SIEMENS
Ingenuity for life

Simcenter for vehicle energy management

Using virtual prototyping to accelerate innovation

Benefits
- Use virtual prototyping to accelerate innovation
- Achieve the optimal balance between performance and energy efficiency
- Limit the number of physical prototypes
- Trace vehicle energy efficiency from concept to late refinement phase

Features
- Provide a single suite for simulation solutions that support all stages of development
- Deliver digital continuity to trace vehicle energy savings
- Provide a combination of system simulation, 3D CAE, CFD simulation tools and engineering services
- Frontload design exploration, validation and integration throughout development

Summary
Current and future environmental regulations not only encourage automotive manufacturers to produce cleaner and safer vehicles, but they also accelerate competition. Combining these challenges with new market trends, such as digital disruption with a growing number of connected cars, urbanization-modifying usage (sharing, commuting, etc.) and an increasing number of requirements, makes it more complex than ever to design a vehicle. Due to conflicting priorities, including the pace of innovation and increased energy efficiency requirements versus opposite attributes such as drivability or comfort, manufacturers are forced to drastically rethink their design methodologies.

It is no longer possible to assess the performance of multiple vehicle architectures with physical testing considering all the above requirements, so moving from physical to virtual prototyping is key to reducing development times and engineering costs.

Developing the digital twin of a vehicle and its subsystems enable you to virtually define the architecture of a vehicle at an early stage of development. It makes it possible to reach the optimal balance between performance and energy efficiency targets and limit the number of physical prototypes.

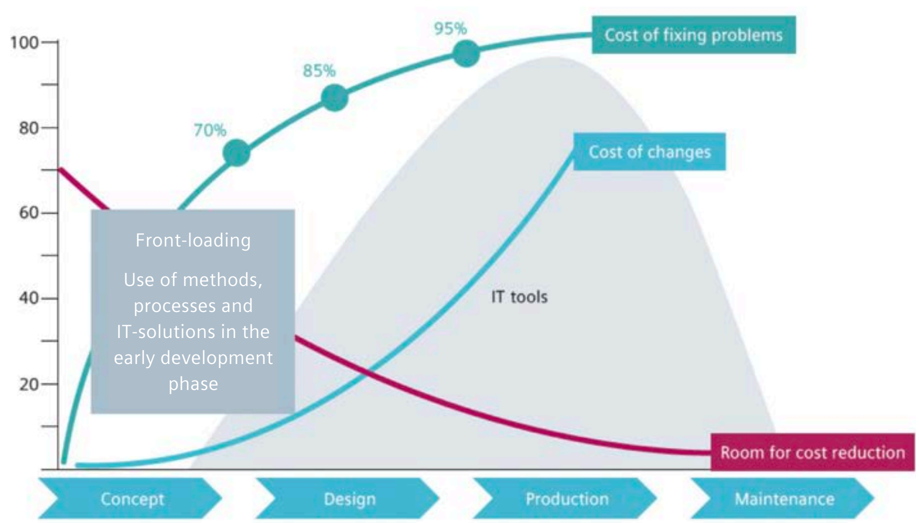

Figure 1: Front-loading of simulation can help reduce costs. Source: Professor Dr. Matin Eigner, Institute for Virtual Product Engineering, University of Kaiserslautern.

Simcenter for vehicle energy management

Opting for an integrated simulation process

With a simulation-driven development method you can digitally explore various architectures and configurations to find the best tradeoffs between conflicting attributes in an efficient and cost-effective manner before a prototype even exists.

This simulation-driven development approach is powered by the Simcenter™ portfolio, which is a single suite of simulation and testing solutions that support all stages of the development cycle with digital continuity to trace the vehicle energy savings. The Simcenter portfolio provides simulation engineers with a combination of system simulation, 3D computer-aided engineering (CAE) and computational fluid dynamics (CFD) simulation tools and engineering services to offer capabilities ranging from benchmarking and target setting for energy management and architectural sizing and control strategy development to design exploration.

Building a digital twin requires you to have the right tool to facilitate accurate analysis at the right time in the development cycle. Siemens Digital Industries Software has developed a full vehicle measurement approach in combination with a scalable modeling methodology so users can trace vehicle fuel economy from early concept to the late refinement phases.

