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# LMS News

Siemens PLM Software

Meet the innovators in automotive engineering



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Engineering the perfect car

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#### 30 – 33 And the winner is... The China FAW R&D Center

The largest research, development, test and inspection facility for the automotive industry in China, the China FAW R&D Center, substantially cut the development time and cost of a recently launched commercial truck using LMS Virtual.Lab™ software solutions. And this new durability engineering process brought in two awards: second prize in the China Award of Science and Technology – Automotive Industry contest, and first prize in the FAW Group Technology Innovation Prize contest.

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#### 34 – 37 Hyundai Conquers mechatronic system complexity

Hyundai engineers have seen an explosion in the number of parameters that need to be taken into account. Dealing with this increasing complexity required the adoption of new development methods and tools to validate possible architectures and fine-tune systems and components early in the design cycle. LMS Imagine.Lab Amesim™ software was quickly selected at Hyundai for supporting the development and validation of innovative transmission systems.

#### 38 – 39 The battle for the solar car world championship

Engineering students around the world have marked their calendars for October 18-25, 2015. These are the dates of the World Solar Challenge, the unofficial world championship solar car race across Australia from Darwin to Adelaide. The teams behind the most energy-efficient cars in the world come from top engineering universities, including two university teams close to our hearts: the Punch Powertrain Solar Team from the Group T Campus of the KU Leuven (University of Leuven, Belgium) and the University of Michigan Solar Car team.

»As we move forward with the automotive industry, we will draw on our experience, sharing expertise amongst industry leaders and innovating in partnership with our customers.«



# The only way forward

Focused on product and process innovation, the automotive industry is still one of the most thriving industries to work in. The list of challenges keeps on growing. Fuel economy and other environmental regulations, including vehicle pass-by noise, continue to become stricter. And meeting government regulations while staying competitive with core brand performance traits requires the right balance of key attributes. In addition to these major drivers, the industry is moving from platform-based processes toward modular system-of-systems approaches. This is a massive change in development.

The product and process innovation needed to address these challenges is increasingly happening at intersections. For example, subsystems have become mechatronic systems that derive their overall performance by combining mechanics and controls, and the various subsystems work together to deliver the total product performance. It doesn't stop here, either. Today, with the Internet of Things, cars need to interact with the surrounding infrastructure. This is opening the industry to an entire new set of challenges, from driverless cars to smart highways and intelligent, active safety systems.

Managing these intersections is critical in today's innovation race. Model-based development and systems engineering or systems-driven product development during all development stages is crucial in this regard. Companies that are actively involved in this transformation right now are developing a true competitive advantage to realize innovation

These new approaches raise the bar for our LMS™ solutions for simulation and testing as well. Our customers must be able to verify and validate the convergence of a new product design to their requirements during all stages of the development process, from the first concept to final product validation on the proving ground. We refer to this as closed-loop systems-driven product development. It is a central driver for our forward strategy.

In this issue, we are pleased to share how our customers like General Motors (GM), Hyundai and Lamborghini are using LMS Imagine.Lab™ software for model-based development and systems engineering, supporting tighter integration between controls engineering and mechanical design to help manage mechatronic system optimization.

We complement the evolution of our simulation technology by continuing to support upfront engineering with new evolutions in testing. One example is our new Siemens Vehicle Energy Management (VEM) Test Center in Lyon, France, where engineers can count on our advanced testing and simulation expertise to help balance vehicle attributes.

Other examples include our continued commitment to develop advanced capabilities in automotive engineering areas, like noise, vibration and harshness (NVH) and durability. Our cover feature explains how Ralf Lehmann and his team at Daimler use LMS testing solutions to tackle modern-day NVH challenges in vehicle engineering. You will also find two articles focusing on durability: the application of our new road load data acquisition (RLDA) solution at GM and the FAW R&D Center in China where engineers optimized the vehicle structure for durability performance using LMS Virtual.Lab™ software.

We are seeing more synergies within Siemens PLM Software. In composites, we are working together to create value by combining the Fibersim™ portfolio for composites engineering, LMS Samtech Samcef™ Composites software and LMS Virtual.Lab software. Dr. Yuta Urushiyama and his team at Honda share their view about working with our applications on engineering composite body structures.

As we move forward with the automotive industry, we will draw on our more than 35 years of experience, sharing expertise amongst industry leaders and innovating in partnership with our customers. All the stories in this issue are great examples of our dedication to realizing innovation. I trust you will find them inspiring to read.

**Dr. Jan M. Leuridan**

**Senior Vice President, Simulation and Test Solutions  
Siemens PLM Software**



# Engineering the perfect car

Mercedes S-Class coupe,  
the quietest car in the world





According to Forbes Magazine, the new Mercedes S-Class coupe is 10 percent quieter than the current S-Class sedan when it comes to wind noise, partly because the sedan does not have such thick side glass. And it is also 20 percent quieter than its predecessor, the CL-Class. The new S-Class is generally considered one of the quietest cars in the world. This is a well-deserved reward for the hard-working noise, vibration and harshness (NVH) and acoustics team of Daimler, but it sets an unexpected new challenge: How can an NVH team further improve the acoustics of a best-in-class vehicle?



### Tackling the modern NVH challenges

There are a number of problems that contemporary automotive NVH teams need to tackle on a daily basis. Ralf Lehmann, manager of the NVH test team (vibro-acoustics and tread noise) at Daimler, shares his view on the challenges that affect NVH teams today.

When attempting to engineer the world's quietest and most comfortable vehicle, the first difficulty is to properly

The second challenge is the management of the incredible amount of vibration and acoustic data that NVH engineers collect and interpret. It is critically important that this data is properly stored, annotated and made available for short-term analysis as well as future reference. Engineers should be able to easily find the individual data that is important for their ongoing tests and analysis. The recent licensing of LMS Test.Lab™ software from Siemens PLM Software is an important step toward streamlining NVH data handling.

The third modern NVH challenge is the need for tight integration of simulation and testing processes. Although Daimler engineers are already consistently comparing and exchanging data, there is room for improvement as techniques and processes could be further optimized to support even faster and more streamlined vehicle development. With its extensive platform of test and simulation solutions as well as its expertise in hybrid test-

simulation engineering, Siemens PLM Software is ideally positioned to support the improvement process.

The final challenge is to optimally utilize the numerous test techniques at hand to set and reach the right NVH targets.

"A transfer path analysis is a fool-proof method to pinpoint the root cause of an NVH issue, but what's the next step once you've revealed the issue?" asks Lehmann. "Which action should you take to resolve it? The answer may lie in the usage of simulation models to predict behavior with adjusted parameters, yet other techniques could prove more efficient to solve this specific problem."

## "We have learned that the Siemens PLM Software tools are also a good fit for the NVH development of our line of hybrid and electric cars."

Ralf Lehmann, NVH Manager, Daimler

define comfort. There are few or no objective metrics to define the acoustic and vibration comfort level in a car. On the contrary, there are a number of subjective values that can be situation- or user-dependent that affect the perception of comfort. Some of these subjective values cannot be ignored when designing the perfect car. One of the challenges of the Daimler team is to objectivize the subjectivity: define new metrics, set new standards or prepare test templates that will help capture the subjective dimension of any test drive.



When attempting to engineer the world's quietest and most comfortable car, the first challenge is to properly define comfort.



"There is no tutorial prescribing a standard solution for each problem," Lehmann continues. "It is up to skilled team members to find the answer using the tools at hand. Also, the last problem you want to face is that once you've found the way to meet the target, you realize that it is not the right target. The balancing of multiple comfort and ride and handling attributes is a tricky exercise, a fine equilibrium between conflicting goals. You need to weigh your vehicle dynamics targets against your comfort target and define that ultimate value that will help engineer the perfect car."

### Spanning the multiple roles

The NVH team at Daimler performs many tasks with a focus on the following engineering approaches: modal analysis on the vehicle body – be it body-in-white, trimmed body, or full vehicle – to exclude potential vibration and acoustic issues due to resonances, and transfer path analysis (TPA) to trace the flow of energy within the structures and find the weak spots through which vibration is transmitted to the car occupants. The team analyzes low-frequency vibration and acoustic phenomena on passenger vehicles, testing those vehicles on a roller bench with the purpose of optimizing the NVH behavior to ultimately design the best-of-bench car.

Perfecting the NVH behavior is a task that is more complex than ever, as other non-NVH related parameters also need to be taken into account, including development, manufacturing, material costs and the weight of the structure and components. All parameters need to be carefully adjusted to design the most comfortable, cost-optimized and energy-efficient vehicle.

Additionally, these tasks need to be performed under challenging conditions: only a very limited number of prototypes are produced on which the team can perform tests and analyses. The shortage of prototypes combined with the compression of development cycles generates enormous time pressure for the team to complete tests as quickly and efficiently as possible. A tight collaboration with the simulation team helps relieve the workload of the test team, yet simulation models cannot represent the magnitude of vibration and acoustic phenomena occurring in a vehicle in motion, and cannot entirely replace NVH tests. Testing remains an essential step in the development process that cannot be replaced by simulation, or even dissociated from it, as simulation models still need to be validated using test data.

In addition to modal and transfer path analyses, the team also intervenes in troubleshooting projects on vehicles late in the development phase, or even on commercialized cars, and is involved in the early development phase for benchmarking existing vehicles and setting new NVH targets. This type of project often requires that vehicles are tested on the road, using the LMS SCADAS™ Mobile hardware to acquire data while driving.

The NVH team at Daimler has resources and expertise to execute the full breadth of possible NVH-related tests and analyses. Reliable LMS simulation and testing solutions from Siemens PLM Software are strong assets in support of this expertise. Siemens PLM Software offers the broadest palette of NVH engineering tools, covering the entire NVH development cycle, but also offering adequate tools for multi-attribute balancing. The team also benefits from the



Other challenges include integrating simulation and testing processes and optimally utilizing numerous test techniques to reach the right NVH targets.

