Validation and release of the ESC vehicle-trailer combination stabilization function for the world market: road tests and HiL simulation working together

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- The ESC vehicle-trailer combination stabilization function ensures controllable conditions even in critical driving situations
- Today the stabilization function’s validation and release can still be handled in real world road tests for the European market
- Due to the variety of configurations, the stabilization function’s release for the world market is only manageable with the support of Hardware-in-the-loop (HIL) simulations
- In cooperation with vehicle manufacturers, TESIS DYNAware has developed a process for the virtual validation of the stabilization function for almost all vehicle-trailer combinations, using validated towing vehicle and trailer models.

Electronic Stability Control systems (ESC systems) are standard equipment in modern vehicles. Their purpose is to maintain the controllability of the vehicle in critical vehicle dynamics situations. Due to additional functions, modern ESC systems are also able to stabilize vehicle-trailer combinations with the aid of control interventions on the towed vehicle. Vehicle-trailer combinations generally have a critical driving speed above which yaw oscillations caused by environmental influences or by the driver's actions will no longer subside by themselves. If the vehicle-trailer combination is not actively stabilized in time by ESC control intervention, an accident may occur.

The European market is subject to strict legislation that keeps the variety of permitted vehicle-trailer configurations within manageable limits. For these typical vehicle-trailer configurations, vehicle manufacturers have developed well-established processes and methods for the validation and release of the ESC vehicle-trailer combination stabilization function on the basis of real world road tests. From a worldwide perspective however, the limitations are not so strict. On the international markets, car-trailer combinations with two trailers or with towing systems that are unconventional for European conditions are permitted.

Testing the wide variety of conceivable combinations with real world road tests alone would be very costly and time-consuming – if not impossible. What is more, the maneuvers involved are very risky, as they have to be carried out at the very limits of driving dynamics. For that reason, some vehicle manufacturers have decided to integrate Hardware-in-the-Loop (HiL) simulation into the validation process. The system presented is a simulation-based validation solution utilizing virtual vehicle-trailer simulation of a vehicle-trailer combination with two trailers
Combinations and was developed by TESIS DYNAware in cooperation with a major OEM. Suitable simulation models are created and parameterized on the basis of real trailers with various designs and physical characteristics. The validity of the models is secured by proven processes for component validation and the complete validation of several single vehicle-trailer combinations. The towing vehicles used are separately validated vehicle models.

Almost any combination of towing vehicle with one or more trailers of different designs and loads can be simulated, even including those that are rarely encountered in reality. With a driver model and the simulated vehicle-trailer combination in the loop, the real ECU is operated on a HiL system and the vehicle-trailer stabilization function is tested fully automated on the basis of a comprehensive test catalogue that is synchronized with the real world road tests. The catalogue includes the systematic variation of test and physical model parameters and extreme maneuvers. The corresponding characteristic value-based evaluation process provides an objective representation of the driving characteristics, classifies the results and marks when the stabilization function performs not satisfactorily in a particular configuration. The automated tool chain based on the DYNA4 simulation framework ensures high test coverage with various vehicle-trailer combinations, thus supplementing the real world road tests that are still responsible for the control system release, but that can now be limited to a manageable scope.

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