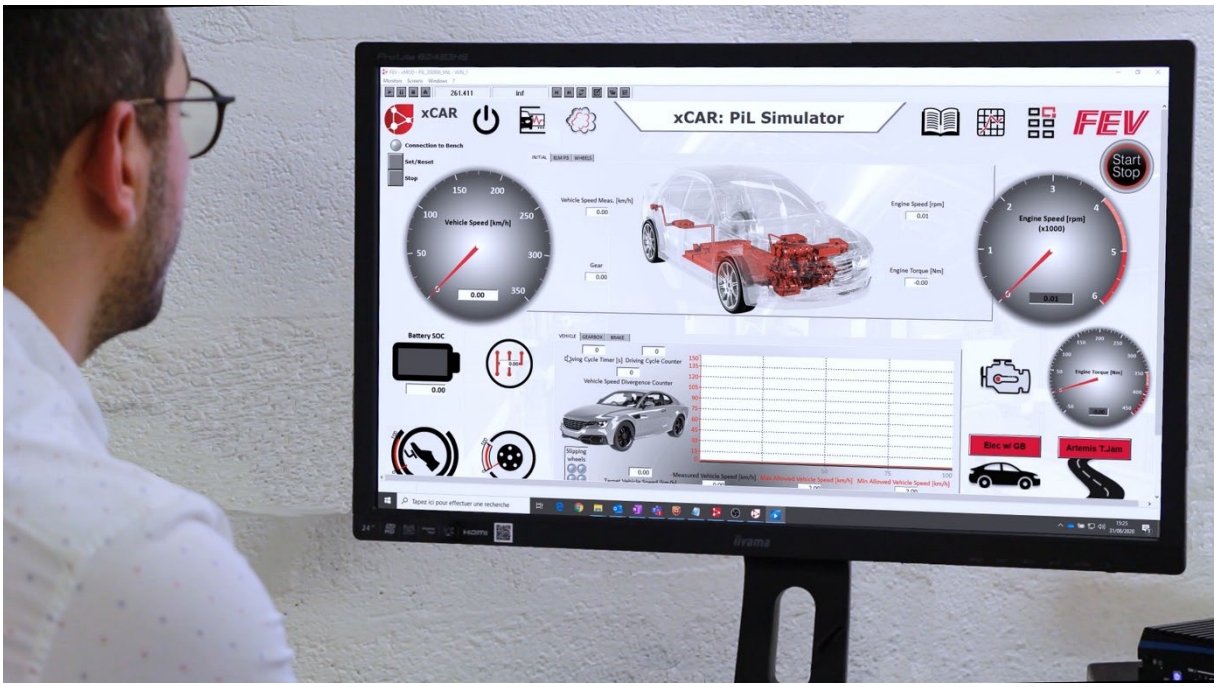
FEV product range for XiL bench (Specimen-in-the-Loop): the xMOD application

When it comes to examples of continuous improvement, many things come to mind – evolutionary theories and advancements in medicine or healthcare for instance. But arguably one of the best examples is within automotive. For over 100 years, the industry has continuously placed technology and innovation at the forefront of its growth. This ongoing innovation brings complexity in design and the need for tools to evaluate and test for functionality and efficiency.

To design and manufacture today's complex powertrains at affordable costs and within acceptable timelines, simulation techniques for example, are necessary. With this approach, engineers can evaluate different powertrain architectures upstream to select the most efficient option, carry out engine and vehicle validations without the need for a prototype vehicle, and even simulate altitude and extreme temperature conditions from their desk, reducing the need for travel to Finland or the Andes.

FEV, one of the global leaders in calibration, has developed simulation methodologies from design to road tests as part of a continuous improvement process in the field. However, it's important to note that the use of simulation does not eliminate the need for actual, physical tests – ultimately, they constitute the final proof. During simulated calibration, various components – combustion engine and its ECU, transmission and its TCU, drive train, vehicle but also driver, road profile and environment – are completely simulated (or "modelled") in the so called Model-in-the-Loop design phase. Going through the process, actual components replace the models, with the final validation stage occurring on track and road using the complete vehicle.

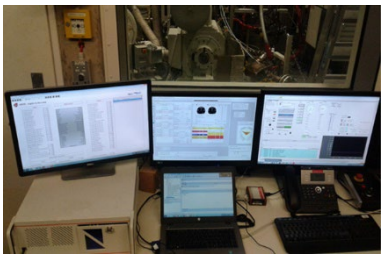
At the junction between the design and validation processes, the XiL bench (X-in-the-Loop) is a key tool for the deployment of virtual calibration, consisting of a standard bench testing an actual component associated with virtual components. In this area, FEV offers comprehensive expertise, covering all types of powertrain, including Engine-in-the-Loop, Battery-in-the-Loop, E-motor-in-the-Loop and Powertrain-in-the-Loop. These allow for calibration of the specimen directly on the bench from the first stages of development, even if certain components of the vehicle are not yet available. These also allow for validations of critical driving that cannot be safely carried out on the road and for obtaining accurate measurement results (emissions, SOC, etc.). Unlike road tests conducted by different drivers, simulated calibration results have a high degree of repeatability, due to the use of a modelled driver reproducing the exact behaviour from one test to the next.



