Application of Design for Six Sigma methods in the development and validation of chassis control systems

Dr.-Ing. Michael Kochem

Dipl.-Ing. Florian Weyer

Dr.-Ing. Henning Holzmann

GM Europe Engineering
Adam OPEL GmbH
Chassis Controls Simulation
IPC S1-01
65423 Rüsselsheim
Tel.: +49-6142-7-68433
Fax: +49-6142-7-78030
Email: **michael.kochem@de.opel.com**

Abstract

Due to the increasing number of body styles, engine/gear combinations and the variety of modern control systems, the use of simulation techniques becomes more and more important in the development process of classical chassis as well as chassis control systems. Following GM's Road-Lab-Math (R-L-M) strategy, the number of prototype cars in ongoing and future vehicle programs will be significantly reduced. The goal is to cancel one hardware step for all future vehicle platform derivatives [1, 4]. Therefore, this paper describes the success of CAE utilization within chassis development and – based on that – in virtual application and release of chassis control systems. Since not all upcoming vehicle variants can be simulated, even with the inhouse developed Test-Automation [2] (which includes automated post-processing) it is necessary to reduce the complexity of this task.

An ongoing Design for Six Sigma project (DFSS) investigates various methods to study the influences of different vehicle parameters on the control systems' performance of the overall vehicle based on vehicle dynamics simulation. After constructing a kriging surface, among other methods, ANOVA (Analysis of variants) is employed to analyze the influences of (deterministic) vehicle parameters like e.g. inertia, CG height, axle load distribution etc. as well as their interaction (see Fig. 1).

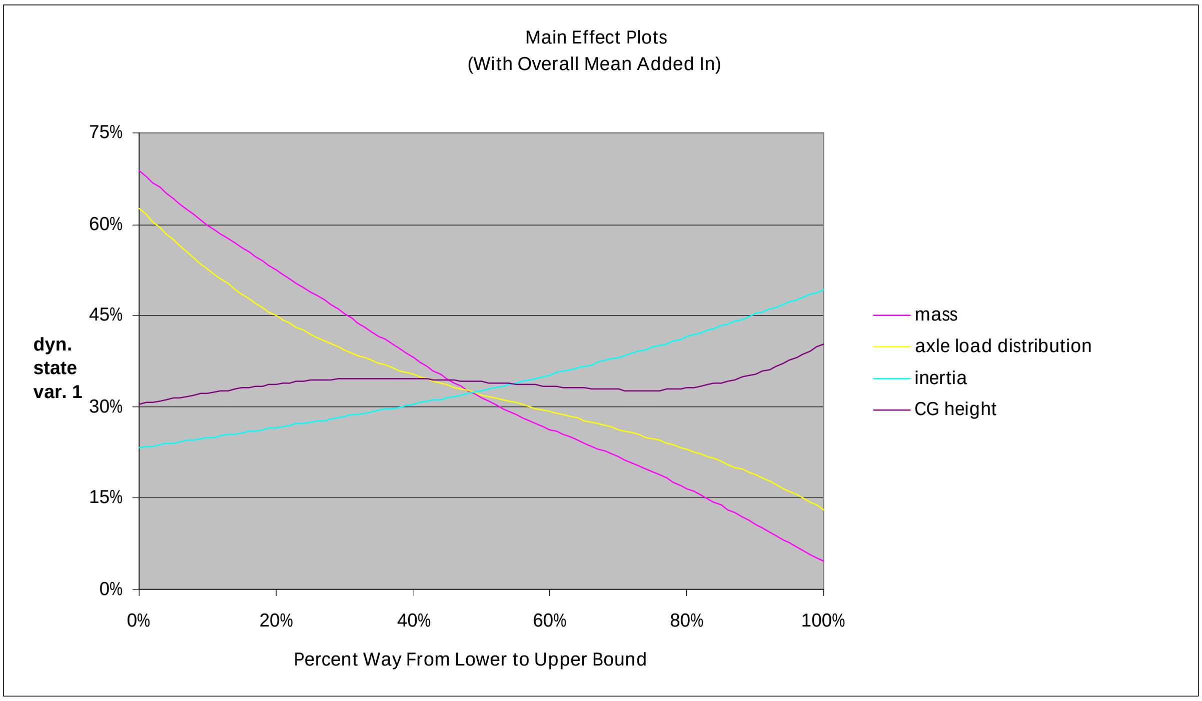

Fig. 1: Example of the influences of vehicle parameter variations on one dynamic vehicle state variable of interest

To create the necessary data, an inhouse developed tool ("Kriging Wizard" developed by GM R&D Warren, [6]) has been combined with a Software-in-the-Loop simulation (SiL) environment currently being used at the GME Engineering Center. This SiL/HiL environment (Fig. 2), consisting of the IPG CarMaker for the vehicle dynamics simulation and the respective controller codes of several suppliers combined in a Simulink environment, has already proven its validity in previous vehicle projects [3, 5]. The described simulation environment allows for fast data generation and analysis.