**"We are able to manage all our NVH target values efficiently in a large database. We are still in the phase of completing our database to get an exhaustive view on NVH values, but we have gathered sufficient experience with the tool to achieve a productivity increase."**

Ralf Lehmann, manager of the NVH test team (vibro-acoustics and tread noise) at Daimler





support of the LMS™ Engineering services experts in times of peak workload in the form of additional, highly-skilled manpower for large-scale projects, or for in-depth expertise for specialized topics. This is certainly a win-win partnership as LMS Engineering experts are able to take advantage of the experience gained during these product development projects, resulting in LMS software and hardware being even better tailored to the needs of NVH teams with every new release.

#### **Managing large amounts of data**

Next to carefully managing and optimizing its human resources, a large NVH team like the one at Daimler needs to ensure that technical resources and, most importantly, test data are administered in the most efficient way. The team recently invested in the LMS Test.Lab data management to optimally handle all its test data.

"We are able to manage all our NVH target values efficiently in a large database," says Lehmann. "We are still in the phase of completing our database to get an exhaustive view on NVH values, but we have gathered sufficient experience with the tool to achieve a productivity increase. The tool is very convenient to use and enables us to go back and access the exact data that we need at the time we need it."

#### **Engineering the quietest car of tomorrow**

All of the NVH engineering tasks previously described not only apply to the development of conventional vehicles with internal combustion engines, but also to one of the new hybrid or electric vehicles.

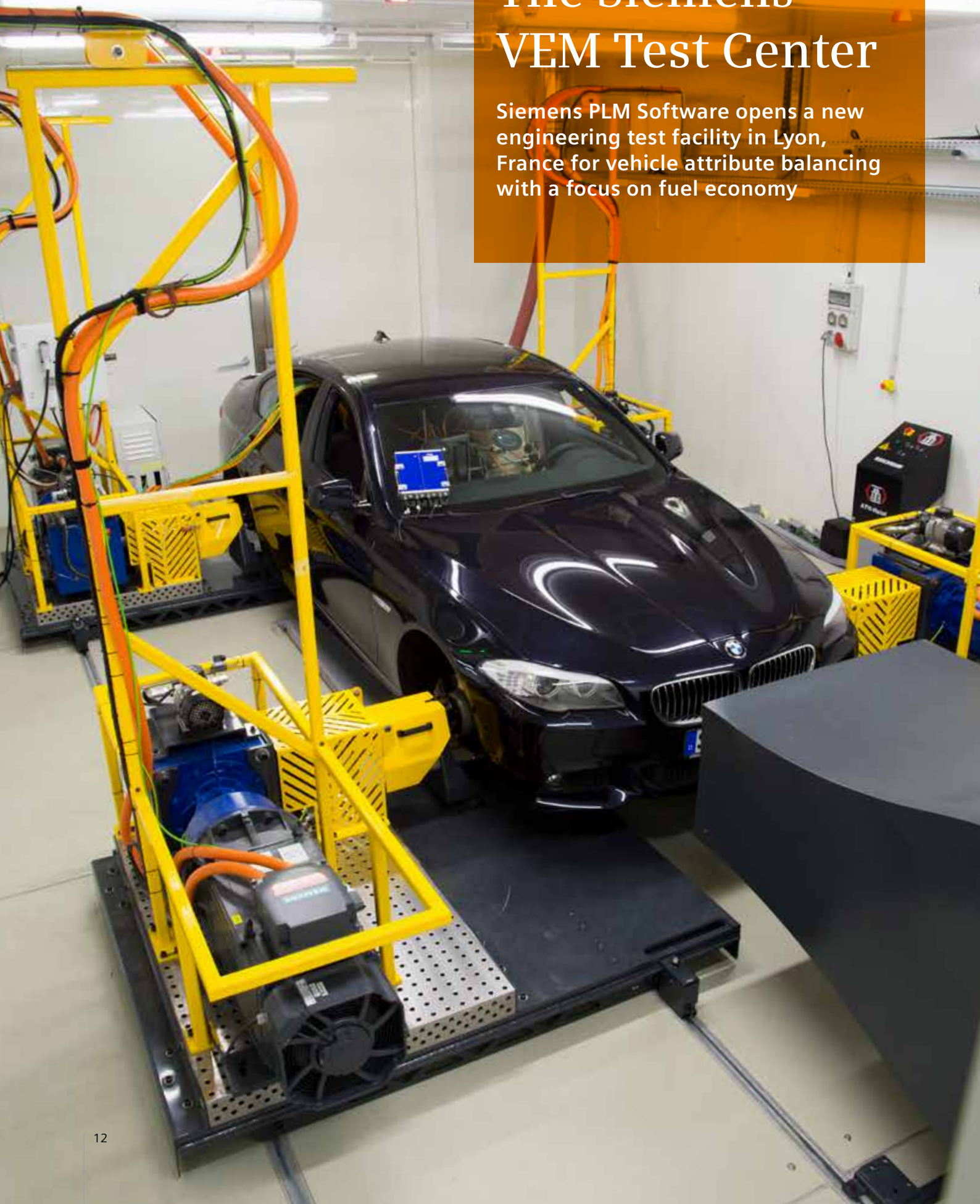
"We have learned that the Siemens PLM Software tools are also a good fit for the NVH development of our line of hybrid and electric cars," says Lehmann. "The engineering methods applied to develop electric vehicles are not fundamentally different from the ones applied in a traditional development process. The LMS Test.Lab software also features algorithms that are dedicated to the study of NVH phenomena that occur in electrically-powered vehicles, such as off-zero harmonic sidebands.

"The major difference between conventional and electrical vehicle development can be found in target NVH values with respect to frequency range, levels and appropriate metrics," Lehmann says. "To a large extent, we cannot rely on experience to set new targets. We need to define those in the cumbersome day-to-day testing process. In the longer term, the creation of an extensive database of NVH values for electric vehicles will certainly help set the right targets. In the short term, our involvement in advanced research projects together with LMS Engineering helps us build expertise."



# The Siemens VEM Test Center

Siemens PLM Software opens a new engineering test facility in Lyon, France for vehicle attribute balancing with a focus on fuel economy





In April 2015, Siemens PLM Software is opening a state-of-the-art vehicle energy management (VEM) test center in Lyon, France. The facility is the first in the industry to couple advanced testing solutions on the full vehicle level with in-depth physics simulation.

Run by VEM experts from LMS Engineering services, the Siemens VEM Test Center will help customers accelerate the design of modern-day mechatronic products through innovative integration of state-of-the-art instrumentation with system simulation technology. Specific attention is given to both fuel economy and drivability for next-generation energy improvement systems and vehicles. Balancing and optimizing both areas relies heavily on the integrated test and simulation approach.

**“Superior performance results from interconnected controls linking mechanical, electrical, hydraulic, thermal and combustion physics.”**

Dirk De Vis, Vice President, LMS Engineering  
Siemens PLM Software

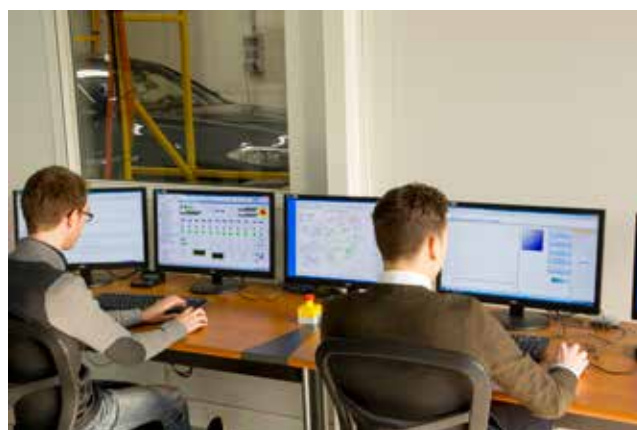
#### The Siemens VEM methodology

##### Benchmarking and target setting for fuel economy

Good fuel economy is an important brand differentiator and a serious competitive advantage. But improved fuel economy often conflicts with NVH, comfort or durability. A well-balanced performance requires system targets to be set within the development process as a whole. Customers turn to the Siemens VEM Test Center to analyze state-of-the-art competitive vehicles or to evaluate improvement potential on current products to set challenging, yet achievable requirements.

#### The Siemens VEM Test Center in detail

- A 4-wheel, direct-spindle-drive dynamometer with torques equal to large sedans and sport utility vehicles (SUVs)
- A temperature-controlled climate chamber with a range of -7°C to +45°C
- A 5 degrees of freedom (DOF) robot to automatically operate manual and automatic transmission vehicles with superior accuracy to follow prescribed profiles
- A multiphysics measurement system to capture energy flows in different physical domains
- Measurement and postprocessing capabilities to convert test data into energy flow maps
- A team of experts specialized in testing for fuel economy improvements. This team works closely with the simulation team to build LMS Amesim models to propose better solutions for improving a vehicle design's fuel economy



#### Test support for multi-attribute balancing

Efficient use of the test data, acquired at full vehicle level, extends simulation to higher dynamics with tools like LMS Imagine.Lab Amesim™ software. Low frequency booming, tip-in shock and shifting can now be predicted and balanced with fuel consumption and energy management right from the concept phase.

#### Troubleshooting vehicle attributes

Today, cars have become complex mechatronic systems. Superior performance results from interconnected controls linking mechanical, electrical, hydraulic, thermal and combustion physics. Testing under full vehicle conditions assures proper boundary conditions, and testing augmented with system simulation enables you to quickly diagnose flaws and identify countermeasures.

# Creating an automotive composite community

According to Dr. Yuta Urushiyama, an expert in composite technology who leads the composite body innovation programs at Honda's Automobile R&D Center in Tochigi, Japan, now is the time to start moving the automotive composite community forward.

