with design of experiment and response surface modeling techniques to gain critical insight into possible design alternatives.

Besides the standard AMESim Advanced package, the platform is available in a "light" version, AMESim Base, an ideal solution for users with basic simulation requirements, and AMESim Expert aimed at expert users.



AMESim Expert: **Extend system models with additional libraries**

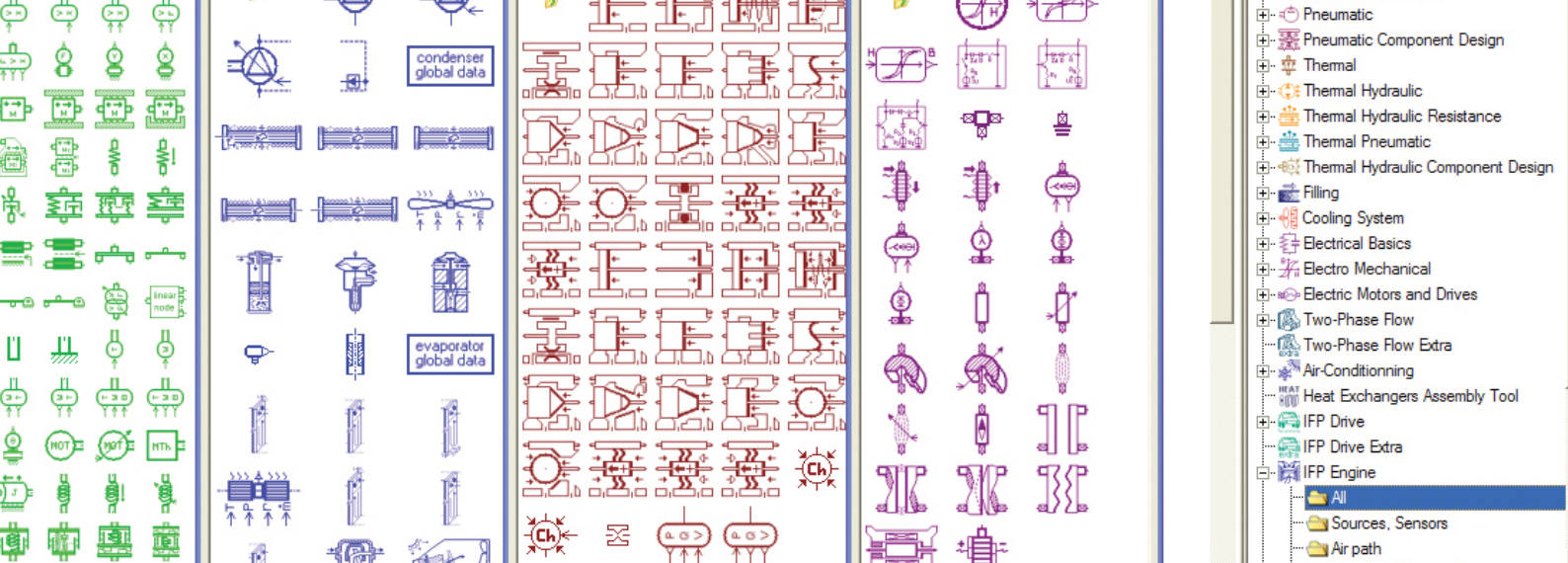
Capitalizing on all know-how throughout the company is crucial in the high-tech sector. In addition to all the AMESim Advanced features, AMESim Expert provides a comprehensive tool set that can easily extend the standard AMESim component libraries. AMESet, the AMESim sub-model editing tool, is designed to help write well-documented, standardized, reusable and easily maintainable libraries. Users can simply follow several simple rules to create fully compatible AMESim component models that are automatically usable on the platform.

AMESim Base: **Design system models**

AMESim Base is the entry-level version for users who need a basic scripting interface and analysis tools to development and analyze multi-domain systems.

