Continental evaluates fast engine control

The development of ever more efficient and, at the same time, increasingly complex engines in concert with a rising number of engine management functions, has the effect of raising the bar for test bench engine control in terms of flexibility, data throughput, and speed. With these considerations as a backdrop, Continental Automotive has evaluated a real-time environment for fast, test bench-based engine control at the Test Center in Regensburg.

Not only on the engine test benches of the Regensburg Test Center but also at locations around the globe, the Powertrain Division of Continental Automotive is engaged in the testing and calibration of engine management systems. In their function as service providers in the areas of development and calibration, the test centers provide test bench instrumentation and ensure automated and smooth test bench operation – seven days a week, and around the clock.

The test centers are centrally supported by the company’s Testing Tools department in Regensburg. The centralized department develops, validates, distributes, and maintains methods, tools, and data management for measuring operations and test bench automation.

An essential service provided by the test centers is the execution of measurements for the basic precalibration of engine ECUs. To determine engine management characteristics of injection, ignition, and cylinder charge, the test centers use their state-of-the-art engine test benches to conduct series of tests involving a variety of engine variants. For example, indexing measurements are used to automatically determine the knocking limit, center of combustion, and associated optimum ignition angle as a function of load and engine speed.

Engine control via test bench
As long as there is no basic engine ECU precalibration available, the engine operation during a test is controlled by the engine test bench itself. At the start of a measuring session, in an effort to provide an optimum setting, the controllers are identified by means of transient steps and then adapted during actual measuring operation. In this context, the quality of test bench-based control exerts a decisive influence not only on the stability of the fully automated measuring operation but also on the quality of measured data. The control cycles must be short enough to prevent control oscillations. The demands for the real-time behavior of the controllers are derived from the cycle times, number of controllers, and volume of transmitted

Fast engine control on the engine test bench at Continental Automotive (schematic diagram). The existing test bench environment (grey) was augmented by new systems, drivers, and connections (blue).
Simulink® models in the real-time environment of the MORPHEE 2 generic test bench automation system. In a fashion reminiscent of prototyping or HIL systems, the test bench-based controllers can be developed and tested in the Simulink® environment. The final system integration occurs at the test bench. Real-time capable drivers connect the Simulink® controllers via CAN with the indexing system, and via EtherCAT field bus to the ES910.3 Rapid Prototyping and Interface Module from ETAS. The EtherCAT/ES910 connection replaces the conventional ASAP3/INCA interface. The ES910 module performs a real-time conversion of the name-based physical output signals of the controls in binary to address-based signals for the engine ECU. Prior to each measurement run, the ES910 module is automatically configured with the aid of INCA and the INCA-MCE (Measurement and Calibration Embedded) add-on through the ASAM MCD-3 MC V2.2 DCOM interface.

Evaluation findings
The evaluation of the new real-time environment commenced in early 2010 and was successfully completed in mid-2010. New controllers can now be modeled with Simulink® offline on the PC, and directly integrated in the test bench environment. This substantially accelerates the development of new controller functions and the construction of controller libraries. Thanks to the real-time communication in millisecond cycles, even highly optimized and complex engines can be operated with quasi-ECU quality. The high control quality provides for unmanned, robust test bench operation over extended periods. Existing operating points or profiles can be engaged quickly and repeatably. The critical points within the environment were identified and used to provide the basis for technical solutions for the optimized integration of subsystems and computer infrastructure.

Outlook
The real-time environment facilitates fast engine control via the test bench itself. Furthermore, the new solution provides a platform for innovative measurement and calibration methods in concert with engine operation on the test bench, in the same transient state as during road travel.

As a next step, a mobile automation system is being equipped with the real-time environment; it is slated for productive deployment at the Regensburg Test Center. This phase is intended as a system test during regular test bench operation, while at the same time enabling testing staff to collect deeper system skills and expertise. This phase will be followed by a worldwide rollout of the new environment.

Navistar followed the traditional ECU software development process for most of these programs, where there is a strict separation between the specifications produced by the OEM and the software developed by the supplier. This separation means many iterations between the supplier and OEM as the specification is refined, resulting in the loss of precious time as each iteration involves a full review and test cycle. For one of their heavy duty truck engines, Navistar has switched to the model-based design approach and is realizing the benefits of closer co-development with their ECU supplier, in this case Bosch. The model works as an executable specification, providing a quick way for the OEM to verify whether the requirements have been correctly specified.

For the heavy duty truck engine program, Navistar is using ETAS’ ASCET tool suite for the specification of new ECU functionality, PC simulation, in-vehicle prototyping, and for the preparation of code generation. The code generation-ready ASCET models are transferred to Bosch, who is responsible for the final code generation and software integration.

Function development and pre-calibration
The new ECU functionality is first simulated on the PC to verify that the model meets the specification, without the need of additional hardware. Since ASCET also provides a built-in mechanism to simulate the