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Simcenter Amesim success slides

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Automotive & Transportation
Aerospace & Defense
Heavy Equipment
Industrial Machinery
Marine
Others

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Automotive & Transportation

Continental Powertrain

Towards Real Driving Emissions standard compliance with Simcenter Amesim

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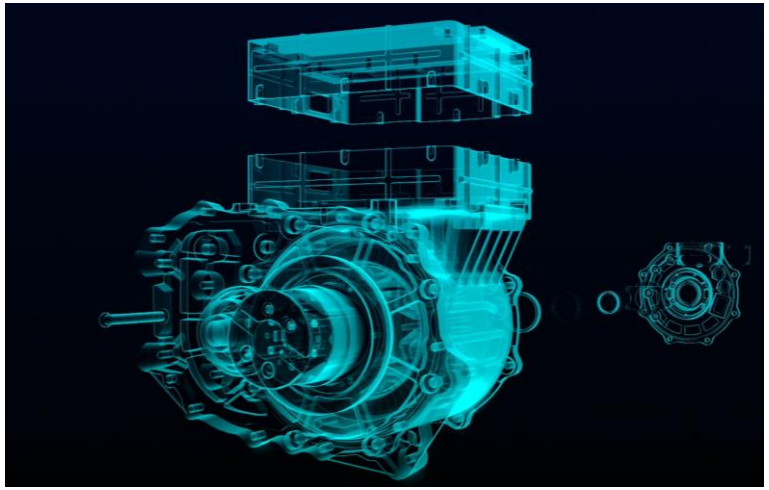

- **Addressed vehicle electrification and RDE challenges when developing new powertrains**
- **Accurate modeling combining all physical domains and control strategies**
- **Virtually assessed CO_2 emissions with an error rate of less than 3%**

“We have the possibility to mix and combine all physical domains to predict CO_2 emissions with inaccuracy below 3%. This is what is needed to make the right decisions for component development.”

Hervé Dupont, Group Leader System Simulation

VDL Enabling Transport Solutions

Aiming for zero-emission buses with Simcenter Amesim and STAR-CCM+

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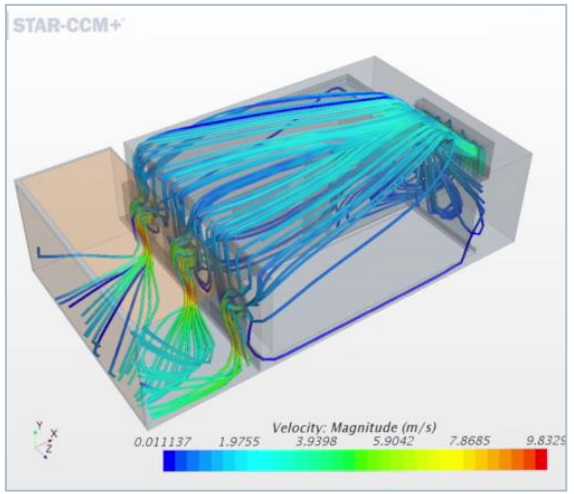
VDL is using Simcenter combining 1D and 3D models to optimize battery operation and driving range of electric city buses

“Electric buses can be cheaper than Diesel – now we are at this transition point”



VDL Enabling Transport Solutions

Aiming for zero-emission buses with Simcenter Amesim and STAR-CCM+

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- **Fully-integrated electric bus model built with Simcenter Amesim**
- **Enhanced battery cooling and control strategies**
- **Optimized vehicle energy management**

“The integration between 1D Simcenter Amesim models and 3D Simcenter STAR-CCM+ models is very simple to use and the run time is very good now.”

Anouk Hol, Aerodynamics and Energy Specialist

Brembo

Developing brake-by-wire technology thanks to Simcenter Amesim

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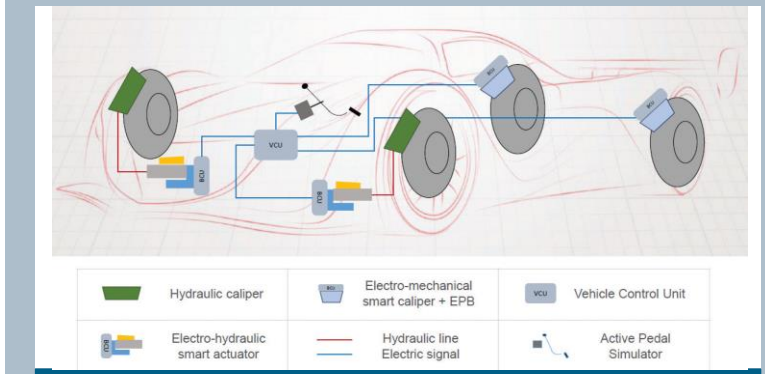
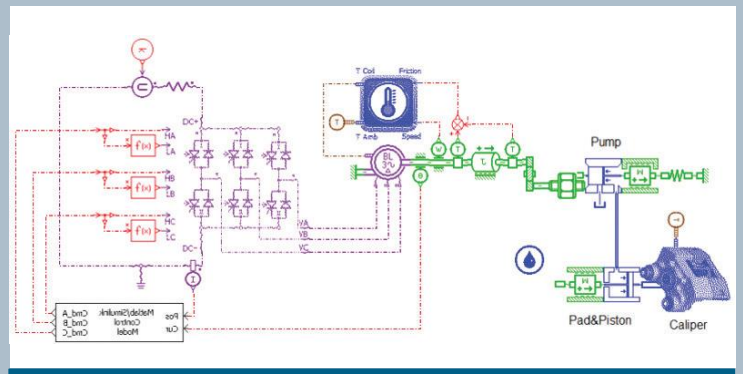
- **Performed actuator sizing without physical prototypes**
- **Studied variations of actuator component parameters at the production phase**
- **Developed internal know-how**

Reducing prototyping cost and time to design new technology



Braking architecture model



Actuator components specification

- Study actuators' dynamic responses, motor heating and battery current consumption
- Take advantage of the Simcenter Amesim co-simulation capabilities

"Since brake-by-wire technology requires sophisticated control strategies, a big step forward was the integration of the controls model and multi-domain component models in a single simulation environment"

Giulio Calamai, Simulation Engineer

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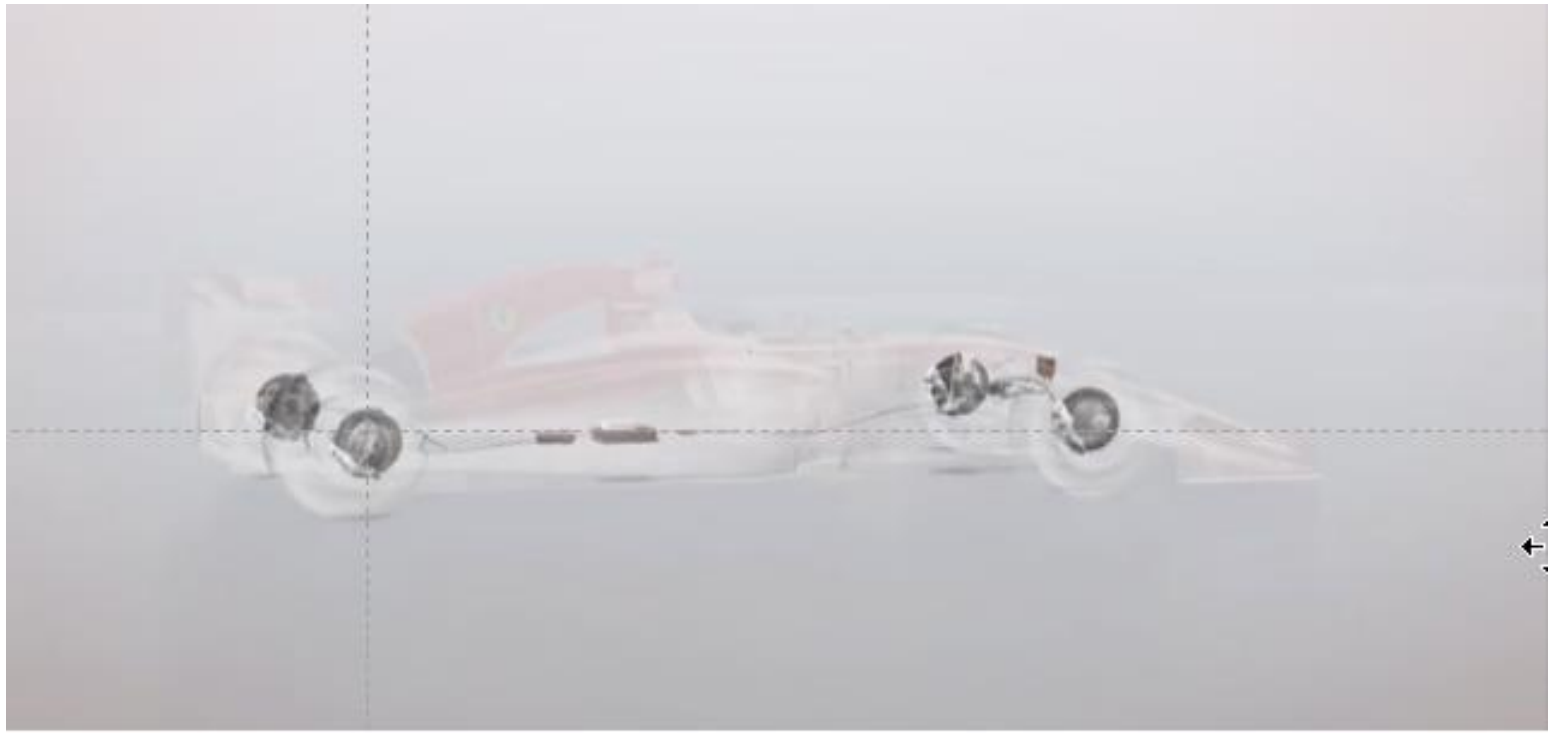

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TwinswHeel gains competitive edge with validated advanced safety mechanisms

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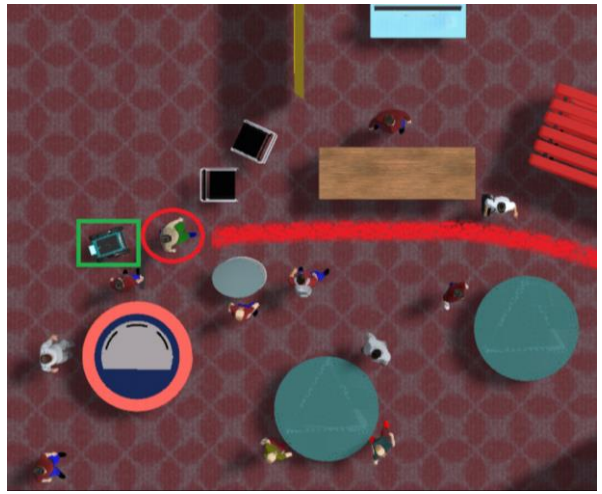
TwinswHeel saves time and costs by streamlining technical choices, development and verification.

$915B

predicted worth of autonomous last-mile delivery market by 2030



TwinswHeel

French startup uses Simcenter to validate advanced safety mechanisms

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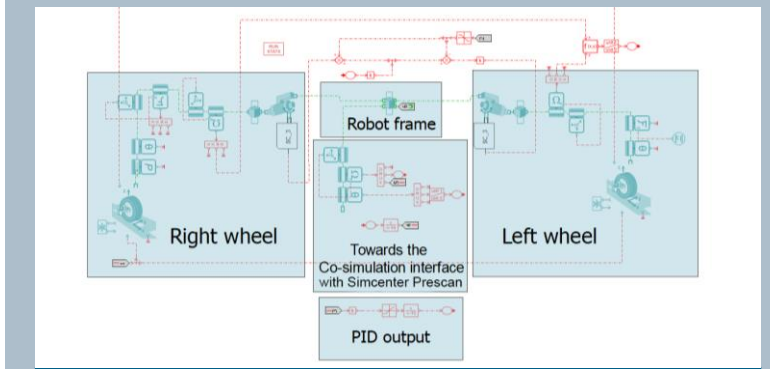
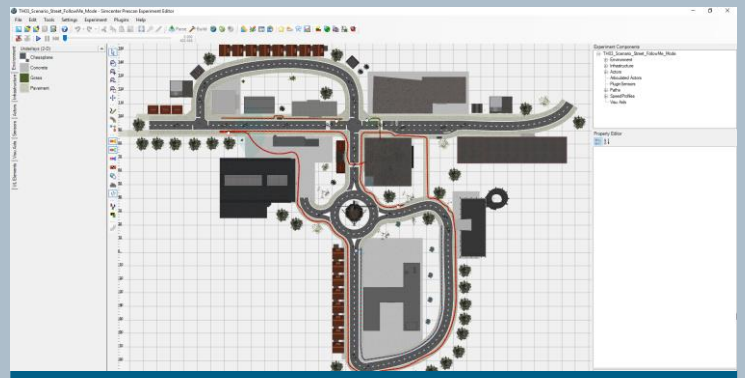
- **Gained competitive edge with validated advanced safety mechanisms**
- **Saved time and costs with accelerated decision-making**
- **Achieved requirements for autonomous vehicle regulations and certification standards**

Using scenarios simulation to get insight of robot behavior



Simcenter Amesim model of the robot



Example of critical scenario

- Use Simcenter Amesim and Simcenter Prescan for digital twin definition and scenarios simulation
- Create and capitalize reproducible and re-usable scenarios

“We use Simcenter Amesim and Simcenter Prescan for model-in-the-loop tests to simulate the latest developments and verify the requirements defined upstream are met. It takes less time and money than doing it on a real vehicle.”

Vincent Talon, CEO

TwinswHeel

French startup uses Simcenter to design smart delivery droid

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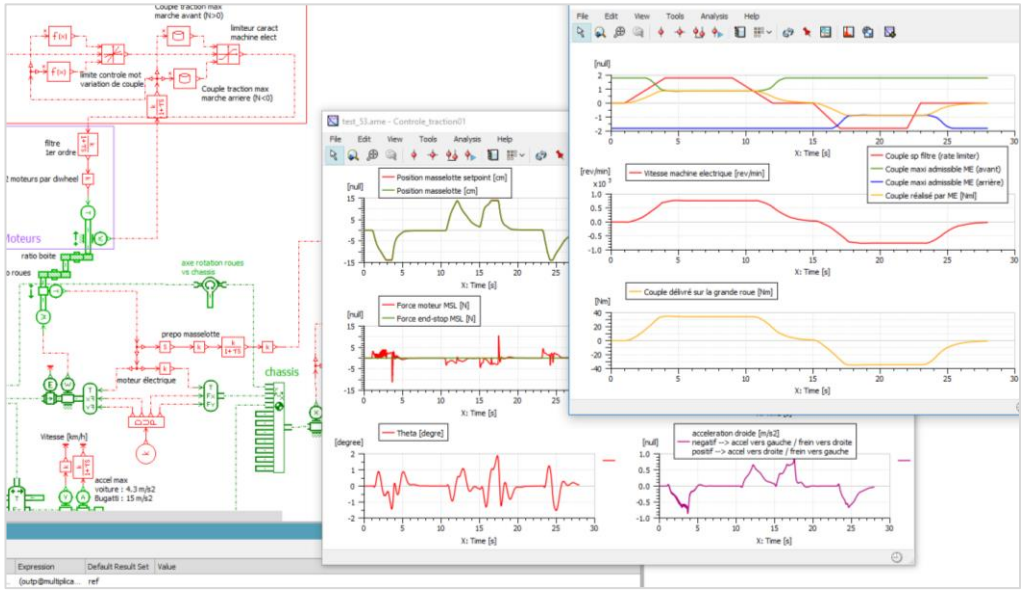

- **Provided robust solutions that enable to move forward rapidly**
- **Built models to select vehicle architectures**
- **Validated control laws and artificial intelligence supervisors for vehicle movements decision-making**

“Simcenter solutions enable start-ups to develop their solutions quickly and test multiple variants to choose the optimal solution. Simcenter Amesim is the optimal software for multi-domain modeling. ”

Vincent Talon, CEO TwinswHeel

Voith Turbo

Optimizing fuel consumption, cooling performance and driving comfort with Simcenter System Simulation solutions

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Ingenuity for life

- **Working algorithm directly imported in transmission control unit**
- **Model availability very early in the development stage**
- **Management of the huge variety of versions**

“Simcenter Amesim helps us fix and predict the complexity of such a huge development project at the very beginning, from a very high level to a more detailed one.”

Oliver Kaufmann, Simulation & System Evaluation Manager

Voith Turbo

Designing hybrid powertrains with Simcenter Amesim

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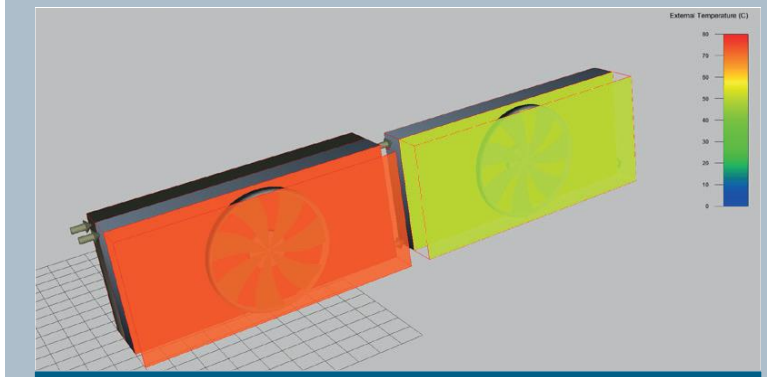
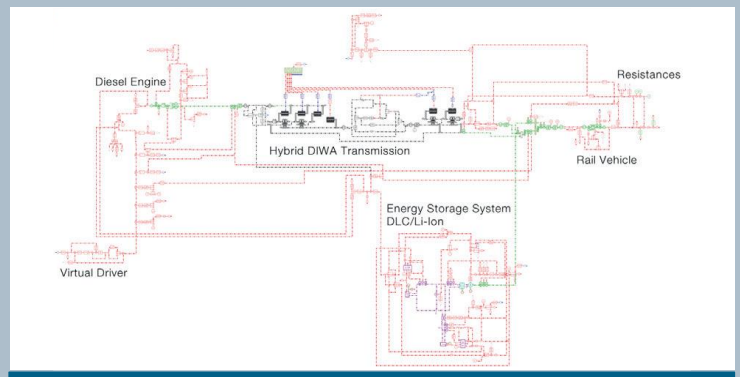
Ingenuity for life

- **Addressed hybrid propulsion system complexity**
- **Predicted lifecycle cost savings**
- **Reduced development and optimization time and costs**

Innovative propulsion solutions for diesel-driven railway vehicles



Stacked coolers behavior analysis



Multi-domain rail vehicle model

- Analyze energy storage system efficiency and lifetime
- Study the economic and technical viability of hybrid projects

"…Simcenter Amesim allows me to save time – to build up a purely signal-based model of a complex train hydraulic system would require much more effort."

Sebastian Schmid, Research and Development Engineer

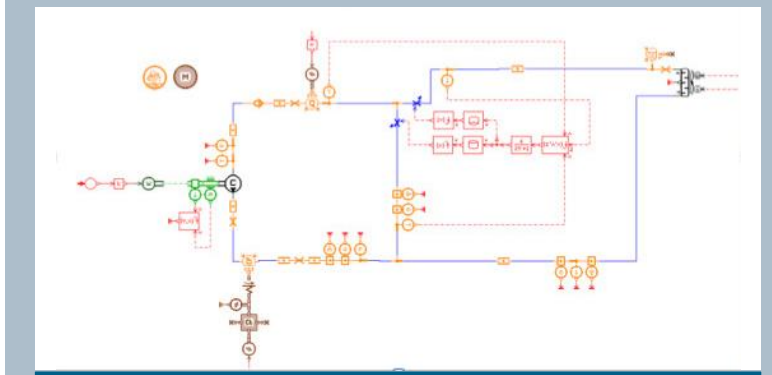
Voith Turbo

Improving rail vehicle cooling system using Simcenter Amesim

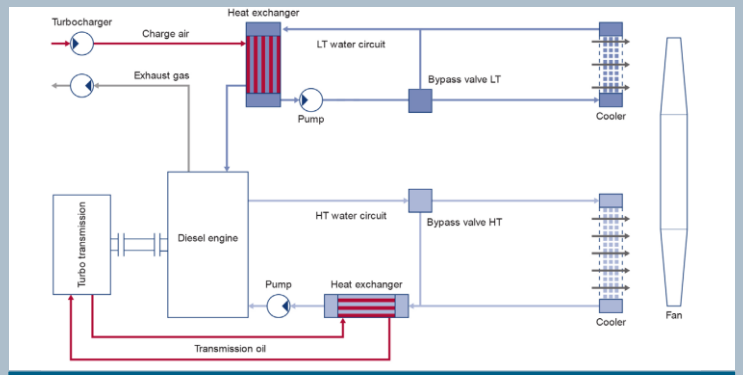
SIEMENS
Ingenuity for life

- **Reduced number of physical prototypes**
- **Optimized design process by using a global mechatronic simulation platform for all product lines**
- **Facilitated analysis of global system behavior**

Develop cooling system model to cut cost and save energy



Cooling system simulation



Cooling network for a hydraulic locomotive

- Extend the use of Simcenter Amesim to locomotive cooling systems design
- Build model with different system details to get real outputs on complex components

“ We use the software for all our simulations on all product lines in this division every day.”

Sebastian Knirsch, Head of System Engineering

Voith Turbo

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Oliver Kaufmann, Simulation & System Evaluation Manager

IDIADA

Engineering Services Provider uses Simcenter software to exploit competitive advantage with system integration at full-vehicle level

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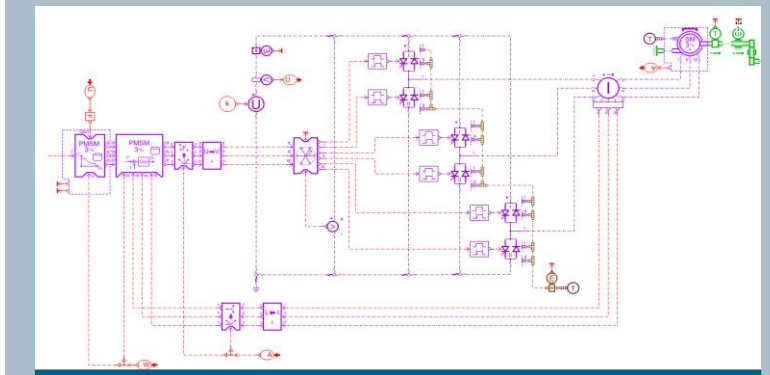
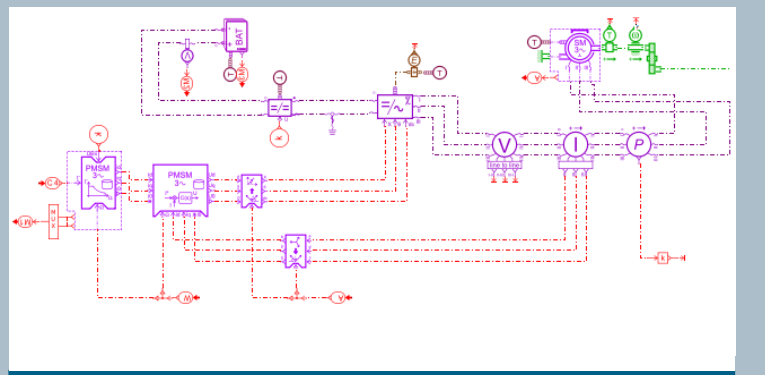
- **Fully-integrated HEV model, prediction capable for energy and performance of all systems, to be used as virtual development mule**
- **Dedicated cross-department task force structure, integrating knowledge in all vehicle attributes'**



System modeling of an electric drive system



Model simplification of an electric drive system

- Pre-size systems for vehicle electrification
- Build a complex system out of validated component models with Simcenter Amesim

"The benefit of Simcenter solutions are calculation flexibility, accuracy, and consistency of results given the right input."