AMERun: **Share simulation models with non-expert users**

AMERun is a run-only version of AMESim. It is ideal for users who just want to run a customized simulation model to analyze and visualize different design alternatives. With AMERun, engineers can easily share validated, tested and customized AMESim models with non-expert users. AMERun offers many of the same features found in the standard AMESim environment so that users can still adjust model parameters and perform analysis runs.



LMS Imagine.Lab AMESim Libraries

Accelerating model creation

To create a system simulation model in LMS Imagine.Lab AMESim, users simply access one of the numerous libraries of pre-defined and validated components from different physical domains, such as fluid, thermal, mechanical, electromechanical, powertrain and many others. All library components are completely validated to guarantee the accuracy and reliability of the simulation. By selecting the required validated component from the related library, users completely avoid the step of creating their own complicated code. Not only does this save enormous amounts of time, it also allows teams to easily create complex system models covering multiple domains. Rather than spending time simply building a functional model, engineers can focus on design-critical tasks like optimizing the design for best-in-class product behavior early in the process.

Easy and accurate model creation

By combining library components, users create an easy-to-understand working sketch of the system model. To aid investigation, varying model complexity can be selected for each component. Parameters and measuring units can be set in an easy and interactive way. Thanks to this completely transparent concept with easy-to-access embedded model information, users can capture, re-use and share engineering knowledge. Engineers can also start from a simplified model representation in the early development stage, and gradually add more detail to the model as design information becomes available.

Extend standard libraries with custom-built components

All AMESim library components are either application-oriented or represent physical phenomena. Users can start from pre-constructed application models to experiment with new ideas and techniques to discover innovative solutions. A unique feature, AMESim users can also create and add to their own libraries. AMESet, the AMESim sub-model editing tool, is designed to help write well-documented, standardized, reusable and easily maintainable libraries. This guarantees that models are completely

compatible with existing AMESim library models. LMS Imagine offers an extensive service to develop dedicated components and customized application libraries for clients.