## An important piece of the puzzle

Composites are not completely new to the automotive world, yet transferring existing composites technology to the next-generation automobile is tougher than it seems. Take the Formula One® race car carbon fiber monocoque shell. It was invented in 1980 and revolutionized the sport, leading to faster, lighter and safer cars. Today this racing-derived composites technology is an important piece of the puzzle when it comes to the next-generation automobile. And lightweight composite materials are a good way to significantly reduce car weight, which means more fuel-efficient and lower-emission vehicles.

So if composites hold such promise, why hasn't the automotive industry embraced these high-tech materials more enthusiastically? Why hasn't the automotive industry jumped on board the way that the aviation or marine industries have?

There are several reasons, and one of the most important is the history of

the automobile. From the start, the automotive industry has been linked to the steel industry. For decades, heavier or bigger cars were considered better and safer. Only recently have automotive manufacturers focused on lightweight vehicles as a response to environmental regulations and the market demand for enhanced economy. This is different than the marine or aviation industries in which the weight of the vehicle is a mission-critical priority linked to functionality. It is not surprising then that composites gained acceptance more quickly in these industries.

Another more recent issue is manufacturing volume. Quite a few industry insiders doubt the composites industry can supply production that tops 100,000 units annually. But this is being addressed by process changes in manufacturing and new supply chain partnerships.

Still another factor is cost. Typically, composites are expensive, and

experts are quick to point out the value factor rather than the cost. According to the Automotive Composites Alliance, a single composite molding can replace 15 to 20 individual steel components and fasteners. Translated to the subassembly level, engineers could reduce the number of total parts from 50 to 20. This impacts assembly time and significantly reduces manufacturing complexity, all factors that affect the vehicle price tag.

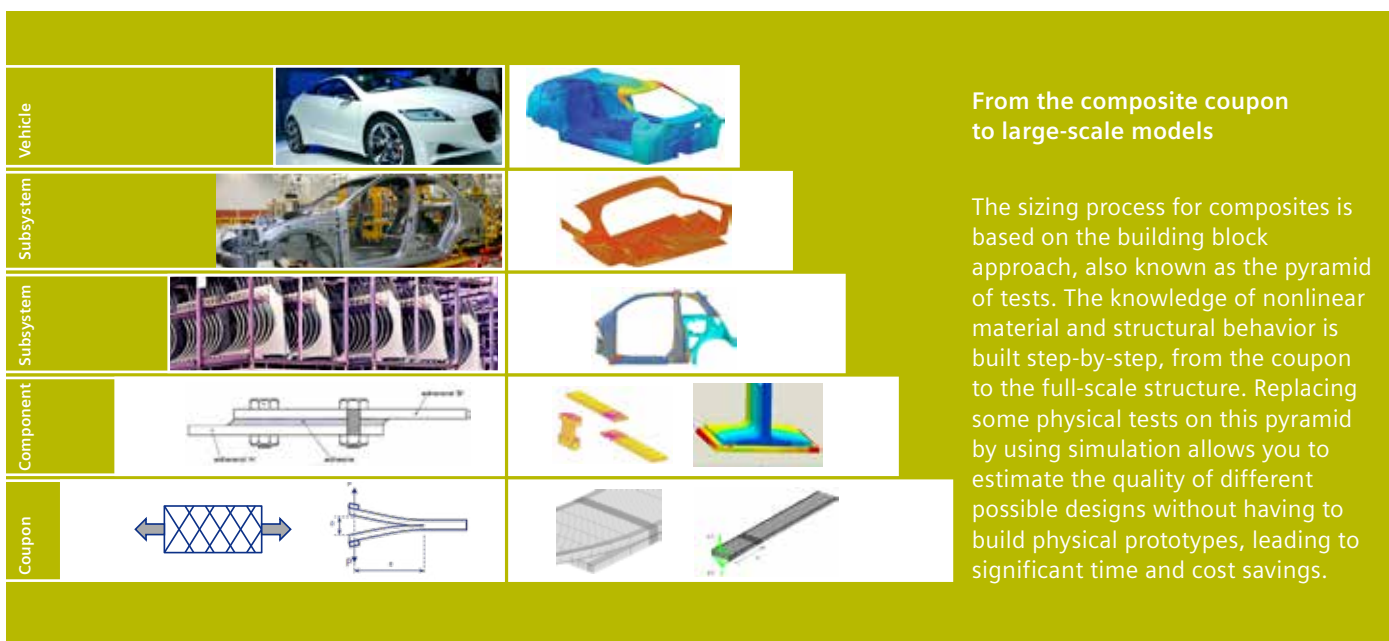
## No miracle solution

At the moment, there isn't a miracle solution to provide the automotive industry with the necessary composite volume at an affordable price. But according to Dr. Yuta Urushiyama, an expert in composites technology who leads the composite body innovation programs at Honda's Automobile R&D Center in Tochigi, Japan, now is the time to start moving the automotive composite community forward.

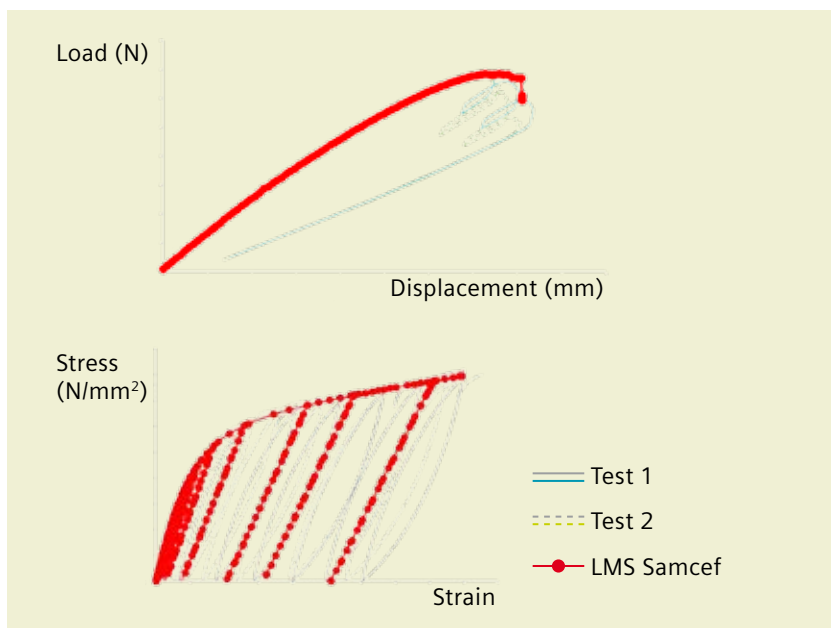




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The building block approach, including the composite structure and virtual and experimental material testing.



Part of the innovative methodology for progressive damage analysis of composites using LMS Samtech Samcef Composites.

"The automotive composite development teams are small in regards to money, people and experience compared to powertrain development or vehicle performance on the proving grounds," explains Urushiyama. "We need to focus more on composites. They are the future of the industry."

Urushiyama understands the potential value of composites. Today he is working alongside industry experts as well as researchers from leading institutes and universities to create a community of composite expertise.

"I personally feel that the link to education is a must," says Urushiyama. "There are a small number of students studying automotive composites today compared to aerospace. If you look at the number of young engineers starting to work in the automotive sector, there are very few with knowledge of composites. It is worldwide issue, but it is especially relevant in Japan and Europe. There is a great need for more expertise in the field."

#### Not your grandmother's metal

Even if it doesn't have the historical impact of steel and aluminum, composites are becoming more mainstream. Composite materials

have different properties and behavior characteristics than, for example, steel or aluminum alloys, which act homogeneously. And since composites are relatively new to the automotive industry, it is only logical that there is limited expertise regarding composite behavior under structurally complex and dynamic loading.

"We don't have enough databases of test information to compare or correlate our results," says Urushiyama. "And we don't have the right material and damage propagation information to model this type of work yet. We need more test and simulation-based product design data and coupon-level testing to establish a dependable simulation process for all the material and design choices at hand."

"Not only at Honda, but many engineers in this field think that we can still make vehicles that have a 50 percent lighter body structure using composites while maintaining the mechanical properties of the replaced metallic parts," says Urushiyama. "This might be possible by 2020 or 2030, but reaching this 50 percent weight reduction benchmark requires experience. And by experience, we mean using the vehicle in real-life conditions. This interaction is important."

#### Meeting new regulatory standards

Composites seem to be a panacea for the automotive industry, especially when it comes to larger vehicles or sport cars. No matter what the size, a lighter car means a more efficient car that pollutes less. These are all things that industry executives want to hear, especially with more regulations going into effect, such as the mandatory European regulations that require a fleet average of 130 grams of carbon dioxide (CO<sub>2</sub>) per kilometer by 2015 and 95 grams of CO<sub>2</sub> per kilometer by 2021. And these regulatory bodies are serious about the new regulations. For instance, the European Union (EU) has put pressure on manufacturers by threatening penalty fees per registered vehicle for fleets that exceed the imposed targets.

"Composites can solve quite a few of our current issues, helping create a more lightweight car that reduces fuel costs and importantly produces less pollution without compromising overall quality or safety," says Urushiyama.

#### Early days for an emerging industry

The automotive composites industry is well on its way with the right tools and processes already in place. Tools such as Siemens PLM Software's composites solution, which incorporates elements of the Fibersim™ portfolio of software for composites engineering, LMS Samtech Samcef™ Composites software and LMS Virtual.Lab™ software, as well as methodologies developed by our experts, have already been integrated into a working process so data gathered on the coupon level and integrated it into the composite design evaluation can be used for the aerospace industry.

Today this process is being aligned to methods and specific load cases in the automotive sector, in which the focus also needs to be on simulation and testing solutions for composite durability, crash and noise, vibration and harshness (NVH) performance.

Urushiyama hopes that the industry is moving toward a community approach, but he is quick to point out that there is much more work to be done, especially on microscale simulation to understand the composite material and on macroscale structural simulation topics.