Guillem Badia, Project Manager, Powertrain Innovation

Continental Engineering Services

Optimizing driving range of electric vehicles with Simcenter Amesim

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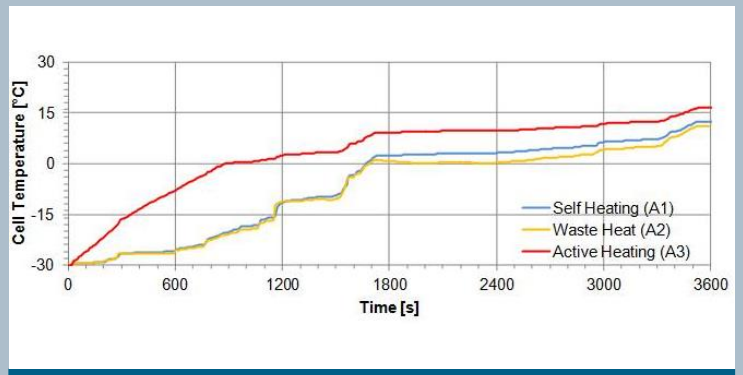
- **Shortened early stages of design**
- **Optimized electric vehicle and increased driving range**
- **Enhanced reputation for expertise and knowledge in the marketplace**

Accelerating strategic decisions and prototype development

Optimize electrical vehicle drivetrain



Battery-heating test in winter conditions

- Evaluate the impact of thermal management strategies on vehicle performance
- Compare different battery heating and cooling methods

“We were able to rapidly select the right architecture with the best performance and focus on the next steps of the project.”

Sebastian Brixner, System Engineer

Lion Electric optimizes battery design and thermal management

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Lion Electric makes the right decisions from the start, speeding time-to-market.

41

projected number of global megacities by 2030

The Lion Electric Co. and Maya HTT

Reducing electric bus development time with Simcenter Amesim

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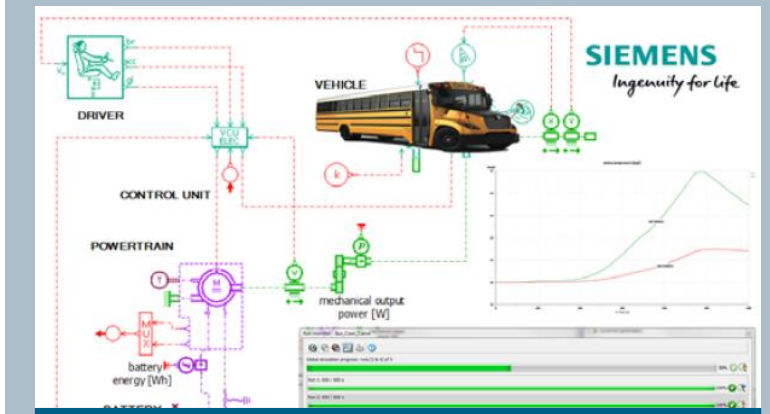
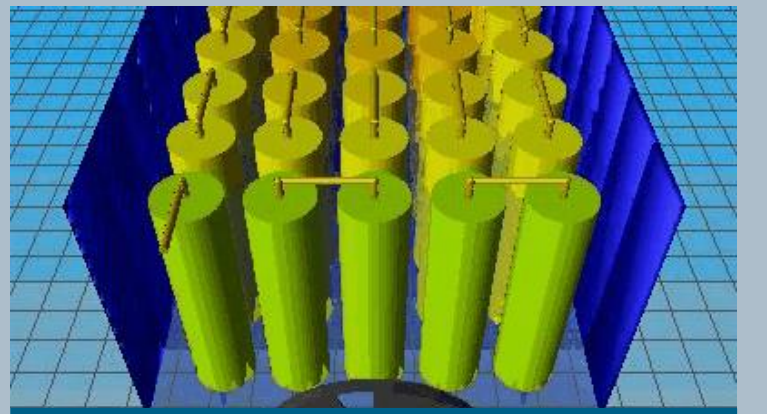
- **Digital detailed model of battery successfully built**
- **Safety, energy consumption, passenger comfort and vehicle performances accurately evaluated**

Electric drivetrain modeling for vehicle performance prediction



Full electric bus model



Battery pack temperature analysis

- Validate different electric drivetrains concepts and driving scenarios early in the process
- Study interactions between mechanical, electrical, thermal and vibrational phenomena
- Integrate supplied components like batteries, heat exchangers, doors mechanisms …

“The Simcenter Amesim software solution will allow our R&D department to improve our vehicle performance while reducing physical test phases and reducing costs”

Hugues Beaudry, Vice-president Product Development, The Lion Electric Co.

Magna Steyr Engineering

Accelerating hybrid vehicle development thanks to Simcenter Amesim

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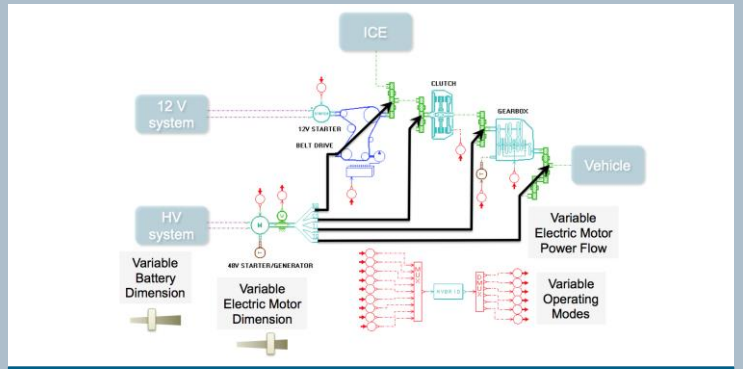
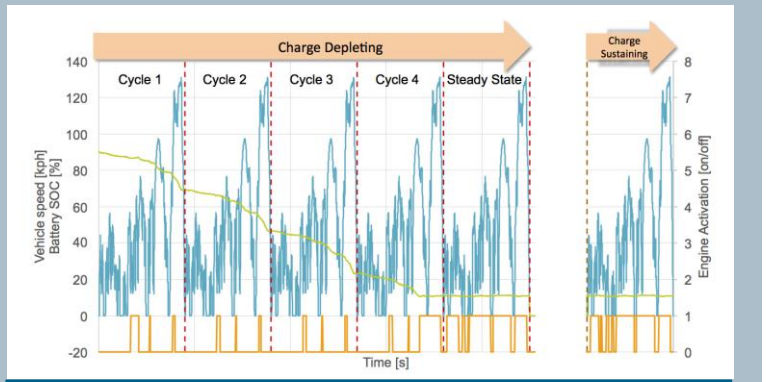
- **Reduced simulation interpretation effort**
- **Boosted components sizing**
- **Maximized design efficiency with minimum development cost**

Forward through model-based systems engineering



Customizable hybrid system modeling



Comparison of battery charge reactions

- Analyze different hybrid vehicle architectures and operating strategies
- Improve validation accuracy of simulation models

“Enabling seamless cost reduction and time savings, Simcenter Amesim is now being used to address more projects.”

Michael Martin,
System Simulation Manager for Driving Performance and Fuel Efficiency

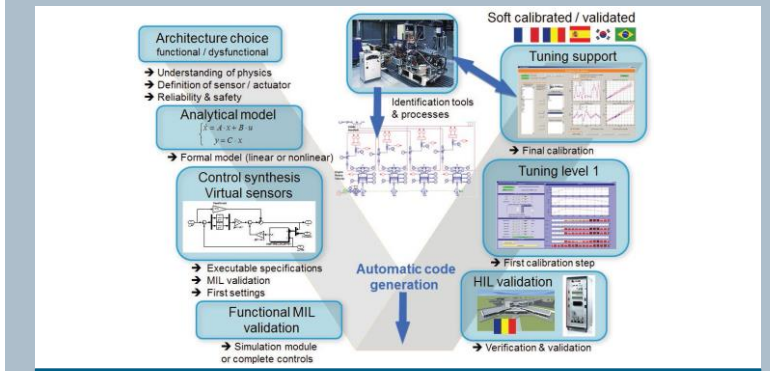
Renault

Focusing on innovation thanks to Simcenter Amesim

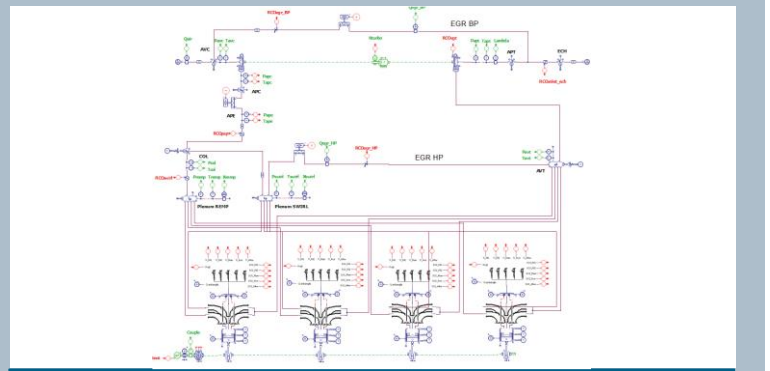
SIEMENS
Ingenuity for life

- **Reduced time needed for model identification by 80 percent**
- **Enabled Renault engineers to focus on innovation**
- **Realized significant cost savings**

Model-based systems engineering applied to control development



Renault MBSE approach for control system



High-frequency 1.6L diesel engine model

- Standardize on Simcenter Amesim for the entire control development process
- Trade physical testing and prototypes for virtual testing and prototypes

“ This project with Siemens PLM Software has enabled us to reduce the time required for complete model identification by a factor of five, from 50 days to only 10.”

Vincent Talo, Team Leader

Renault
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Reaching high energy savings in hybrid vehicles using Simcenter Amesim

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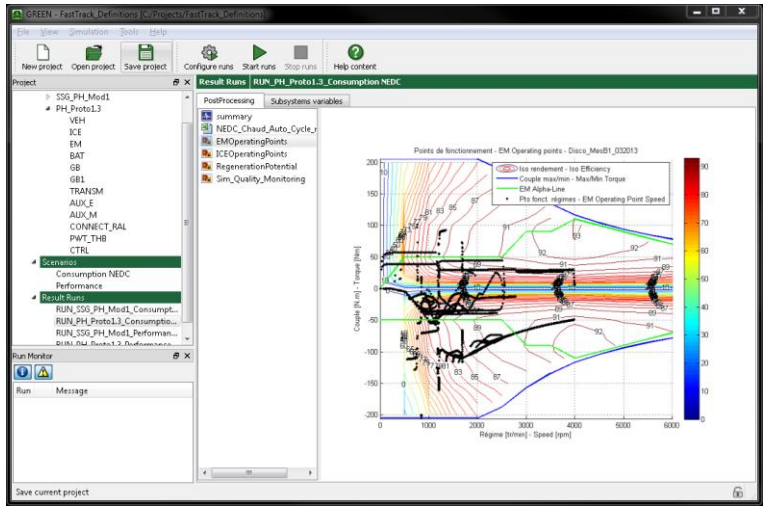
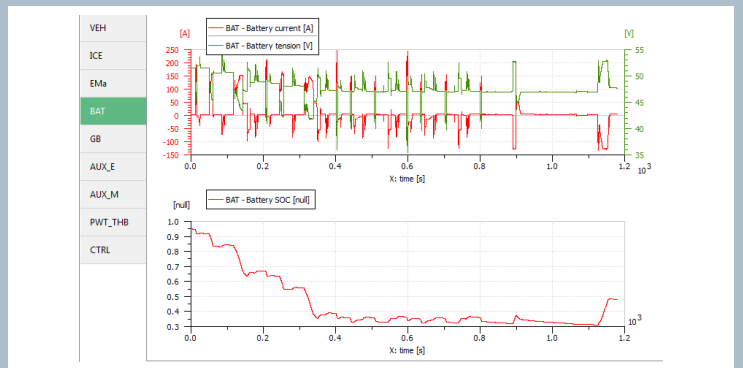
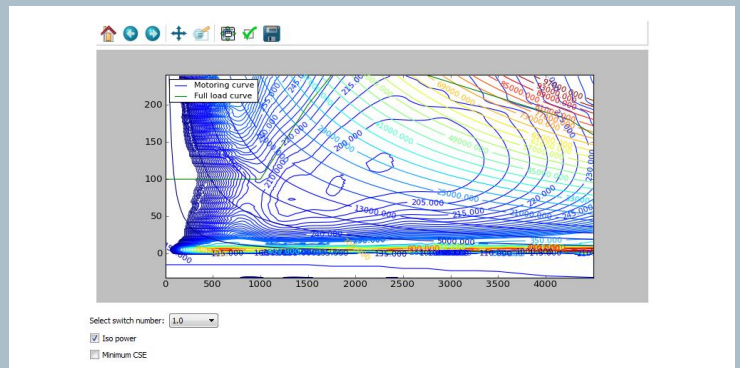


- **Delivered high-quality product on-time and with reasonable costs**
- **Created flexible development platform to support future projects**
- **Shortened time-to-market**

Operating complex multi-domain analyses



Battery behavior simulation



Internal combustion engine analysis

- Facilitate communication and decision-making thanks to a common platform
- Implement co-simulations to assess the energy synthesis of any hybrid configuration

“Simcenter Amesim enables us to get a deep insight on energy performance of hybrid architectures and helps us select optimal architectures that fit our requirements early in the design process.”

Eric Chauvelier, Method and Simulation Manager

Renault

Reaching high energy savings in hybrid vehicles using Simcenter Amesim

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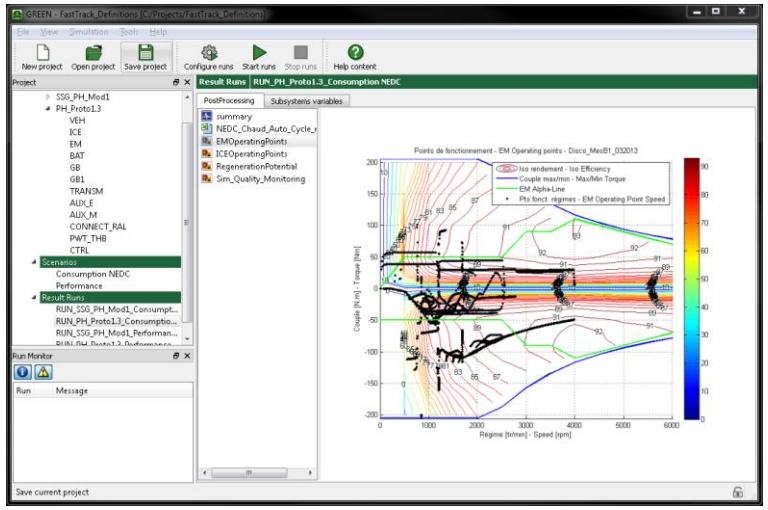

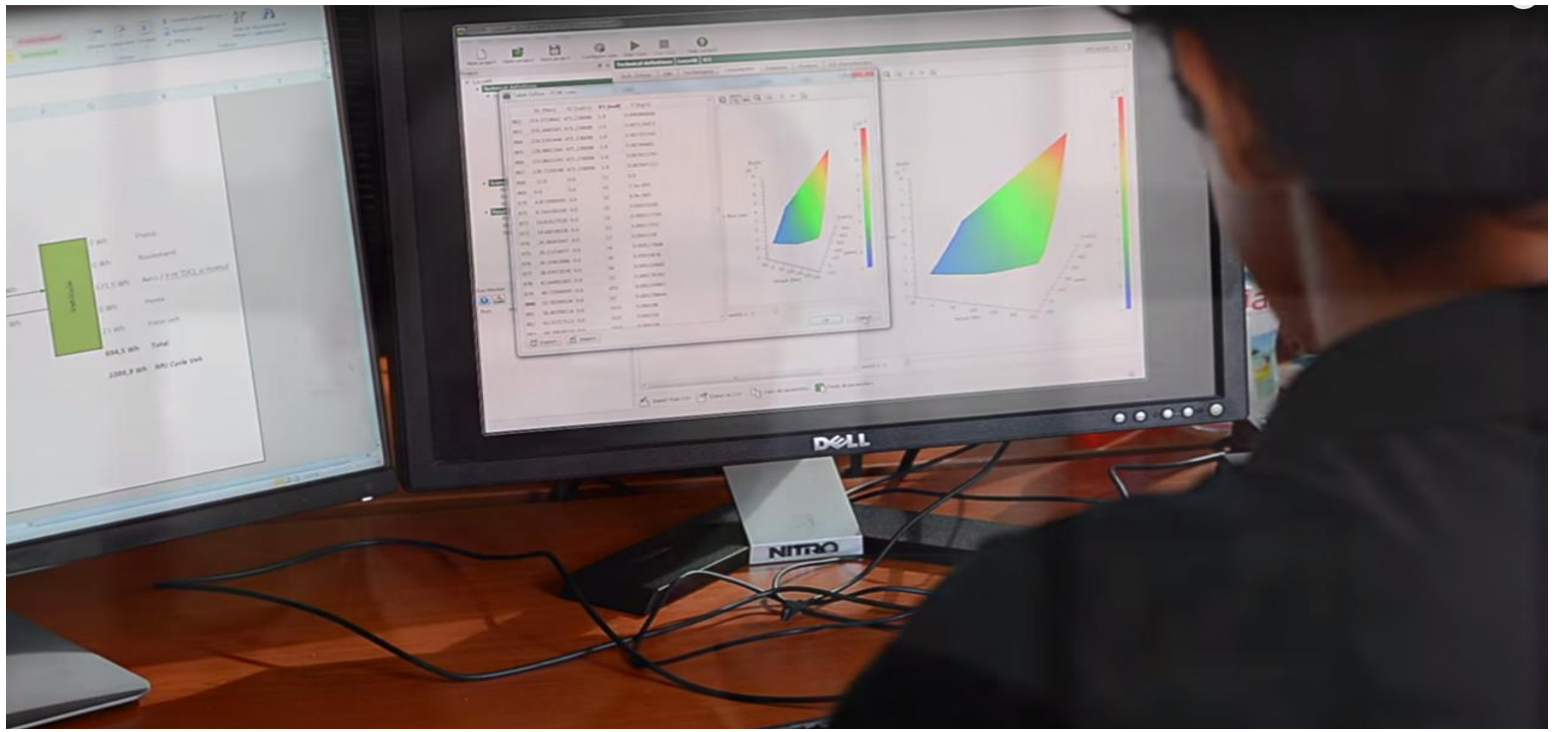

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Renault

Smoothing out the cold start of its diesel engine using Simcenter Amesim

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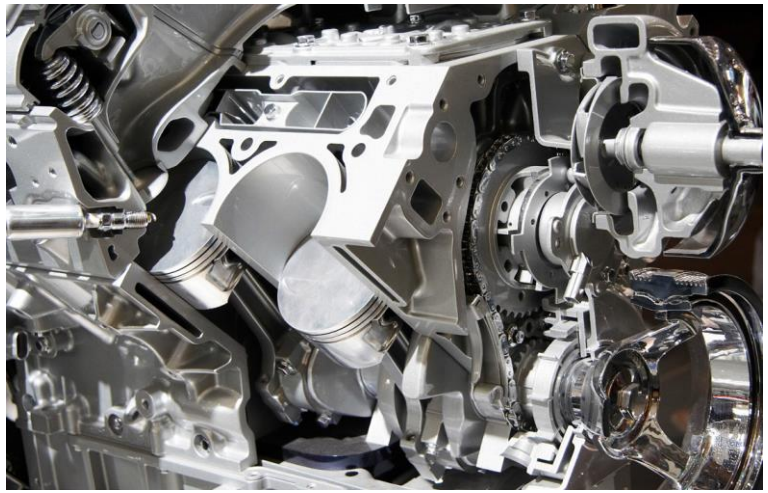
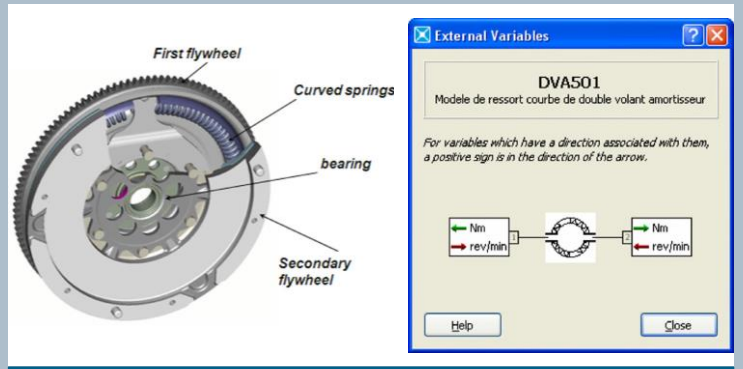
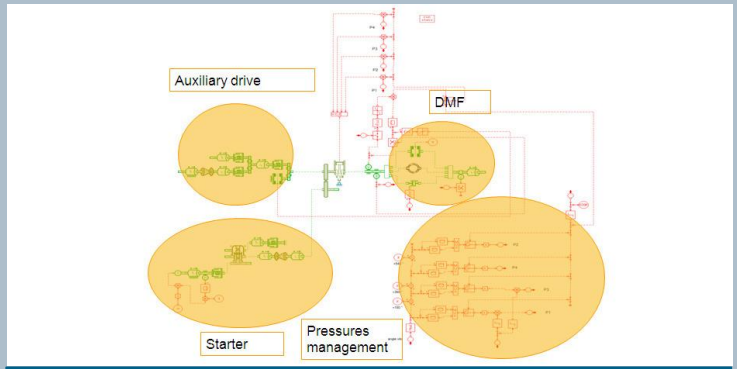


- **Reduced analysis time significantly compared to test-only studies**
- **Enabled Renault to answer questions raised by test measurements**
- **Facilitated the ability to study several physical domains together**

Model customization to investigate engine cold start



In-house model of dual mass flywheel



Model developed to study engine cold start

- Use Simcenter Amesim to analyze test measurements
- Develop complete overview by integrating test and simulation into the design process

"This type of first-order approach is extremely effective and couldn't be done quicker or at a lower cost without the use of such innovative software as Simcenter Amesim."

Michel Gizard, Torque Transfer Expert

Renault

Drastically cutting time on AMT development with Simcenter Amesim

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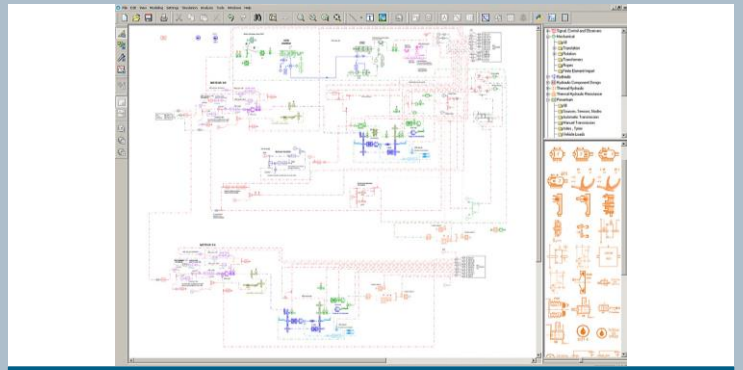
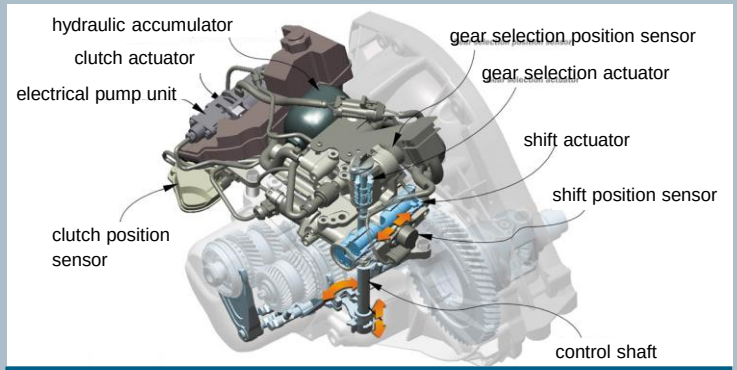
- **Cut AMT development time almost in half**
- **Refined performance of the mechatronics system up-front**
- **Achieved optimal powertrain performance**

From model to design optimization of automated manual transmission



Complete AMT system model



AMT complex mechatronic system analysis

- Avoid late-stage problems and delays
- Use virtual engine and transmission as stand-ins while the hardware is in development

“Using Simcenter Amesim for simulation-based development enabled Renault to shorten AMT development time considerably.”