A broad range of applications and physical domains

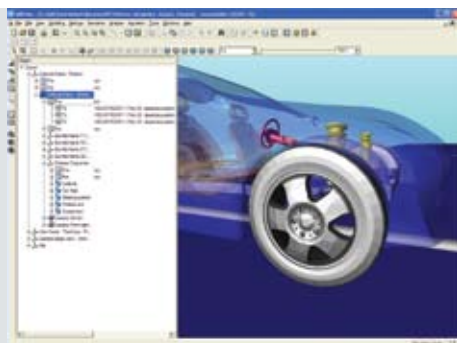
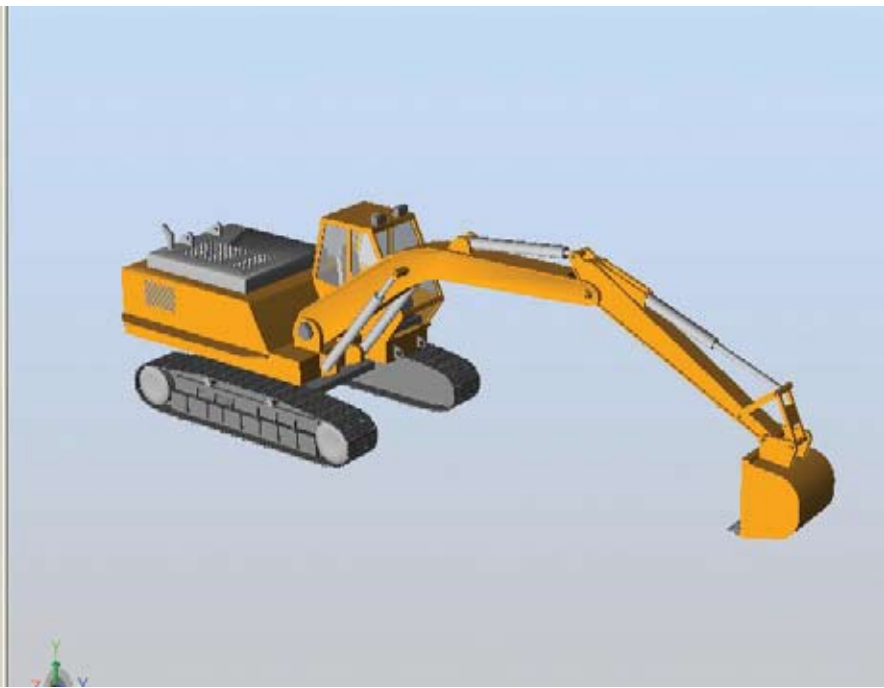
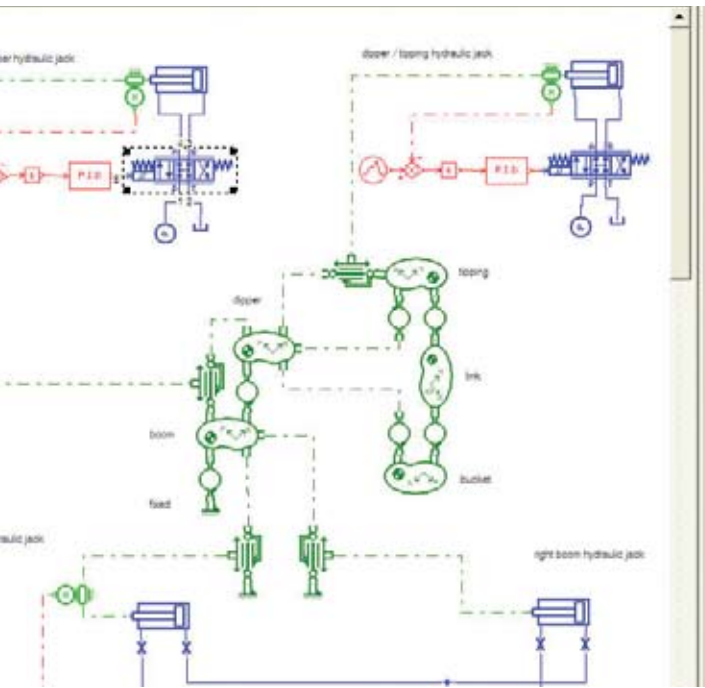
The various AMESim libraries filled with dedicated and validated components cover a multitude of physical domains and engineering applications:

- Control: Signal, Control & Observers
- Electromechanical: Electrical Basics, Electromechanical, Electric Motors & Drives
- Fluid: Hydraulic, Hydraulic Component Design, Hydraulic Resistance, Filling, Pneumatic, Pneumatic Component Design, Gas Mixture, Moist Air
- Internal Combustion Engine: IFP-Drive, IFP-Engine, IFP-Exhaust, IFP-Combustion 3D
- Mechanical: Mechanical, Planar Mechanical, Powertrain, Vehicle Dynamics
- Thermal: Thermal, Thermal-Hydraulic, Thermal-Hydraulic Component Design, Thermal-Pneumatic, Two-Phase Flow, Air Conditioning, Cooling System, Heat Exchanger Assembly Tool.

LMS Imagine.Lab AMESim Tools

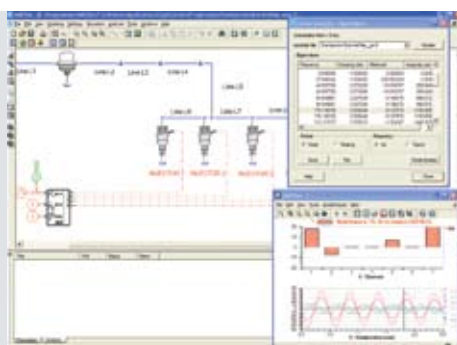
Powerful tools for design optimization

LMS Imagine.Lab AMESim offers an extensive tool set to optimize not only the design, but vital aspects of the entire design process. Besides its excellent design optimization capabilities, users can analyze multi-domain systems and graphical renditions of simulation results and generate customizable HTML reports. Pre-processing and post-processing tools include AMETable, a table editor that can handle N-dimension tables and create a 3D representation of the N-dimension table, and AMEPlot, a tool that displays complex plots.



