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A modern approach to face current and future testing needs as part of the entire development process for vehicles and engines

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ABSTRACT

Nowadays lead times and quality demands for the development of entire vehicles, or components for them, require new methods, which must be supported by new tools. This paper describes the key demands to modern test cell equipment as well as solutions for the area of test cell management systems. An outlook to the evolution of the way of testing and the role of a test cell in the entire development process is given to discuss the needs and possible solutions of the future.

INTRODUCTION

Nowadays goals regarding low cost and short time for the development of new products or new versions of them are already very challenging, - and the process to achieve them will become even more challenging in the future. Especially this is true for the automotive industry, where the technical goals and constraints for the products under development themselves are also very demanding and become more complicated from year to year. The legislative regulations restrict the allowed emissions rapidly on one hand and the customers' expectations for fuel economy, reliability and comfort are rising on the other hand. More and more influence factors must be used by vehicle and engine developers to achieve those virtually contradictory goals. This means that the experiments, which are a very important part of the entire development process, become very complex and hard to handle. Due to the increasing number of controlled parameters, the number of possible calibrations rises tremendously so that the required time is also increased a lot. To compensate these effects high sophisticated tools using intelligent methodologies must be provided by suppliers and used as efficient as possible by the engine developers.

NOWADAYS DEMANDS

Those global goals introduce demands and constraints for the daily work in and with different testing environments:

- short training
- operators, who can work in nearly any kind of test environment
- reuse of test definition elements
- good overview
- configuration replaces programming, but user-defined items are also available
- platform independence of the software
- same system for virtually all different testing environments
- easy integration of third party products

Those second level goals make up and define requirements for the tools and the equipment, which is used to perform the different tests in different testing environments:

- ease of use
- modularized system structure
- scalable systems in terms of hardware, software and functionality
- well known and wide spread way of handling the system (user interface)
- possibility to adapt the system to the user's philosophy in order to allow efficient usage of the system
- predefined functionality on one hand and open programming interface on the other
- support of ASAM-interfaces
- test cell independent test definition
- active information propagation

AN APPROACH FOR THE AREA OF TEST CELL RELATED SYSTEMS

To handle most of the tasks in a typical engine test cell, the concept is based on two main systems, the TestCellManager coordinating all activities in the test cell, the other one, the TestObjectManager, providing all functionality directly linked to and specialized for the engine, such as control loops, basic security etc.

Both systems are fully scaleable in terms of hard- and software. That means processing power can be added by simply distributing the functionality across multiple hardware units, functionality can be extended by plugging in software modules, exactly tailored to the current testing needs.

The TestCellManager is responsible for the coordination of all devices in the entire test cell, including data logging, limit monitoring, integration of intelligent subsystems, etc.

It consists of a small base system and a large number of modules. The base system provides a framework with basic services, in which all modules can be operated without being coupled too tight. In other words, the modules are self sufficient and don't require the existence of other modules around them. Communication is done by standard names of channels and events, which are available and needed anyways, so that a very flexible binding between modules, carrying different functionality, is achieved.

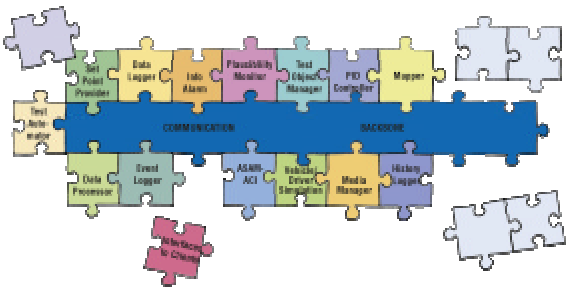

Figure 1: Modular Approach of FEV's product line

The entire set of available modules can be grouped into two categories. The first category contains modules, which provide an open interface to configure their behavior in a wide range, so that almost every special and proprietary requirement can be realized by the customer himself. On the other hand there is a complementary group of modules, which provide predefined functionality, which is ready to use and therefore can be used very quickly after only a short and easy configuration phase.

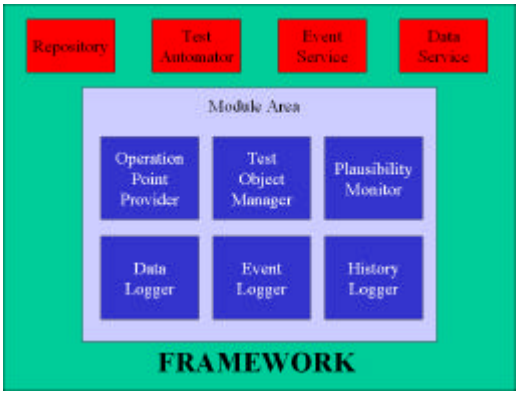

Figure 2: System Structure of the TestCellManager

Every module shows its capabilities in a simple and intuitive way. The main navigator window, the project view, is based on an "Windows-Explorer" - type tree view, where all modules are represented as nodes and can be opened to see the details of their functionality and configuration.