Edouard Négre, Senior Design Engineer

Hyundai Motor Company optimizes hybrid vehicle performance

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Hyundai Motor Company improved energy efficiency and saved HEV development time and cost.

40%

amount of physical vehicle testing reduced

Hyundai Motor Company

Optimizing hybrid vehicle performance with Simcenter Amesim

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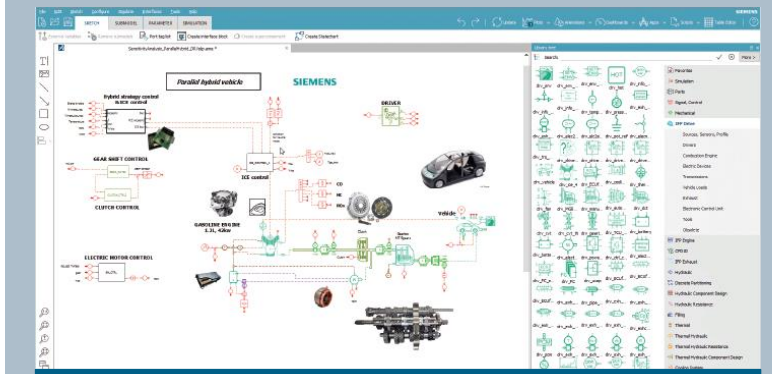
Ingenuity for life

- **Increased vehicle performance while improving energy efficiency**
- **Dramatically reduced the required number of physical tests**
- **Significantly saved HEV development time and cost**

Implementing a simulation-based approach & reducing physical testing



Model the subsystem controllers

Optimize overall performance

- Building realistic simulation models for the full vehicle, including controls
- Creating a closed-loop, model-based system simulation model that can run in real time for HiL validation

“By pre-defining major calibration values using HiL simulation, we were able to reduce the number of actual vehicle tests by 40 percent.”

Bang Jae-Sung, Ph.D., Senior Engineer R&D Center

Hyundai Motor Company optimizes hybrid vehicle performance

SIEMENS
Ingenuity for life

Hyundai Motor Company improved energy efficiency and saved HEV development time and cost.

40%

amount of physical vehicle testing reduced

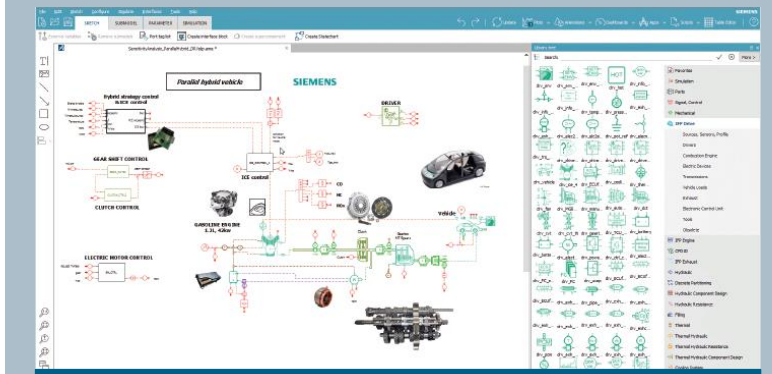
Hyundai Motor Company

Optimizing hybrid vehicle performance with Simcenter Amesim

SIEMENS
Ingenuity for life

- **Increased vehicle performance while improving energy efficiency**
- **Dramatically reduced the required number of physical tests**
- **Significantly saved HEV development time and cost**

Implementing a simulation-based approach & reducing physical testing



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CAE Value

Performing multi-attribute balancing of hybrid vehicles with Simcenter Amesim and Simcenter HEEDS

SIEMENS
Ingenuity for life

- **Optimized powertrain mount characteristics**
- **Performed tradeoff studies for NVH, durability and vehicle dynamics**
- **Streamlined collaboration between different engineering groups**

“Thanks to the integration of these two software we managed to generate thirty promising designs for future studies. If we had used the traditional manual approach we would have ended up with 2 or 3 designs.”

Erik Wendeberg, Senior Technical Consultant

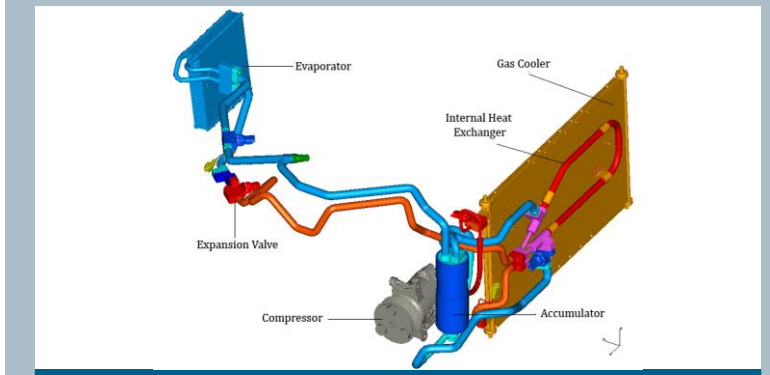
Calsonic Kansei

Optimizing the thermal management with Simcenter Amesim

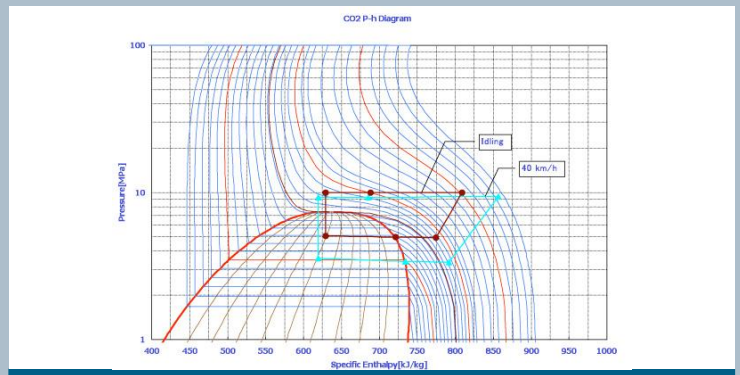
SIEMENS
Ingenuity for life

- **Reduced the number of physical prototypes by 50 percent**
- **Increased accuracy of models by at least 80 percent**

Simulating with accuracy the air conditioning system performance



Cooling system architecture



Mollier pressure-enthalpy diagrams

- Speed up design process
- Link the engine model with the AC system and cabin models

“The beauty of Simcenter Amesim Vehicle Thermal Management is that the model […] can be used as a basis for a wide range of future designs without starting from scratch each time.”

Junichiro Hara, Senior Engineer and Project Manager

Automobili Lamborghini

Creating a new driveline concept design using Simcenter Amesim

SIEMENS
Ingenuity for life

- **Designed the torsional vibration characteristic of the Aventador LP700-4 driveline**
- **Supported torsional vibro-acoustic driveline optimization**

Designing the Aventador LP700-4 torsional vibro-acoustic driveline

Powertrain and gearbox noise optimization

Torsional behavior of the driveline

- Model easily complex dynamic systems using prepackaged components
- Generate models in function of the phenomena the user intends to investigate

“The true power of Simcenter Amesim is demonstrated by how easy it is to evaluate different driving conditions, software or hardware changes and even different configurations”.

Ing. Claudio Manzali, R&D

Honda uses Simcenter solutions and services to solve hybrid engine restart vibrations

SIEMENS
Ingenuity for life

Simcenter Engineering services uses testing and simulation tools to help minimize noise and vibration

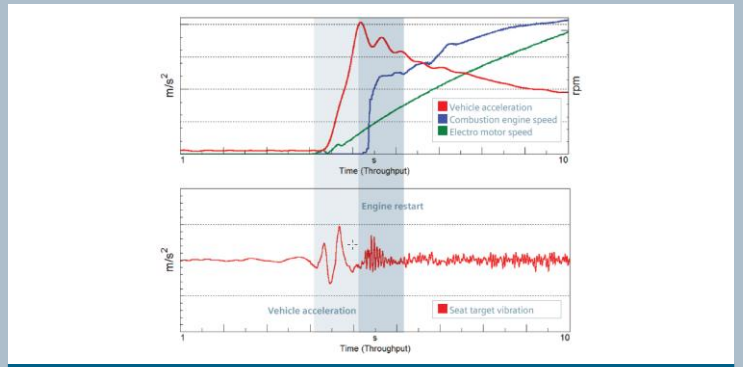
Integrated
1D, 3D CAE and test

Honda R&D
Resolving NVH of hybrid vehicles with Simcenter solutions

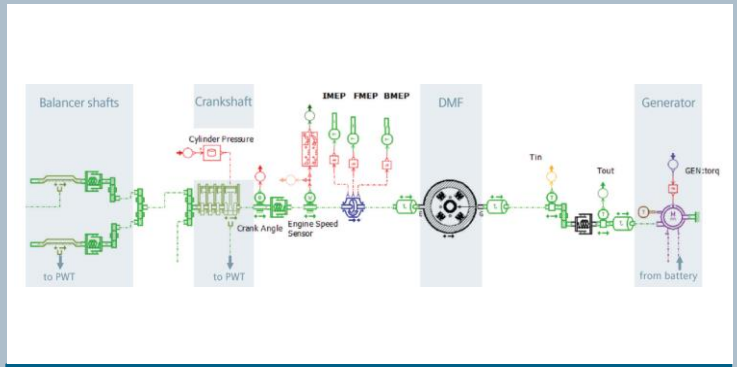
SIEMENS
Ingenuity for life

- **Development of a new methodology that allows accurate prediction of powertrain behavior during idling restart**
- **Integration of model-based development throughout Honda departments**
- **Better prediction of time to market through better control of the development cycle**

Predicting the entire powertrain restart process



Vehicle acceleration maneuver analysis in hybrid mode



Hybrid driveline torsional modeling to study ICE restart vibrations

- Develop a solid, long-term partnership for collaboration and co-development
- Use testing and processing hardware and software for data acquisition, model development, analysis and validation

"Thanks to our collaboration with Simcenter Engineering, our development cycle time is under better control."

Satoshi Watanabe, Model-Based Development for Powertrain NVH

YouTube movie

Dongfeng Motor shortens development cycle by optimizing simulation design

SIEMENS
Ingenuity for life

Dongfeng Motor enhances accuracy of steering force characteristic models.

≤10%

margin of error for EPS simulation results

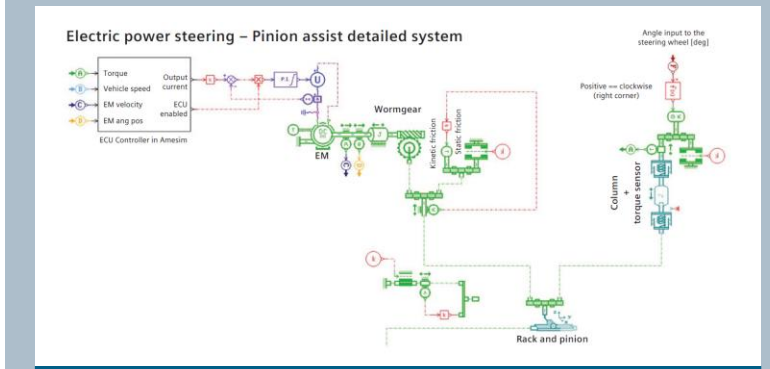
Technical center of Dongfeng Motor Corporation

Improving accuracy of steering-force models with Simcenter

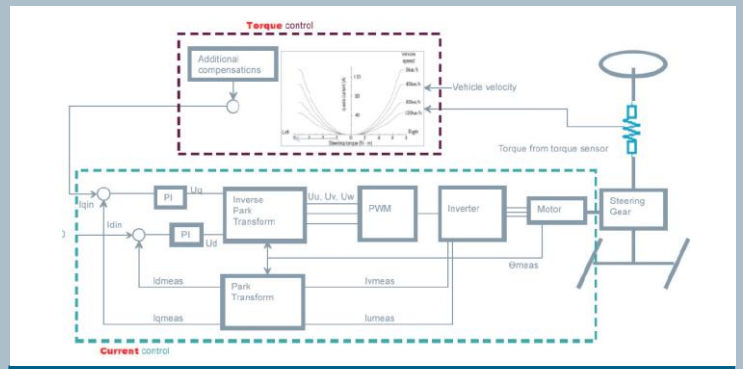
SIEMENS
Ingenuity for life

- **Shortened development cycle by optimizing simulation design**
- **Enhanced accuracy of steering-force characteristic models**
- **Significantly increased efficiency of EPS system parameter calibration**

Modeling the electric power steering system



Simcenter Amesim model of P-EPS system



Model schematic diagram of the project

- Enable joint simulation with multibody system dynamics software
- Create multi-layer, multi-level models of different complexities

“Furthermore, Siemens Digital Industries Software greatly outmatched other service suppliers with much more comprehensive and reliable solutions and services.”

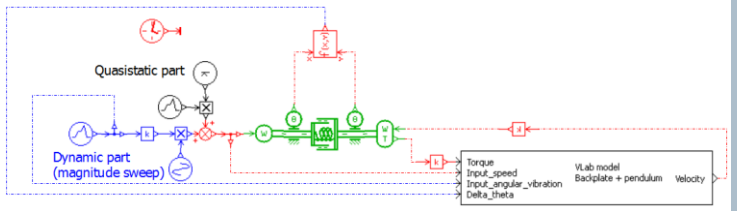
Dr. Li Lingyang, Senior Engineer, Application and Development, CAE Technology

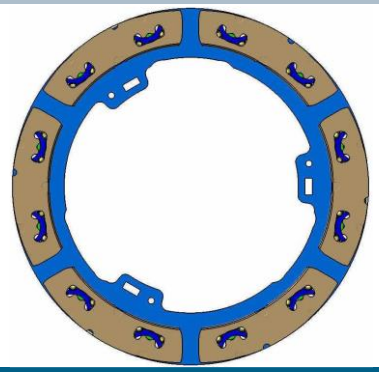
Valeo
Complementarity of 0D-3D simulations tools

SIEMENS
Ingenuity for life

- **Achieved engine downsizing and downspeeding necessary for fuel consumption and CO2 together with NVH comfort based on pendulum proposal**
- **Developed new simulation strategy at Valeo**
- **Adapted models to keep the best compromise productivity/complexity/accuracy**

Prediction of the pendulum instability





Simcenter Amesim model coupled with pendulum LMS Virtual.Lab Motion model

- Need of technological breakthrough to go beyond limitations of conventional damping systems

“Complementarity of 0D-3D simulations tools : application to pendulum damper.”

Hervé Mahé, Yannick Lefebvre, Valéo Transmission

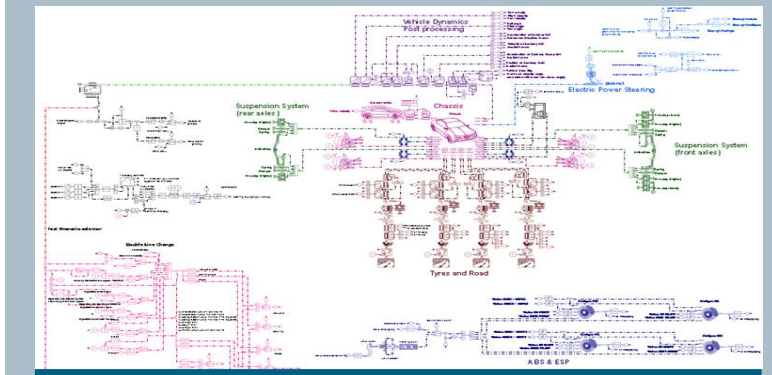
FAW

Building a virtual platform for vehicle development and controls verification with Simcenter Amesim and Simcenter Engineering

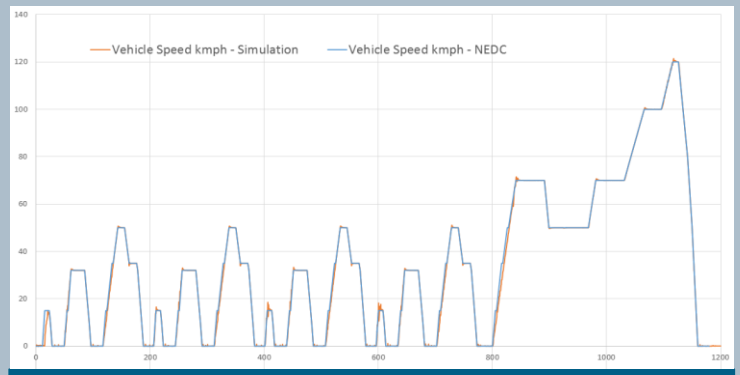
SIEMENS
Ingenuity for life

- **Provided a consistent modeling approach throughout the product development process**
- **Leveraged a complete vehicle development environment**
- **Greatly reduced the electric control system development cycle**

Optimizing fuel consumption, drivability, handling and comfort



Simcenter Amesim vehicle dynamic model



Comparison of online simulation and NEDC simulation results

- Simulate subsystems in real time and applied hybrid HiL testing for controls verification
- Apply a consistent modeling approach throughout the development process

"By using Simcenter solutions, we now have the capabilities to model independently, which makes us even more competitive."

Dr. Zheng Lei, Administrative Office Director, R&D Department, Intelligent Networking Vehicles

FAW builds virtual platform for vehicle development and controls verification

SIEMENS
Ingenuity for life

FAW uses an open development environment that enables joint modeling between departments and suppliers.

>20

Scenarios defined for validation on HiL test bench

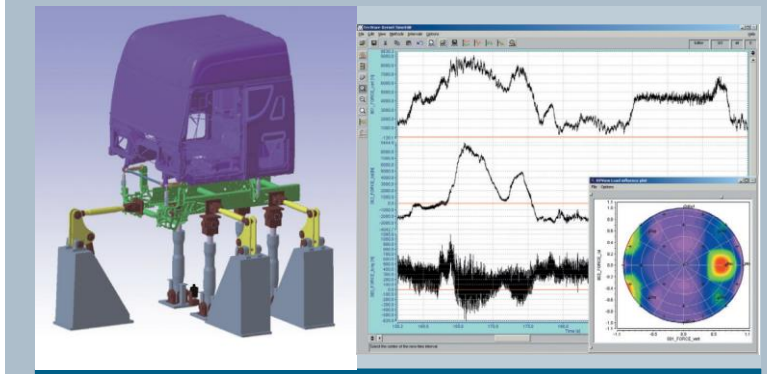
China FAW

Cutting significantly vehicle development time and costs for durability engineering

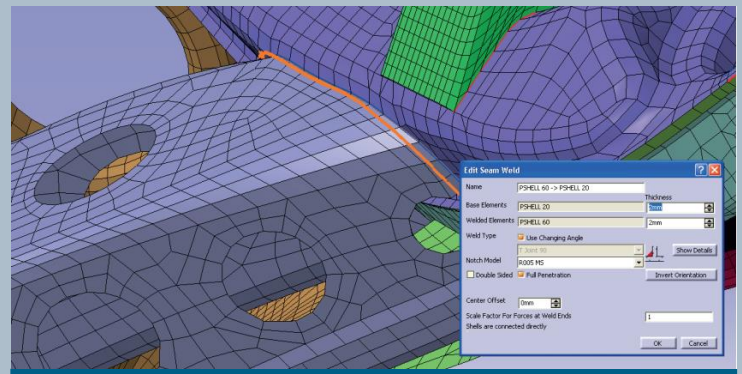
SIEMENS
Ingenuity for life

- **Optimized component structures for durability performance**
- **Significantly cut the cost of vehicle development by shortening the design cycle**
- **Brought robust products to market faster than the competition**

Durability as a key differentiator in challenging times



Optimizing structural components for durability performance



Accurately predicting road loads on vehicle components

- Employ a pragmatic approach that includes data measured on the track in a complete, integrated simulation solution
- Replicate a laboratory vehicle road load test using multibody simulation and experimental data

“Thanks to the use of Simcenter solutions from Siemens PLM Software, we cut costs during the development of the commercial truck by 20 million rmb.”

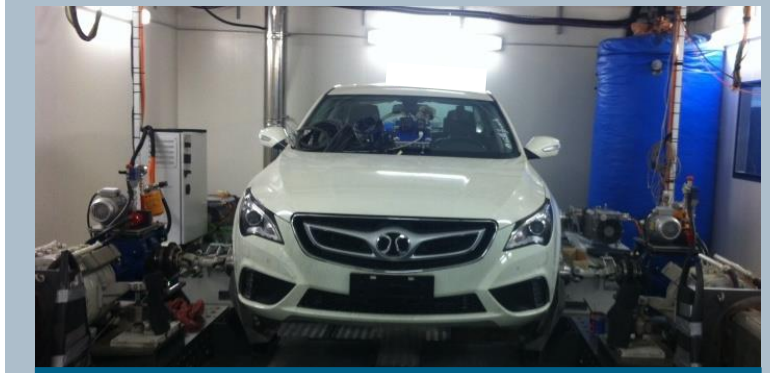
Xin Yan, Body Department

BAIC Motor
Improve fuel economy performance in the D60

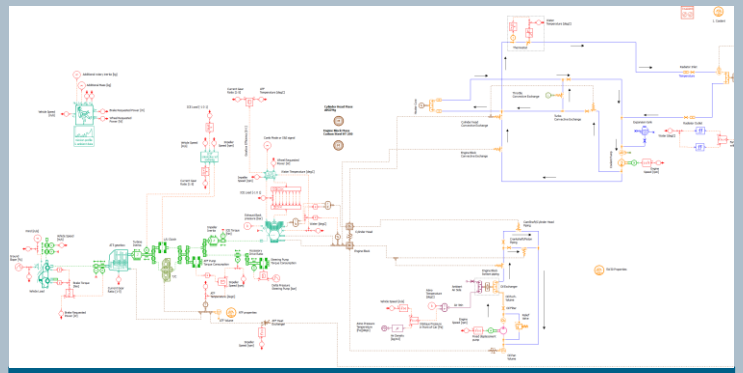
SIEMENS
Ingenuity for life

- **Significantly reduced fuel consumption in the D60**
- **Compliance with fuel efficiency standards**
- **Refined development process, including confronting blind spots and previously ignored problems**

Combination of physical testing with digital simulation



Test data to develop a virtual system model



Vehicle energy management

- Track and lab-based test campaign to provide accurate simulation model data
- Skills, equipment and expertise in MBSE and vehicle energy management

“Working with Simcenter Engineering services has helped us restructure and refine our development process. We are determined and ready to take on previously ignored problems. We will definitely keep setting ambitious targets, beyond fuel economy and durability performance.”

Lv Yuan, Engineer, BAIC Motor R&D Center

SAIC MAXUS uses Siemens Digital Industries Software solutions to optimize vehicle development efficiency

SIEMENS
Ingenuity for life

China's largest automaker selects the Simcenter portfolio for full-vehicle design analysis.