AMEAnimation: create a 3D animation

AMEAnimation is a convenient way to create a 3D animation of any AMESim simulation. Users can simply create and link objects in AMEAnimation to the simulation itself. Users can easily visualize the physical component behavior according to set parameters to demonstrate the final results of the simulation.



Analysis tools: understanding intrinsic system behavior

Analysis tools, such as Fast Fourier Transform (FFT), spectral map, linear analysis order tracking and activity index, help explain system behavior, highlighting main dynamics so that the user can simplify the modeling process with a managed level of accuracy. Linear analysis can also help users obtain sufficient intrinsic system behavior. AMESim provides a comprehensive set of methods: eigenvalues, modal shapes, root locus, and transfer function representation thanks to Bode, Nichols and Nyquist plots.



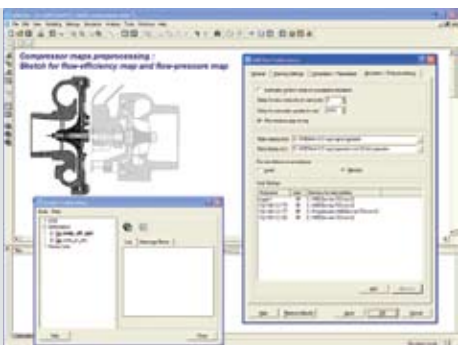
LMS Imagine.Lab OPTIMUS Exploring the parameter space and optimizing the design

In the world of multi-domain system simulation, the realm of 1D is probably the place where design exploration techniques are the most effective. Whether used for design or validation, system models can provide global parameter access that directly influences design decisions. LMS Imagine.Lab OPTIMUS is a design optimization software application that captures and manages LMS Imagine.Lab AMESim engineering simulations. Users can quickly explore the design space with Design of Experiments (DOE) and Response Surface Modeling (RSM) techniques to gain critical insight in possible design alternatives.

Design of Experiments (DOE) permits parameter screening and helps define an optimal set of experiments in the design space to obtain maximum information with the highest accuracy level at the lowest cost.

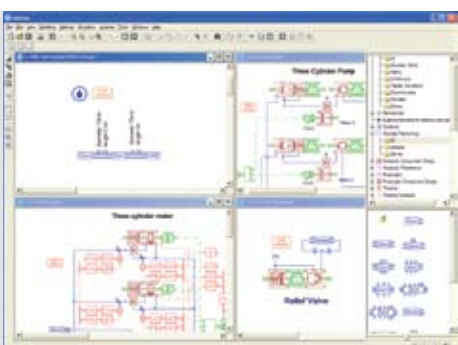
Thanks to the multi-objective state-of-the-art optimization methods adapted from Noesis OPTIMUS, another LMS technology, LMS Imagine.Lab OPTIMUS can find the best-possible set of design variables to satisfy all constraints and provide optimal values for established objective functionality.

To assess and optimize design responses taking into account the variability present in the LMS Imagine.Lab AMESim design input parameters, LMS Imagine.Lab OPTIMUS deploys robustness and reliability engineering methodologies as well.



Parallel Processing: CPU maximization

With a sole single processor, design exploration or batch runs can take some time. In this case, it is best to use more than one processor. LMS Imagine.Lab AMESim can use the MPICH standard for parallel processing. This option is a much more convenient method to handle robust design runs. It uses separate networked processors.



Discrete Partitioning: Simulations beyond your wildest dreams

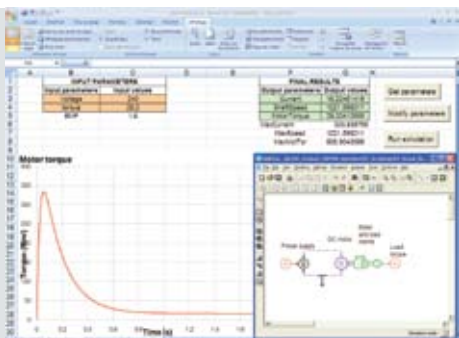
Discrete partitioning is a technique that can lead to extremely large run-time reductions for certain types of hydraulic systems, such as fuel injection, automatic gearbox command, and ABS. Discrete partitioning uses genuine physical discrete communication to produce a model that is suitable for co-simulation without accuracy loss. It takes advantage of wave propagation physics in hydraulic lines.



