

modeFRONTIER

FOR CALIBRATION

modeFRONTIER for Calibration (mFC) toolbox is the new dedicated solution for fast, automated Model-Based Engine Calibration, included in modeFRONTIER.

By replacing the manual tasks required at the engine test bench, it automates the generation of optimal ECU maps. mFC toolbox streamlines this complex process by exploiting ESTECO optimization technology through a simplified interface, tailored to the specific needs of engine calibration.

The calibration process consists in tuning the Engine Control Unit (ECU) parameters to **enhance efficiency and performance of the engine**. Targets to achieve are usually based on trade-offs between opposing requirements. Crucial goals include:

- the minimization of environmental exhaust emissions to meet local emission regulations
- the reduction of the fuel consumption
- the enhancement of engine's power output (e.g. torque), durability, and drivability (NVH domain).

An efficient way to approach engine calibration is combining Model-Based Calibration (MBC) with an Hardware-in-the-loop (HIL) setup.

With the two modeFRONTIER dedicated profiles the calibration experts perform the initial setup that can then be reused by test bench specialists, making license use efficient.

DESIGN EXPERT

Full control of the process for calibration engineers

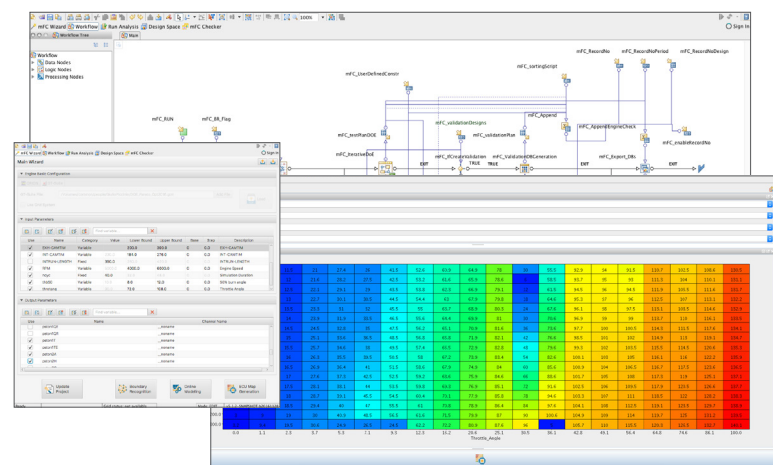
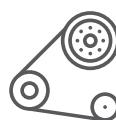
Experts take care of the initial system configuration, selection of model and identification of relevant variables and suitable parameters. Restricting the input space to the safe operation region is easy with the function generated by the mFC Classifier node. Experts customize the real time monitoring dashboard - the mFC Online Checker - and empower Test bench specialists with a tailored tool to control and adjust the execution.