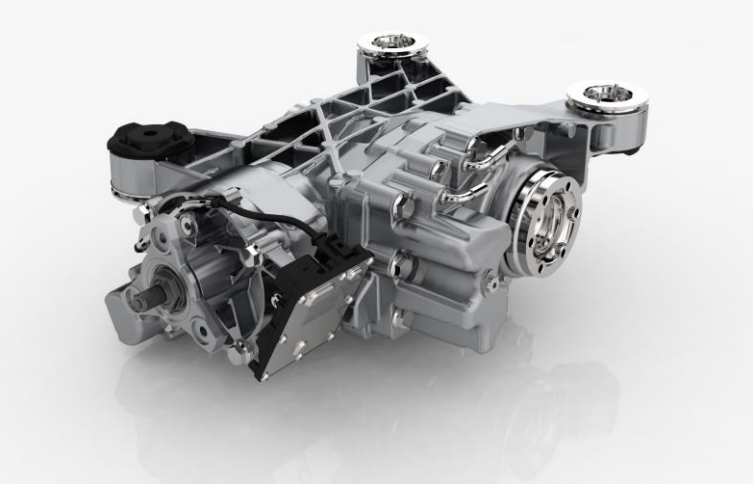
100%

success rate using Simcenter testing solutions to precisely define "hiss" noise in air intake system

BorgWarner

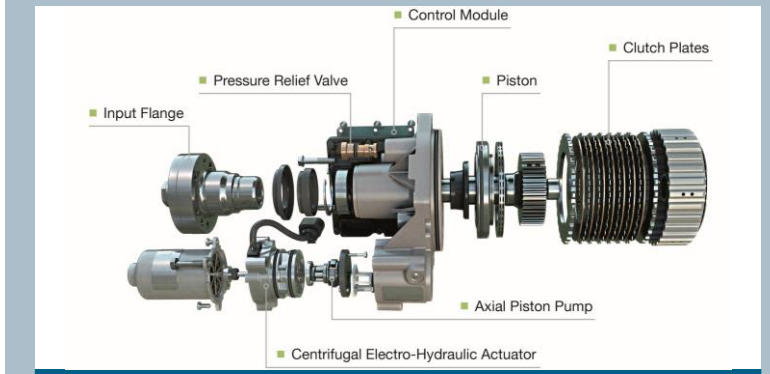
Designing all-wheel drive systems with Simcenter Amesim

SIEMENS
Ingenuity for life

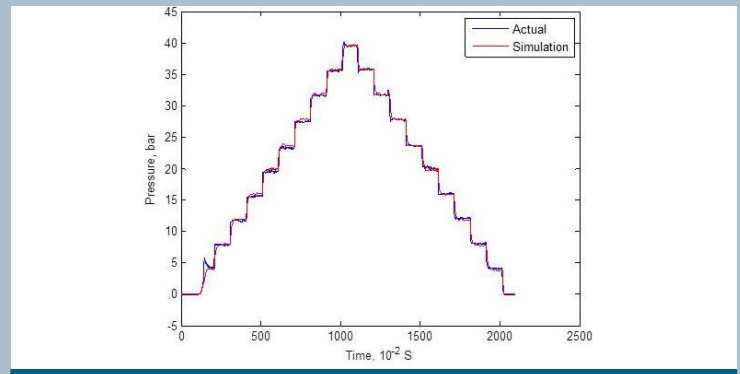


- **Maximized performance of the pump and the coupling**
- **Optimized component size**
- **Reduced number of prototypes, testing costs, time and effort**

Maximizing the performance of the coupling pump



All-wheel drive coupling



Oil pressure analysis

- Study coupling response time at different temperatures
- Analyze pressure fluctuations and pulsations in the axial piston pump

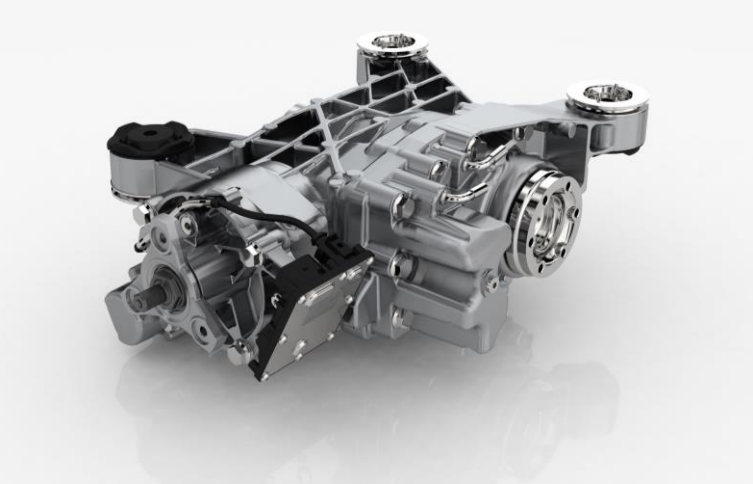
"We can optimize the design using Simcenter Amesim rather than trying it out on a prototype, which would require much more time and effort."

Kathiravan Ramanujam, Simulation Engineer

BorgWarner

Designing all-wheel drive systems with Simcenter Amesim

SIEMENS
Ingenuity for life



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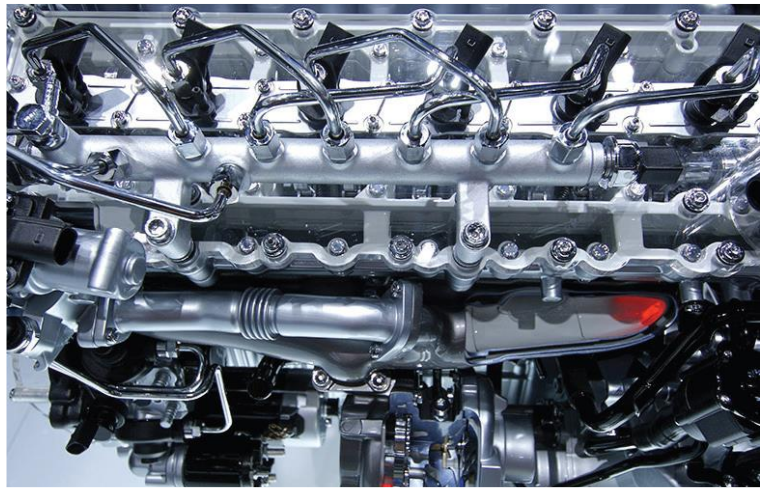
Kathiravan Ramanujam, Simulation Engineer

Delphi Diesel Systems

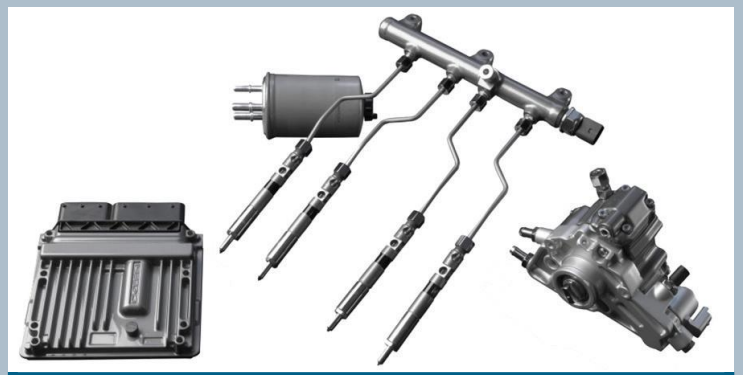
Decreasing vehicles environmental impact with Simcenter Amesim

SIEMENS
Ingenuity for life

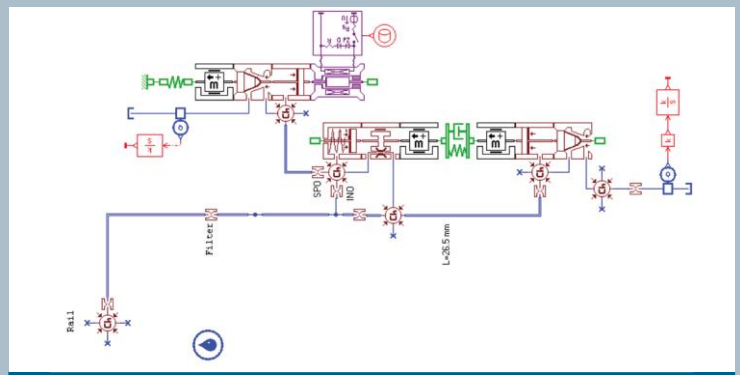


- **Reduced testing, costs and time-to-market**
- **Delivered high-fidelity fuel injection system models**
- **Advanced brand attributes: sustainable development and reduced impact on the environment**

Enhancing diesel fuel injection systems with an optimized design



Diesel injection system components



Model of fuel injection system

- Reduce the number of costly, time-consuming physical tests
- Exchange models among internal teams and customers

“Simulation enables us to study as many injector architecture choices as possible, with different parameters and test conditions. Simcenter Amesim is an ideal tool for this.”

Vincent Pichon, Solenoid Injector Simulation Manager

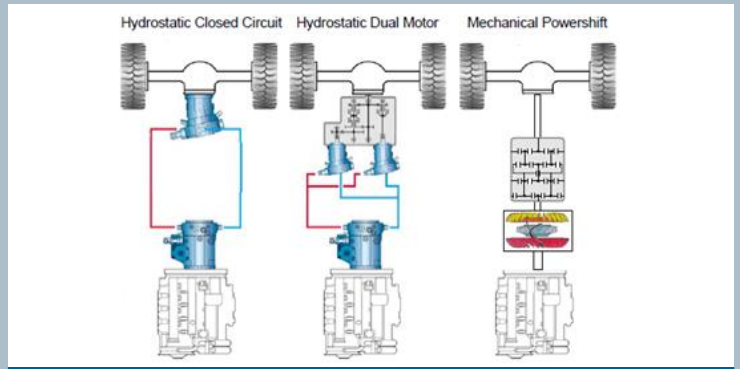
Bosch Rexroth

Simulating hydraulic drive systems using Simcenter Amesim

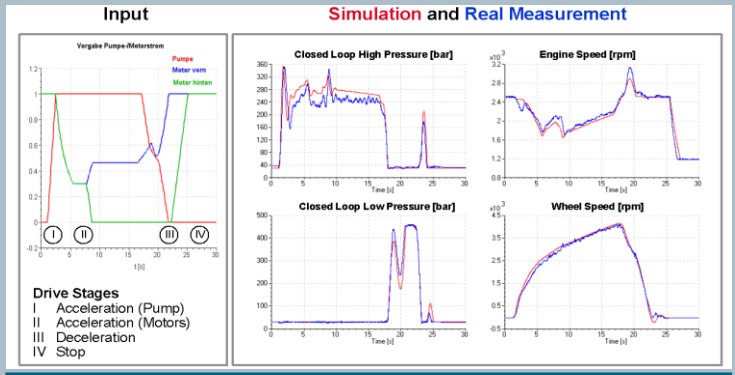
SIEMENS
Ingenuity for life

- **Reduce product development time and cost**
- **Predict dynamic behavior for safe and dependable operation.**
- **Diffusion of simulation activities into engineering departments with different key-activities**

Decision making process based on simulation



Transmission concepts



Comparison simulation – test of a typical drive cycle

- Ergonomic user interface in addition to powerful technical capabilities.
- A library of elements developed “on the job”, i.e. parallel to development projects.

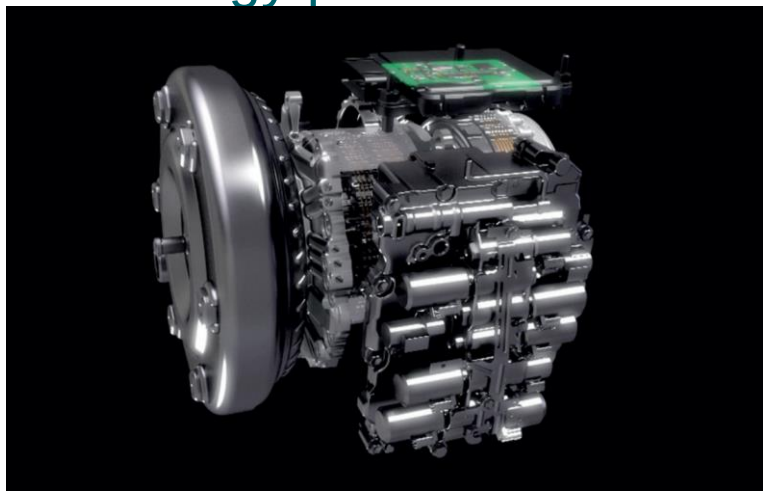
“Simulation of Hydraulic Drive Systems using Library Elements.”

Sorn Stoll, Markus Kliffken, Martin Behm, Steffen Mutschler, Ximing Wang, Bosch Rexroth

Aisin AW

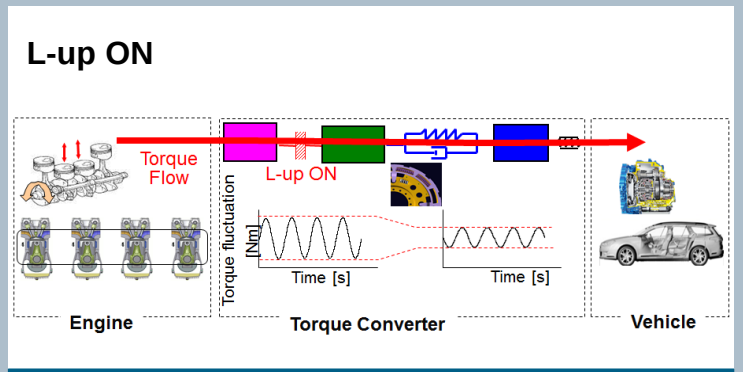
Relying on Simcenter Engineering to strengthen its position as technology partner

SIEMENS
Ingenuity for life

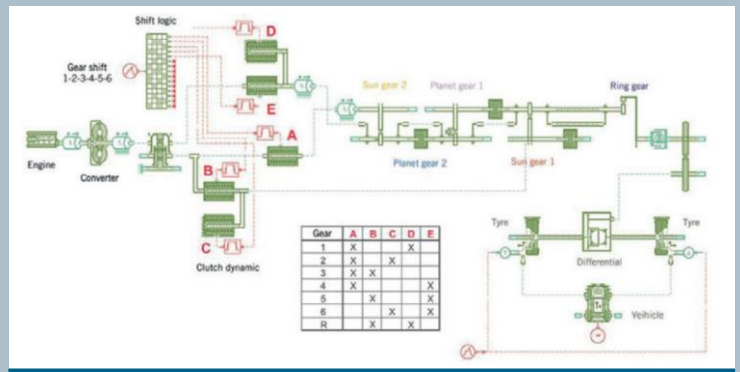


- **Gained 50 percent time reduction when troubleshooting a new NVH issue**
- **Significantly reduced overall development time**
- **Recognized as technology partner of automotive OEMs, resulting in competitive advantage**

Reducing booming, judder and gear noise



Energy flow lock-up booming



Full-vehicle simulation

- Deploy a full vehicle model based approach for the prediction and elimination of clutch judder
- Employ full vehicle modeling approach combining test, 3D and 1D simulation methodologies

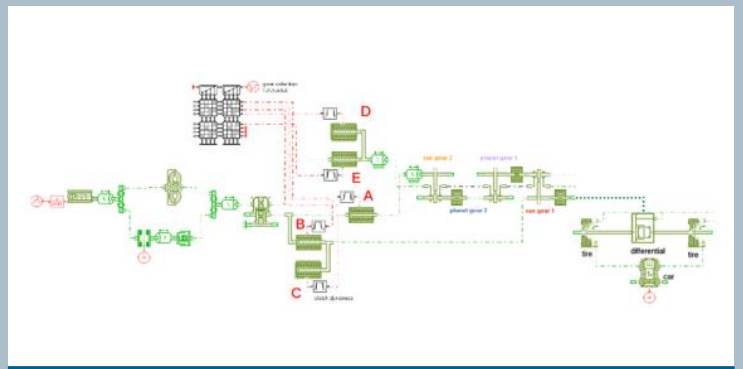
“Many NVH techniques we learned from Simcenter Engineering services are now part of our standard development process, such as transfer path analysis.”

Hiroki Tsuji, Group Manager, Core Component Engineering Department

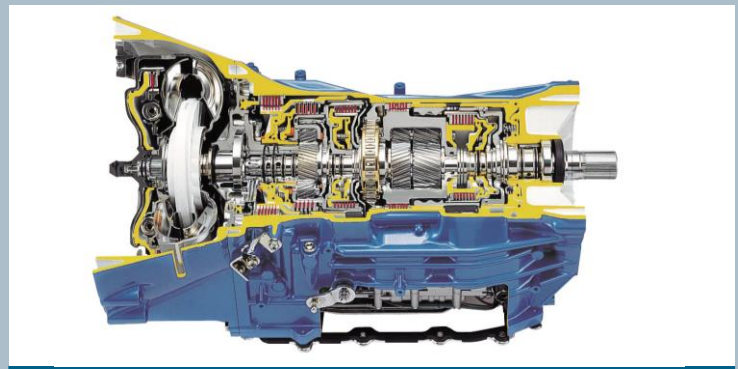
AISIN AW
Establish a procedure to avoid judder

- **Deployed a full vehicle model-based approach for the prediction and elimination of clutch judder**
- **Increased passenger comfort**
- **Engaged on-site assistance for technology, follow-up and communication**

Optimal design of gearbox components



Full vehicle simulation



Torque converter clutch judder

- Take vehicle characteristics into account
- Upfront validation of design modification based on accurate predictions

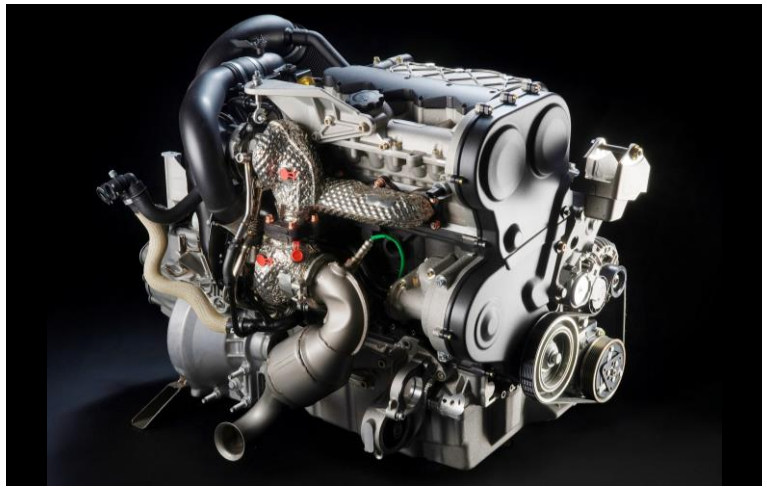
“Thanks to technology transfer, we now addresses issues such as judder upfront in the design phase.”

Hiroki Tsuji
Group Manager, Starting Device Analysis Group, Core Component Engineering Department

MCE-5 DEVELOPMENT

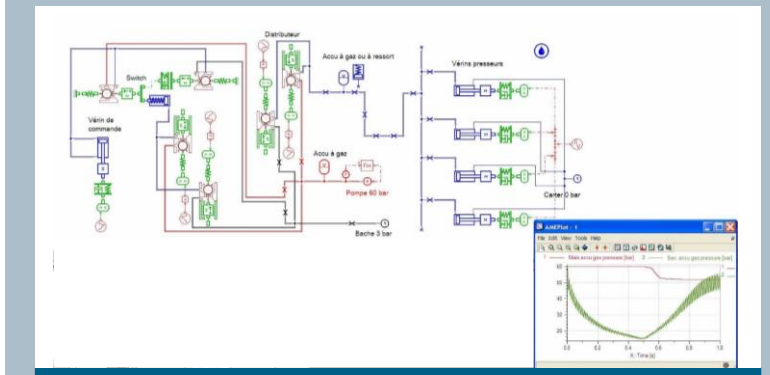
Stretching fuel energy boundaries using Simcenter Amesim

SIEMENS
Ingenuity for life

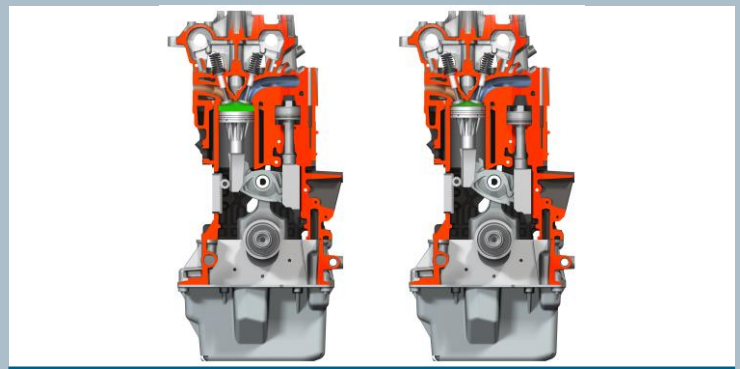


- **Optimized the model during the early design stages**
- **Enhanced internal expertise**
- **Improved quality and efficiency**

Towards a highly energy-efficient mass-series VCRi engine



Model of the pressure-regulating system



Mechanical impact of compression rate (CR)

- Model virtual prototypes early to confirm performance and reliability
- Assess engine behavior without developing a full scale prototype

“Simcenter Amesim helps us clarify our project in terms of tangible costs and time saving.”

Vianney Rabhi, Director of Strategy and Development

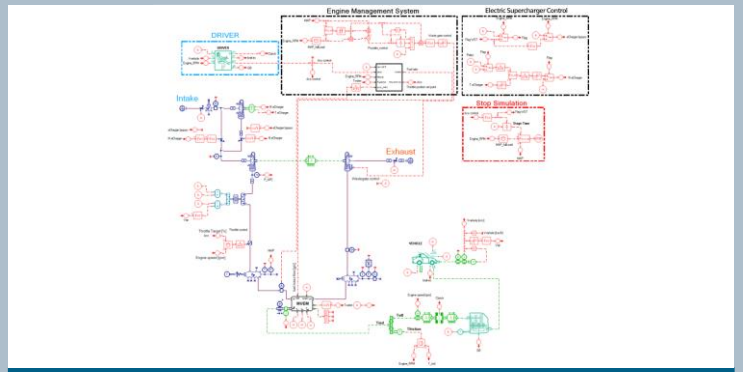
Valeo

Developing groundbreaking technologies thanks to Simcenter Amesim

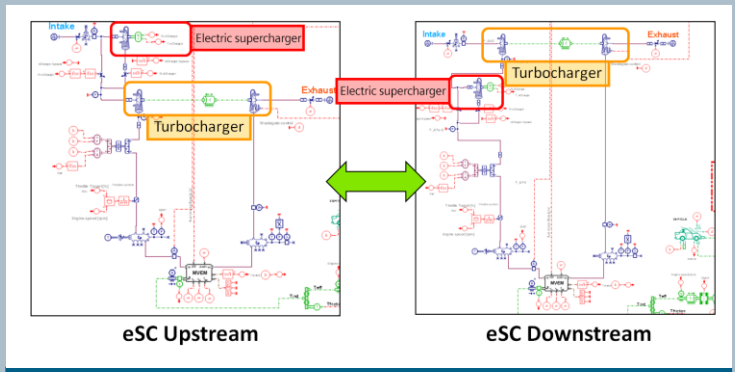
SIEMENS
Ingenuity for life

- **Facilitated rapid decision-making when evaluating new projects**
- **Optimized costs by standardizing the use of mechatronic system simulation**
- **Played a central role for the Powertrain Innovation Department in the development process**

Implement innovative technologies to improve vehicle performance



Electric supercharger (eSC) vehicle model



eSC upstream and downstream positioning

- Reduce CO2 emissions primarily by modifying the powertrain system
- Create, test and validate new concepts within a restricted time and cost framework

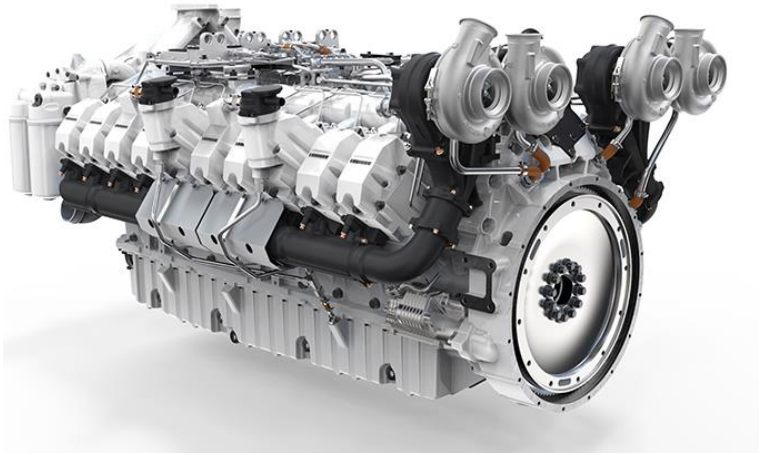
“Simcenter Amesim enables Valeo to better understand the behavior of systems and subsystems, accelerating innovation while reducing costs.”

