DEVELOPMENT OF CONNECTED POWERTRAINS AT THE POWER TEST BED

Navigation-based advanced driver assistance systems will find their way into actual vehicles. That implies a challenge for the engineers to reliably assure the complete system vehicle. Therefore Audi, AVL and the Technische Hochschule Ingolstadt are currently cooperating in a joint project on an integrated validation environment that for the first time allows virtual test drives to validate navigations based vehicle systems at the test bed without adapting the systems.

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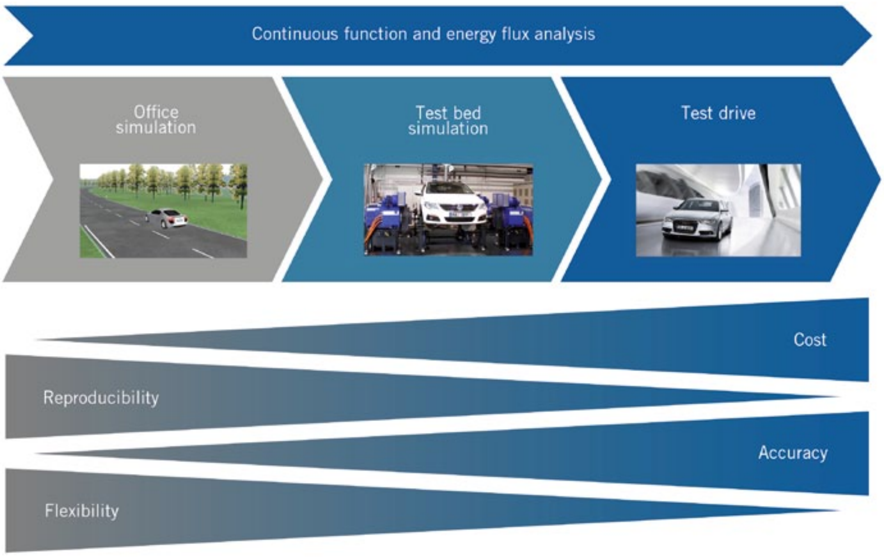
MOTIVATION

In response to the requests on raised energy efficiency, new Advanced Driver Assistance Systems (ADAS) with influence on the vehicle propulsion system will find their way into new vehicles. Predictive assistance systems based on satellite navigations systems, e.g. predictive shifting strategies for automatic transmissions [1, 2] as well as operations strategies for hybrid electric vehicles [3] respectively battery electric vehicles [4], have already been realised in vehicles. Autonomous longitudinal dynamic regulations systems (Green ACCs) are in a close-to-production stage of development [5, 6]. Advanced functions e.g. for particular autonomous highway drives [7, 8] are at the moment also under development, but will find their way to the roads in the medium term.

The integration of the propulsion system with other vehicle systems and environment sensor systems is well illustrated by the expression „Connected Powertrain". The reliable safeguarding of such highly networked, predictive vehicle networks is a challenge for vehicle development. New methods are required which exceed the test drive on real test track. To master the validation of such systems a reliable test environment for the overall system is necessary. The pure office simulation offers results at a very early stage, however the evidential value is limited even with very high modelling effort. The real test drive delivers significant results as well as real behaviour. However, due to environmental influences the reproducibility of the results is missing in this case.

The test bed respectively hybrid simulation, here demonstrated at the example of a power test bed, creates a bridge between pure simulation and the real test drive, as it owns the properties of both environments to a certain degree. Through the application of the test bed simulation such highly networked propulsion systems can be validated relia-



❶ Approach for the continuous energy flux analysis for the validation of predictive vehicle systems according to [9]

ble. In the process a high reproducibility as well as a high evidential value is reached. With this it is e.g. also possible to compare two different parameterisations of a longitudinal dynamic regulations systems. Through an integrated approach, ❶, the advantages of the particular test environments can be associated [9].

