Drive Safely with MTest

In the development of chassis control systems, complexity is increasing as development times decrease. BMW is therefore focussing strongly on verifying the systems at an early stage. MTest from dSPACE is a tool that allows extensive function tests to be performed efficiently on the Simulink® platform. During the production development of a shock absorber control, this verification level considerably enhanced the quality of the function logic, and therefore the efficiency of all downstream development steps such as code generation.

◤ BMW Group boosts efficiency with MTest

◤ Early verification in function development

◤ Electronic shock absorber control ensures vehicle dynamics and safety
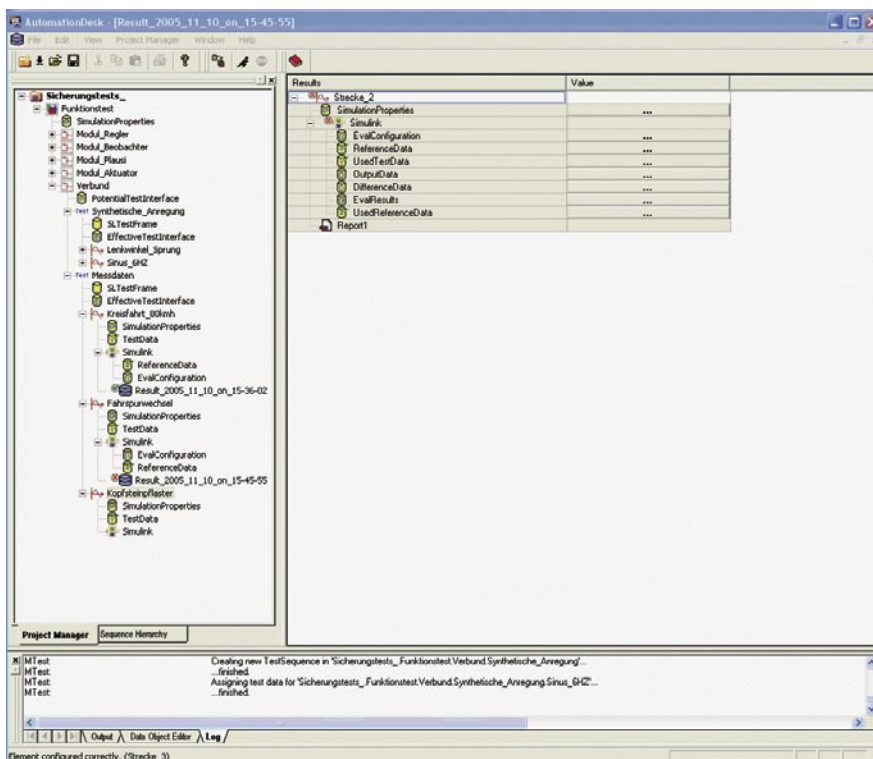
Safety Versus Comfort? Problem Solved!

Safety and comfort are conflicting objectives in the design of conventional chassis. For a high level of comfort, the car body must be largely decoupled from road effects, while for a high level of safety, dynamic wheel load variations have to be minimized. These two requirements often run contrary to one another in the design of chassis components. An electronic shock absorber control has now considerably reconciled the two. It does this by adjusting optimum damping forces between the car body and the wheels according to the driving situation and the excitation coming from the road. The desired damping forces are computed from the variables for vertical vehicle movement and other data on the driving situation,

for example, the steering wheel angle, by means of a control strategy.
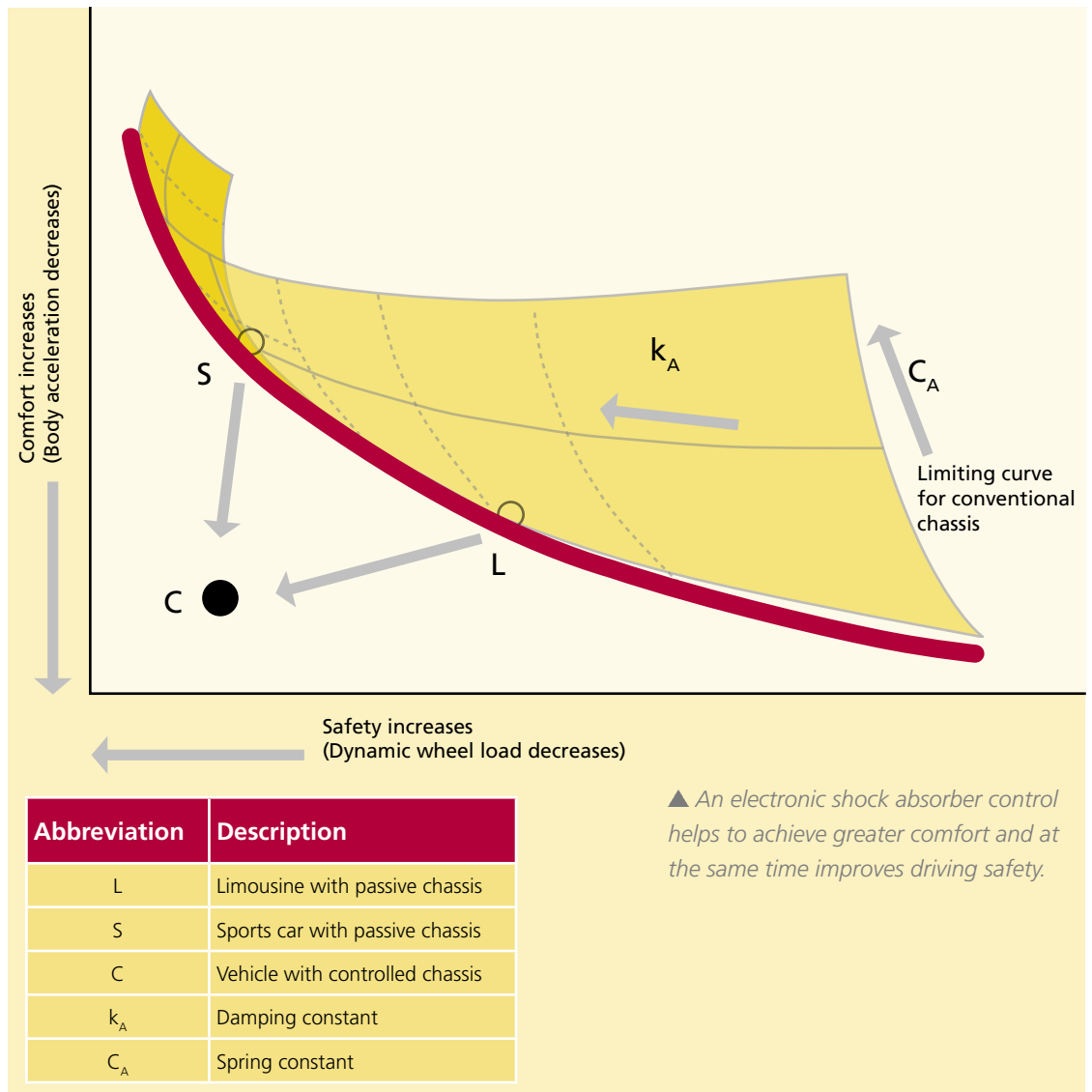
Function Tests Reduce Error Propagation