LMS Imagine.Lab AMESim Interfaces

Seamless design process integration

LMS Imagine.Lab AMESim is an open platform for efficient integration with third-party software for control, real-time simulation, multi-body simulation, process integration and design optimization. Besides its integration functionality, LMS Imagine.Lab AMESim features a generic co-simulation interface to couple multi-domain system simulation to any kind of dynamic 3D model, for example, a computational fluid dynamic simulation or finite element analysis. This allows LMS Imagine.Lab AMESim to be seamlessly integrated into the extended digital development process.



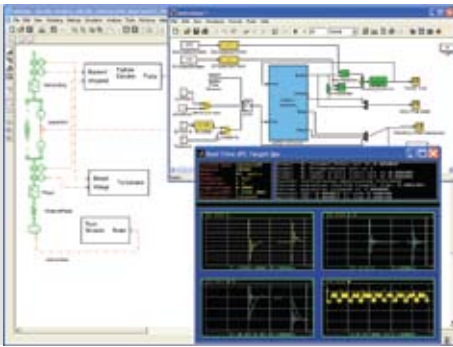
Scripting: automate complex and repetitive tasks

A time-saving feature, LMS Imagine.Lab AMESim provides a comprehensive set of scripts that support programming in higher abstraction-level languages like Python, MATLAB, Scilab, Microsoft Excel or Visual Basic Application to automate model interaction for batch runs, perform complex or automated pre-processing, or integrate an AMESim model within an external application.



Control system design: maximal interaction

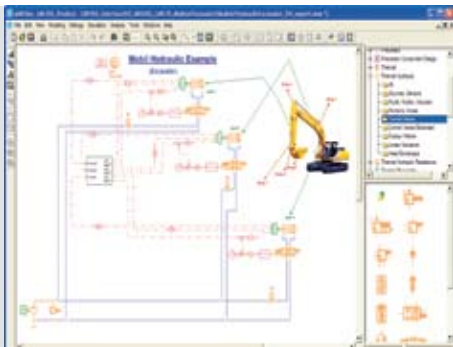
LMS Imagine.Lab AMESim is a complete systems engineering platform and Simulink from Mathworks is the de facto standard for control system design. How to link the two? The point-to-point AMESim-Simulink interface provides an easy-to-use and efficient tool to link an AMESim plant model with a Simulink control system model. Thanks to its simplified model exchange, users significantly benefit from more efficient communication between control systems teams and systems engineering teams as the link eliminates the need to re-write complex multi-domain models for various platforms. In addition, the Blackbox Export option allows users to export a standalone model into Simulink. This facilitates model sharing with suppliers, customers or other internal partners or departments using Simulink without rewriting the model itself.



Real Time: from high-fidelity modeling to HiL simulation

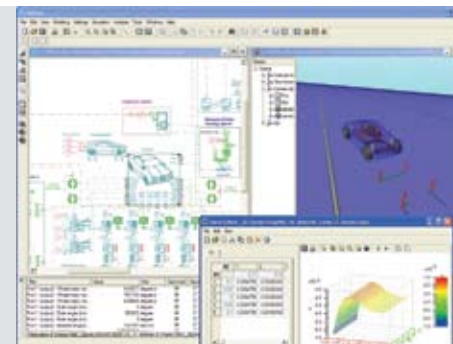
The Real Time option lets users export an AMESim model to a real-time hardware target for a hardware-in-the-loop (HiL) simulation. This makes it possible, for instance, to test an ECU before installing it in the real system and eliminate bugs early in the development process. Thanks to AMESim's real-time functionality, creating a real-time simulation model is simpler and faster. Development cycle uncertainty resulting from late design process integration is practically eliminated, translating to significantly improved product quality and reliability.