Pascal Menegazzi, Powertrain Systems Simulation Manager

Liebherr

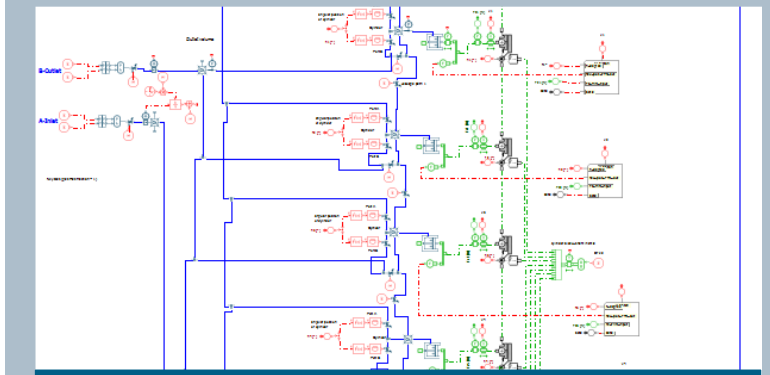
Rankine cycle expander and system design with Simcenter Amesim

SIEMENS
Ingenuity for life

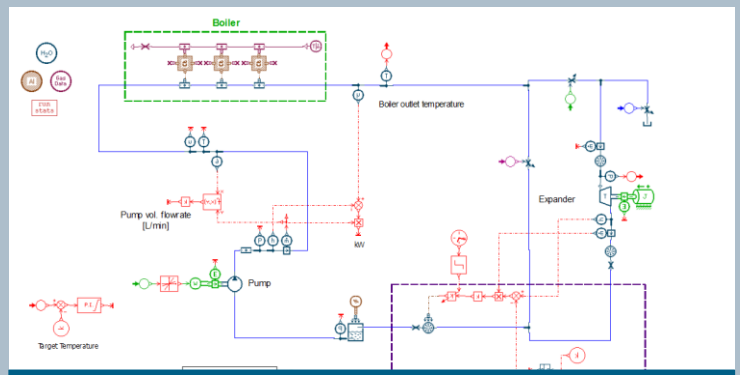


- **Validated expander design**
- **Designed control strategies (Feedforward and predictive)**
- **Optimized Rankine cycle system**

Expander performances evaluation and system controller design



Axial piston expander detailed model



Complete waste heat recovery system model

- Achieve high isentropic efficiency and mechanical power
- Minimize torque ripple as a function of the number of pistons
- Validate Rankine controller robustness against fluid temperature variations

"Simcenter Amesim allows us to realize detailed models in the field of Heat recovery, particularly in Rankine system components. Furthermore the controller design can be performed in combination with design software."

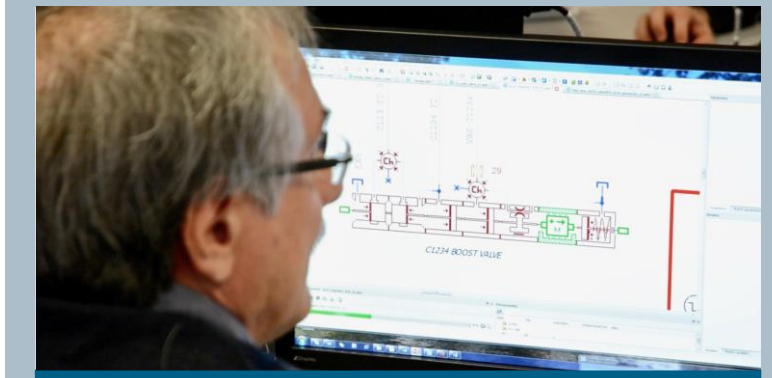
Bouzid Seba, Head Of Department Predevelopment at Liebherr Group

PUNCH Powerglide
Optimizing transmission performance with Simcenter

SIEMENS
Ingenuity for life

- **Reduced lubrication circuit design time from months to weeks**
- **Better control of noise and vibration**
- **Reduced test phases**

Developing innovative transmissions faster than ever



Streamline the design process using LMS Amesim

Benefit from mature and flexible LMS testing solutions

- Implement a multidisciplinary engineering simulation and test approach
- Rapidly test different configurations to balance performance, comfort and energy efficiency

“Simcenter portfolio solutions help us in an early stage of the project, especially to do early simulation and give us indication for performance and fuel economy .”

Wolfgang De Loth, Director Technical Center

PUNCH Powerglide

Optimizing transmission performance with Simcenter

SIEMENS
Ingenuity for life

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SIEMENS
Ingenuity for life

Aerospace & Defense

Irkut Corporation uses Simcenter solutions to develop and integrate MC-21 airliner systems

SIEMENS
Ingenuity for life

Simcenter Amesim helps reduce MC-21 aircraft system development period and physical test cycles.

25%

reduction in physical testing

IRKUT

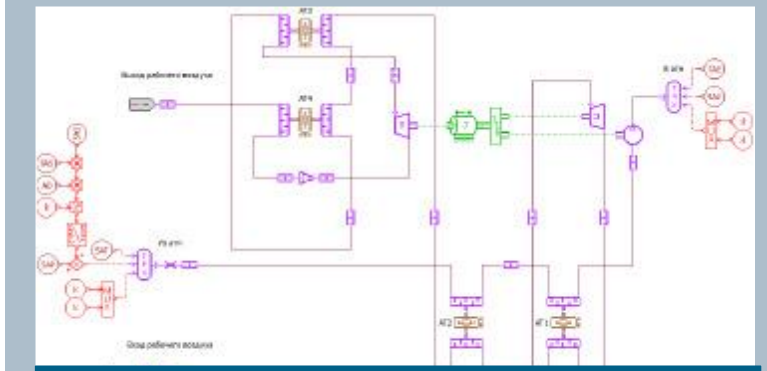
Using Simcenter system simulation solutions to develop and integrate MC-21 airliner systems

SIEMENS
Ingenuity for life

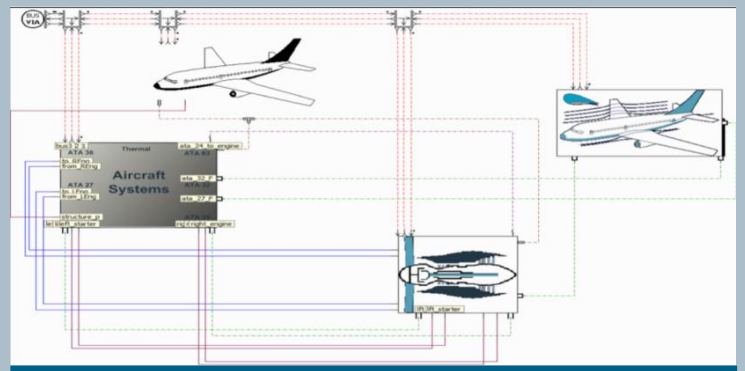
© Irkut Corporation: irkut.com

- **Reduced physical testing for several systems by 25 percent**
- **Introduced integrated aircraft model incorporating third party system/equipment supplier data**
- **Extended simulation model, architecture and product configuration management processes**

Using system modeling to address system integration



Simcenter Amesim air condition system model



Virtual integrated aircraft

- Introduce Simcenter Amesim as a standard solution for aircraft system simulation
- Introduce the virtual integrated aircraft technology to support system integration

"Virtual testing using simulation models has reduced the number of bench tests. For example, for the fuel system we have managed to remove 25 percent of the tests."

Mikhail Pylnev, Head Engineering Analysis Department

Airbus Helicopters cuts time and costs for certifying airworthiness

SIEMENS
Ingenuity for life

Airbus Helicopters predicts thermal behavior of hydraulic systems under any flight conditions.

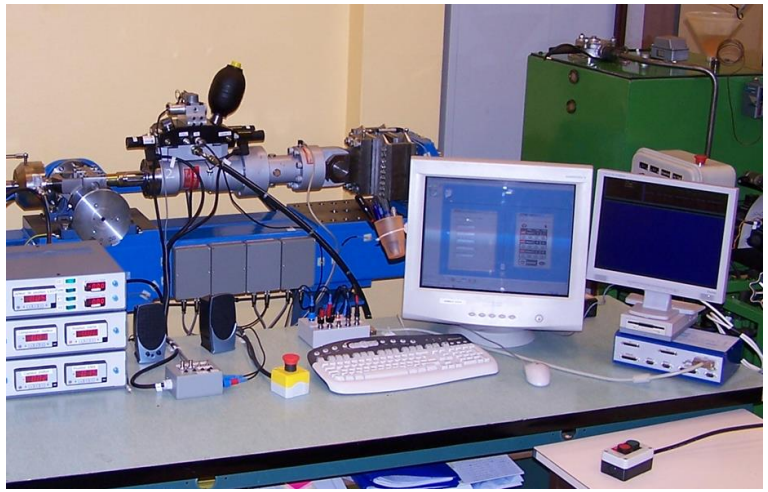
+/-5

Celsius difference between simulation/test results

INSA Toulouse

Designing electromechanical actuators using LMS Imagine.Lab Amesim

SIEMENS
Ingenuity for life



- **Improved modeling and simulation process for flight control design**
- **Supported a new approach for the actuators conception**
- **Built a multi-physic model of the actuators**

“The interest of LMS Imagine.Lab Amesim […] is to be able to combine multi-physical domains: mechanics, electrics, electrotechnics, power electronics, hydraulics, thermal and so on.”

Jean-Charles Maré, Professor

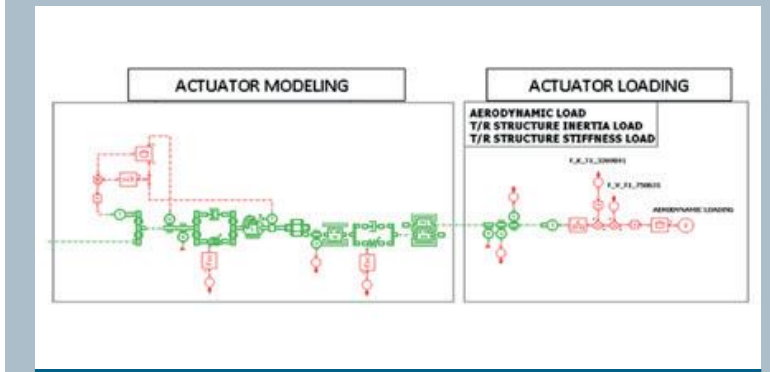
Safran Nacelle

Smoothening out actuation in engine nacelles using Simcenter Amesim

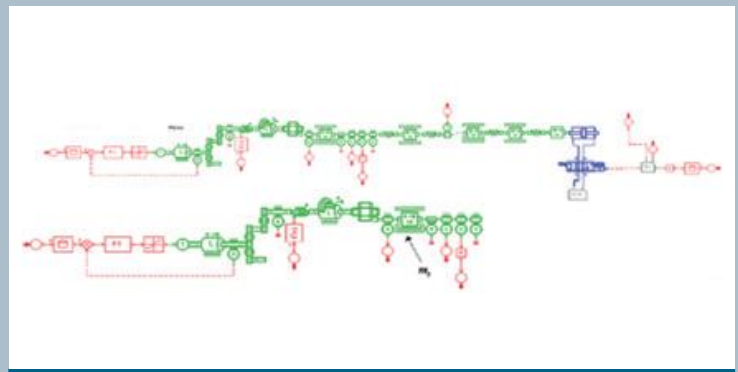
SIEMENS

- **Carried out performance analyses on the electrical and hydraulic components of the actuation system**
- **Optimized nacelle design to withstand difficult stress factors and critical environmental conditions**

Designing actuation system for robust engine nacelles



Nacelle actuation system model



Electrical and hydraulic simulation

- Simulate actuation architectures under several working conditions
- Study interactions between the actuation system and the thrust reverser door structure

“What we appreciate in Simcenter Amesim are its multi-domain capabilities, the solver’s robustness and the simple ‘block-by-block’ interface that still remains open to customization.”

Rodolphe Denis, Head of Actuation System Mechanics and Simulation

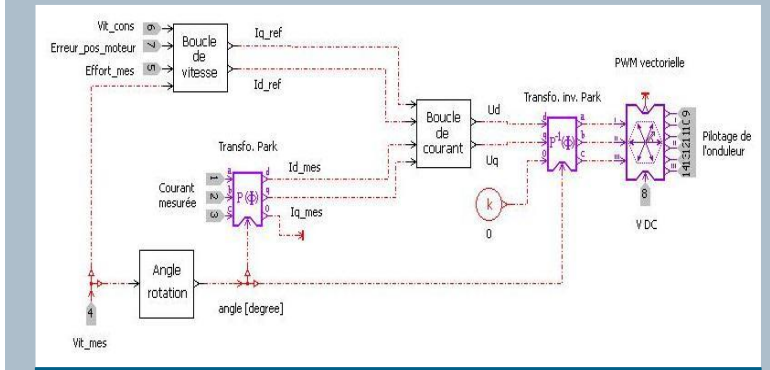
Aeroconseil

Enhancing flight control actuation with Simcenter Amesim

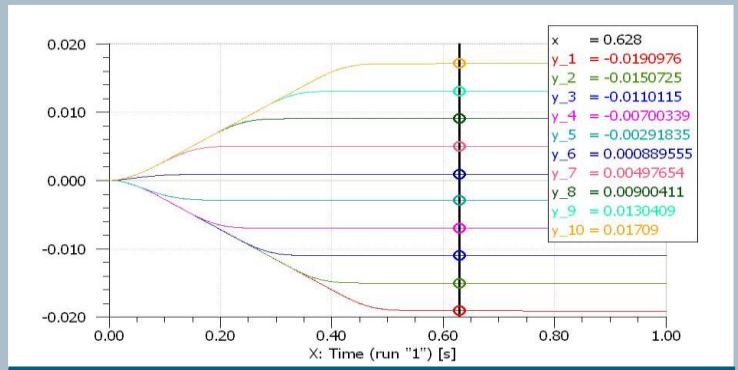
SIEMENS
Ingenuity for life

- **Reduced component modeling time**
- **Achieved required level of model accuracy**

Optimizing the systems design process



Electromechanical actuator control loop



Response time analysis

- Accurately represent and connect multi-domain systems
- Analyze systems' behavior when integrated into the aircraft

"…Validated Simcenter Amesim component models allow design engineers to significantly reduce component modeling and validation efforts."

Franck Dietrich, Tools, Simulation and Integration Team Leader

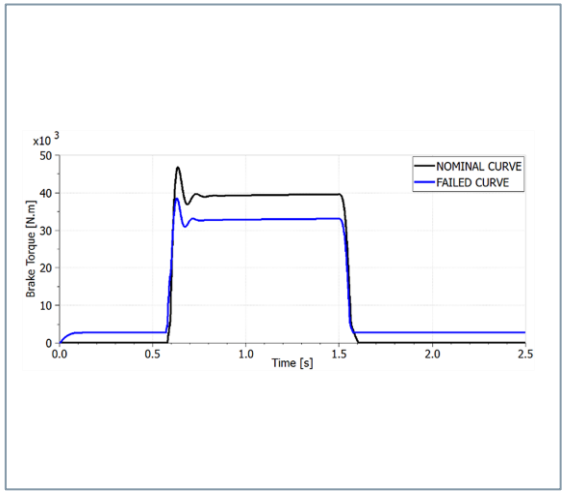
ITA prepares new engineers for the Brazilian aircraft industry

SIEMENS
Ingenuity for life

University enhances the ability to assess aircraft brake system behavior in case of failure.

2x

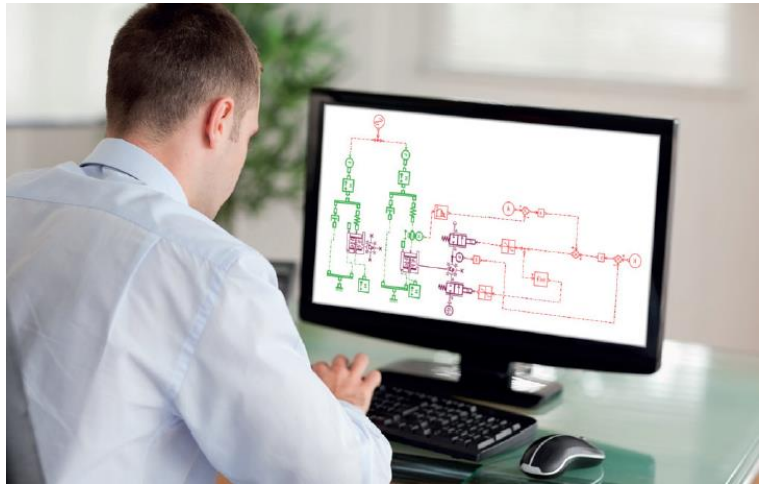
number of grads in the last decade



Samara State Aerospace University

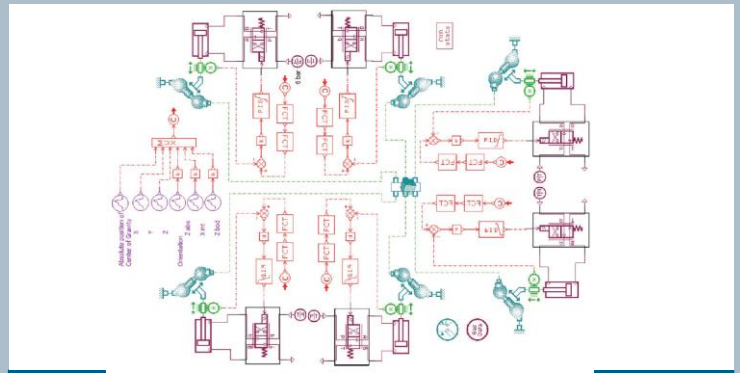
Training mechatronics experts for the industry

SIEMENS
Ingenuity for life

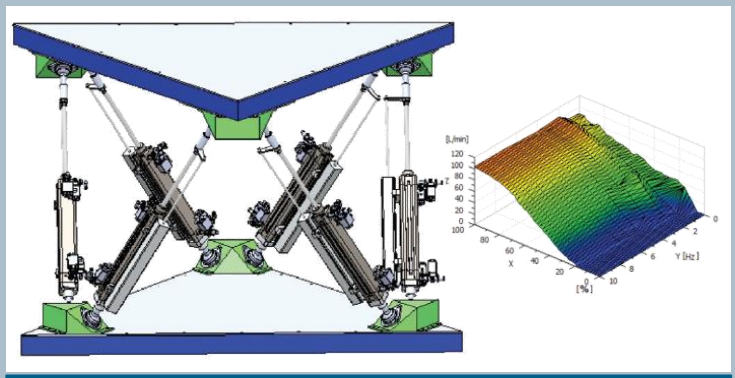


- **Solved many engineering dynamics and vibroacoustic research problems**
- **Successfully completed joint projects with manufacturing companies**
- **Prepared graduates to use advanced mechatronics modeling tools**

Use of Siemens PLM Software solutions into the academic process



Simcenter Amesim provides a wide range of libraries and data analysis tools



Multidisciplinary modeling of mechatronic systems

- Develop engineering vibroacoustics and system dynamics theory
- Implement research and development in industry

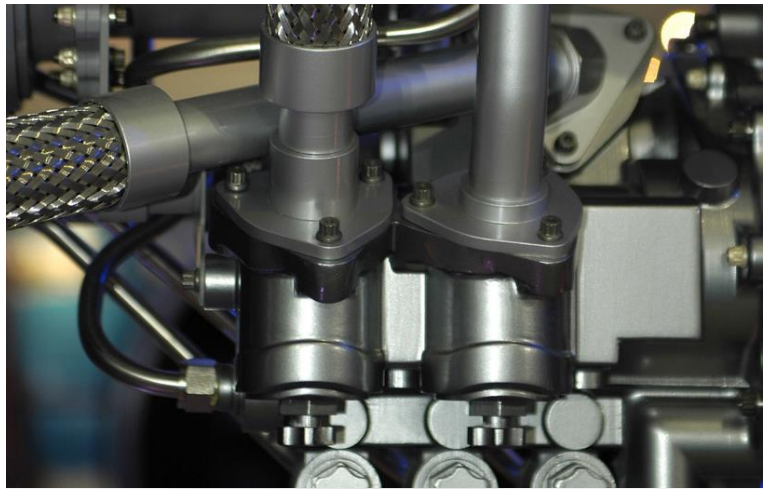
“ To develop such integrated products we need advanced software systems. They make the manufacturing simple, fast, and cost-efficient. That is why multidisciplinary modeling has become a crucial part of innovation.”

Anton Sinyakov, Junior Researcher, Department of Automated Energy Systems

CERTIA

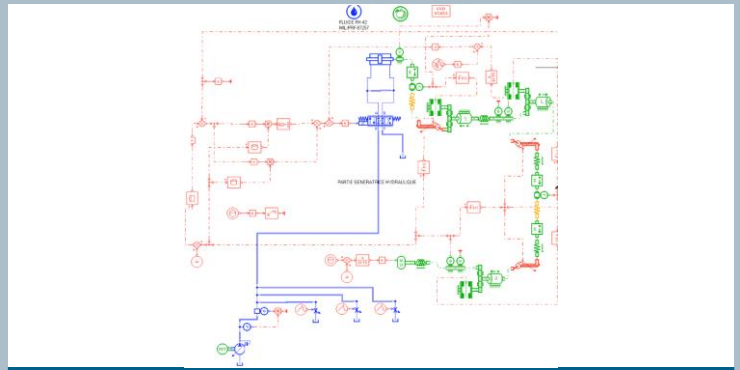
Increasing test rig performance with Simcenter Amesim

SIEMENS
Ingenuity for life

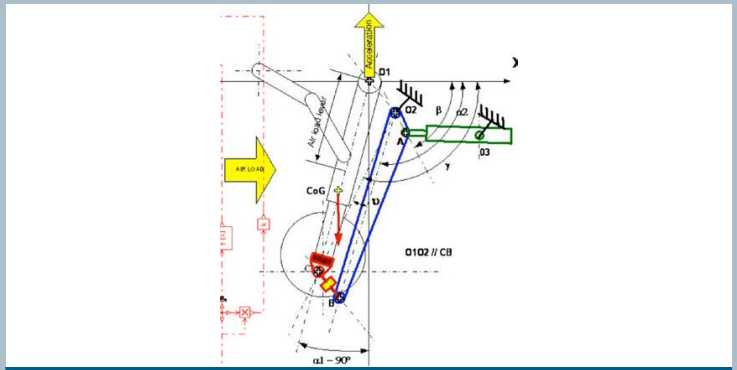


- **Reduced test rig development time by 25 percent**
- **Increased the availability rate of the physical testing platform by 60 percent**
- **Advanced development readiness for virtually designing intelligent test rigs**

Performing virtual designs of intelligent test rigs



Multi-domain model of a test bench



Stiffness, inertia and masses analysis

- Implement a virtual platform for testing
- Notably enhance test bench capabilities

“Having a virtual platform has become an absolute necessity. We have to be ready and anticipate requests from customers like Airbus to do testing in a common virtual environment...”