A large number of small iteration loops are run through during the development of the control system, to achieve the greatest possible functionality and high reliability. This is done by making repeated functional modifications or extensions in Simulink and then converting these into ECU code by means of TargetLink. The iteration loops are error-prone, and must therefore be verified at the earliest possible stage to avoid error propagation and the unnecessary workload it involves. Moreover, the project has a fixed time schedule of integration stages,

◀ The structure of the test trees makes test cases easier to view and use.

Chart axes:
- Vertical: Comfort increases (Body acceleration decreases)
- Horizontal: Safety increases (Dynamic wheel load decreases)

Labels on chart: S, C, L, k_A, c_A, Limiting curve for conventional chassis

Abbreviation	Description
L	Limousine with passive chassis
S	Sports car with passive chassis
C	Vehicle with controlled chassis
k_A	Damping constant
c_A	Spring constant

▲ An electronic shock absorber control helps to achieve greater comfort and at the same time improves driving safety.

each of which requires software that is completely verified if at all possible. However, all OEMs are under pressure to reduce the verification and testing times spent on cost-intensive prototypes, so to keep quality at the same high level, alternative methods are needed. One important step towards meeting these requirements is to verify the function logic in Simulink. This is called the executable specification. These tests are called function tests below. To run them, BMW looked for a test tool that would fulfil the following criteria:

- Support for the Simulink/TargetLink platform
- Options for tests on modules within the function model and for overall tests
- Realistic verification via specifications for sample time, excitation data from measurements, and all inputs
- Linking of specifications and test cases
- Black-box and white-box tests

MTest Used in Production Development
When BMW developed the software for the shock absorber control, it was the first time we had used the MTest tool from dSPACE in the production development process. One of MTest's great advantages is that it enables users to construct well organized test trees. The test trees currently consist of two test groups: In one group, individual models are selected from the overall system and tested for proper functioning

(module tests). In the other, the overall system is verified in what are known as network tests. The aim is to test specific function modules from the overall system using appropriate test cases. Each test contains a large

> *"Using software tests can significantly increase efficiency in the development of complex vehicle control systems."*
> *Jan Kirschbaum*

number of test sequences which address individual working points of the function under test, forming a tightly knit test net that will ideally detect all errors. Both generated stimuli and measurement data from various driving maneuvers are used as excitation for the test sequences. If a function is defined as error-free after a test run, its test results are used as a reference for all further test runs. In a subsequent test run, MTest evaluates the tests by comparing the test results with the references according to selected criteria. Another advantage of the tool is that it allows individual test sequences to be selected and executed if required, so it is not necessary to run through the complex test tree in its entirety every time. The tool also supports the automated execution of several selected tests, so extensive simulations can be run overnight and do not block computing capacity by day. To evaluate the tests, we use the Report Generator included in MTest. This shows test results graphically in a PDF document, which is then used for test evaluation.

Higher Function Quality with MTest

Verifying the executable specifications in Simulink increased the quality of the function logic quite noticeably and reduced the number of unnecessary iteration loops due to erroneous implementation. These tests played a major part in making BMW's development process even more efficient. MTest enabled us to handle the increased test requirement in developing vehicle control systems. However, further verification stages are needed to guarantee constantly high quality despite growing complexity. In future we will therefore increasingly need suites of tools that will support testing throughout the process and on all platforms. MTest's user-friendliness was further improved via good and constructive cooperation with dSPACE in the form of feedback session. Further optimizations will enable the tool to establish itself as a standart in this area.

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