### Understanding composites

To understand the entire sphere of composite car performance, load path identification is a basic but efficient technique for designing the correct structure. It can be a good tool to help determine how to design each part and understand how they function together. Compared to other materials found in the automotive industry, composite damage behavior and delamination bring

“The internal fracture paths of composites include many different modes,” says Urushiyama. “There are many different design factors to consider, such as joints and curvatures compared to metal parts. Today we perform quite a few tests to determine the best-possible composite design. With a better simulation process in place, we hope we can significantly reduce the number of prototype testing cycles.”

**“Tools and methodologies developed by Siemens PLM Software experts have already been integrated into a working process so data gathered on the coupon level can be incorporated into the composite design evaluation for the aerospace industry.”**

Dr. Yuta Urushiyama, Honda Automobile R&D Center

nonlinear side effects into the picture. And this introduces a need for better predictive models and material characterization procedures and processes.

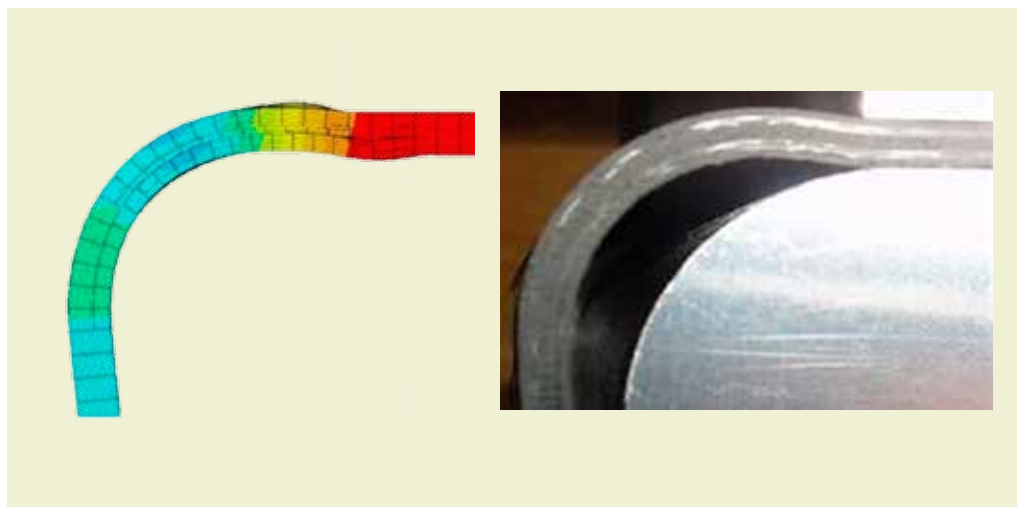
For metals, engineers classically distribute the loads throughout the body; for composites, it is better to have well-identified local load paths that vary in strength depending on need.

Experts such as Urushiyama agree that dedicated load distribution paths specifically for composite materials are required to adapt to the inherent material strength characteristics.

### The future is composites

So just which direction will the automotive composite world take? At the moment things seem quite bright. Experts such as Urushiyama are leading the way, joining forces with other experts and automotive manufacturers. The group hopes that this is the start of the best-practice sharing that the industry desperately needs.

“Some OEMs may think that composite know-how is a core in-house advantage,” notes Urushiyama. “My opinion is that we must create a composite community to work together to design the best-possible composites for the automotive industry and the cars of the future.”



These images show the simulation and a physical example that illustrates the innovative methodology for progressive damage analysis of composites using LMS Samtech Samcef Composites.

# **Designing the right concept for the Lamborghini Aventador LP700-4 driveline**







Automobili Lamborghini supercars are built to impress. Besides a breathtaking design, sporty driving experience and powerful explosion when pushing the throttle, customers expect to hear that typical Lamborghini growl.

#### Noise is not the same as sound

Giacomo Papotti and Claudio Manzali, research engineers in the Lamborghini transmission department, witnessed

booming noise from the powertrain and a clunking noise from the gearbox while testing prototypes during the development phase. The traditional way to solve such problems was by adding mass elements to change the eigenfrequencies, or by modifying support stiffness.

"But increasing weight obviously has to be avoided at all times, and there is a risk of introducing new resonances.

This manual process requires a lot of iterations and is very lengthy. Our mission was to find an effective simulation process to detect the root cause of noise issues and perform optimization."

#### Fast and correct modeling

Being a satisfied LMS Test. Lab software customer for many years, Lamborghini decided to use LMS Imagine.Lab Amesim software, also from product lifecycle management (PLM) specialist Siemens PLM

Software. LMS Amesim was employed to evaluate the torsional vibration response of the driveline to the cylinder pressures. The Lamborghini engineers are especially pleased with the efficiency, scalability and reliability of LMS Amesim.

**"The true power of LMS Imagine.Lab Amesim is demonstrated by how easy it is to evaluate different driving conditions, software or hardware changes and even different configurations."**

Claudio Manzali, R&D, Transmission Department, Automobili Lamborghini

the complexity of conflicting targets while designing the Lamborghini Aventador LB700-4 driveline.

"Even the smallest noise that can disturb the driver needs to be avoided," says Papotti. "Our test drivers experienced





"The prepackaging of components helps a lot when modeling complex dynamic systems," says Papotti, "and the modularity of the software enables generation of models with a complexity in function of the phenomena the user intends to investigate. Thanks to the availability of detailed dedicated libraries, users can efficiently create models that simulate real-life behavior."

"During the simulation, a few secondary variables, like the rotational speed of the gearbox shaft, were successfully correlated to measurements, giving us full confidence in the correctness of the model."

Generating a correct model in a fast and easy way is an important strength of LMS Amesim. The entire simulation model for torsional behavior of the driveline can be created with ready-to-use components from the powertrain library, in addition to a few components from the mechanical design and signal control libraries.

"The construction of the model was very easy because all building blocks were already there," says Manzali. "Only about 25 percent of our time went into the modeling. The remaining 75 percent was calibration work that includes defining all the parameters. Most of those were acquired by testing. We only sometimes needed data from suppliers. The data could easily be plugged into our LMS Amesim models."

Despite the rather simple model setup, the LMS Amesim simulation models were able to be used to provide

Lamborghini with the necessary insight to solve the noise issues much more effectively than in the traditional way.

"All parameters can be analyzed during simulation," says Papotti. "Batch simulation allows producing graphs for calculated values in function of the different parameters. This ensures fast, easy and detailed insight into the system's dynamic behavior. This efficient workflow is a real added value to our process and saves us a lot of time. We can give more precise directions to our suppliers and save a lot of hardware loops. We have really succeeded at evaluating many more possibilities in a shorter time by using LMS Amesim."

#### The tool of the future

With a successful introduction, Lamborghini engineers plan to continue using LMS Amesim. Both the model and results have been adopted by the entire Lamborghini research and development (R&D) department.

"Owning a complete simulation model of the driveline is a huge added value to our development work," says Manzali. "It will allow us to easily evaluate changes to the base model, and can be used any time the market or legislation pushes us into a new challenge."

Manzali summarizes the value of the solution: "The true power of LMS Amesim is demonstrated by how easy it is to evaluate different driving conditions, software or hardware changes and even different configurations and by the speed at which those modified models give us correct results and trends."

**"We can give more precise directions to our suppliers and save a lot of hardware loops. We have really succeeded evaluating many more possibilities in shorter time thanks to using LMS Imagine.Lab Amesim."**

Giacomo Papotti, R&D, Transmission Department, Automobili Lamborghini

A red Chevrolet pickup truck is parked on a dirt road in a mountainous, forested area. The truck is viewed from the rear, showing its bed and tailgate. The background features a steep, rocky hillside with sparse vegetation and evergreen trees. The scene is captured in a wide-angle shot, emphasizing the rugged environment.

# Test track warriors

Safety, quality and durability are critical elements in any world-class vehicle. But just how does one make a safe, quality vehicle that can really go the distance? A solid durability engineering process is the answer.





An important element in the durability testing process is road load data acquisition, or RLDA for short. Providing core performance input, this step combines hardware and software to maximize testing productivity during test track laps and off-road campaigns.



The RLDA process is a critical part of developing world-class GM vehicles.



GM's home test track in Milford, Michigan.

Clocking thousands and thousands of data-gathering miles on General Motors' (GM) home test track in Milford, Michigan, the vast Arizona desert and even the famous Nürburgring in Germany, the road load data acquisition (RLDA) team puts next-generation GM models and

test vehicle with measurement equipment. This includes installing the LMS SCADAS™ Recorder hardware and various transducers to collect forces, strains, accelerations, displacements, revolutions per minute (RPM) and temperatures throughout the vehicle. Then the test driver completes specific

**“Despite the growing use of simulation, durability engineering departments are facing an ever-growing and challenging volume of testing work.”**

prototypes like the Corvette, Camaro and Silverado through their paces on a daily basis. Their mission is to provide high quality and timely road load data to drive laboratory tests and computer-aided engineering (CAE) models. Providing core performance input, the RLDA process is a critical part of developing world-class GM vehicles.

#### **So what exactly happens with RLDA?**

To start, a team of engineers and technicians, led by measurement engineer John Davis, instrument the

maneuvers on GM proving grounds to gather the required data. This might be the road load forces into the wheels or suspension components while going over rough terrain like Belgian Blocks, measuring driver inputs from the onboard vehicle controller area network (CAN) bus network, and tracking vehicle speed and position with a Global Positioning System (GPS) to confirm that the test events were completed correctly.

The RLDA loads data are then typically edited, and repeated according to the applicable durability test procedure,





New GM models clock in thousands and thousands of data-gathering miles in tough terrain

then conditioned to run a test simulator or math model to exercise the test vehicle (or analysis model) in a manner that simulates customer service at an accelerated rate.