LMS Imagine.Lab AMESim offers a similar kind of approach compatible with National Instruments products. Users of these measurement automation and control systems can export LMS Imagine.Lab AMESim models to LabVIEW and its Real-Time Module.



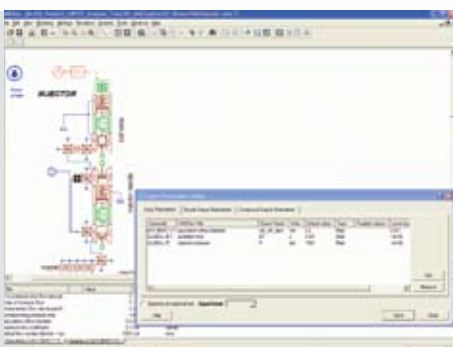
Multi-Body: a scalable simulation process with 3D mechanical systems

Physical systems are often composed of different elements all working together, such as pneumatics, mechanics, hydraulics, electronics or control systems. Interactions between multi-disciplinary systems and complex multi-body systems can be difficult to manage in a single modeling software package. This is why users can connect AMESim to a specialized multi-body package, such as LMS Virtual.Lab Motion or MSC.ADAMS. The multi-body interfaces provided by LMS Imagine make it simple to model each sub-system directly in the appropriate environment and perform combined simulation using either model export facilities or co-simulation.



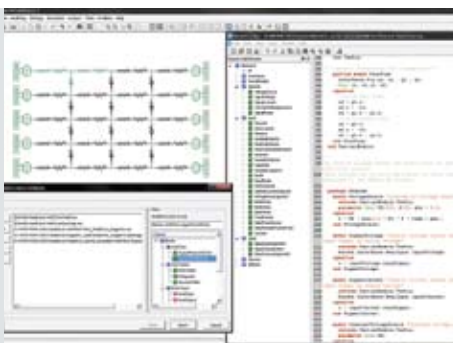
Process Integration: automate simulation across engineering disciplines

Besides native design exploration tools, AMESim provides users with an additional direct interface for Noesis OPTIMUS or iSIGHT through AMEPilot. AMEPilot features an easy way to initiate AMESim model runs from outside the platform. With this, users can simply change the model parameters to obtain post-treated simulation results. The AMESim Export module sets up suitably formatted parameters for AMEPilot.



Co-simulation: CAE software integration and legacy codes

Co-simulation means that two models are simulated within their own simulation environments (including solvers), but communicate at regular intervals. The Generic Co-simulation Interface is primarily intended for establishing co-simulation with third-party software, such as Computational Fluid Dynamics (CFD), but it can also be used for parallel AMESim-AMESim co-simulation.



Modeling Languages: AMESim proprietary support and the open-source Modelica language

Modelica is an object-oriented modeling language designed for multi-disciplinary system modeling. LMS is a core team member in charge of language improvement and promoting the standard. LMS Imagine.Lab AMESim is able to import Modelica models and link them to models in the AMESim libraries, securing the investment users may have made in developing Modelica libraries.





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LMS is an engineering innovation partner for companies in the automotive, aerospace and other advanced manufacturing industries. With approximately 30 years of experience, LMS helps customers get better products to market faster and turn superior process efficiency into key competitive advantages.

With a unique combination of 1D and 3D simulation software, testing systems and engineering services, LMS tunes into mission critical engineering attributes, ranging from system dynamics, structural integrity and sound quality to durability, safety and power consumption. With multi-domain solutions for thermal, fluid dynamics, electrical and mechanical system behavior, LMS can address the complex engineering challenges associated with intelligent system design.

Thanks to our technology and dedicated people, LMS has become the partner of choice of more than 5,000 leading manufacturing companies worldwide. LMS is certified to ISO9001:2000 quality standards and operates through a network of subsidiaries and representatives in key locations around the world. For more information on LMS, visit www.lmsintl.com.