Accelerating multi-domain engineering decisions

With Simcenter solutions you can easily explore, design, analyze and improve vehicle energy management (VEM) and fuel efficiency by innovating in a wide range of areas such as:

- Powertrain design
- Vehicle electrification and hybridization
- Vehicle heat protection
- Cabin driver and thermal comfort
- External aerodynamics

Powertrain design

Optimizing powertrain systems and subsystems performance and emissions car manufacturers must start to consider. Simcenter solutions make it possible to front-load design exploration, validation and integration throughout the development process. It supports multi-attribute performance engineering of mechatronic systems over different phases of development, from requirements capturing and target setting, architecture selection and evaluation and detailed engineering of powertrain subsystems to powertrain integration and controls validation.

The internal combustion engine (ICE) will remain an important player for the next few decades, either as part of the main source of power in conventional or hybrid vehicles, or as an auxiliary source of energy in range extenders. Innovation in conventional powertrains in many instances implies an increase in technological complexity, while alternative technologies imply an immediate need for removing uncertainty using rapid system development. Using Simcenter solutions, such as Simcenter Amesim™ software and Simcenter STAR-CCM+™ software, allows you to fine-tune and optimize air-path and charging systems, combustion systems and exhaust after-treatment to meet standards for real-driving emissions (RDE) and worldwide harmonized light vehicles test procedure (WLTP).

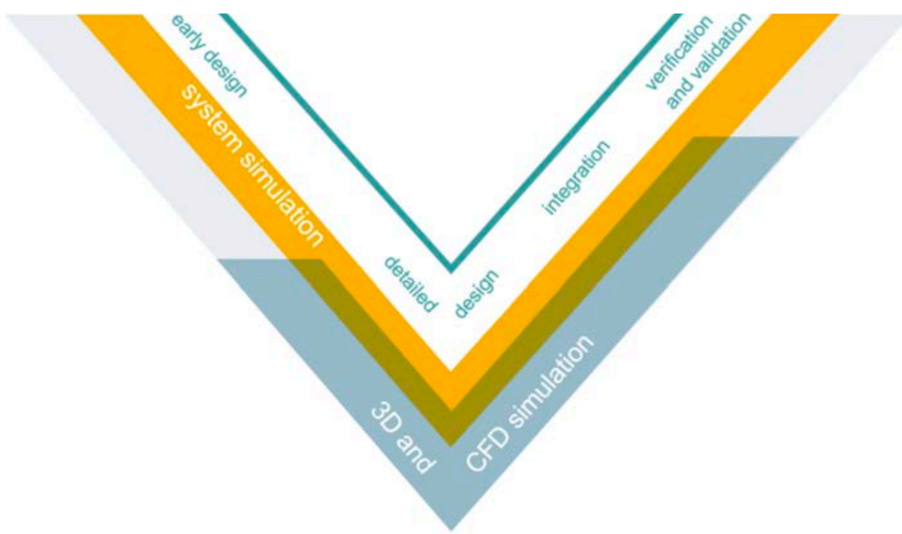

Figure 2: Simcenter portfolio all along the development cycle.

Another way to improve vehicle energy management is to focus on the transmission design. Using scalable models in Simcenter Amesim – from functional to high fidelity – enable you to accurately reproduce high-frequency and nonlinear phenomena. Any type of transmission can be modeled and combined with the ICE and vehicle models so the user can study interactions and minimize the impact on driving comfort. (Please find more information about simulation for powertrain design).

Vehicle electrification and hybridization

In addition to improvements introduced for conventional vehicles, challenges to reach emission and fuel consumption regulation targets are increasingly being tackled with hybridization.

To answer all the questions around hybridization and electrification, Simcenter tools (Simcenter Amesim, Simcenter SPEED™ software and Simcenter Battery Design Studio™ software) support engineers in virtually assessing and validating battery, fuel-cell, e-machine and power electronics designs choices. You can easily size a pack, design a cooling subsystem, optimize a control strategy, reduce the fuel consumption or maximize the range. (Please find more information about vehicle electrification).

The vehicle heat protection

Design department needs to make sure components work under severe operating conditions at early stage. System analysis can help determine how much cooling air, or what kind of coolant system, is needed. As the design matures, tests need to confirm each component operates within the required range. This includes testing thousands of components, which vary in material properties and critical operating conditions. The earlier in the design cycle these components can be virtually tested in a representative environment, the cheaper it is to protect the component.