All elements of a module can be used for "drag&drop" operations, so that time consuming and error prone typing of names for channels and functions can be avoided. The TestCellManager does contain a special view to navigate through all configured channels and other test elements by different criteria. A filter can be selected in order to show the test elements ordered by name, module, physical unit, etc. This feature eases the preparation of test procedures and helps the user to keep the overall overview.

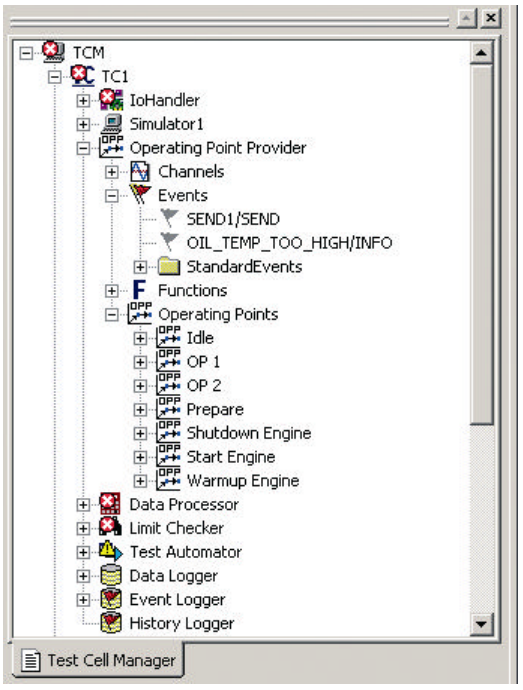

Figure 3: Self explaining module overview

The TestObjectManager is one of the intelligent subsystems in a test cell. It controls the test object, which is a combustion engine in case of an engine test cell, regarding its operating point (speed and load in our case), monitors the most important signals and reacts on limit violations accordingly.

The module inside the TestObjectManager, which contains the control strategy, is based on the wide spread modeling tool MATLAB/SIMULINK and assures easy, safe and fast adaptation to special control requirements on one side and other types of test objects (such as engine components, gearbox, other components of a vehicle, entire vehicle) on the other side.

The TestObjectManager can be run as a pure software module on the TestCellManager's hardware or, in case of higher demands, on a separate computer. The handling of this subsystem inside the TestCellManager stays the same in both situations. Even the test configuration of the automation system does not have to be changed for the transition from the software to the hardware version. This is only one example of user-friendly scalability of the FEV approach.

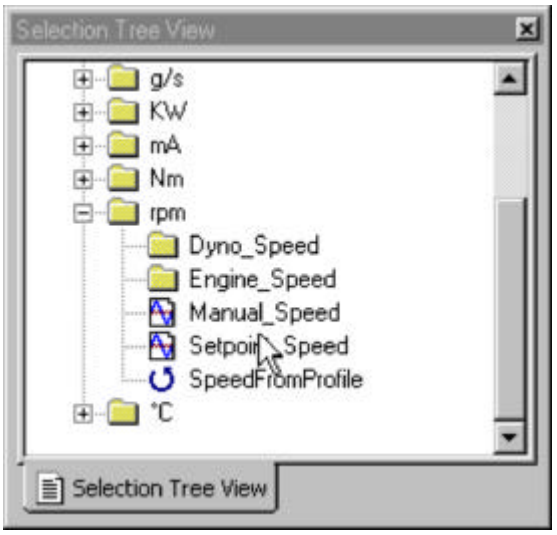

Figure 4: Test Navigation supported by different views and filters: channels ordered by unit

EVOLUTION OF THE WAY OF TESTING / FUTURE DEMANDS

Looking back some years, the term "testing" closely coupled to experiments conducted at test cells equipped with physically installed test objects. Besides this experimental approach, one can see a growing involvement of simulation and prediction tools in the whole development process. Historically this two branches are separated and performed with different tools on different platforms. But, at least for the near future, they can not live without each other. This means, the results of simulation runs must be validated using conventional test runs on a conventional test cell. On the other side, results coming from an experiment in the test cell very often need investigations based simulation runs in order to be fully understood or to be generalized. This means, results coming from those two environments, very often must be compared with or transferred into the "opposite world". The tests, being conducted in both environments, are very similar in large parts.