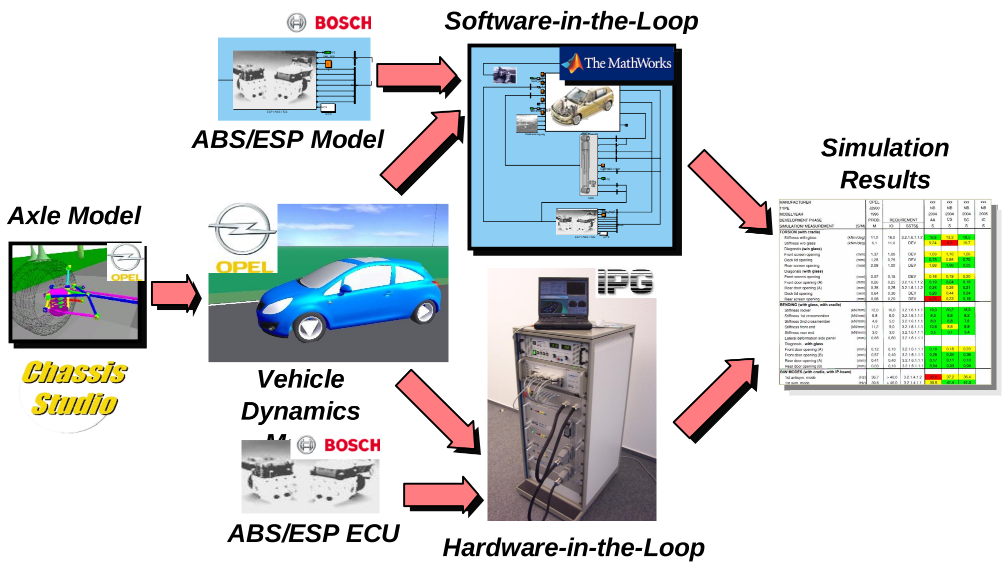

Fig. 2: HiL/SiL – simulation environment for chassis control system development and validation

The simulation based investigations presented in the paper will result in a guideline on how to cluster different vehicle variants based on the prioritized influence of different (vehicle) parameters. As a result the complexity of control systems parameterizations can be reduced in the future.

The paper shows the simulation environment, the statistical evaluation environment as well as the simulation results with different vehicle variants. Furthermore, validation results based on real vehicle measurements show the validity of the simulation models as well as the overall simulation environment. It will be concluded with the clustering results based on several prioritized vehicle parameters.

Previous publications on the topic and adjacent areas

[1] Holzmann, H.; Hiemenz, R.:
Einsatz moderner Simulationsverfahren bei der Entwicklung von vernetzten Fahrwerkregelsystemen am Beispiel Integrated Chassis Control (ICC)
Tagung „Fahrwerktechnik“, Haus der Technik, München, 03.+04. Juni 2003

[2] Holzmann, H., Hahn, K.-M.:
Einsatz von HiL-Simulation im Entwicklungsprozess von modernen Fahrwerk-regelsystemen am Beispiel Integrated Chassis Control (ICC)
VDI-Tagung AUTOREG 2004, Wiesloch, 02.+03. März 2004

[3] Kochem, M., Holzmann, H.:
Virtuelle Entwicklung von Fahrwerkregelsystemen am Beispiel des IDS^{plus} Fahrwerks im neuen OPEL Astra
VDI-Tagung Berechnung und Simulation im Fahrzeugbau, Würzburg, 29.+30. September 2004

[4] Kochem, M., Holzmann, H.:
Einsatz der Road-Lab-Math Strategie bei der simulationsbasierten Entwicklung von Fahrdynamikregelsystemen.
VDI-Tagung AUTOREG 2006, Wiesloch, 07.+08. März 2006

[5] Holzmann, H., Halfmann, H., Hahn, K.-M., Kochem, M.:
Virtual Development and Application of Chassis Components and Chassis Controls at GM Europe.
2007 SAE International World Congress and Exhibition, Detroit, USA, April 16-19, 2007

[6] Neal, M., Tu, J., Jones D.:
A response surface based tool for evaluating vehicle performance in the pedestrian leg impact test.
to be published in the 2008 SAE Congress Proceedings