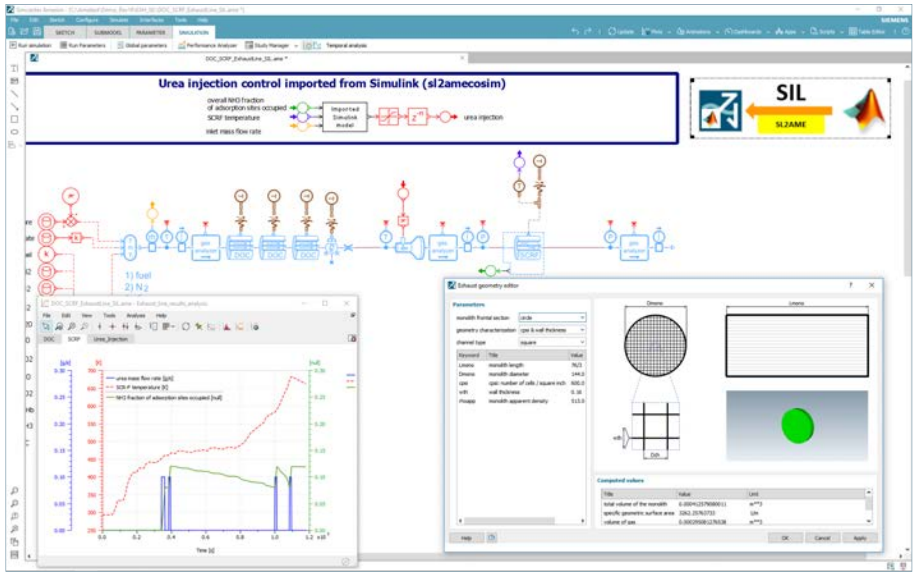

Figure 3. Simcenter Amesim helps to optimize after-treatment system design for reducing emissions.

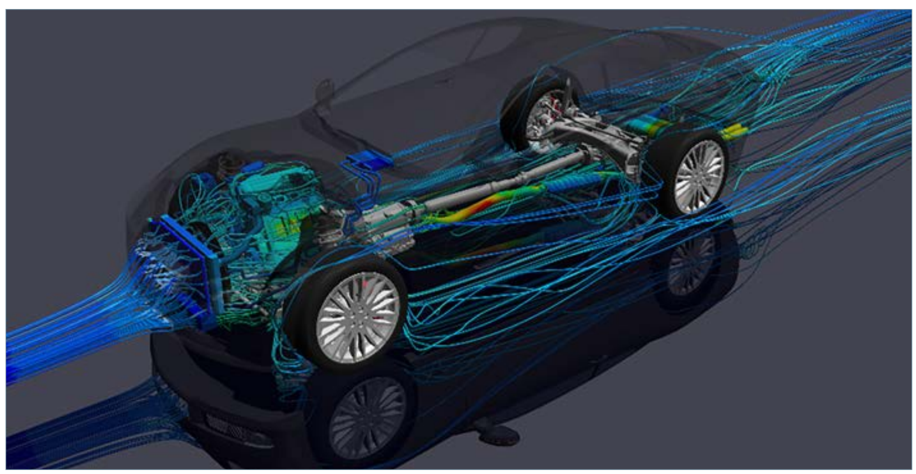

Figure 4. Simcenter STAR-CCM+ for heat protection.

Simcenter STAR-CCM+ provides templates that allow users to quickly link their computer-aided (CAD) data to simulation. In addition, fluids and solids are tightly coupled for long thermal transients (30 to 90 minutes depending on the case). This facilitates simulation of critical conditions, such as soak condition, to be completed earlier in the design process. Previously, most original equipment manufacturers (OEMs) relied more on physical tests to determine thermal failure, which is more expensive when the failures occur late in the design process. By having information on hot spots, air flow can be directed into critical areas, or heat shields can be added as needed. It allows to secure heat protection while optimizing costs.