Since the LMS SCADAS data acquisition system is streamlined for efficiency, it lets engineering teams get their jobs done much more quickly and easily. This is something that Davis, lead measurement engineer at the Vehicle Dynamics Center on the General Motors (GM) Proving Grounds in Milford, Michigan and his colleagues can appreciate.

#### Plug-and-go data acquisition

LMS SCADAS comes in a nice small, but powerful package. It can handle a wide variety of transducers, including the latest implemented technology, such as transducer electronic data sheet (TEDS) interfaces, vehicle CAN bus compatibility, integrated GPS connectivity, and multiple signal conditioning options. The main unit that the RLDA team uses at GM is LMS SCADAS Recorder hardware configured with 40 universal signal-conditioning channels based on DB8-II modules. Every unit is also configured with embedded GPS, one CAN bus, two tacho inputs and an optical connection link. With the optical link, multiple LMS SCADAS units can be connected to run higher channel count measurement projects.

#### Efficient hardware, easy-to-use software

The LMS SCADAS units are just the hardware side of the LMS durability testing solution story. The LMS Test.Lab™ software complements the process nicely. Spreadsheet-based, it is easy to use and set up. LMS Test.Lab offers an array of export

#### Innovative tools for better brand confidence

Continuous customer involvement is an important innovative aspect when it comes to developing LMS solutions, like the new tablet-based LMS Smart™ Control application. With mobile functionality, engineers will be able to do more on-the-fly

**“A popular choice among vehicle manufacturers, the LMS end-to-end solution for road load data acquisition (RLDA) lets engineers have complete control of the RLDA process.”**

capabilities in different formats for sharing data with other groups or exporting raw data directly to the other LMS Test.Lab users, like GM's Noise and Vibration group.

A dedicated Siemens PLM Software technical support team is available to answer any technical question or help the GM RLDA team solve issues. Located in Detroit, the support team interacts with customers like Davis and his team, implementing their suggestions to improve the LMS hardware and software solutions.

data acquisition and run validation. This will further improve testing efficiency and, in the end, long-lasting quality. And that is something that every durability engineer wants to achieve.

# Balancing attributes and other feats of vehicle development

To comply with company policies along with market expectations and regulations, the Advanced Transmission Controls Group at General Motors (GM) decided to frontload controls development using a model-based systems engineering (MBSE) approach. For GM, MBSE has gone from being an enabling to a required technology. That's why the company has been developing MBSE methodologies and tools for the past 15 years.





Original equipment manufacturers (OEMs) are under pressure from the market to maintain vehicle performance, quality, safety and a high level of driving satisfaction. Balancing all these attributes means that OEMs must spend a huge amount of money to make sure they get to market on time while maintaining profit margins and customer satisfaction.

Optimizing vehicles involves strategic choices when it comes to selecting systems and components, as each of them has an impact on global vehicle performance and efficiency. In this context, the optimization of transmission systems, especially controls, plays a significant role in determining global energy savings. Today, controls make up the majority of the new content in vehicles, and have become very complex due to the

increasing number of vehicle variants to design. Moreover, controls are the last link in the development chain, making delays very visible and increasing the pressure to become more efficient.

The pressure to achieve high quality also means that manufacturers need to make hardware architecture decisions early in the program to effect maximum safety and reliability, and provide vehicle performance that will not degrade over time.

#### **Pressure on controls development**

GM is strongly committed to continuous improvement and innovation in order to reduce the environmental impact of its vehicles and facilities. Having a culture of environmental responsibility, GM is leading the way in thinking creatively, being consistently innovative, leaner and more efficient,

focusing on several areas in which it can make a difference, especially in developing more fuel-efficient vehicles.

To cope with ever-increasing requirements for reducing development cycles and prototype hardware, GM decided to improve its ability to develop controls in the virtual space through the use and re-use of transmission plant models. But implementing these approaches and related tools required an appropriate strategy. The MBSE approach is being adapted by GM to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later lifecycle phases in order to manage engineering complexity. And the guiding principle is to impact every step in the development cycle so that





it contributes to a positive return on investment (ROI).

"This evolution of engineering practices is no longer a strategic advantage, but rather a requirement to meet the challenges of today's increasingly difficult regulations, shortened development cycles and reductions in hardware prototypes," says Keith Lang, who is the engineering group manager of the Advanced Transmission Controls Group at GM.

GM's commitment is to always keep in mind that the customer is what really matters. Hence, the company is focusing its efforts on hardware, algorithms and

algorithm and calibration in parallel with hardware development. In that context, LMS Imagine.Lab Amesim™ software from product lifecycle management (PLM) specialist Siemens PLM Software has been a decisive ally. The multi-domain, open-ended system simulation platform has been used as a key asset in the CAE tool chain to implement the MBSE strategy.

The key elements are costs related to the engineers' learning curve as well as development of models. That's why GM focused on developing a step-by-step process to ensure ROI at each stage.

The company started by using LMS Amesim for dynamic open-loop simulations in order to validate the new transmission behavioral model, capitalize on this model and achieve detailed enhancements with minimal rework. During this step, the use of LMS Amesim enabled GM to confirm architecture and design choices, enhance the understanding of component physics, develop controls requirements, analyze

**"This evolution of engineering practices is no longer a strategic advantage, but rather a requirement to meet the challenges of today's increasingly difficult regulations, shortened development cycles and reductions in hardware prototypes."**

Keith Lang, Advanced Transmission Controls Group, General Motors

calibration reliability that are today the main contributors among the attributes that can make a significant difference in the market.

#### Deploying an efficient strategy

Given the growing complexity of systems, controls have been the bottleneck of new product design. To overcome this, GM has incrementally implemented a sequential approach for developing and validating controls via computer-aided engineering (CAE) and MBSE.

Implementing this approach enabled the company to identify architectural issues and controllability early in hardware design. The approach also enabled it to better understand and document the systems' physical behavior through CAE, allowing it to leverage these tools for

components and perform sensitivity studies. As an example, the engineers were able to identify and troubleshoot a torque's peak in a transmission system. In the past, without simulation, it would have taken months to examine, check and refine the controls. With LMS Amesim, it only took the engineers one week to replicate the phenomena and another week to identify the possible solutions and fix it.

While running closed-loop simulations in the second step of the MBSE methodology, GM needed to focus more on controls integration for software development and validation as well as re-use of the models built for the open-loop stage to support maximum ROI. To implement a software-in-the-loop (SiL) methodology, the controls



LMS Imagine.Lab Amesim™ software from product lifecycle management (PLM) specialist Siemens PLM Software provides a multi-domain, open-ended system simulation platform that can be a key asset in the CAE tool chain to implement the MBSE strategy.



integration required the engineers to obtain a behavioral model of the transmission control module (TCM) to run source code and validation; behavioral models for sensors and actuators; signal-based representation of controller area network (CAN) communication; and a method for quickly updating software and calibrations.

This enabled them to develop the algorithms quite quickly. MBSE is now being used to develop controls for all of the company's new transmissions, and the methodology is so finely tuned that the engineers are able to make a change and test it in under a minute (with C-code). They were also able to perform a dynamometer (dyno) vehicle calibration early in the development process, which enabled them to save a significant amount of costly dyno time. This was accomplished by using the co-simulation models with the actual vehicle/dyno calibrations to validate that the algorithms and calibrations were working properly before testing the hardware. As a result, validation before testing in hardware is becoming standard work at GM.

This co-simulation methodology enables GM to offload some of its hardware-in-the-loop (HiL) testing into the virtual space. This reduces the need to purchase additional hardware simulators, even though the number of transmission variations continues to increase. The methodology can also be used to run robustness studies (for example, to evaluate friction material and other designs) to reduce hardware testing and increase variation analysis.

"Heterogeneous co-simulation enables the co-development of hardware architecture, algorithms and calibration," says Lang. "Co-simulation allows model-based systems engineering to bridge domains that have traditionally been developed independently."

#### A positive outcome

GM has been pioneering the implementation of MBSE methods, and is addressing the high costs by delivering a positive ROI at each step of development. GM has moved past demonstrating how MBSE could be used to frontload controls, and is now implementing it as standard in several key areas. Plant models are re-used by the CAE, controls and validation teams, enabling closer collaboration among almost one hundred engineers using these MBSE methods, and GM plans to continue this growth.

"The return on investment for model-based systems engineering is hard to measure; however, the shortening of the development cycle and the ability to develop controls algorithms, calibrations and architecture assessments without having those vehicles available has huge returns for the controls development organization," says Lang.

"Our organization is the last link of the product development chain, and by increasing the throughput of controls development through that last link, we increase the throughput of the entire organization."



# And the winner is...

The China FAW Co., Ltd. R&D Center significantly cuts vehicle development time and costs by using LMS software and services for durability engineering.





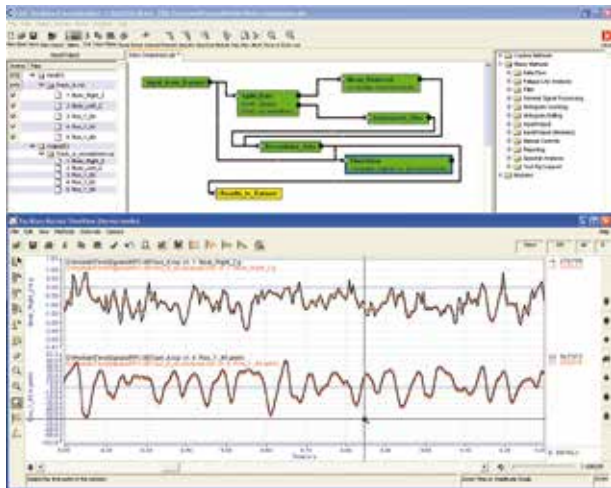
Durability strongly influences perceived vehicle quality. It is more than a crucial selling point. Customers take it for granted that their cars will survive for approximately 300,000 kilometers, or their trucks will withstand a rough operational environment.