Achour Debiane, Head of Automation

SIEMENS
Ingenuity for life

Heavy Equipment

Hidromek enhances construction equipment performance

SIEMENS
Ingenuity for life

Hidromek maximizes productivity by performing tasks such as ISO certification.

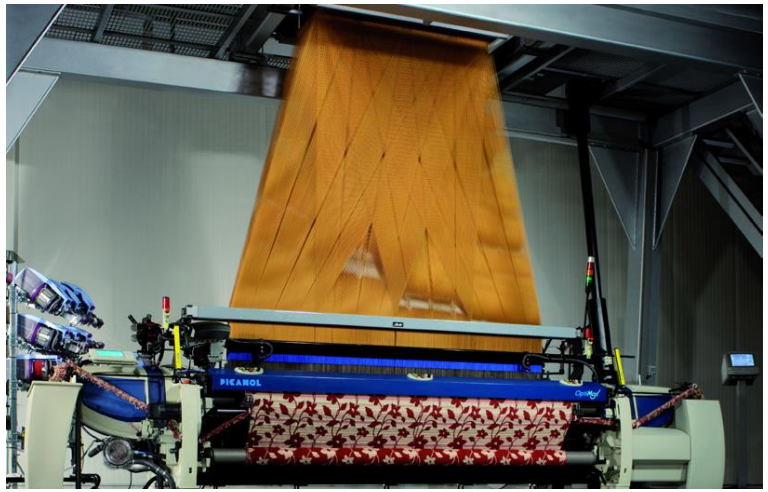
50%

reduction in overall measurement time

Picanol

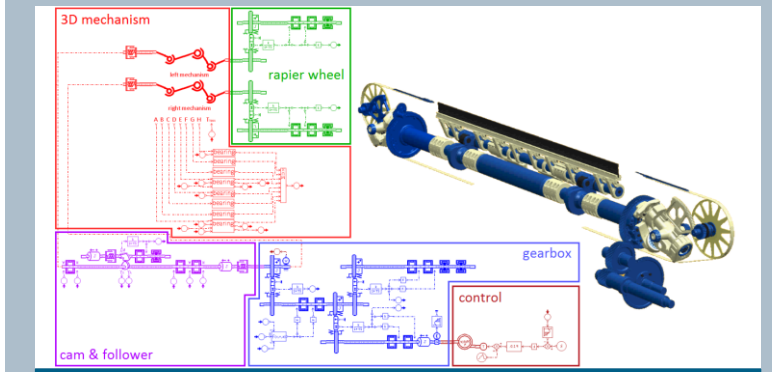
Launching a highly energy-efficient loom thanks to Simcenter Amesim

SIEMENS
Ingenuity for life

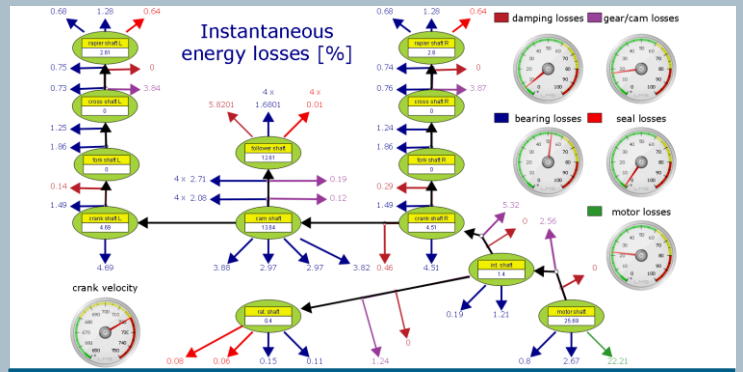


- **Designed the “most energy-efficient weaving looms on the market”**
- **Balanced performance, durability, noise and vibration parameters while minimizing energy consumption**
- **Implemented advanced model-based system engineering**

Optimizing the design towards energy performance



Co-simulation with LMS Virtual.Lab Motion



Flow chart of instantaneous energy losses

- Support the scalable optimization of energy flows
- Use energy efficiency and total cost of ownership as key performance criteria

“A platform like Simcenter Amesim offers extensive libraries of components that also connect to describe complete multiphysics systems, a prerequisite for advanced model-based system engineering.”

Kristof Roelstraete, Manager Research and Development

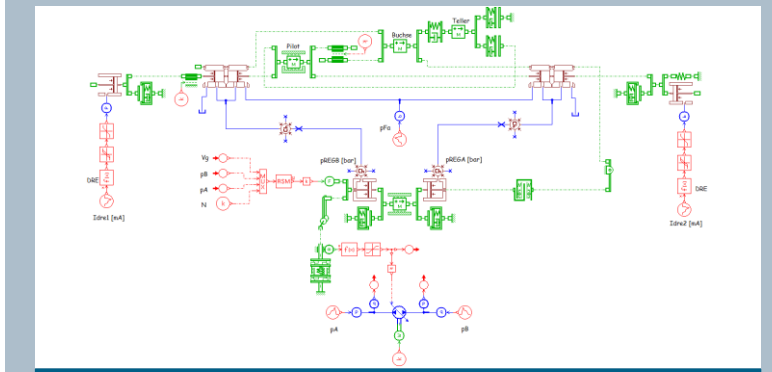
Liebherr Group

Streamlining hydraulic component development with Simcenter Amesim

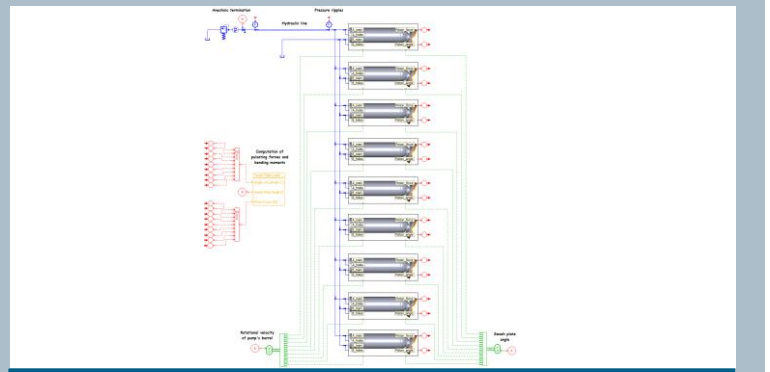
SIEMENS
Ingenuity for life

- **Significantly reduced number of prototypes**
- **Enhanced collaboration among company sites**
- **Strengthened internal expertise from component design to system integration**

Different angles to design optimization targets



Model of axial piston pump servomechanism



Pressure transients simulation for valve plate

- Optimize swash plate dynamic behavior
- Reduce noise emissions

Using Simcenter Amesim facilitated simulation model and parameter exchange among the Liebherr plants involved in the project

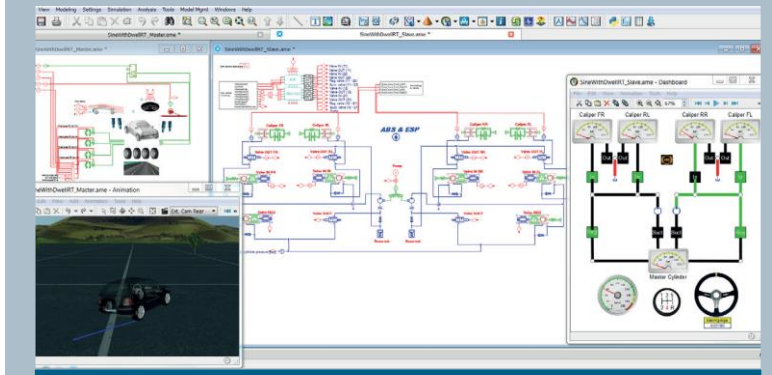
Bosch

Designing hydraulics applications using Simcenter Amesim and Simcenter Sysdm

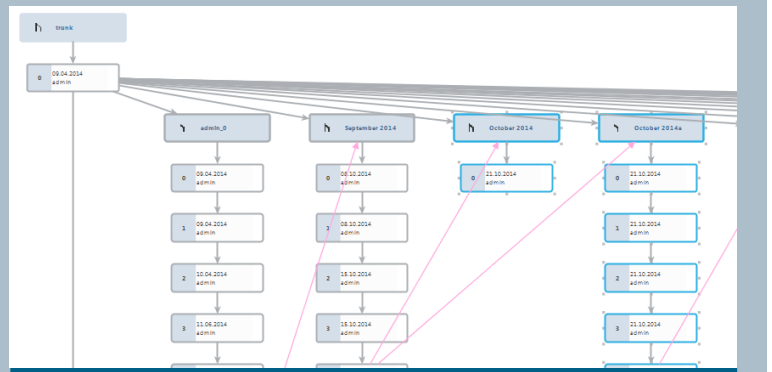
SIEMENS
Ingenuity for life

- **Gained better insight into the source of problems at early design phases**
- **Reduced development efforts, cycle and costs**
- **Enabled traceability of the design process**
- **Optimized data access management via roles**

Boosting the quality of fuel injection and braking systems



Design of the overall braking system



Keeping track of all steps of development

- Use of Simcenter Amesim by 300 specialists globally
- Manage efficiently models and data with Simcenter Sysdm

“Simcenter Amesim is our preferred simulation tool for hydraulics applications, not only in Bosch’s Mobility Solutions but also in the Industrial Technology business sectors.”

Sebastian Kanne, Simulation Group Manager

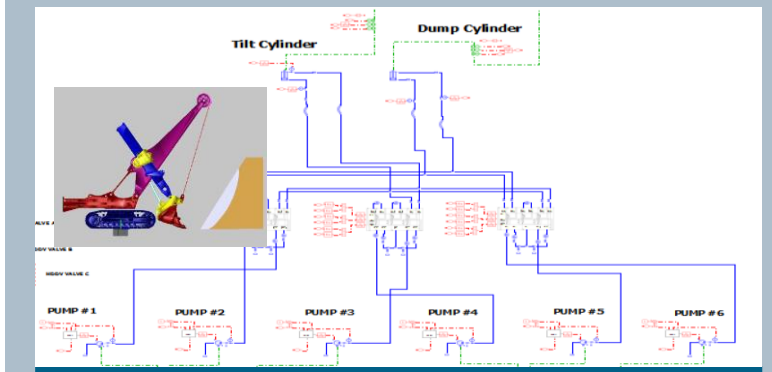
Komatsu Mining

Predicting equipment systems performance using Simcenter Amesim

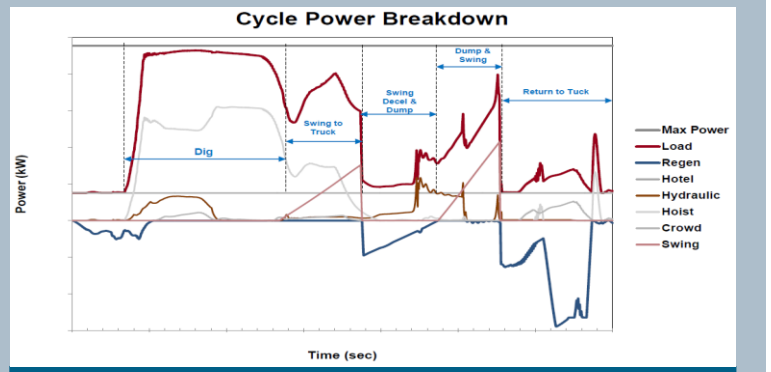
SIEMENS
Ingenuity for life

- **Limited existing data was sufficient**
- **Avoided expensive on-site trial and error**
- **Accurate fuel consumption prediction**

Predict performance, fuel consumption and cycle time



Model



Performance prediction

- Dynamic representation of all major electrical and hydraulic systems/sub-systems
- Rigid-body representation of machine structure (drive-line transmissions, rope…)
- Coupling external C/C++ codes for soil model, power management and hydraulic controls

“The use of Simcenter Amesim helps us to save a lot of development time as well as minimize risks during the integration phase ”

Anab Akanda, principal mechatronics software engineer Komatsu Mining

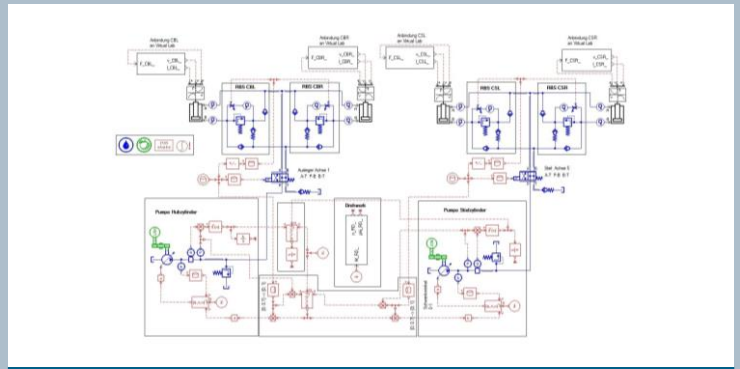
Liebherr Group

Stepping beyond prototyping with Simcenter Amesim and LMS Virtual.Lab

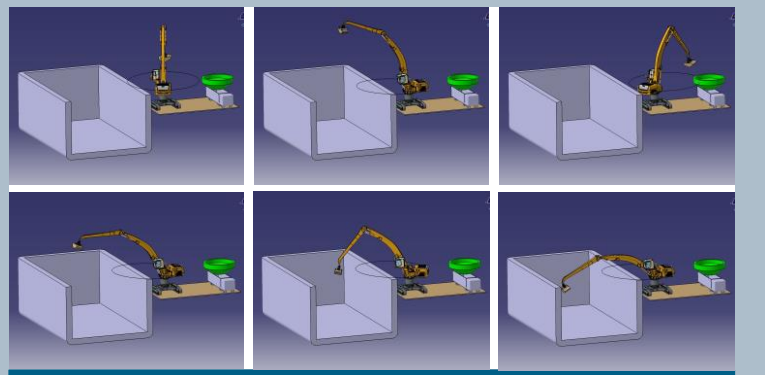
SIEMENS
Ingenuity for life

- **Analyzed behavior of subsystem without building expensive prototype**
- **Determined best possible design to avoid backlash and reliability issues**
- **Saved time and money, helping to maintain Liebherr strong competitiveness**

Combined simulation of excavator dynamic behavior



Model in Simcenter Amesim



Visualization in LMS Virtual.Lab Motion

- Use Simcenter Amesim together with LMS Virtual.Lab Motion
- Simulate several system versions, including diverse mechanical systems

“The design table functionality is extremely helpful for changing the mechanical system very easily and quickly using LMS Virtual.Lab Motion.”

Martin Bueche, Head of Calculation and Simulation Department

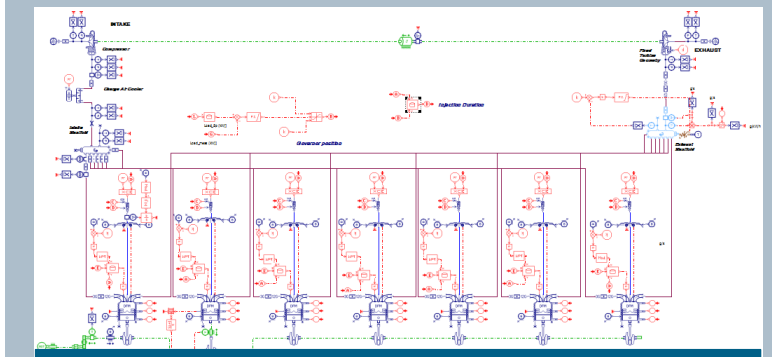
Hyundai Heavy Industries

Engine design and integration into a hybrid vessel with Simcenter Amesim

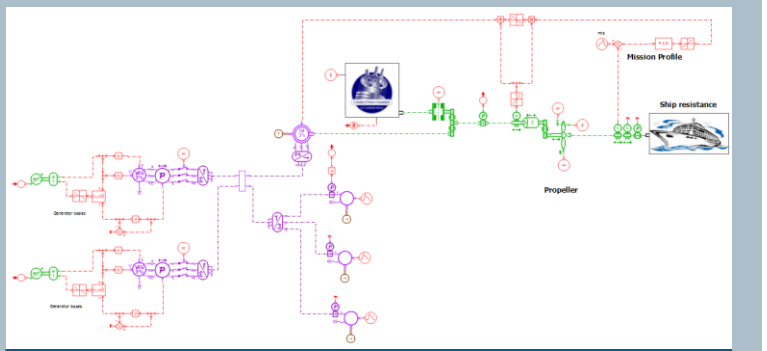
SIEMENS
Ingenuity for life

- **Shorter simulation time compared to software competitor results**
- **Streamlined modeling process from engine design to ship integration**
- **Fuel consumption and NOx emissions efficiently assessed over different load cases**

Existing engine model conversion to Simcenter Amesim with real-time capability and hybrid ship integration



High-Frequency engine model for design



MVEM model integrated in hybrid vessel

- Validate HF engine model versus baseline model in steady and transient operations
- Generate Mean Value Engine model for Hardware-in-the-Loop validation
- Integrate engine model into hybrid ship architecture for analysis on different load cases

“Simcenter Amesim is helpful in the integrated interpretation of systems through the provision of sufficient libraries in various fields. It also has a strong advantage in computing speed in HiL”

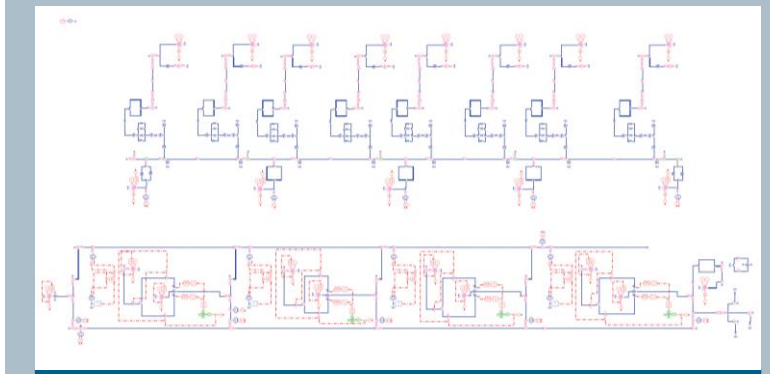
Dr Hyun Sook Yoon, Senior researcher, Engine and Machinery, Hyundai Heavy industries

SDF
Optimizing a lubrication system with Simcenter Amesim

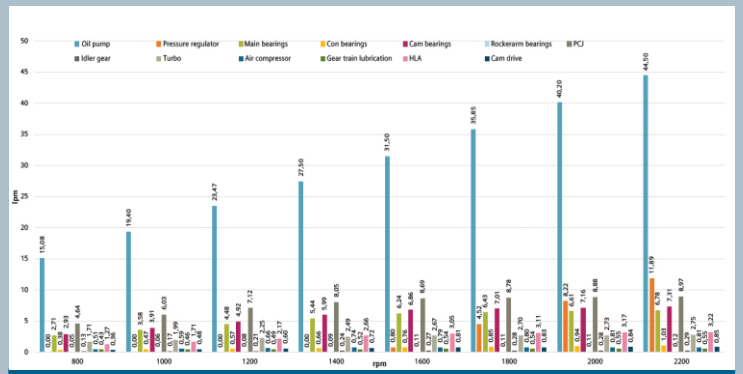
SIEMENS
Ingenuity for life

- **Compressed development cycle by up to 30 percent**
- **Switched the testing stage approach from trial-and-error to validation only**
- **Improved system performance by optimizing parts definition**

Check and optimize mass-produced lubrication systems



Engine lubrication system model



Flow distribution efficiency evaluation

- Capitalize on Simcenter Amesim flexibility to create complex system models
- Quickly generate quality data and multiple-criteria analysis

“The flexibility of Simcenter Amesim is a key feature. You can choose many different components and the mathematics behind it is very robust.”

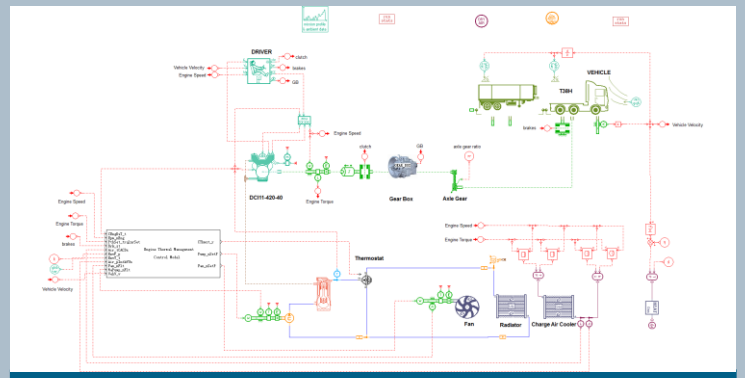
Ricardo Bonacina, Base Engine Validation and Reliability Lead Engineer

Dongfeng Commercial Vehicle
Optimizing engine cooling controls strategies with Simcenter Amesim

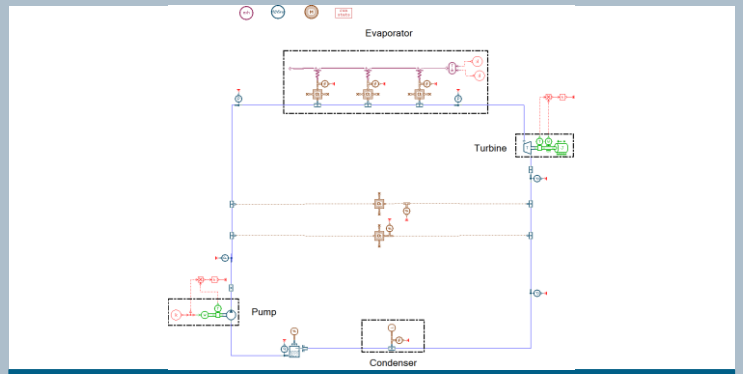
SIEMENS
Ingenuity for life

- **Optimized engine cooling controls strategies**
- **Analyzed behavior of the combustion, cooling and lubrication subsystems**
- **Studied rankine cycle technology before the first prototype was available**

Boosting fuel efficiency with innovative energy recovery technology



Co-simulation Simcenter Amesim and Simulink



Rankine cycle loop model

- Design an efficient engine cooling system with advanced controls strategies
- Analyze the impact of the exhaust heat recovery technology

"Our research and development activity around the rankine cycle technology wouldn't be possible without the two-phase flow library of Simcenter Amesim..."

Zhang Xin, Controls Engineer

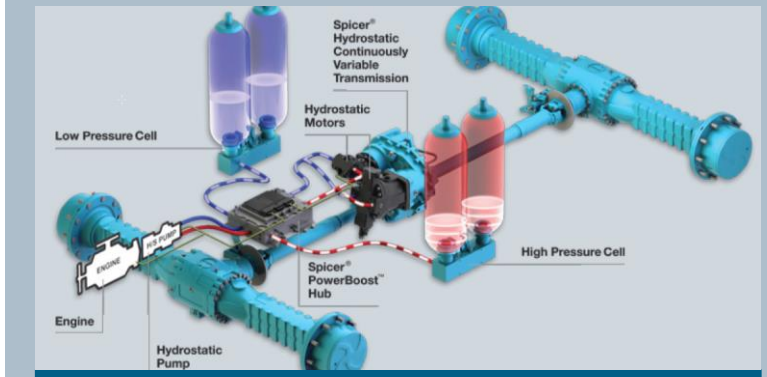
Dana

Designing innovative powertrain system thanks to Simcenter Amesim

SIEMENS
Ingenuity for life

- **Achieved between 20 to 40 percent fuel savings and reduced operating costs**
- **Reduced modification evaluation time from 1 to 2 weeks to 1 day**
- **Dramatically reduced number of loops needed for physical testing**

Increase system integration in order to optimize vehicle efficiency



Multi-domain system simulation

Vehicle fuel consumption analysis

- Use the model-based systems engineering approach to design fuel-efficient powertrain
- Model complex multi-domain systems using pre-packaged components

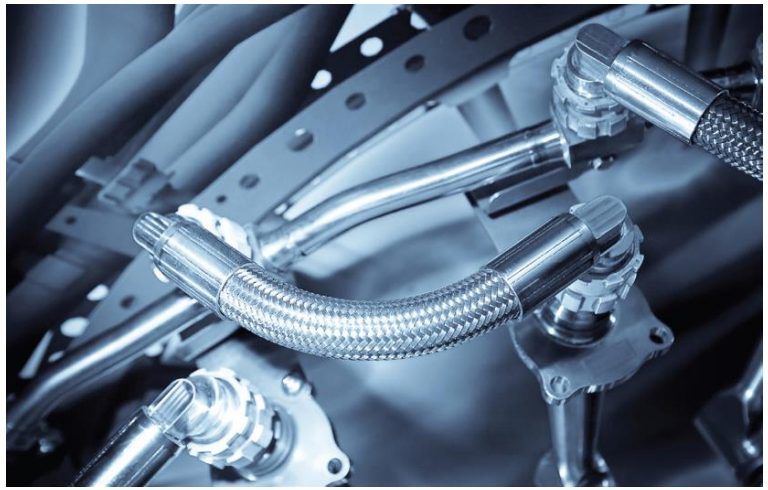
“ We can definitely say that Simcenter Amesim reduced a considerable part of the development time by a factor of 5, and then we are not even talking about cost.”