The cabin driver and thermal comfort

Thermal management is crucial not only for component reliability and systems safety, but also for performance (thermal engine, electric machines, battery, etc.), fuel consumption (highest efficiency at optimal temperature), emissions (post-treatment devices) and passenger thermal comfort. Simcenter Amesim offers a comprehensive set of simulation models so you can easily and accurately simulate interactions between the air conditioning system and various cooling systems and the cabin, especially in the context of high-efficiency engines or electric vehicles with negligible thermal losses. The different analysis capabilities enable you to study in detail the behavior of the entire system according to heating/cooling strategies and drive cycles in specific operating conditions. For example, you can virtually develop enhanced engine warmup strategies by simulating the influence of topological modifications of each subsystem (such as split cooling, energy storage tank, material changes or electric pumps).

From the beginning the system models can be coupled with 3D fluid simulation whether it is for under hood thermal management, aerodynamic. In early design, a simplified cabin can be used to help provide improved control logic in the systems model. This can be extended with embedded CFD inside Simcenter Amesim, where it is used to build and run the CFD model for the user. As the design matures, the geometry of the cabin is used to look at the position and design of the heating and cooling vents. In addition, passengers are included in the digital model so you can assess passenger thermal comfort. Additionally, the vents are digitally tested to make sure the car meets government regulations for deice/defog on the windshield and side view mirrors. The 3D detail passenger comfort models are done using Simcenter STAR-CCM+ and includes solar radiation, conduction, humidity and heat rejected by the passengers. The results can be mapped back into the system model for improved logic on the controls system for meeting passenger thermal comfort.

For electric vehicles, subsystems designed for cabin comfort and their control logic have become more critical. For example, designers need to look at the correct tradeoff between passenger comfort (heating/cooling), battery system thermal management and vehicle driving range. Simulation enables designers to improve this tradeoff yet to minimize thermal subsystems

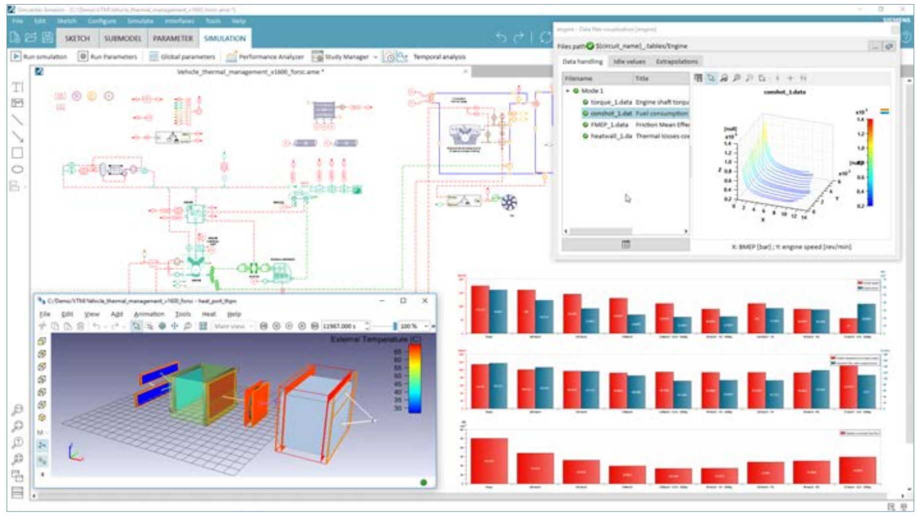

Figure 5. Simcenter Amesim for thermal management.

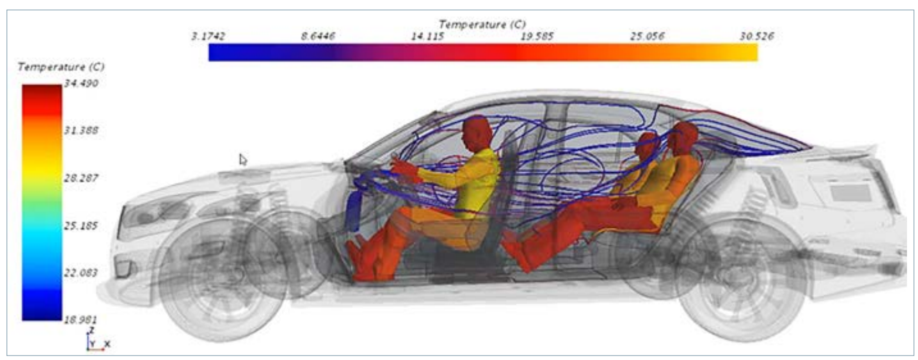

Figure 6. Simcenter STAR-CCM+ for cabin comfort.

losses (heat transfers, pressure drops, mechanical efficiencies, etc.).

