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Real Virtuality

Automatically creating test tracks and realistic traffic scenarios based on vehicle measurements

How do you test vehicles on tracks that no test driver has ever driven before? The ZF technology group uses a virtual process based on map data and vehicle measurements to test vehicle functions during development. The resulting virtual world is realistically simulated using the ASM tool suite.

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To meet the mobility requirements of the future, vehicles must act predictively and be networked with their environment. Assistance functions support the driver while driving, and autonomous functions are set to assume all driving tasks in the future. This is why the real road, along with its multitude of variables, is the perfect place to conduct customer-relevant functional testing. However, the random influences that occur in reality make it almost impossible to perform two road tests under exactly the same conditions. To reproduce the variety of real influences for testing the active powertrains, ZF transfers relevant in-vehicle measurements to virtual scenarios. This makes it possible to generate driving profiles from reference routes. However, if, for example, driving behavior on a certain route is to be analyzed, the actual route would first have to be measured with the right measuring equipment. This can involve a great deal of time and expense, especially if the route is not in the immediate vicinity. As a result, the process also has to generate scenarios using data from digital maps. These scenarios must include not only the actual road with the corresponding altitude information, but also the surrounding traffic, other road users such as pedestrians or cyclists, as well as obstacles, signs, traffic lights, etc.

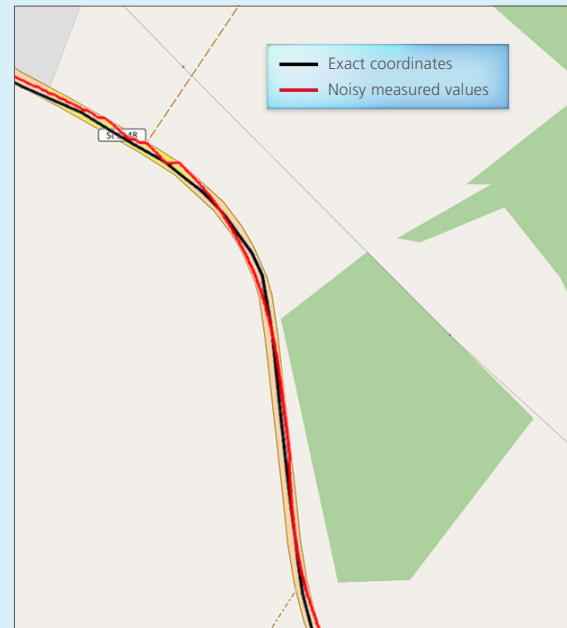
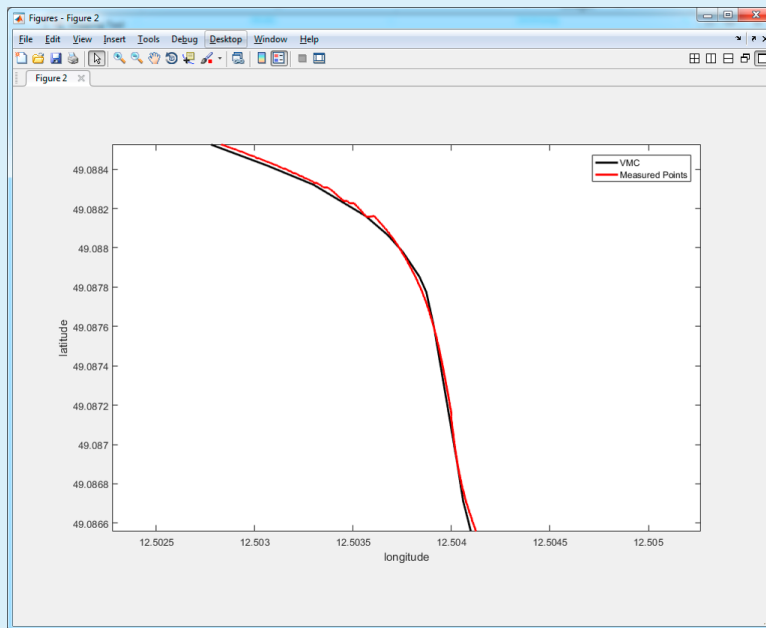
The Virtual Track

Routes can be generated using high-precision vehicle measurements or smartphone recordings. It is also possible to define the test track by setting only a few waypoints on a map or simply by entering the start and end points. These days, positioning is usually performed with the Global Navigation Satellite System (GNSS).