But trends in the automotive industry to launch more vehicle variants, as well as minimize weight in view of fuel economy demands, challenge engineers to deliver robust, high-quality vehicles on time and at an attractive price. So-called design-by-experience leads to recurrent prototype testing and very long and expensive development cycles. Therefore, automotive original equipment manufacturers (OEMs) and their research centers look for new durability engineering technologies,

including simulation that frontloads design decisions and delivers better performance from the first prototype.

#### **A new durability engineering approach**

Defining correct road loads and understanding how they affect individual vehicle components is crucial to successful fatigue life predictions. Calculating those analytically is challenging, especially with the presence of active suspension systems. Measurement data is usually only partially available, or not at all, during the concept phase. Over the years, multibody simulation has been advanced as reliable technology to accurately calculate road loads. Several methodologies exist to handle different levels of model complexity and available measured data.



An enormous amount of data from the campaign was processed in LMS Tecware software to obtain the load data for the simulation.

Siemens PLM Software has developed a full computer-aided engineering (CAE) approach called the digital test track as well as a combined test and CAE approach. The latter, included in LMS Virtual.Lab™ Motion software, is based on time waveform replication (TWR), originally a test technology for exact recreation of measured field data on a laboratory shaker system. This process helped China FAW R&D Center substantially cut the development time of a recent commercial truck.

The Center is the biggest research, development, test and inspection facility for the automotive industry in China.

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

Xin Yan, CAE Engineer, Body Department, China FAW R&D Center

This key technology center for both the OEM FAW Group Corporation and the Chinese government focuses on product innovation while developing commercial vehicles, such as passenger cars, minivans, buses and trucks, as well as automotive components. Its engineering expertise covers the entire vehicle development cycle, from styling and design to simulating and testing several functional performance aspects and computer-aided manufacturing (CAM). To implement a more efficient and reliable durability engineering approach, specialists from the Center decided to collaborate with experts from LMS Engineering services, and afterwards deployed a complete, integrated software solution.

“We had issues with damage in components, such as the fracture of critical parts in the front or on local areas of the body,” says Xin Yan, CAE engineer in the body department of the Center who specializes in cabin development for commercial trucks.

“We used to design the cabin based on static analysis and using our experience,” Xin Yan explains. “But in this way, we often had fatigue damage while testing the prototypes. That meant that we had to modify the structure recurrently, which lengthened the development cycle. Thanks to our collaboration with Siemens PLM Software, we could investigate the problem of fatigue cracking, and deploy a simulation process that allowed us to accurately describe road loads and optimize the structure for durability. The driver’s cabin prototype of the first commercial truck we developed using LMS solutions immediately met the durability requirements during the first test.”

#### **Accurately predicting road loads on components**

The TWR-based approach offers engineers a pragmatic way to include test track measurements in simulation for the road load prediction, starting from any type and number of tested data. The process replicates a laboratory vehicle road load test using an unconstrained multibody model and the experimental data as boundary condition, and yields back-calculated equivalent drive signals through an iterative control technique. By computing these drive signals for the wheel centers, LMS Virtual.Lab Motion software enabled China FAW to avoid the need to model complex elements, such as dedicated tire models, digitized roads and driver models, which usually takes a

lot of time. The simulation corresponds to a durability test rig. LMS Virtual.Lab Motion features a powerful and accurate solver and dedicated modeling functionalities, such as flexible bodies, as well as active suspension components with their controls through co-simulation with LMS Imagine.Lab Amesim software. The software is used to calculate the individual component loads for further use in a simulation with LMS Virtual.Lab Durability software.

“The implementation of this new process started through collaboration with LMS Engineering experts,” says Xin Yan. “We did measurements on the track for road load data acquisition. The enormous amount of data resulting from this campaign was processed in LMS Tecware software to get the load data for simulation.”

This software package helps engineers efficiently validate and understand gigabytes of raw mobile testing data. The data signals are consolidated by various operations, such as removing anomalies, filtering, deriving new channels based on mathematical operations and many others. In this way, the data is ready for further use in simulation.

LMS Tecware allows subtracting durability-specific content and contains a wide range of dedicated data interpretation methods to help efficiently qualify and quantify the load data durability potential. The data can be readily imported into LMS Virtual.Lab Motion.

In the next step, the engineers built a multibody model of the commercial truck, including the cabin and the mounting system. "LMS Virtual.Lab Motion is very user friendly," says Xin Yan. "Moreover, we received very good training and daily help from the local support team. With their help, we could easily build the multibody model and calculate the drive signals, and in the next step the component fatigue loads."

The Center's engineers were impressed by the performance and the capabilities of LMS Virtual.Lab Motion TWR. "The twist road event we wanted to replicate is a difficult case, because the low-frequency behavior is very dominant, and that can complicate convergence in a time-domain iterative process," says Xin Yan. "But the powerful algorithm in LMS Virtual.Lab Motion TWR can handle this very well. On top of that, our model was very detailed and could even include an accurate physical description of the air springs between cabin and suspension thanks to co-simulation with LMS Amesim."

#### Optimizing structural components for durability

By combining the calculated component fatigue loads with material curves, cyclic fatigue parameters and stress results based on finite element analysis (FEA), LMS Virtual.Lab Durability can be used to accurately determine

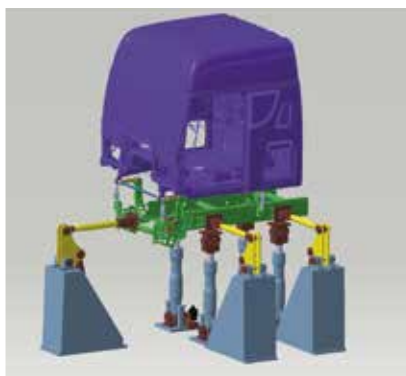
8,000 kilometer durability test. Using the same process, we have also solved some other problems. We found the solution for fatigue cracking of the front part that belongs to an off-road vehicle, and for fatigue damage in mounting systems."

An extra and critical advantage of this TRW-based durability engineering process is that the drive signals calculated by LMS Virtual.Lab Motion TWR can be recovered for a different vehicle development process because these loads are invariant. This is very useful in the early design stages of a new vehicle, when no prototype is available, and hence no testing can be done. It allows frontloading durability engineering to the very early phases of the development process.

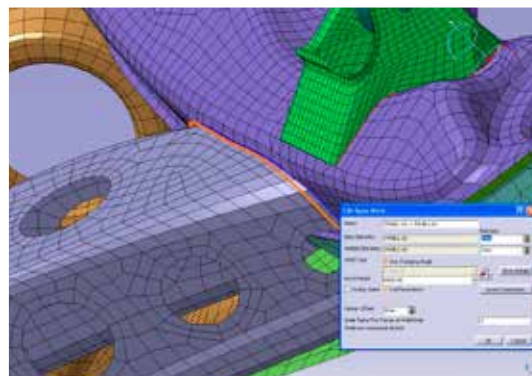
"It is part of our intent to completely break with our former procedures and to make this approach the standard one in our company," says Xin Yan. "In that context, we want to set up a load spectrum for common use. This will be used as a reference for all research and development activities in the field of fatigue analysis, and will drastically reduce the time we spend on data acquisition in the future."

#### Deploying award-winning technology

China FAW engineers plan to further deploy the simulation-based fatigue analysis process and explore more capabilities. "In the Chinese automotive industry, we are a pioneer in this area, and we want to keep this leading position," says Xin Yan. "In practice, that means that we will start investigating fatigue problems in



The simulation corresponds to a durability test rig.



And even includes specific modeling features for spot welds and seam welds.

critical fatigue areas and assess the expected fatigue life.

"The software has very specific modeling features for spot welds and seam welds, which are typically areas sensitive to fatigue," says Xin Yan. "And by using dedicated postprocessing functions, we can quickly identify and solve problems." The entire process can be parametric, allowing experimentation with multiple design options and structural optimization.

"We especially appreciated the integration of the entire process chain," Xin Yan explains. "That makes this solution very effective. When designing the commercial truck, the prototype of the driver cabin immediately passed the

nonmetal materials and optimizing the fatigue life of shock absorption systems. We want to achieve the highest possible precision because reliable durability simulation helps us control the length of the development cycle. That enables us to bring our products to market earlier than our competition.

"Thanks to the use of LMS solutions from Siemens PLM Software, we cut costs during the development of the commercial truck by 20 million RMB. The new durability engineering process brought us two awards. We won second prize in the China Award of Science and Technology – Automotive Industry contest, and first prize in the FAW Group Technology Innovation Prize contest."



# Balancing act

## Hyundai conquers mechatronic system complexity with LMS Imagine.Lab

**Competitive pressure pushes automotive manufacturers to design increasingly complex products within a very short timeline, while reducing fuel consumption, pollutant emissions and costs and optimizing reliability, performance, comfort and safety. Innovation is critical to success, impacting all vehicle systems.**

Ten years ago, driving pleasure, brand image and engine capabilities were the chief concerns for automobile manufacturers. Today, stringent environmental regulations and eco-friendliness are also key factors.

Balancing all these attributes and managing the complexity of mechatronic systems required for developing innovative vehicles has resulted in the implementation of new and advanced design processes and tools. Such tools and processes enable manufacturers to frontload the architecture definition in order to keep development costs and times under control.