The external aerodynamics

Traditionally, the aesthetics of the external design determined market appeal. But with strong government regulations on fuel consumption and the push to extend the driving range of electric vehicles, external aerodynamics has started to play a vital role in reducing energy losses and determining a car's appeal. At highway speed, air resistance accounts for the vehicle's largest use of energy. Additionally, the aerodynamics of the vehicle needs to drive air for cooling the powertrain and critical components, as well as maintain down-force balance between front and rear wheels for improved vehicle handling.

To produce an energy-efficient vehicle, the designer needs to look at the tradeoff between style, vehicle drag, cooling performance and driving stability. Having grill shutters is becoming more common to help reduce the drag at high speeds. For this, it becomes critical to understand the control logic when aerodynamics devices open and close. Simcenter Amesim provides a system model that helps run scenarios for long-drive cycles and defines control logic for opening and closing the devices. Simcenter STAR-CCM+ provides input on vehicle drag, depending on the configuration of the active-flow device. It also helps evaluate the thermal environment around the engine during driving to make sure enough cooling air is being driven to the correct location.

Finding the right balance between performance attributes

Although individual performance departments focus on design optimization in their domain and look for best-in-class solutions, management is confronted with the need to deliver an overall balanced performance scorecard for the vehicle. This leads us to focus on delivering tools and processes to support you in balancing positive and negative impacts using multi-attribute performance engineering.

Adopting an engineering process that considers the complete vehicle to balance all its attributes is crucial and the nature and extent of this tuning exercise is largely dependent on customer requirements and preferences as well as emissions regulations. For example, car use can be slow and smooth versus a fast and sudden tip-in, all the while keeping a close eye on the performance of other attributes.

The Simcenter portfolio enables you to effectively find the right tradeoff architecture that considers all performance attributes. The software supports early design phases by enabling you to create simulation models for range and performance and vehicle energy management models, including predictive dynamic modeling of the engine, electric powertrain, battery and heating, ventilation and air conditioning (HVAC) as well as all the associated thermal management systems. Finally, it enables you to fine-tune the control strategy throughout the development cycle.

Figure 7. Simcenter STAR-CCM+ for vehicle aerodynamics optimization.

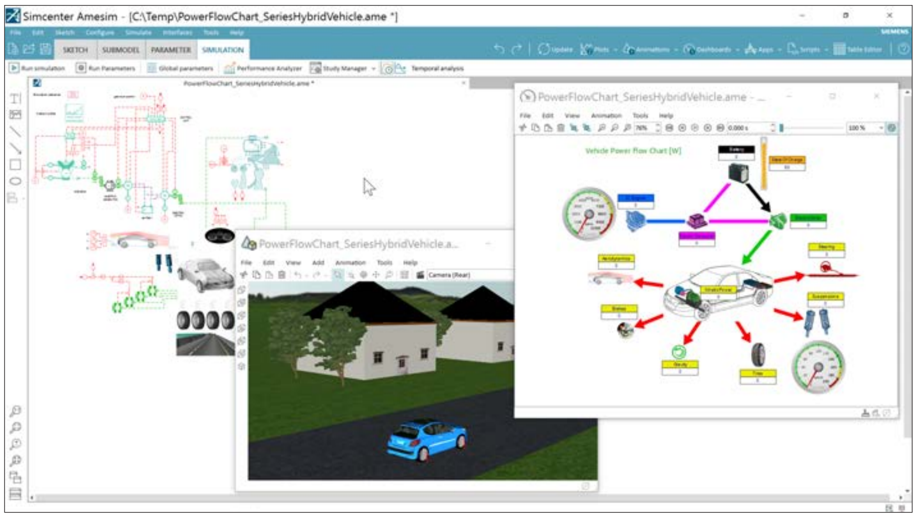

Figure 8. The Simcenter portfolio enables you to effectively find the right tradeoff architecture that considers all performance attributes.

Siemens Digital Industries Software
siemens.com/software

Americas +1 314 264 8499
Europe +44 (0) 1276 413200
Asia-Pacific +852 2230 3333

77517-C5 10/19 M