VIRTUAL TEST DRIVE

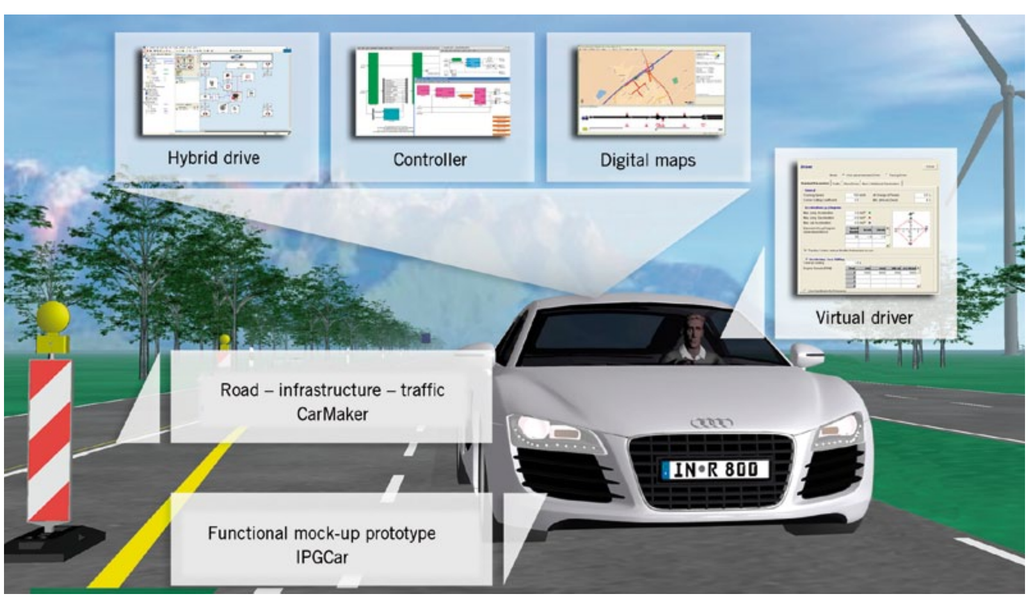
For the validation of ADAS it is necessary to reproduce the real test drive also in the simulation. That means as base for the validation process manoeuvre based tests have to be used. Therefore for the test bed simulation a (real-time) driving simulation is used, that allows virtual test drives, ❷. Here a virtual driver moves a virtual vehicle through a virtual world, in which the road including all marks and traffic signs as well as the environment with traffic and objects are mapped. The vehicle mockup also contains virtual sensors (radar, ultrasonic sensor, camera, etc.) for the detection of environment objects [10].

The virtual road as reproduction of a real track can be produced from different data sources, ❸. The quality of the imported road, that means the available accuracy and the supply of altitude information, as well as the possibility to use additional information, e.g. speed limits or junctions, depends on the used data source [11]. While driving such a route information on the GPS position of the vehicle is available. Via a connection to Google Earth the test drive can be tracked during the simulation by the test engineer. Over an interface the integration of various test beds is possible, so that different Units Under Test (UUT) can be integrated in-the-loop and validated.

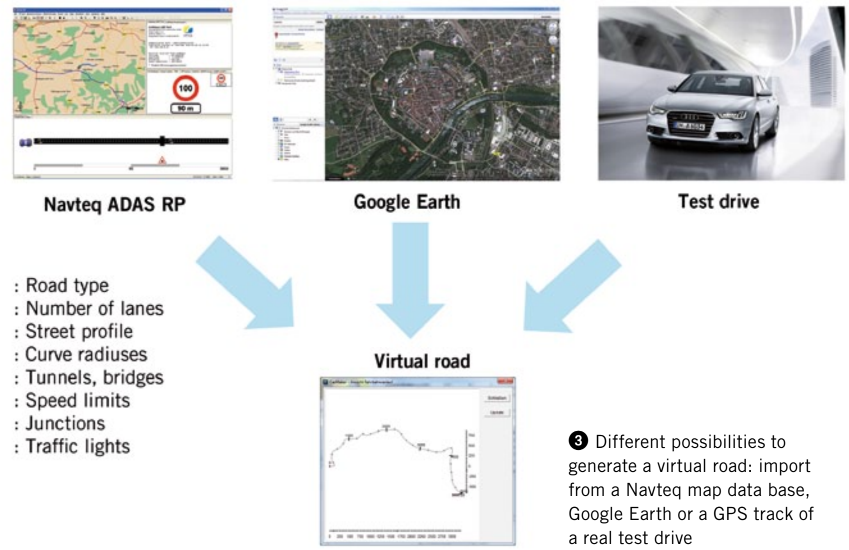
FUNCTION AND ENERGY FLUX SIMULATION

For the validation of a complete vehicle a test bed is used which is able to validate only the powertrain (Powertrain-in-the-Loop) as well as the complete vehicle (Vehicle-in-the-Loop), ❹. This integrated validation environment is here referred as function and energy flux simulator.

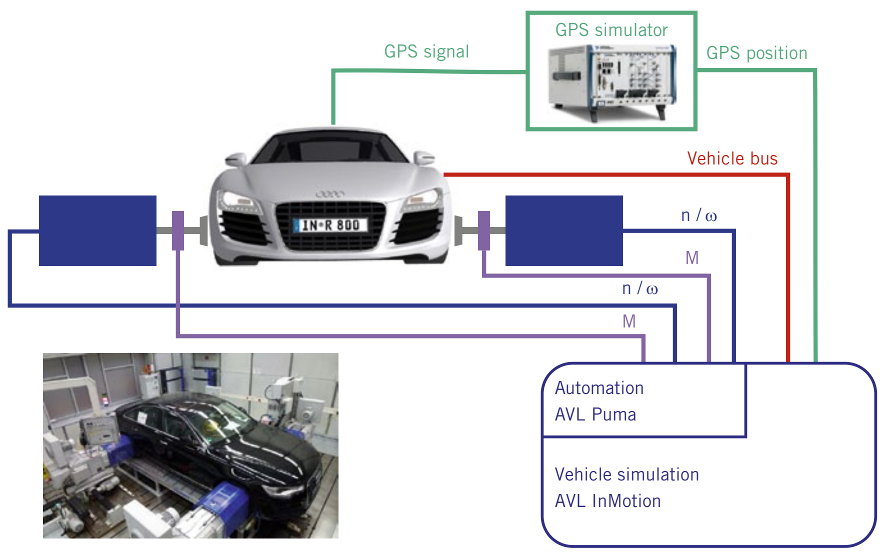
The test bed is connected via the automation system with the real-time system, on which the vehicle simulation AVL InMotion is running. So real test drives can be emulated at the test bed. With dynamometers the occurring wheel speeds are impressed on the vehicle. The operation of the vehicle is