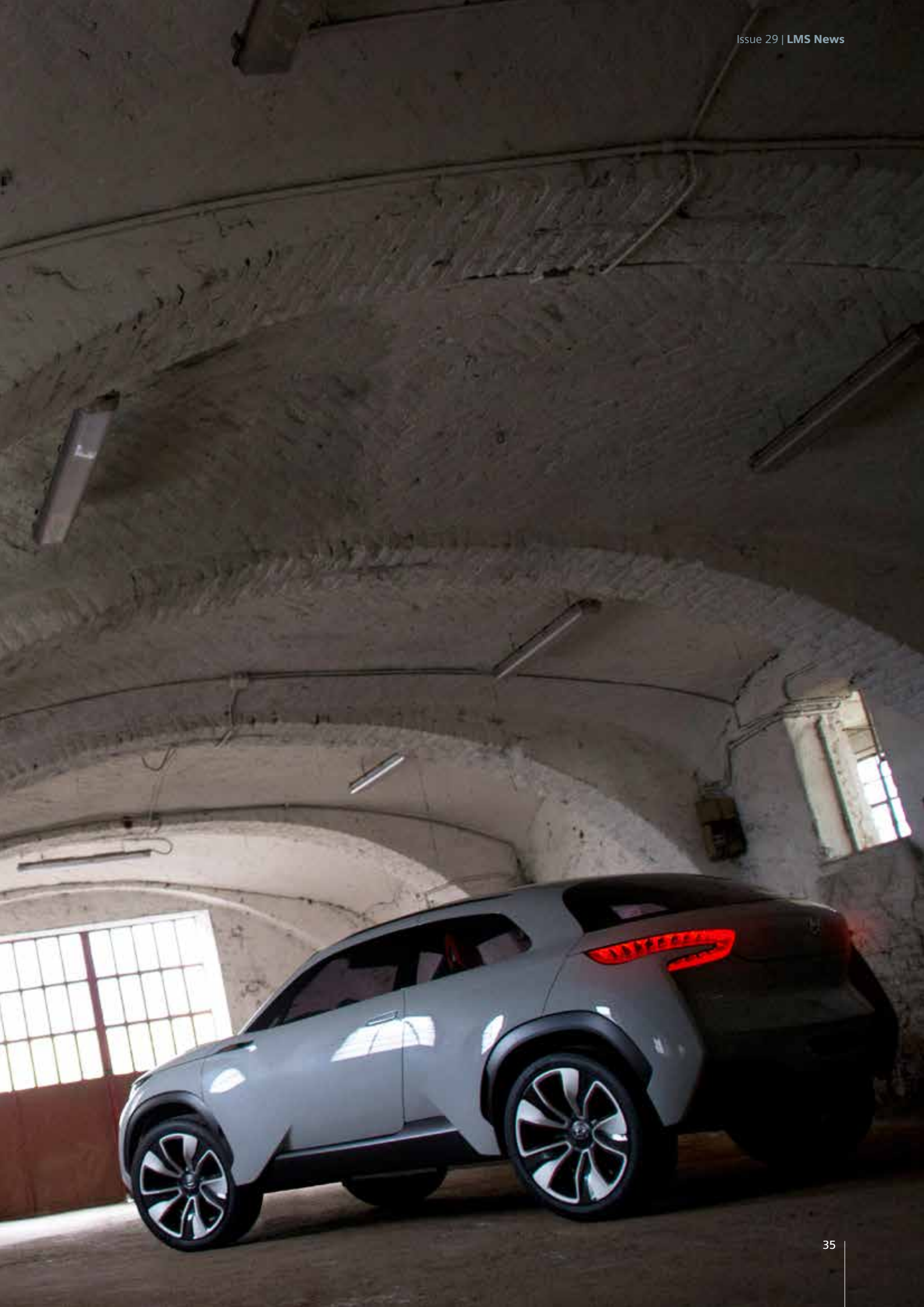
Hyundai Motor Company (Hyundai), a multinational automotive manufacturer headquartered in Seoul, South Korea, is at the forefront of vehicle innovation, efficient environmental delivery and cost

management using the industry's best practices and technologies. As the fourth largest automaker in the world, its "new thinking, new possibilities" approach is strongly reflected in its Kia brand. In fact, with its low-carbon, green technology strategy, called Blue Drive, Hyundai is going beyond reducing carbon dioxide (CO<sub>2</sub>): the company is steadily developing technologies to achieve zero emissions and improve the eco-friendliness of its cars. These include direct injection systems that improve efficiency and reduce emissions in gasoline engines, advanced high-strength steels that reduce the weight of vehicles, and high-efficiency transmissions that deliver excellent fuel economy.

Following these corporate initiatives, the research and development (R&D) center based in Namyang, South

Korea, has been developing advanced systems. The manual transmission engineering design team develops a variety of manual and dual-clutch transmissions for the Hyundai and Kia brands.

Global market expectations and stringent regulations have completely changed the way that Hyundai engineers design their transmission systems. Balancing fuel economy with performance, drivability and safety has imposed a number of technological constraints, including reduced engine speeds, space and weight, and increased input torques, torsional excitation, robustness and durability. All these come with technical requirements, including increased mechanical efficiency, more gears, start/stop and hybrid capabilities, an increased number of shafts and higher ratio speed.







Hyundai is going beyond reducing carbon dioxide emissions. The company is steadily developing technologies to achieve zero emissions and improve the eco-friendliness of its cars.

Developing manual transmissions that answer all these requirements has become critical given the short delivery timeframes. Hyundai engineers have seen an explosion in the number of parameters that need to be taken into account. Dealing with this increasing complexity required the adoption of new development methods and tools that could enable them to validate possible architectures and fine-tune systems and components early in the design cycle. The engineers needed to easily assess gear train loads and life cycles, clutch temperature and wear for fatigue and durability

selected at Hyundai for supporting the development and validation of innovative transmission systems.

"LMS Amesim is considered the ideal software to model and analyze the transfer efficiency and fuel consumption," comments Kijong Park, senior research engineer at Hyundai. "It is a very effective tool for optimizing design parameters."

LMS Amesim has been used at Hyundai to work on several applications for the design of manual and dual-clutch transmission systems. "CAE software tools have played an important role in

to model subsystems and components that were able to handle different oil types and oil viscosity (depending on the temperature, gear slip and other factors).

Using the IFP-Drive and powertrain libraries, the engineers were then able to evaluate the transmission efficiency and calculate the fuel consumption of the entire vehicle by assessing the gear and bearing losses. In addition, a shift-feel simulator has been developed, enabling them to calculate shift forces and strokes and to virtually evaluate the shift feel using the signal and observers, mechanical and powertrain libraries. This simulator enables the Hyundai team to optimize the design of synchronizer and control systems at early design stages by analyzing various design possibilities and their impact on shifting force.

Transmission engineers have also been able to predict the temperature of the clutch components under various operating conditions using virtual vehicle tests in order to correctly size the complete clutch system and evaluate system durability.

#### A streamlined development process

The versatility and adaptability of LMS Amesim has enabled Hyundai engineers to model and simulate transmission systems and components, from advanced and detailed engineering to systems validation. The multi-domain, multi-level libraries of physical components enable them to rapidly build the systems to analyze and then conduct a first evaluation of the transmission

## "CAE software tools have played an important role in transmission development, and will continue to do so. LMS Imagine.Lab Amesim plays a central one in CAE deployment."

Kijong Park, Senior Research Engineer, Hyundai Motors

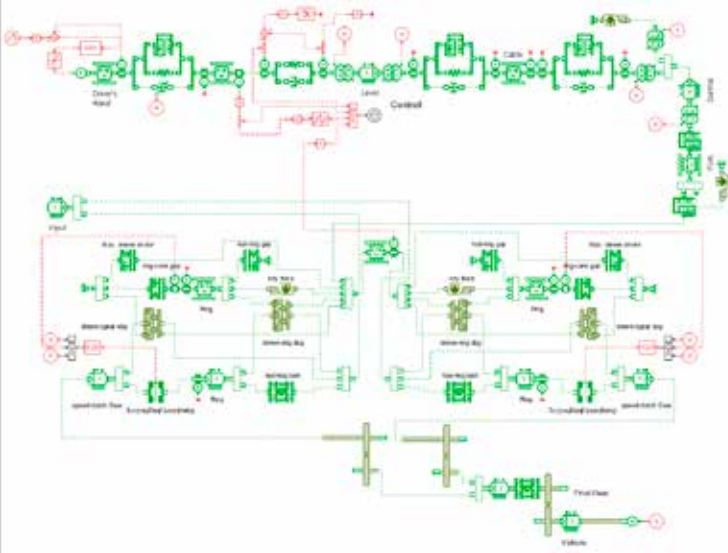
analysis, gear and bearing losses and shift force and strokes to evaluate transmission efficiency, fuel consumption and shift feel.

#### Optimizing transmission design

The implementation of computer-aided engineering software has become a must-have in the automotive and transportation industry to cope with all the various engineering constraints. LMS Imagine.Lab Amesim™ software from Siemens PLM Software was quickly

transmission development, and will continue to do so," says Park. "LMS Amesim plays a central one in CAE deployment."