The conclusion of this thoughts is the idea to open the term "testing", so that simulation runs also are regarded as test procedures. Testing should be understood as analyzing one of multiple representations of the test object. One of them is the entire test object itself, others are computational models or hybrid configurations, where parts of the original test object are combined with simulation models of the rest.

As a logical consequence, testing in all this variants should be handled very similar; even better, should be based on the same tools as far as possible.

A second aspect is the utilization of knowledge of experienced people in the testing process. This approach can be implemented in multiple steps of the engine testing process. Using data models of the test object instead of working with it directly is used to reduce the tests to be conducted in the test cell, as described in the previous section. Using those data models to prepare test runs, to find good starting points for optimization procedures, to determine initial settings of constants used during the testing process is the next step.

Taking the approach of "Design of Experiments" as an example it is obvious, how the knowledge of experienced people can be used to gain a data model of a test object by only taking a comparably low number of measurements in the real test cell. The assumptions regarding the principle behavior of the test object are defined by the user, and, based on that, the DOE-module determines the points to be measured in the test cell. Analyzing the results coming from the test cell, the DOE-module is able to calculate the coefficients for a mathematical description of the test object. This can be used for all kinds of post processing, e.g. optimization procedures.

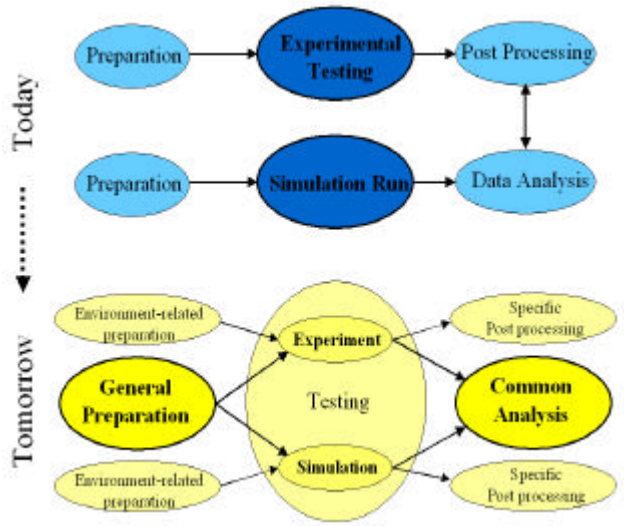

Figure 5: Changes in the way of testing

FEV has taken into account this evolution and designed its new tools to provide an optimum support in the described direction. The tools are ready-to-use on one side, but have open interfaces to integrate simulation-, DOE- and optimization tools on the other side.

The center of work moves from the test cell to a seamless combination of simulation and experimental testing. The test cell is an important data source, which is indispensable, but not the center of the world. It must be robust in order to deliver reliable data, and therefore must come with powerful facilities to check limits and monitor plausibility of acquired data.

CONCLUSIONS

In order to fulfill current and coming requirements of modern engine testing FEV has introduced the TestCellManager and the TestObjectManager, both members of a new generation of testing tools, which provide optimum support for today's testing needs and which are well prepared to face coming requirements:

- easy to learn and maintain -> low efforts and cost
- configuration instead of programming -> avoid time consuming mistakes
- ready to use -> fast start
- scaleable regarding software and hardware -> low initial investment
- optimal adaptation to (testing) task -> best utilization of equipment and investment
- "What you see is what you need" -> avoid information overflow
- active information propagation -> avoid information gaps
- install same components -> easy communication between steps of the development process

The described features can be concluded into the following benefits to the customer:

- higher efficiency during testing
- shorter testing times
- more reliable test results
- save investment and testing philosophy
- good support of and integration into the overall vehicle and engine development process

OUTLOOK

Today the focus is still on preparation, execution and post processing of tests. This will change more and more towards an overall support of the entire development process. This transition is necessary to make best use of experience gathered during already executed tests in upcoming test orders.

The following functionalities will be necessary in the future in order to reduce the number of measurements to be taken during a test process. They must concentrate the experience, which nowadays is distributed over multiple human heads, at one central location.

Authorized people, who are involved in test planning and preparation, must have access to these data, in order to avoid unnecessary loops and test cell time.

The consequence is that expert systems will be used to assist test definition and post processing of an testing procedure. Examples for the utilization of knowledge stored in an expert system are the determination of constraints, the selection of methods, the definition of variation ranges for parameters during the tests.