Since GNSS measurements are often noisy (shading, attenuation), it is necessary to subsequently optimize the geographical coordinates. The recorded coordinates are compared with the data on a detailed map by means of map matching, and the suitable road is selected from the map. ZF uses tools of the Virtual Measurement Campaign (VMC®) developed by the Fraunhofer Institute for Industrial Mathematics. VMC makes it possible to perform map matching and directly define a route. The map data is imported using a dSPACE converter, which transforms the data into road segments for the Automotive Simulation Model (ASM) tool suite from dSPACE. More detailed information on legal speed limits and the positions of traffic lights, etc. can be automatically added to the route on the basis of data imported from OpenStreetMaps (OSM), for example. Subsequently, reference data, such as the transverse gradient of the road, can be used to further optimize vehicle measurements. Different driver types can be used to generate different driving modes. It is also possible to differentiate between open roads as well as medium and high traffic density. This makes it easy to influence the driving behavior.

Various Test Scenarios

The generated scenarios are the basis for vehicle dynamics simulation with ASM. The scenarios for the virtual test drives are created from variations to the specifications of the virtual environment and the other road users. The influences and variations become transparent, making it possible to look closely at each individual effect separately. The virtual road or virtual road network is available in ModelDesk, which is the parameterization soft- >>



Left: The exact coordinates (blue) of a test track are determined from the noisy measured values (orange) by means of map matching. Center: For comparison, the route as displayed in OpenStreetMap. (Contains information from OpenStreetMap (openstreetmap.de), which is available here under the Open Database License (ODbL) opendatacommons.org/licenses/odbl/.)

“We rely on the ASM tool suite to conduct highly accurate experiment- and simulation-based analyses and evaluations of the shifting behavior and efficiency of transmissions.”

Oliver Maschmann, ZF

ware for ASM, and can be previewed there. ModelDesk provides the Scenario Editor for defining the driving maneuvers for the vehicle under test and, optionally, the surrounding traffic. For driving on a reference route, it is sufficient to define the reference speed for the route. This can be done directly in ModelDesk. If the surrounding traffic also has to be factored in, the start and end points of the vehicle under test (ego-vehicle) have

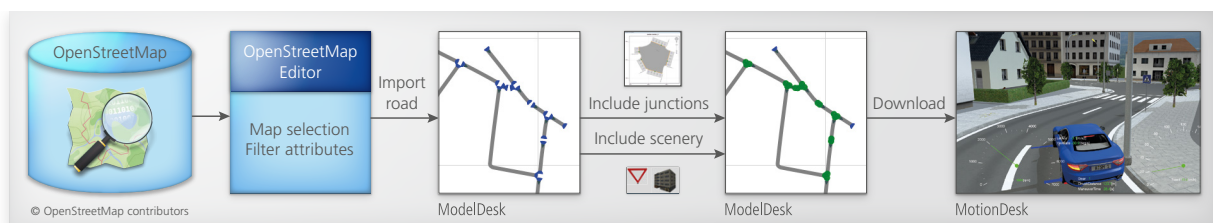
to be defined as well as trajectories for the fellow vehicles that also perform defined maneuvers in the ego-vehicle's environment.