The mechatronic system simulation platform and its multi-domain libraries have been used to assess the efficiency of the transmission systems by analyzing the friction losses of the bearings and synchronizers, as well as the power and drag losses. The use of LMS Amesim enabled Hyundai engineers



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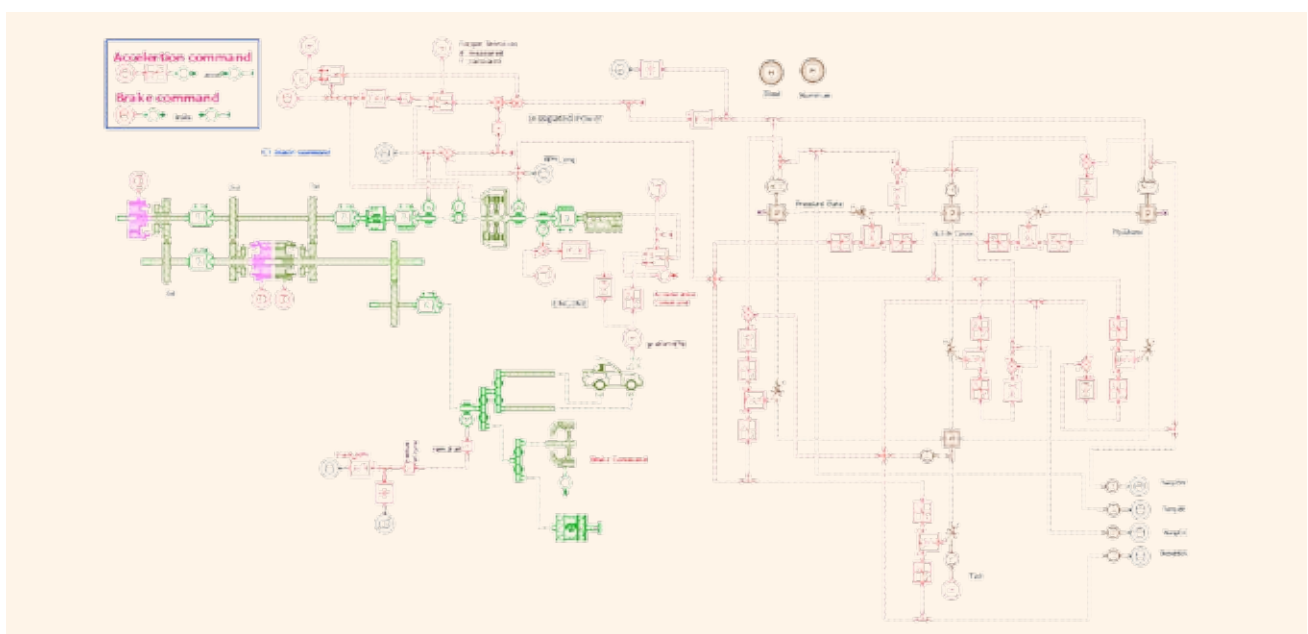
performance in a matter of hours instead of days. Various studies have been successfully performed with a high level of accuracy of the simulation results when compared to experimental test data.

“LMS Amesim has proven to be extremely robust, with a more-than-excellent solver stability,” adds Park. “Models can be rapidly built and first results quickly obtained without data that is already available, such as 3D CAD.”

LMS Amesim easily interfaces with many CAE environments to fit in Hyundai’s development process, from prototype and design stages to validation. The variety of applications it addresses – such as shift feel analysis, clutch temperature prediction, power losses assessment, fuel economy and efficiency evaluation – enabled engineers to have a very accurate picture of the

performance of the systems to be designed in record time. “LMS Amesim enabled us to drastically reduce development time by 50 percent by enabling early investigations of possible architectures,” says Park. “Siemens PLM Software’s solution has granted us more flexibility, more reactivity and more freedom to focus on innovation and anticipate market expectations.”

More than 10 Hyundai engineers are now using LMS Amesim every day. Hyundai also appreciates the fast response and quality support of the Siemens PLM Software engineers, and the successful deployment of several LMS Engineering services projects has made LMS Amesim the favorite tool for future projects on hybrid electric, electric and fuel cell vehicles.



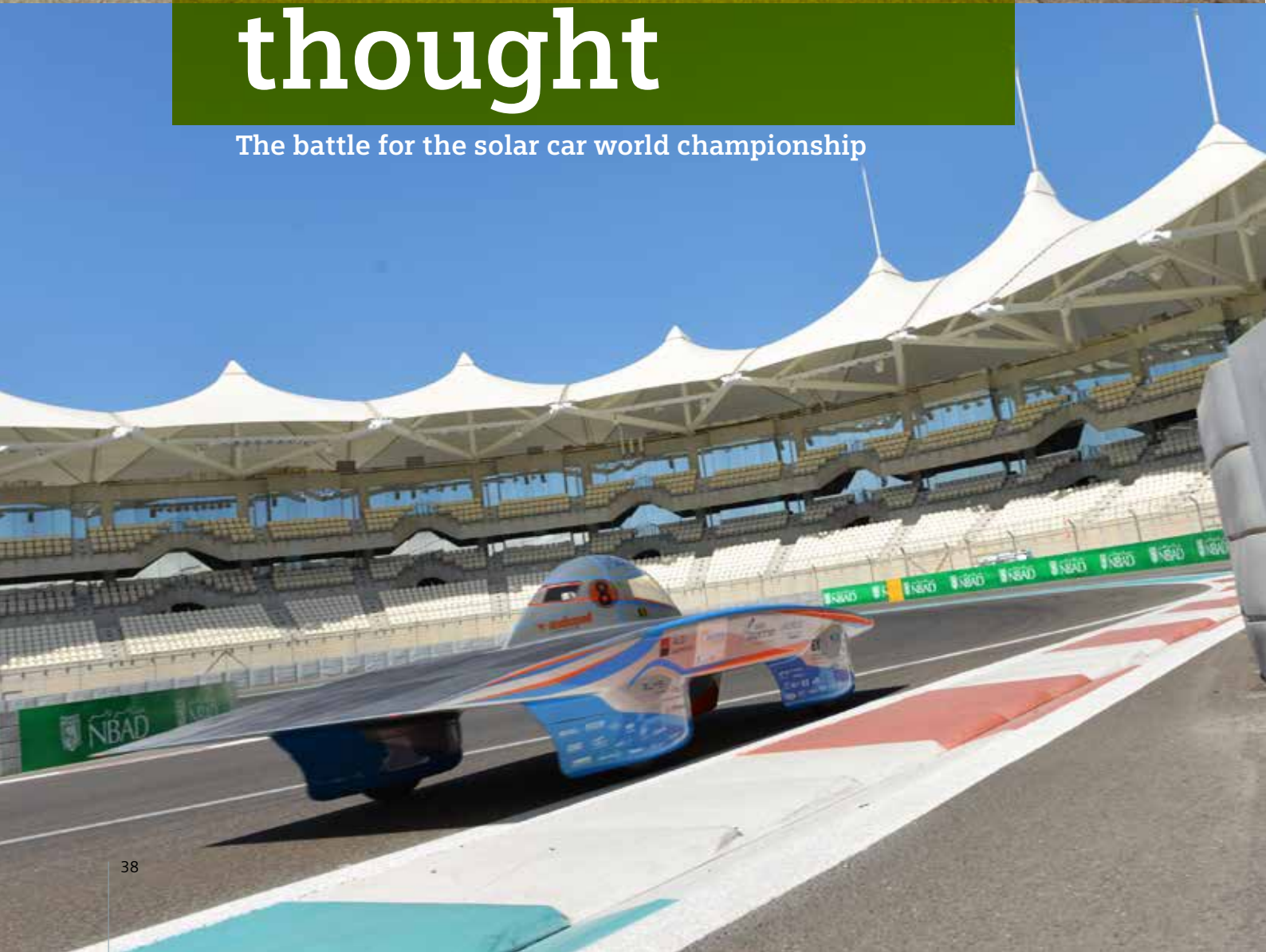
Transmission engineers can use LMS Imagine.Lab Amesim to predict the temperature of clutch components under various operating conditions.





# Food for thought

The battle for the solar car world championship



Engineering students around the world have marked their calendars for October 18, 2015. It is the starting date of the World Solar Challenge, the unofficial world championship solar car race across Australia from Darwin to Adelaide. Probably the most energy-efficient cars in the world, the teams behind these finely tuned machines come from some of the leading engineering universities in the world, including two university teams close to our hearts: the Punch Powertrain Solar Team from the Group T Campus of the KU Leuven (University of Leuven, Belgium) and the University of Michigan Solar Car team.

A long-time sponsor of the Group T car from the University of Leuven, Belgium that placed third in Abu Dhabi in January 2015, Siemens PLM Software has a double shot at the championship this year. They also sponsor the winner of the Abu Dhabi (United Arab Emirates) challenge, the University of Michigan's car, whose other sponsors include Ford and GM.

#### The king of all solar car races

Not only is it fun to follow, the World Solar Challenge showcases advanced automotive technology and promotes alternatives to conventional vehicle engines. Today, while solar cars test the ultimate boundaries of energy efficiency, they also provide incredible insights into everyday vehicle technology. This innovation is at the heart of all electric cars, whether they are powered by hydrogen fuel cells, hybrid engines or are fully electric. Electric cars today all use the technology that is continually honed to perfection in the World Solar Challenge.

#### The rules

Utilizing no more than six square meters of solar panels, some of the world's brightest young minds are on track to develop the most efficient electric vehicles possible. And every two years, teams from leading international universities and technical institutes along with private entrepreneurs travel to Australia to test and promote the

ultimate synergy of nature, motion and innovation.

"The World Solar Challenge for us is one of the most lucent platforms for young engineers to expose future possibilities. By competing in this challenge, we are able to fulfill our goals, which include promoting top technologies, creating awareness for durable solutions, motivating young people for science and engineering, exposing entrepreneurship with innovation and building a performing solar car," stated a spokesperson for the Punch Powertrain Solar Team.

#### Serious business

Today, these solar car teams are just as serious as professional motor racing teams, with drivers, mechanics and extensive support teams. Teams must carefully monitor weather patterns and adjust driving strategy accordingly. The mix of city and highway driving on public roads of varying conditions makes careful energy management critical. Teams must also ensure that they follow the route precisely and obey all the rules of the road or they risk costly time penalties.

#### A tight race

The University of Michigan Solar Car Team is an entirely student-run organization that designs and builds solar electric vehicles. Since its establishment in 1990, the team has built 12 vehicles, won the American Solar Challenge eight times, and placed third in the World Solar Challenge five times. The team is recognized as the most successful team in North America. That being said, the Belgian team is hot on their heels, placing third in Abu Dhabi in January. All we have to say is, "May the best team win." We will all be watching closely.

On the 18th of October 2015, the World Solar Challenge starts again in Darwin, Australia.



The inaugural Abu Dhabi Solar Challenge (ADSC) took place January 15-19, 2015, starting and finishing in the United Arab Emirate's capital, Abu Dhabi. Over the course of four days, 15 teams from the world's top university solar car teams traveled 1,200 kilometers. Two teams sponsored by Siemens PLM Software placed in the top three. The University of Michigan team placed first while the team from the Group T campus of the University of Leuven came in third.