Dr. Lorenzo Serrao, Advanced Engineering

Parker Hannifin

Acting on quality for high-precision systems with Simcenter Amesim

SIEMENS
Ingenuity for life



- **Enabled fast and efficient troubleshooting**
- **Improved ability to deal with internal quality requests**
- **Positioned as a technology and integration partner**

Quality control of motion and control technologies

Analysis of precision-engineered technology

Identification of valve potential defects

- Assess how components interact
- Solve malfunction problems

With a traditional engineering approach, it would have taken the engineers several more months to identify the defect. Using Simcenter Amesim, it only took a few days.

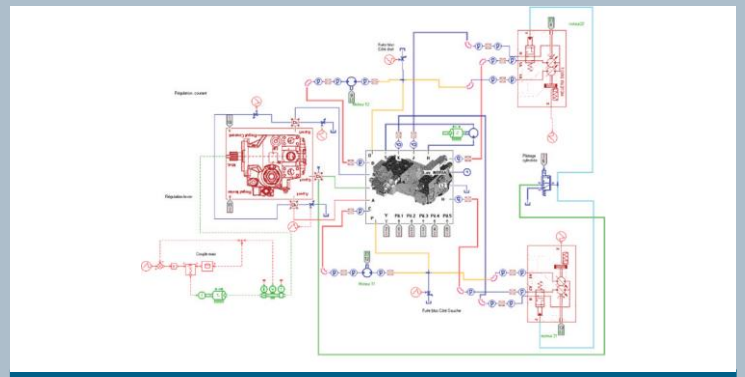
Fluidesign/New Holland

Optimizing emergency braking for grape harvesters with Simcenter Amesim

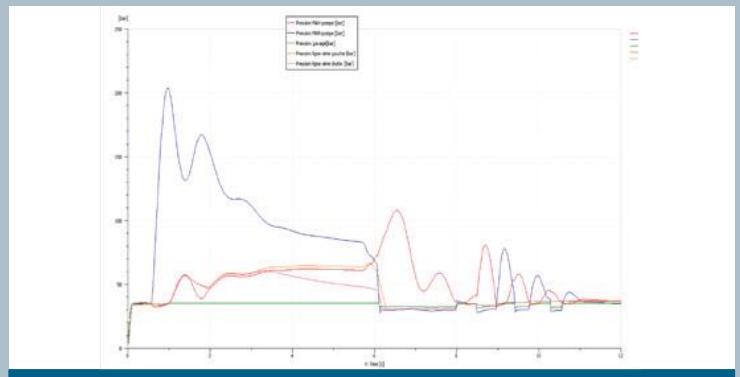
SIEMENS
Ingenuity for life

- **Cut total project costs by 25 percent and reduced development timeframe**
- **Optimized braking system**
- **Certified vehicles**

Enhancing emergency braking through better and faster development



Hydraulic bloc model



Simulate pressures of a braking maneuver

- Investigate various architectures and visualize vehicle dynamic behavior
- Simulate dangerous maneuvers

“Using Simcenter Amesim has been a real asset and enabled New Holland to save several months of engineering studies as they worked on this safety optimization project.”

Frederic Lagors, Technical Director

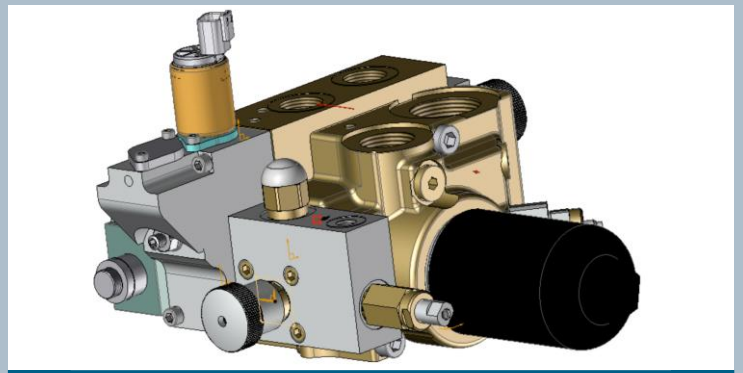
Fluid-System

Solving dynamic instability with Simcenter Amesim

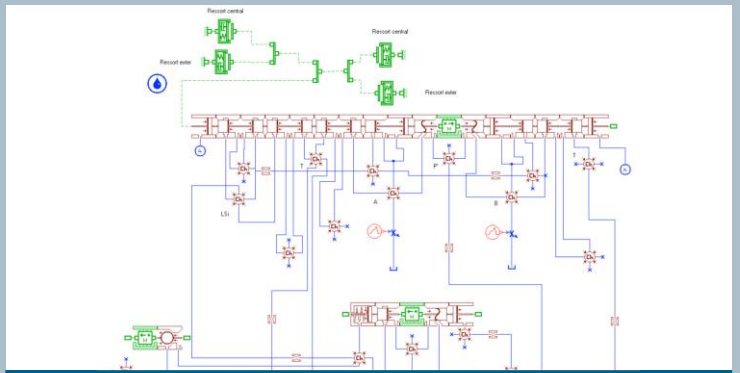
SIEMENS
Ingenuity for life

- **Cut the time spent on prototype adjustments by 50 percent**
- **Saved money by finding potential issues before prototype creation**
- **Gained a greater understanding of phenomena in different valve shapes**

Evaluate the tradeoff between stability and performance parameters



Product performance evaluation



Pressure flows model

- Assess product performance based on customer scenarios
- Support the production and quality check process

“Simcenter Amesim stood out amongst other competitors. The solution is really robust, technically precise and the various libraries are comprehensive.”

Xavier Tardy, Chief Executive Officer

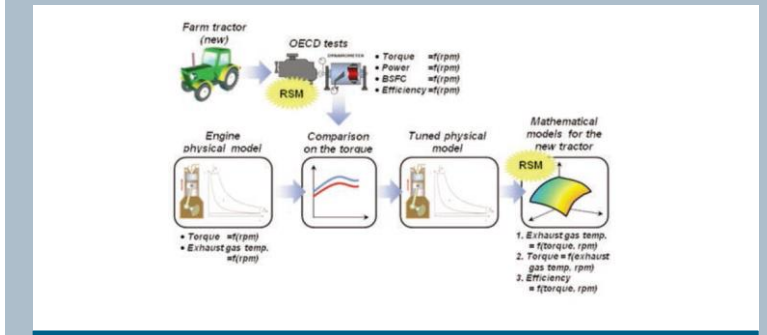
Bolzano Faculty of Science and Technology

Tractor predictive maintenance based on Simcenter Amesim engine model

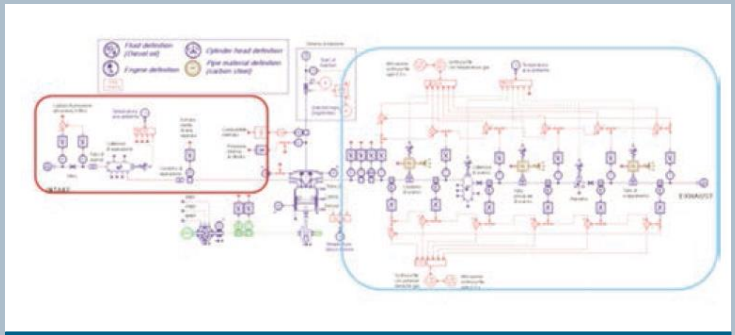
SIEMENS
Ingenuity for life

- **Validated engine model based on few measurements data**
- **Integrated simulations into the remote predictive maintenance process**

Engine efficiency and environmental impact monitoring



Engine model calibration process based on field data



Layout of the Simcenter Amesim model of tractor engine

- Tune engine model with reference dynamometer engine tests (exhaust temp., torque & efficiency)
- Compare the field engine efficiency with the model to quantify the its performance decrement

“A first numerical model of an engine shows the high potential of Simcenter Amesim: it can simulate real combustion and heat transmission phenomena and lets user access to many quantities in every point of the layout”

Dr. Marco Bietresato, Researcher, Fa.S.T., Bolzano, Italy

Bolzano Faculty of Science and Technology

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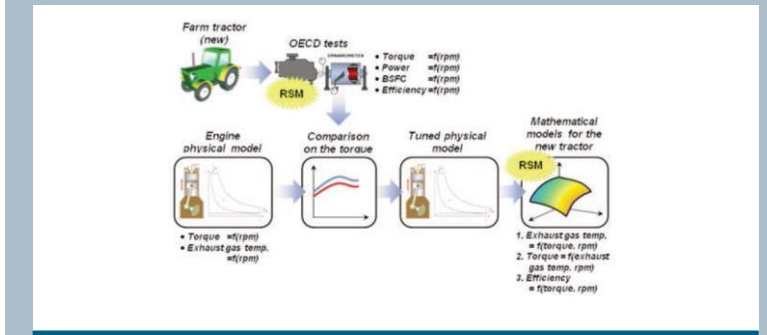

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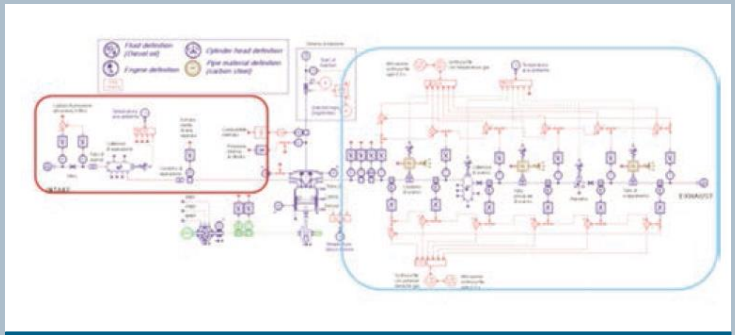

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Dr. Marco Bietresato, Researcher, Fa.S.T., Bolzano, Italy

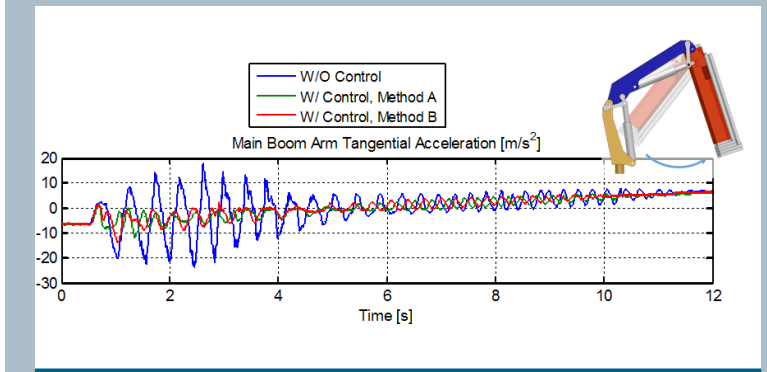
Maha Fluid Power Research Center

Using Simcenter solutions to help industry design hydraulic subsystems

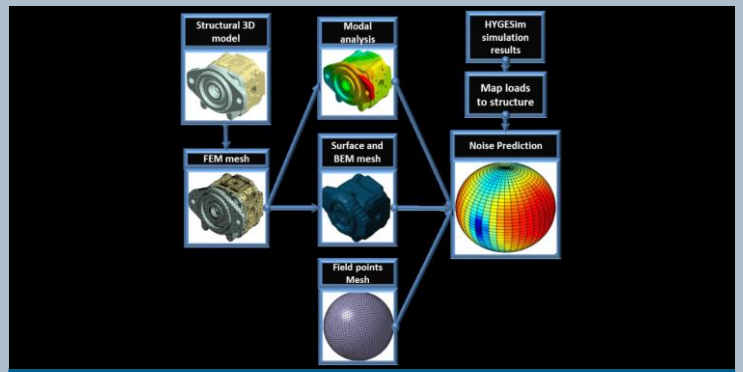
SIEMENS
Ingenuity for life

- **Reduced time of model implementation by up to 50 percent**
- **Reduced machine vibration with system control design by up to 78 percent**
- **Reduced noise emission of fluid power systems by up to 5 dB**

Helping customers reduce machine energy consumption



Develop design control strategies with Simcenter Amesim



LMS Virtual. Lab Acoustics to investigate noise emissions

- Set up hydraulics subsystem and component sizing
- Develop design control strategies
- Investigate noise emission with 3D simulation

"For this research particularly, we save a lot of time. Up to 50 percent of model implementation time can be saved by using Simcenter Amesim."

Andrea Vacca, head of research team at Maha Fluid Power Research Center

Mecalac creates first time right prototype with help of Siemens Digital Industries Software solution

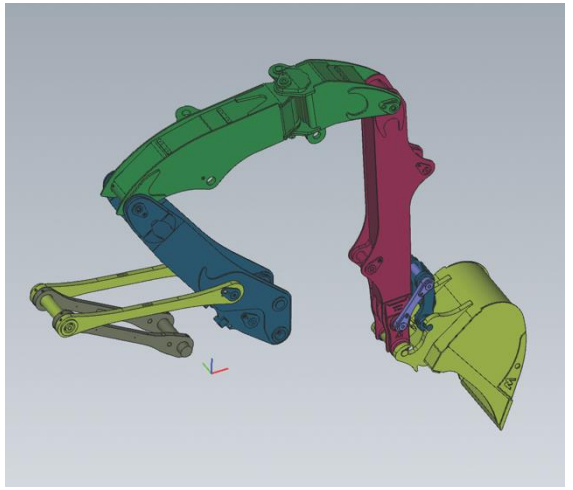
SIEMENS
Ingenuity for life

French construction machinery manufacturer uses Simcenter Amesim to develop first electric wheeled excavator.

just

1

prototype needed using Simcenter Amesim



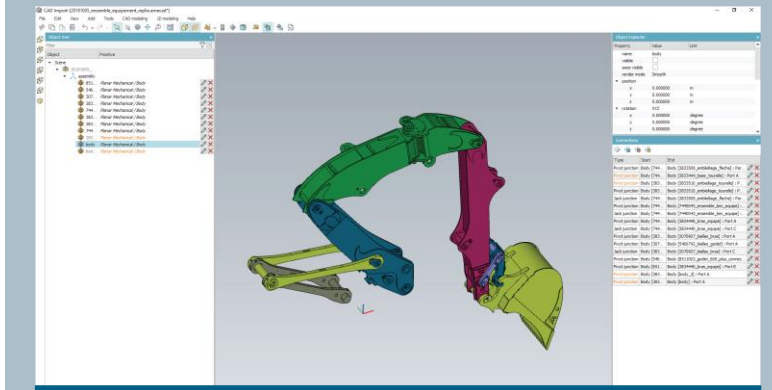
Mecalac

Developing a 12t full electric excavator with Simcenter Amesim

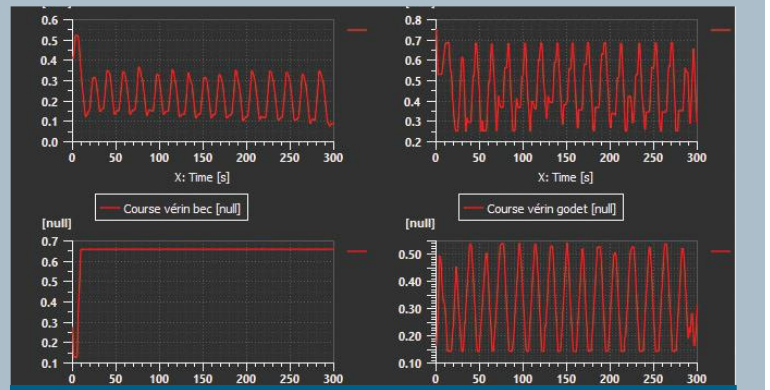
SIEMENS
Ingenuity for life

- **Completed modeling and analysis phase in three months**
- **Integrated a Li-ion battery that meet end of life capacity and packaging requirements**
- **Developed world first fully electric wheeled excavator**

Modeling and simulation of the Mecalac e12



CAD import of the e12 mechanical parts



e12 operation simulation results

- Accurate sizing of battery, inverter and permanent magnet synchronous motor
- Battery ageing analysis
- Coupling with software development tool for Software-In-the-Loop verification

“Simcenter Amesim allows us to proactively explore new innovative designs”

Max Boni, Research & Development Director, Mecalac Group

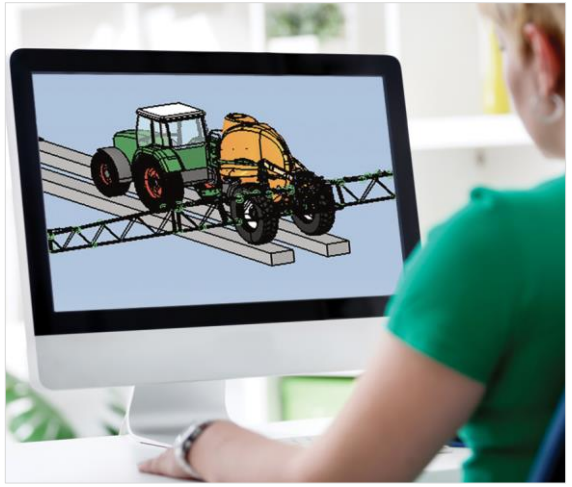
AMAZONE burnishes its reputation for quality and innovation

SIEMENS
Ingenuity for life

AMAZONE uses improved simulation process to decrease the number of prototypes.

66%

time saved from concept to production

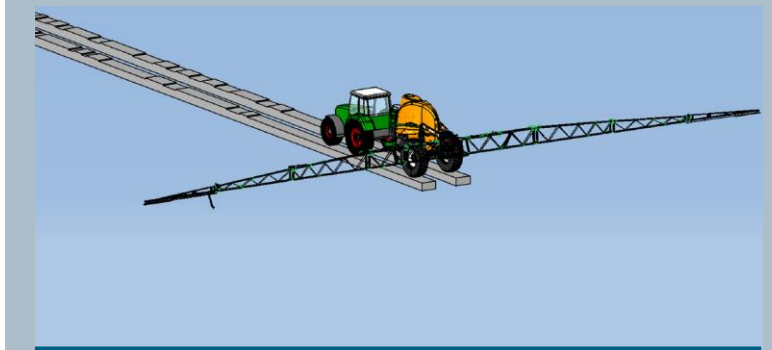


Amazone
Optimized equipment equals efficiency and precision

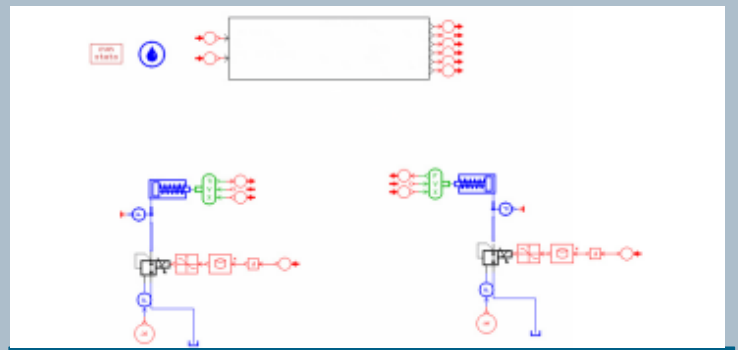
SIEMENS
Ingenuity for life

- **Reduced time from concept to product**
- **Decreased number of prototypes**
- **Reduced the amount of physical testing**
- **Facilitated the prediction of design flaws earlier**

From concept to production in three months



Sprayer boom 3D simulation



System simulation model

- Create virtual test track using Simcenter and predict performance

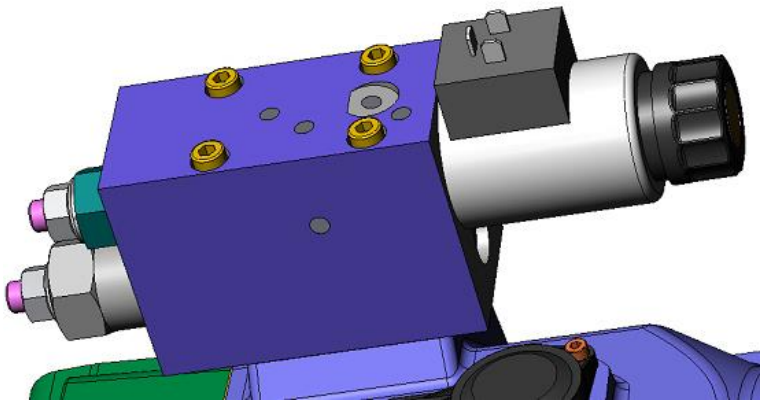
“In the past, it took us about one year from concept to production, and today we have cut that down to three or four months.”

Anna-Gret Borchert, Calculation Engineer, Amazone

IMAMOTER

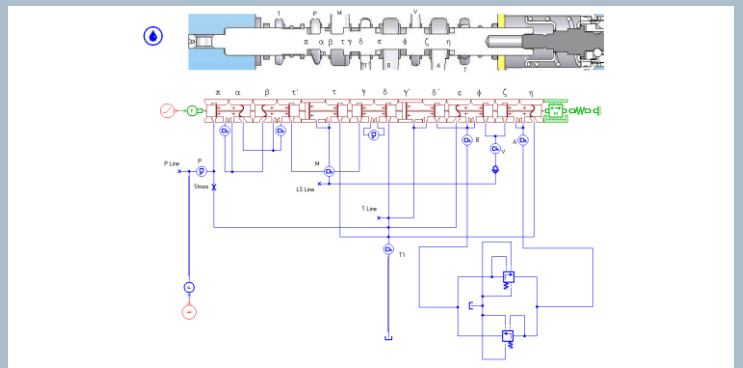
Embedding electronic controls in farm equipment with Simcenter Amesim

SIEMENS
Ingenuity for life

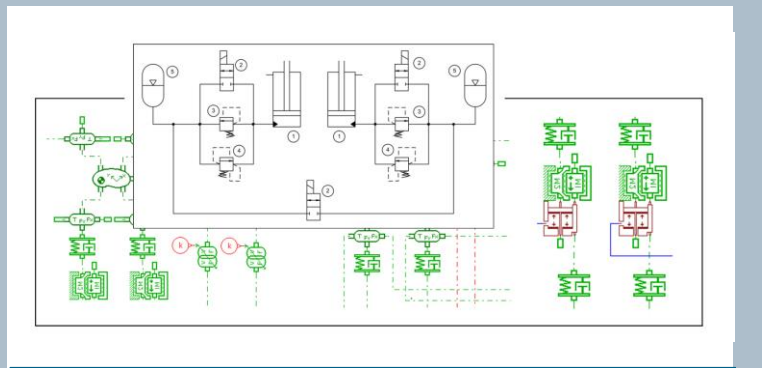


- **Spared time and costs by developing conceptual schemes for experimental activities**
- **Significantly enhanced hydromechanical simulation capabilities**

From accurate modeling to numerical simulations



Physical modeling of the system dynamics



Co-simulation with MATLAB® /Simulink®

- Develop accurate physical modeling of the system and sub-system dynamics
- Use Simcenter Amesim numerical simulation to detect critical control strategy parameters

“Today, Simcenter Amesim saves us time and money, and makes it possible to develop conceptual schemes for which experimental activities are not feasible or affordable.”