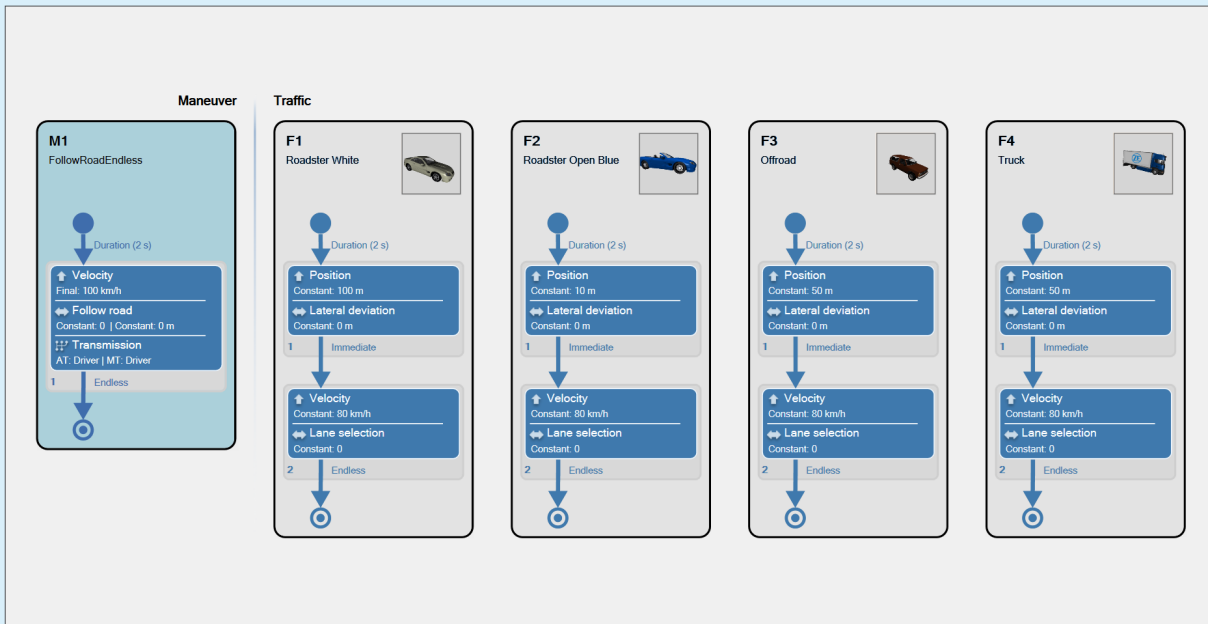
On the Test Bench

The article "Virtual Torque" (dSPACE Magazine 1/2018, page 36) previously described how ModelDesk can be used to integrate ZF-internal models into the simulation of the complete vehicle. Combining highly accurate

models for the powertrain and versatile scenarios for the environment with the vehicle dynamics simulation enables realistic analyses and evaluations so that engineers can examine the effects that have occurred during the test drives. In addition, tests on the test bench can be performed using more complex measurement data, which achieves more meaningful and reliable results. It therefore makes sense to work with virtual driving

Workflow for generating the road from OpenStreetMap data.





The Scenario Editor can be used to define the trajectories of the vehicle under test and, optionally, of the surrounding traffic.

“Performing a comprehensive, realistic simulation of the powertrain is easy because ASM lets us use both vehicle measurements and synthetically generated surrounding traffic.”

Oliver Maschmann, ZF

scenarios as early as possible in the development process.

Evaluation and Next Steps

The process and the tool chain offer sufficient flexibility to process GNSS coordinates recorded by either a tracking app on a smartphone or high-precision GNSS data loggers. Tracking apps, in particular, are an efficient method for quickly analyzing and verifying problem reports from the field test. This opens up new, faster, and cheaper methods for analyzing and correcting potential errors. These analyses can also be performed on the PC-based simulation platform VEOS. Other dSPACE tools, such as ControlDesk and AutomationDesk, are used to perform the tests and evaluate the data. Virtual tests and analysis tools make PC-based simulation the tool of choice when it comes to analyzing

effects and optimizing algorithms. This requires highly accurate data and models. Both can be achieved with map matching and the ASM tool suite. Compared to driving tests, this has decisive advantages: Virtual tests are reproducible, fast, and cost-effective. It is also very easy to include other variables in an analysis, which in road tests would only be possible with additional measuring equipment. In addition, the simulation can also be used as a basis for load tests on mechatronic test benches. These test benches are already in operation at ZF. A new generation of test benches is currently being set up. It will be able to fully exploit the potential of the described tool chain. By replacing the VEOS simulation platform with a dSPACE SCALEXIO system, data, models and tools can be easily reused on the test bench. Tool chain validation is advan-

ced jointly by ZF and dSPACE. This will open up new possibilities for further development, e.g., driver behavior on roads where the driver has limited visibility due to bends in the road, for example. ■

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Oliver Maschmann

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