HIL tests for truck ESC

How can you evaluate the control performance and safety effectiveness of stability enhancement systems used on heavy trucks? This is the question faced by researchers at the University of Michigan Transportation Research Institute (UMTRI) in a current project that is being sponsored by the National Highway Traffic Safety Administration.

Control systems available on heavy trucks to assist drivers go beyond simple anti-lock brake systems (ABS), potentially including electronic stability control (ESC), roll stability control (RSC), roll stability support (RSS), and various combinations of the above. While the systems are designed with specific interventions in mind to enhance safety, the question is, how will they respond throughout the broad envelope of possible driving situations and to what extent will this enhance safety?

Evaluating control system responses over a wide range of driving situations by means of full vehicle tests is simply not feasible. Consequently, UMTRI researchers addressed the response problem by developing a comprehensive hardware-in-the-loop (HIL) test system, using a truck dynamics simulation program as the surrogate truck in conjunction with real pneumatic-brake hardware and ABS, ESC, RSC, and RSS controllers installed in their laboratory. The truck dynamics simulation program of choice is TruckSim RT (real-time version) – a proven, commercially available software package from Mechanical Simulation Corporation in Ann Arbor, Michigan, USA.

The TruckSim software allows the researchers to devise test matrices that encompass typical variations in the vehicle (primarily loading and center-of-gravity height), variations in road friction and curvature, and variations in driver throttle, brake and lateral control. Equally important to the research protocol is the versatility of TruckSim that allows the vehicle to be driven through a realistic pre-test driving scenario, during which the controllers learn about the current load condition to adjust their calibrations.

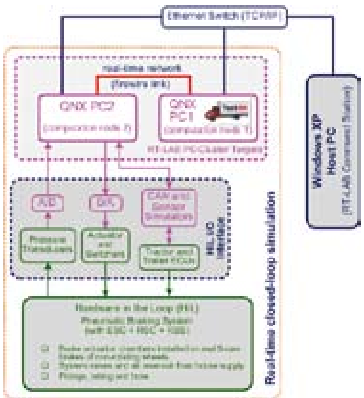

FIGURE 1 (TOP): **A TRUCKSIM ANIMATION OF A TEST VEHICLE**
FIGURE 2 (RIGHT): **SIMPLIFIED SCHEMATIC DIAGRAM OF THE LABORATORY COMPUTER SETUP**

The HIL setup consists of three computers as shown in Figure 2. A Windows host PC supervises two Opal-RT targets – one interfacing with the brake hardware system and electronic controllers, the other running the TruckSim RT simulation. Communication with the brake system hardware and electronic controllers is routed via analog-digital and controller area network (CAN) interfaces. The brake system mock-up consists of the actual brakes, actuators, air plumbing, valves, sensors, and controllers. As the hardware is on a non-moving platform, TruckSim is used to generate the wheel speeds, steering wheel angle, lateral acceleration, and yaw rate. These digital motion values are translated into required analog/digital signals through sophisticated sensor simulators, and inserted into the ECU circuitry in place of the physical sensor signals.

The vehicle under study is a five-axle tractor semitrailer (three-axle tractor with a two-axle semitrailer). The controller combinations being evaluated are ESC+ABS, RSC+ABS, RSS+ABS and ESC/RSS+ABS. Up to ten vehicle configurations will be used, covering multiple load and center-of-gravity height conditions. Road conditions encompass four friction levels, including split-μ, and a variety of road curvature values. Common test maneuver scenarios producing elevated rollover and loss of control risks have been culled from a combination of crash reports and naturalistic field operational test databases. To take all variables into account, more than 500 test scenarios are required.

It is likely that this type of high fidelity simulation of vehicle, driver and safety systems will play an increasingly important role in future work on active safety technologies, both in development and safety benefit analysis. Combining these simulations with real-world data from crash and naturalistic driving offers new opportunities to understand how these complex technologies can best be applied to improve highway safety.

EXTRA DETAILS
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