SimulationX is the standard multi-domain simulation software for the holistic 1D to 3D design, modeling, simulation, functional mock-up, analysis, validation, test, and optimization of powertrain and transmission components. The software is applied by well-known customers in the automotive industry such as Audi, BMW, Daimler, FAW, Fiat, Ford, Getrag, Honda, Iran Khodro, Mitsubishi, Schaeffler, Volkswagen, and ZF.

The reproduction of engine behavior for testing engine ECUs in real time requires the modeling of a number of physical effects, which are measured by the ECU and are used to monitor the status of the engine such as speed, air mass, manifold pressure fuel pressure. The multi-domain modeling and simulation tool SimulationX provides an easy way to assemble a customized engine model fitting precisely the testing requirements for the ECU.
System reliability analysis challenges

For the test system the engine model has been extended by a complete real-time driveline model with automatic gearbox, which is real-time capable and is assembled from standard library components. A state-machine controller operates the gearbox inside the SimulationX model, so that no additional gearbox ECU is required on the HiL system. Drive resistances such as air drag, rolling friction and road gradient are considered. The model is operated through accelerator and brake pedal inputs and through the interaction with the ECU in the HiL. It is simulated with a 1ms sample rate.

Engine model

- Engine model combines detailed mechanical and thermodynamic air flow modeling
- Model is not just a mean-value model, but resolves engine excitations such as mass forces and combustion over crank angle
- Resulting speed fluctuations and their impact on the ECU speed sensing can be evaluated in the real-time test
- Air flow through the engine is modeled as a mean-value setup based on the SimulationX pneumatics library
- Air flow is controlled through a throttle model and the fuel combustion is executed depending on the available amount of air

Gearbox and controller

- Gearbox is an automatic transmission operated through physical friction models for clutches and brakes
- Dynamics of the gearshift are part of the model behavior
- Gearbox is operated by a state machine controller, parameterized through upshift and downshift maps as function of vehicle speed and accelerator pedal position

Using SimulationX means to set up an engine and driveline simulation model in a short time frame, which is tailored to the requirements of the ECU to be tested. Modeling, model testing and model calibration have been performed efficiently within SimulationX, minimizing the time required for setting the model into operation on the test system.

* Picture on the left: National Instruments HiL Platform based on PXI Realtime Hardware with NI VeriStand RealTime Test Software