### Product
LMS

### Business challenges
- Develop cost-effective, smooth-shifting AMTs
- Predict the performance and functionality of complex, multi-domain systems
- Optimize the design of the AMT early in the development process

### Keys to success
- Avoid late-stage problems and delays
- Use a virtual engine and transmission as stand-ins while the hardware is in development
- Achieve optimal powertrain performance

### Results
- Cut AMT development time almost in half
- Refined performance of the mechatronics system up-front
- Created AMT designs that met exact target performance requirements
- Achieved optimal powertrain performance

### Seeking synchronization
One of the features consumers increasingly look for in a new car is an automated manual transmission (AMT), a system that behaves like an automatic transmission but allows drivers to shift gears electronically using a push-button command without a clutch pedal. AMTs combine the fuel efficiency, performance and control of manual systems with the convenience of automatics, an especially handy feature in stop-and-go traffic.

### Cut AMT development time by almost 50 percent with LMS Imagine.Lab Amesim

Many drivers facing daily traffic congestion appreciate the ease and convenience of AMTs, so automakers are equipping a growing number of new vehicle models with this type of transmission.

With the automotive industry still experiencing challenging times, carmakers are focusing considerable development effort on cost-effective, smooth-shifting AMTs as a way of wooing buyers. However, these complex mechatronics systems are difficult to design because their performance depends on the operation of three different subsystems all working together in perfect synchronization: an electromechanical actuator that shifts the gears, electronic sensors that monitor vehicle status and software embedded in the transmission control unit (TCU), the “brains” that control the powertrain.
Ordinarily, it takes up to a year to define overall functional requirements, design the actuator mechanics, develop and calibrate TCU software and validate the complete system. Software development and calibration present particularly troublesome bottlenecks since these tasks typically require extensive trial-and-error physical testing cycles that cannot be performed until hardware prototypes are built.

By then, mechanical and electronics designs are nearly finalized and cannot be changed appreciably to improve powertrain performance. Considerable time is spent troubleshooting problems near the end of the design rather than refining TCU control strategies. To meet looming vehicle launch deadlines, engineering teams must often settle for an overall design that barely meets application requirements rather than one that optimally balances mechanical, electronics and software performance.

### Optimizing the design early

In a pioneering initiative, French automaker Renault S.A. is streamlining the AMT development process with a simulation-based approach using LMS Imagine.Lab Amesim software from Siemens PLM Software, a 1D simulation solution for predicting the performance and functional-ality of complex multi-domain systems using a single, unified physics-based model. Engineers drag, drop and interconnect simple icons to graphically create the model displayed on the screen with a working sketch showing the relationship between all the various elements to:

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

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**Edouard Négre**

Senior Design Engineer

Powertrain Control Engineering Division

Renault
“By using the multi-domain simulation approach based on LMS Amesim, we can see early in development how all the various parts of the complex AMT system will operate together: mechanics, electronics and control software,” says Edouard Négre, senior design engineer in the Renault Powertrain Control Engineering Division. “With this understanding of the complete mechatronics system, we can readily optimize the entire design up-front in development and avoid many late-stage problems and delays.”

Throughout the process, the model created using LMS Amesim evolves as the design progresses and system requirements are defined in greater detail. Renault most recently used the method to develop a new actuator for one of its existing AMT models, redefine the existing TCU control strategy and evaluate the entire AMT performance.

A simplified model was initially created to define overall powertrain load constraints and size the major mechanical components, including hydraulics, electric generator and gear reductions. Next, parameters from design drawings and technical data from engineering specifications were added to plot overall performance curves, define basic control commands and determine the overall response of the complete mechatronics system. In these conceptual phases, engineers explored the behavior of various alternative mechatronics configurations – including actuator designs to provide for smooth gear shifting – until the best powertrain performance was achieved.

Based on these simulation results, the model was then used to develop control algorithms that served as a basis for performing co-simulation between LMS Amesim and the real-time software development and integration platform to develop first-order TCU logic software. LMS Amesim was used to simulate the powertrain hardware in this software-in-the-loop (SiL) approach, essentially providing a virtual engine and transmission as stand-ins while the actual hardware was still in development.

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Finally, the TCU software performance was validated and calibrated using a hardware-in-the Loop (HiL) approach to exercise the system model in real time. On a test rig, a TCU with control code embedded in the electronics sent signals to operate a physical prototype of an AMT actuator based on simulated load and sensor signals generated by LMS Amesim for the rest of the powertrain. In this way, engineers fine-tuned the TCU software to achieve optimal powertrain performance according to fuel efficiency, dynamic response and other operational factors.

**Hastening time-to-market**

“Using LMS Amesim for simulation-based development enabled Renault to shorten AMT development time considerably,” says Nègre. “Refining the performance of the mechatronics system early in development avoids problems that take considerable time to resolve later in the development cycle. Moreover, using SiL and HiL approaches to develop, calibrate and validate TCU software in parallel with hardware development and fabrication constitutes an immense time savings.

“Simulation lets us reduce development time almost in half and create AMT designs that meet exact target performance requirements. The models developed and lessons learned with this project will be used as a basis for further time and development savings in the future. With this process, Renault will be launching more new vehicle models with AMTs months sooner than would otherwise be possible.”

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