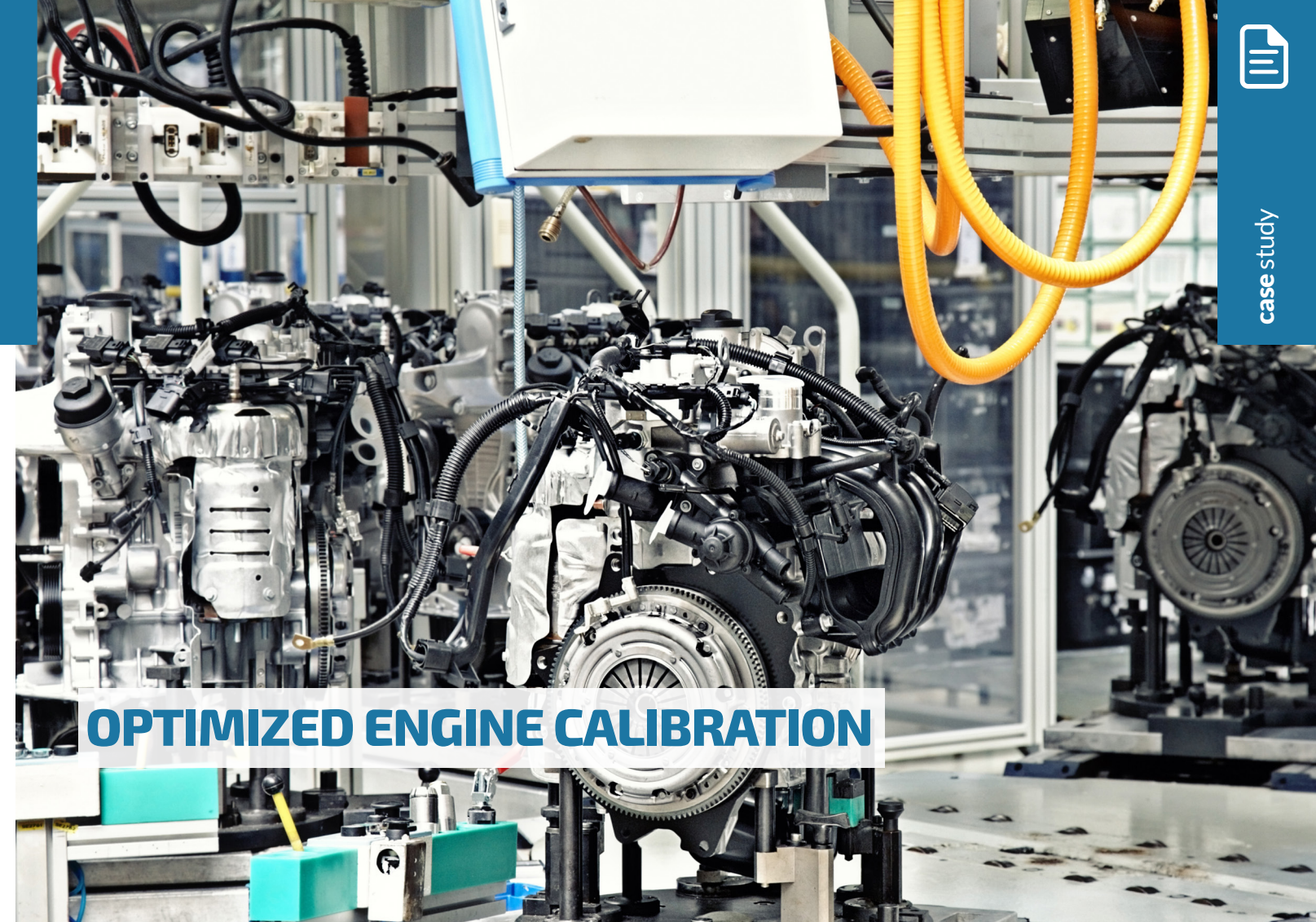
ENGINE ROOM

Real-time monitoring tool for test bench specialists

Test Bench specialists use the dedicated and lighter profile to start and stop the execution while iteratively refining the DOE in the Boundary definition phase or increment the RSM accuracy in the Online Modeling phase. In addition, with the advanced post-processing tools, monitoring and immediately improving the calibration process becomes straightforward and time is significantly reduced.



product information



OPTIMIZED ENGINE CALIBRATION



MODEL-BASE ENGINE CALIBRATION SHORTENS THE DEVELOPMENT TIME AND IMPROVES THE QUALITY AT TOYOTA TECHNICAL DEVELOPMENT CORP.



mFC succeeds in reducing the difficulties experienced by calibration engineers when using tools for model-based calibration.

Mr. Go

Project manager, TMC Laboratory Automation System, Toyota TD

Toyota has virtualized a significant portion of its calibration and testing process, dramatically reducing the development time and man-hours dedicated to it. Mr. Go [Project manager, TMC Laboratory Automation System, Toyota Technical Development Corp.] and Mr. Goto [Group Manager, Power Train Company, Engine Management System Development] talk about the benefits of using automated Design Exploration techniques to verify actuator responses and identify the best control values. "It's easy to find the optimal control value for a single actuator", says Mr. Go. "However, when looking to improve EGR, supercharging, VTT, direct injection, etc. With the number of actuators and consequently the number of the output variables and constraints, manually identifying the optimal control values would require a massive amount of time due to the large number of measurement tasks."



The integration platform for multiobjective optimization, multidisciplinary automation, and analytical decision making.

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case study

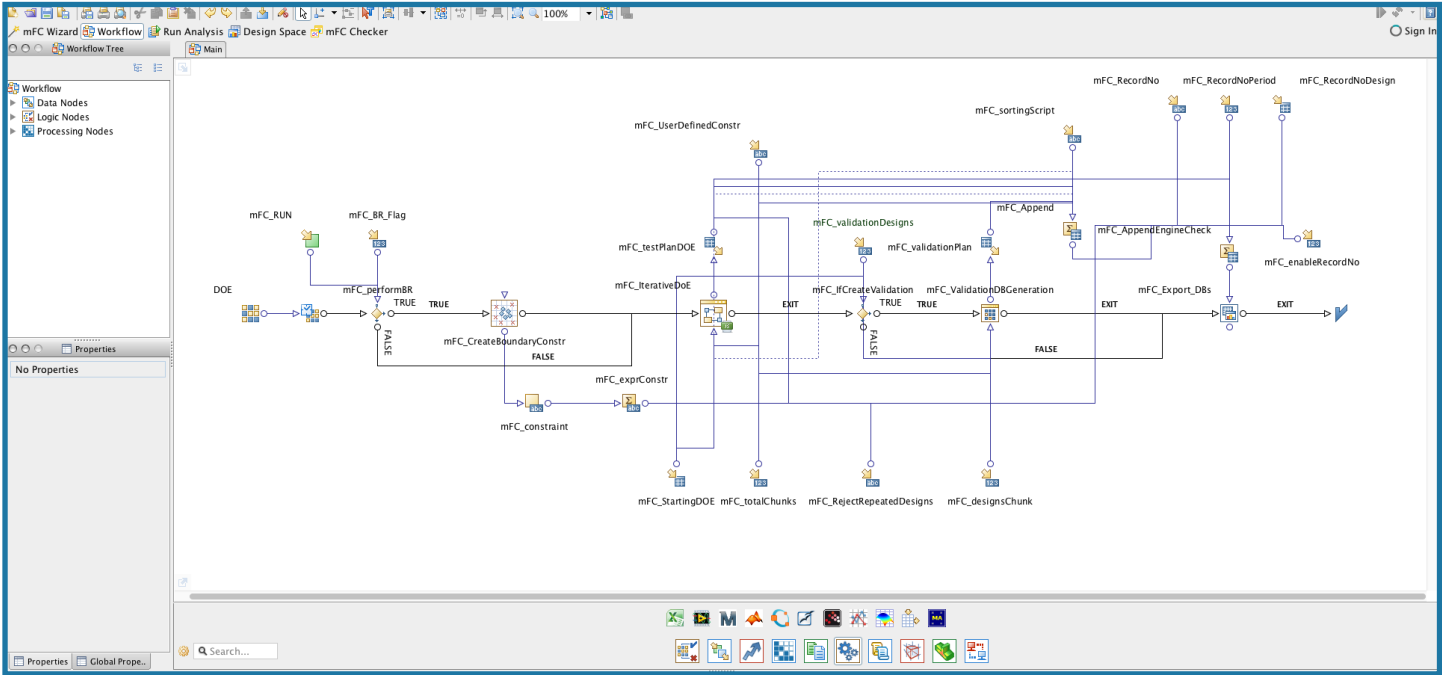
To test the engine, temperature and pressure sensors, torque and fuel consumption (gauge) meter and exhaust gas analyzer are installed and the control systems are implemented accordingly.