Massimo Martelli, Researcher at Fluid Power and Mechatronics Department

SIEMENS
Ingenuity for life

Industrial Machinery

Spit Paslode increases efficiency and saves costs with Simcenter Amesim

SIEMENS
Ingenuity for life

Siemens Digital Industries Software solutions enables Spit Paslode to quickly and accurately analyze design.

100+

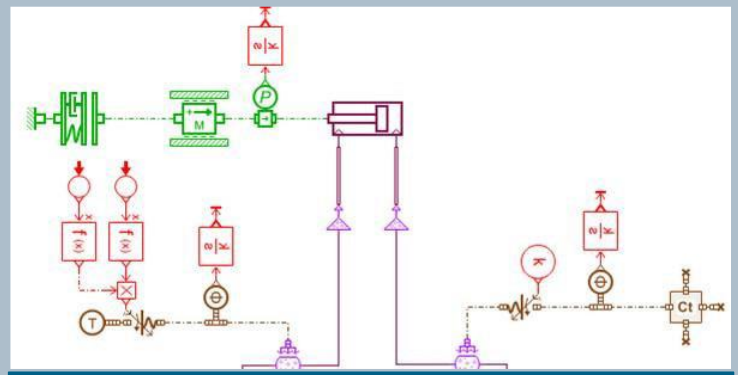
global parameters Simcenter Amesim allowed Spit Paslode to analyze

Spit Paslode

Construction manufacturer uses Simcenter Amesim to increase efficiency and save costs.

- **Realized time and cost savings with Simcenter Amesim**
- **Adopted digitalized method to analyze designs**
- **Optimized complex interactions between different systems**

Analyze the dynamics of complex, multi-domain systems



Model developed for this project comprises more than 100 global parameters

Digital method allows to quickly explore a large number of configurations

- Improve system stability and performance
- Gauge accuracy of new combustion technology

“We have accurately analyzed the influence of the parameters and understood the modifications that needed to be made to our product in order to optimize its operation. Without Simcenter Amesim, all of this would have been extremely long and costly, if not impossible.”

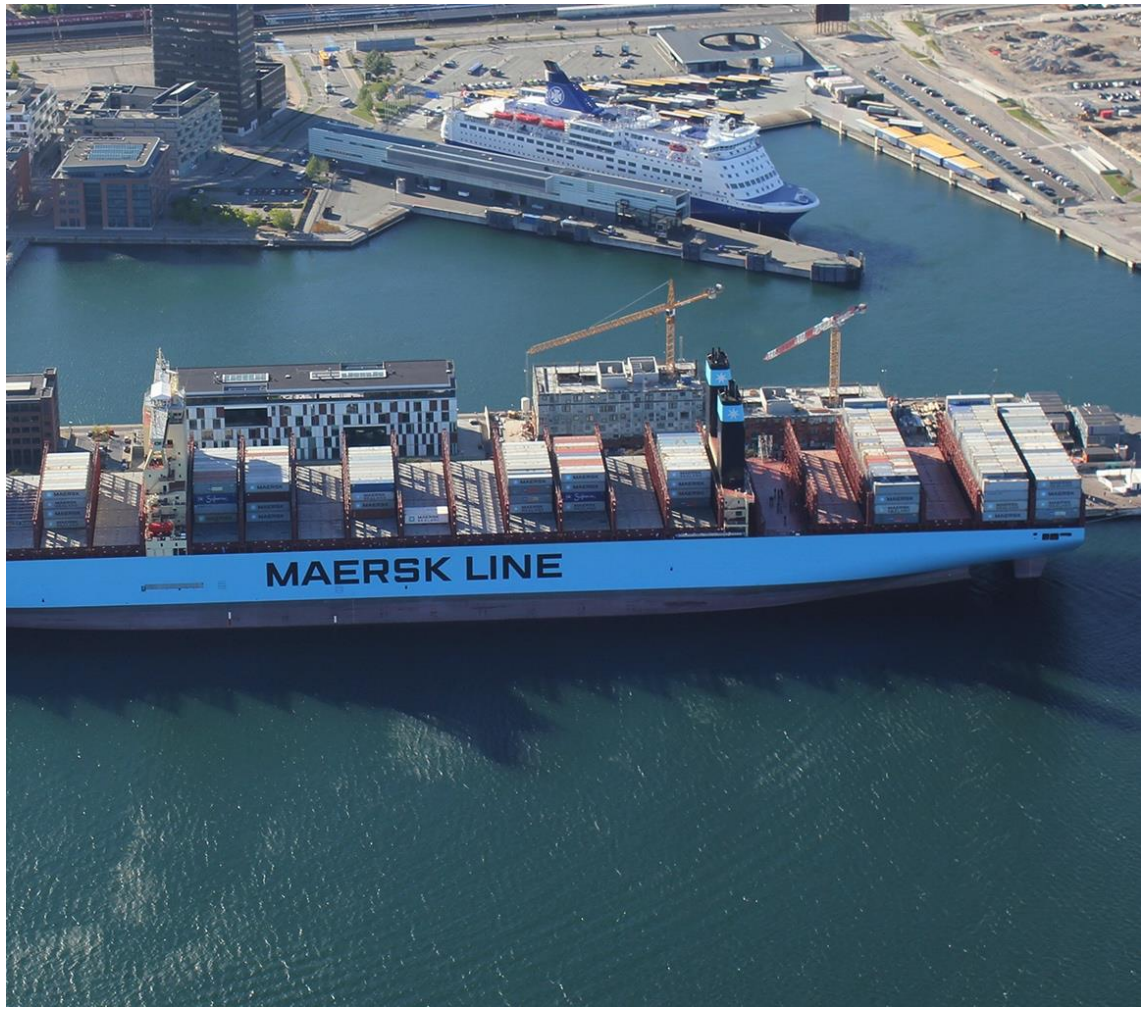
Olivier Baudrand, R&D Engineer

SIEMENS
Ingenuity for life

Marine

MAN Energy Solutions accelerates development of dual fuel engines

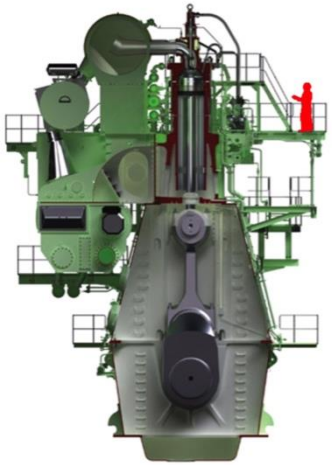
SIEMENS
Ingenuity for life



MAN Energy Solutions rapidly applies design changes by modifying off-the-shelf component parameters.

5X

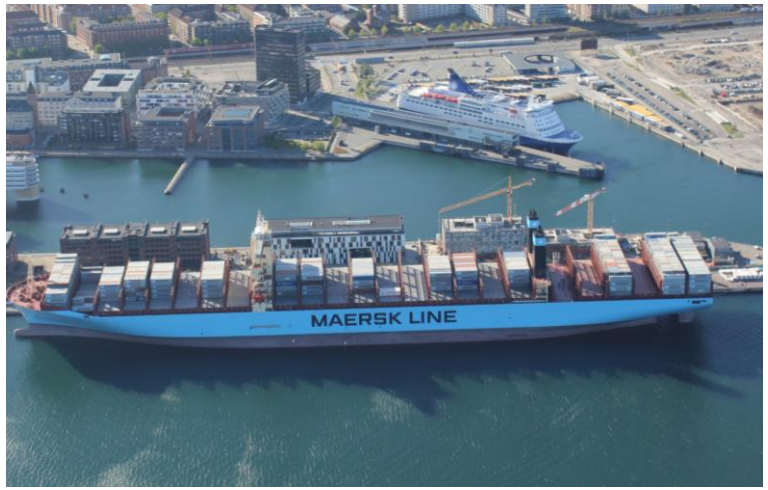
reduced development time for fuel injection system



MAN Diesel & Turbo

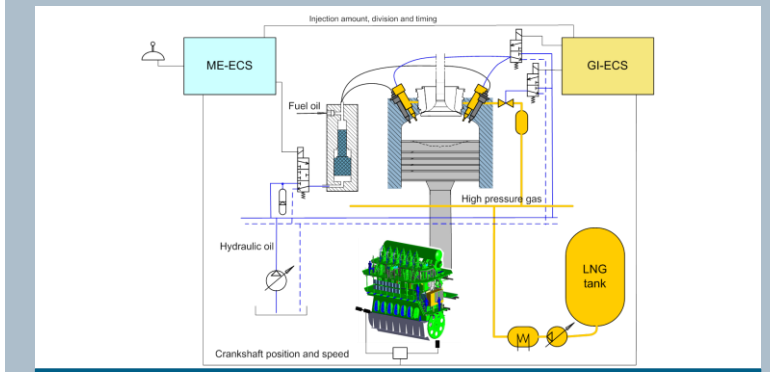
Accelerating the development of dual-fuel engines with Simcenter Amesim

SIEMENS
Ingenuity for life

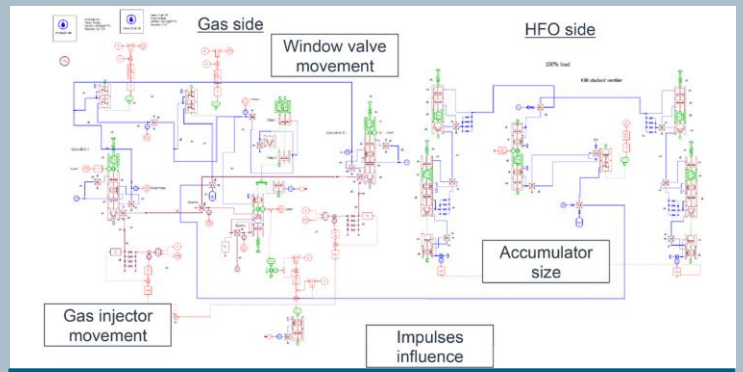


- **Reduced development time for new fuel injection systems by a factor of five**
- **Lowered testing costs**
- **Simplified training process for new research engineers**

Along the model-based systems engineering approach



View of dual-fuel engine operating on LNG



Model with gas and injection systems

- Adapting HFO fuel systems to gas injection constraints
- Quickly applying design changes by modifying parameters of off-the-shelf components

“Using Simcenter Amesim, development time has been reduced by a factor of five.”

Mikkel Thamsborg, R&D Project Manager

SIEMENS
Ingenuity for life

Others

Siemens Process Instrumentation uses Simcenter solutions to predict product performance

SIEMENS
Ingenuity for life

Simcenter solutions and services enable an automated process for virtual testing of electropneumatic positioners.

1,000s

of component combinations analyzed

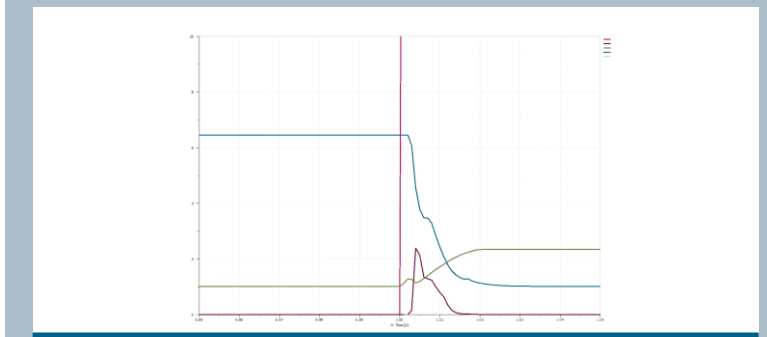
Siemens Process Instrumentation

Predict flag SIPART PS2 product performance using Simcenter solutions

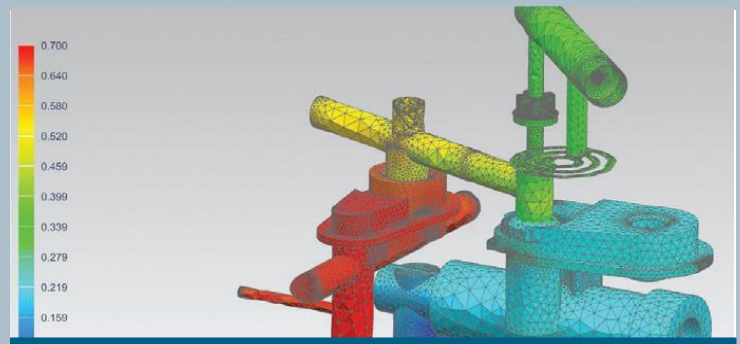
SIEMENS
Ingenuity for life

- **Established an automated process for virtual testing using digital twins**
- **Evaluated thousands of component combinations to quickly find the best configuration**
- **Saved time and cost by reducing testing efforts at the end of the project**

Fine-tuning valve digital twins



Step response Simcenter Amesim plot



Pneumatic flow pressure analysis with Simcenter 3D

- Develop an automated virtual testing environment with Simcenter Engineering
- Create digital twins of devices
- Use data from Simcenter 3D to fine-tune Simcenter Amesim valve models

“We use the data from Simcenter 3D and include it in the Simcenter Amesim model to refine it. Using Simcenter solutions helped us to get more robust products and to quickly solve customer challenges.”

Philippe Labalette Project Manager, R&D Siemens Process Instrumentation

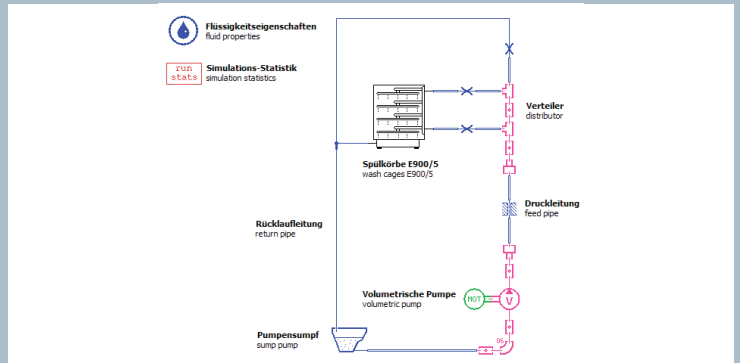
Miele

Raising standards of medical instrument cleaning with Simcenter Amesim

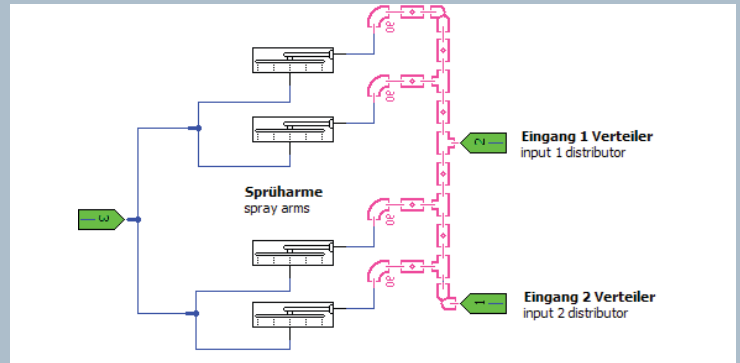
SIEMENS
Ingenuity for life

- **Reduced the need for physical prototypes**
- **Fostered quality during the early development stage**
- **Achieved the best possible results in complex systems with multiple parameters**

Explicit modeling integrating custom super-components



Integration of the rack as super-component



Exploration of the nozzle design impact

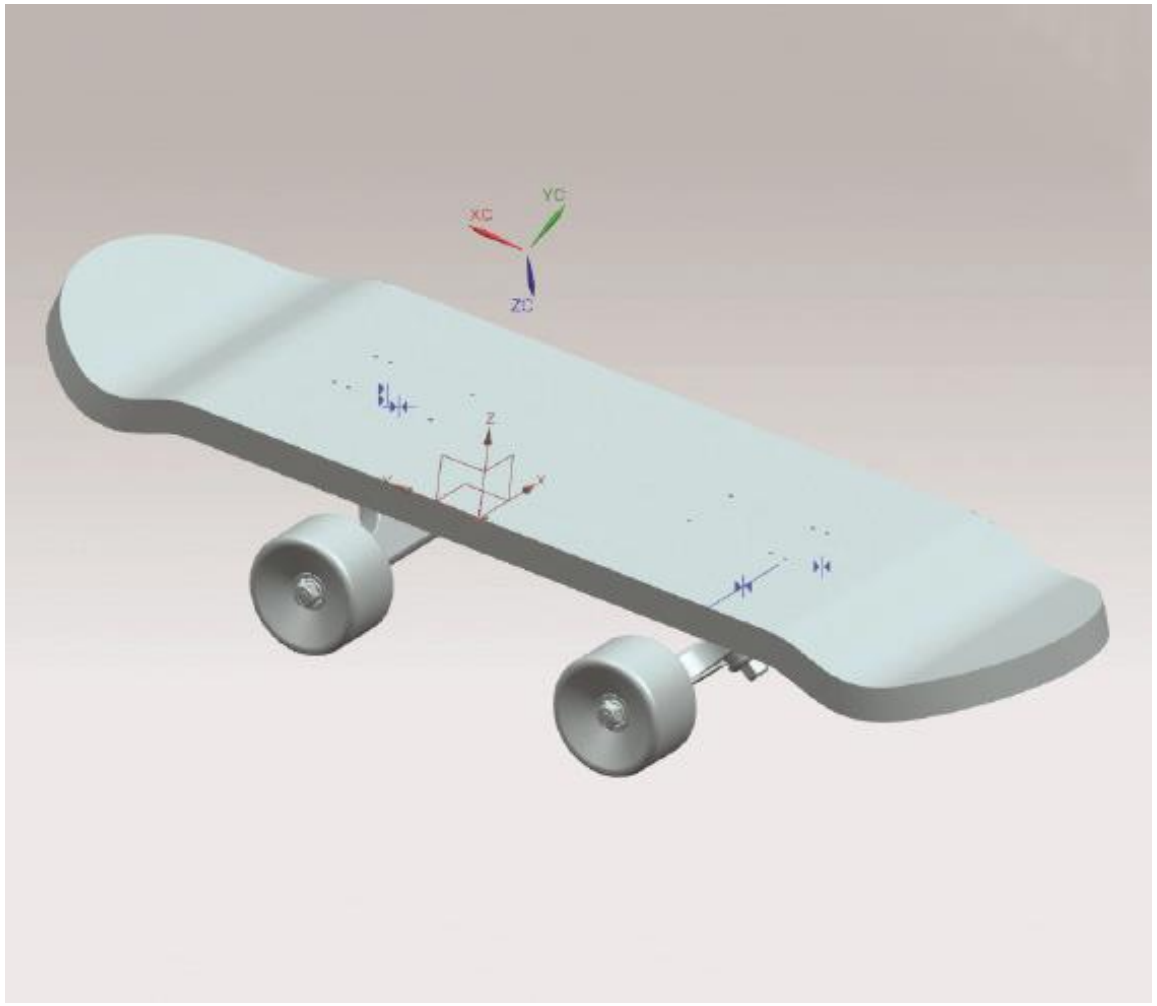
- Use an intuitive, clear and adaptive work environment
- Rely on useful and clear documentation

“Using this software, we are now much more effective in the predevelopment phase.”

Tobias Malec, Development Engineer

Indiana University Purdue University Indianapolis uses Siemens' MBSE tool suite to equip students for Industry 4.0

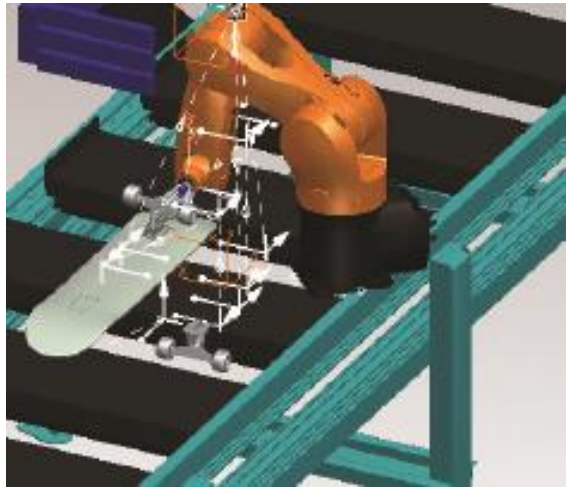
SIEMENS
Ingenuity for life



Siemens provides solutions that university students use for real-life product development.

3

major curriculum elements which utilize Siemens tools



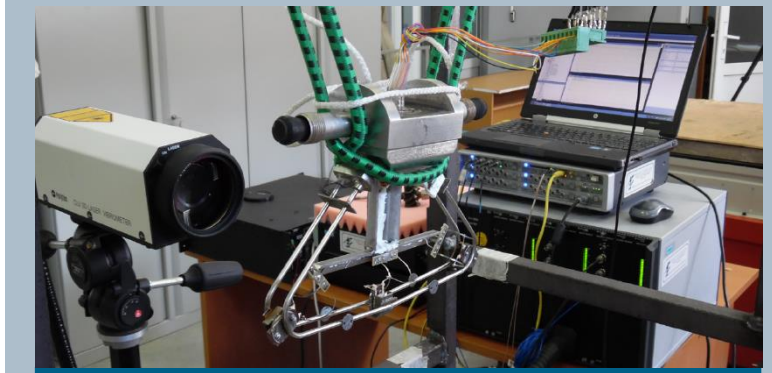
South Ural State University

Developing Russia's first virtual shaker test procedure with Simcenter solutions

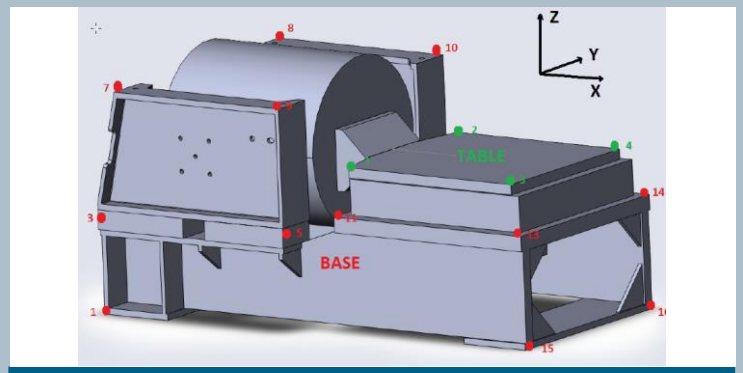
SIEMENS
Ingenuity for life

- **Development Developed Russia's first virtual shaker test procedure for mission-critical and highly expensive products**
- **Carried out commercial projects for AO SKB Turbina and PAO KAMAS**

Showing correlation between physical testing results and virtual modeling results



Performing modal analysis of a device using laser dopper vibrometer (LDV)



CAD model of the shaker

- Deploy Simcenter technologies
- Used projects to establish an innovative approach to complex and mission-critical component testing

"Simcenter supports a combination of analysis and physical testing that their competitors do not offer."

Dr. Pavel Taranenko, Director Experimental Mechanics Research and Education Center

South Ural State University

Supporting complex product development with Simcenter

SIEMENS
Ingenuity for life

- **Joint projects with the leading Russian aerospace and automotive companies**
- **Enhanced university's engineering education**

Master the modal analysis methods

Professional experimental research

University's engineering education

- Access to Simcenter testing procedures
- Master the new virtual testing approach

"As we considered the testing of mission-critical products that require excellent skill and fine-tuning, the Simcenter capabilities could hardly be overestimated."

Dr. Pavel Taranenko, Director Experimental Mechanics Research and Education Center