❷ Virtual test drive in AVL InMotion powered by CarMaker (Figure © IPG Automotive) done with a driving robot. The resulting wheel torque, consisting of the load and the driving torque are induced back in real time in the simulation. Necessary sensor information, e.g. acceleration, steering angle, is inducted into the vehicle over the particular bus system. For the acquisition of the signals and measurement values test bed and as well as mobile measurement instrumentation can be used.



❸ Different possibilities to generate a virtual road: import from a Navteq map data base, Google Earth or a GPS track of a real test drive



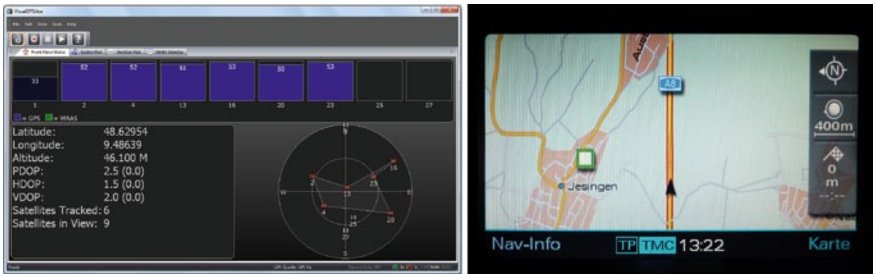
❹ Simplified structure of the function and energy flux simulator

NAVIGATION-IN-THE-LOOP

As mentioned during the virtual test drive the GPS position of the vehicle is available. In pure office simulation it is very easy to provide the position to the module that should be tested. Formerly it was necessary for the validation of real vehicle systems to have an interface in the navigation unit, the manufacturer specific protocol had to be known or a standard (ADASIS protocol) had to be implemented. Through the combination of the vehicle simulation system AVL InMotion and a GPS simulation system, developed by National Instruments, the direct test of vehicles with satellite based ADAS becomes possible, ❺. With the new simulation system GPS L1 Coarse Acquisition Signals (C/A signals) can be simulated. Over a signal generator the simulated signals can be emitted to perform GPS receiver tests. A GPS receiver needs at least four satellites to fix the position. With the system it is possible to create scenarios with up to twelve satellites and a simulation time up to 24 h [12].

The GPS position of the vehicle from the driving simulation AVL InMotion is sent to the GPS simulator via CAN bus. With the position and the time the visible satellites for the receiver, i.e. the vehicle, are determined based on orbit data. For the visible satellites the C/A messages are calculated. After that the messages are summarised and over a signal generator and a RF connection directly induced into the GPS receiver. With in-car navigation devices there exists a so called FAKRA plug (ISO 20860-1) which is a standardised interface that is used in most vehicles. Indeed, a direct emitting of the signals over an antenna is possible, however the legislative frame conditions have to

❺ Simplified system structure consisting of a real-time system with the vehicle simulation AVL InMotion, the NI GPS simulation system and a portable navigation device



❻ GPS simulation: emulated virtual orbit (left side) and detail view of an in-car navigation devices in an Audi A6 (right side)

be regarded. Over the receiver the navigation system can determine the position and pass this information along with additional map-based information (e.g. speed limit) via the vehicle bus to the ADAS-ECUs. Therefore, it is possible to validate vehicles with navigation based ADAS reliably without adapting the system, like e.g. the simulation of the navigation units or the use of special test ECUs.

The realisation of a simulation is shown in ❻. For the example a virtual test drive on the Auto-Motor-Sport consumption track was performed in the test factory in in Graz.

SUMMARY AND OUTLOOK

With the presented integration environment it is feasible to analyse the energy flux of new, predictive powertrain and assistance systems, as well it is possible to secure their functionality. At the moment an optimisation and the series integration of the test bed are in process. In the future an extension by a fault simulation is planned. With the simulation system it is possible to simulate various impairments such as low power levels, to emulate foliation or urban canyons, satellite drop out or the presence of interference or jamming signals. Furthermore an enhancement on new satellite navigation systems as Galileo or Glonass is intended.

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THANKS

The authors would like to thank the following persons for their support at the realisation of the system: Barbara Wallner, Herbert Kelz from AVL List, as well as Klaus Dinnes, Ken Tobler and Helmut Wurm from National Instruments.

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