The combined software iTEST and ORION – the automated control and measurement system for engine bench test implemented at Toyota – manages the control equipment and collects the output from each instrument. These values are then validated by checking the reference maps. The complexity of the calibration procedure is streamlined by including modeFRONTIER for Calibration (mFC) in the process, directly integrated with ORI-



01 Toyota 1.3L Gasoline engine

02 The modeFRONTIER workflow editor including mFC toolbox



ON – which is used for automatic measurements. This replaces all the manual measurement tasks conducted at the engine test bench (laboratory) and relieves the team from the burden of repeated iterations of repeated iterations between the design and testing phases of the project, where now measurement, modelling and accuracy evaluation can be automatically repeated.

“During the evaluation, it is easy to stop mFC and change the DOE. Given certain scenarios, with this technique we can reduce the number of evaluation by 50%.”

Mr. Go
Project manager, TMC Laboratory
Automation System, Toyota TD

“To understand the output trend and find the optimal solution with experimental points, we used mFC to create a Design of Experiment (DoE), measure data, train and compare metamodels (RSMs). The next step in the process consists in determining the optimal Engine Control Units maps and finally testing again on the real engine.”

“mFC succeeds in reducing the difficulties experienced by calibration engineers when using tools for model-based calibration by providing a dedicated graphic interface to directly set parameters, lower and upper bounds. mFC



03 Toyota experts Mr. Go [Project manager, TMC Laboratory Automation System, Toyota TD] and Mr. Goto [Group Manager, Power Train Company, Engine Management System Development]

automatically generates designs and RSMs, then iteratively evaluates the accuracy and stops the evaluations when the target model accuracy is reached.” Mr. Go says. Since real engine test is influenced by the variability of control variables and by measurements error, sometimes

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the combination of temperature, pressure and torque causes the test to be stopped for safety reasons.

By using a visual filter in mFC, this issue is easily identified and the DOE is automatically substituted with a more suitable dataset. “In any case, during the evaluation, it is easy to stop mFC and change the DOE. Given certain scenarios, with this technique we can reduce the number of evaluations by 50%” Mr Go says. This method empowers the system engineering process by adding the capabilities of simulation and automation in the right side of the V-cycle, the experimental evaluation phase of the Verification and Validation model, where traditionally, it is hardly used.

ESTECO technology technology has been widely used in the engine modeling phase, in combination with GT-SUITE. Mr. Goto says that by reciprocally using optimization results as continuous feedback between the design and testing phases, there is great potential for further accuracy improvement. “By performing optimization with real engine data, we can leverage the efficiency and accuracy gained during the testing back in model design. Thanks to the industry-wide use of data and models, designer and calibration experts can work together and further improve our operations” concluded Mr. Go, stressing collaboration among experts as a major benefit of this technology.

LEARN MORE
For further information
www.esteco.com

About ESTECO

ESTECO is an independent technology provider that delivers first-class software solutions aimed at perfecting the simulation-driven design process. With more than 15 years’ experience, the company specializes in customer-focused solutions for numerical optimization, CAE integration, process automation and simulation data management, and supports over 250 international organizations in designing better, more efficient products across a wide spectrum of industrial sectors.

About Toyota Technical Development Corporation

As a subsidiary of Toyota Motor Corporation, Toyota Technical Development Corporation provides research and development services. The Company researches and develops vehicle, electronic systems, communication systems, material technology, measurement hardware, and other technical facilities. Toyota Technical Development also provides facility maintenance, information analysis, and technical training services.
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