Picture 1 – X in the Loop : here Powertrain in the loop

In an XiL bench, the virtual world and the real world come together to create a single system, in this case the vehicle. xMOD™, FEV's real-time software for co-simulation and virtual experimentation, enables these two worlds to communicate with each other. It receives the measurements from the test bench through the automation system and exports the simulated instructions to the bench. For example, in an engine test bench, the automation system sends the torque measurements to xMOD™, which then returns the pedal and speed instructions for controlling the engine.

On the bench, the specimen operates by definition in real time. This means the virtual components – in the engine test bench case the gearbox, the driver, the vehicle, etc. – must be in tune with the specimen, and the information coming from the models must be perfectly synchronized with the test carried out on the engine. This is what xMOD™ does. In fact, it has the ability to run simulation models 10 to 40 times faster than any other system in the market. This provides the opportunity to manage bench models in "hard" real time without loss of information, even for very complex models.



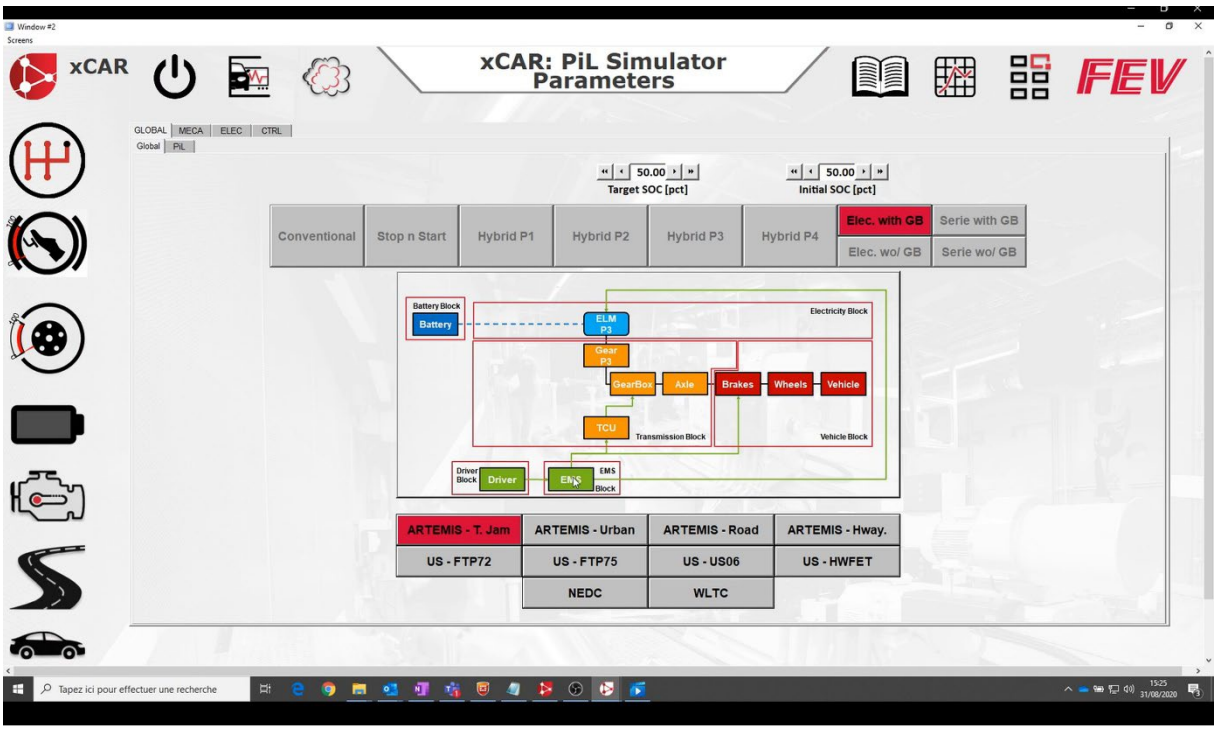
Picture 2: The application at the test bench

In order to achieve accurate and relevant bench test results, the entire simulation process must be controlled. Significant preparatory work is required before the final step at the bench. Initially, the models of the various components are designed with different packages, such as MATLAB Simulink®, Simcenter AMESim® or GT-Suite®. This aspect is where FEV customers have a choice – use their own

models or those provided by FEV. They are then integrated into xMOD™ for the co-simulation and Model-in-the-Loop stage (MiL), which verifies correct operation of the system.

After the MiL preparation stage, the connection to the test bench in a XiL configuration can start. In preparing the bench, communications between the automation system and xMOD™ is set up. Once completed, the bench is operational and in an EiL (Engine-in-the-Loop) configuration, RDE tests can be performed on the engine test bench itself.

The xMOD EiL Simulator™ has been created to be used by simulation specialists as well as calibration engineers and bench operators. In a user-friendly interface *(see PiL interface parameters*), they can easily choose the architecture they need – combustion-engine, hybrid- or electric-motor. It enables online modification of parameters of each component (gearbox, brakes, wheels, vehicle, etc.) as well as the import of RDE cycles from the customer. In short, the customer benefits from a comprehensive and flexible application. A procedure for easy test bench integration has been introduced into the xMOD™ XiL application, allowing for standard tests to be carried out ensuring flawless dynamics between the bench and the simulator. Consequently, this simplifies duplication or complete migration of the simulator from one test bench to another.



Picture 3: Parameters interface

Comparisons between the data obtained on the EiL bench and in reality display the high relevance of the use of this type of rig. And while road tests are still the final proof in the testing cycle, FEV's simulation tools and techniques support manufacturers to bring complex powertrains in a more qualified, efficient and cost-effective manner to market.