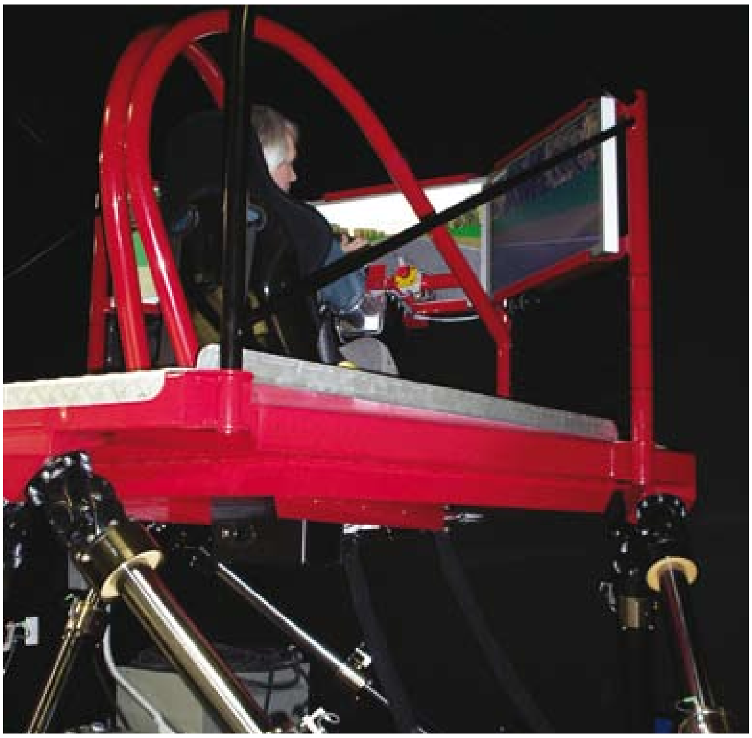
Powertrain calibration

Powertrain calibration is usually one of the most expensive, time-consuming tasks in the vehicle development process due to the need for on-road testing under a wide range of environmental conditions. But it does not have to be so.

Tuning the powertrain in a laboratory setting for a specific vehicle application is limited when dynamometer feedback is controlled by a simple vehicle model. These models replicate only vehicle inertia and road loads (aerodynamic and tire rolling resistance). Modern vehicle dynamics software, such as CarSim, replicates an extensive range of vehicle behavior, while running in real time to create 'powertrain-in-the-loop' test systems. These extended test systems provide realistic dynamometer loads, encompassing most on-road experiences under controllable and repeatable laboratory environments, and handle large portions of the powertrain operating envelope – as in the following examples.



TYPICAL CARSIM SCENARIO IN A DRIVING SIMULATOR. THE VIRTUAL WORLD OFFERS COST BENEFITS

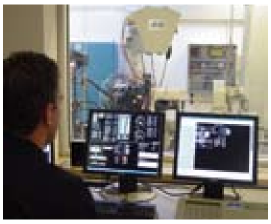
The start-up/launch process at high throttle angle challenges the powertrain to deal with heavy transients arising from non-linearities of tire slip and suspension reactions not represented in simple vehicle models. Tire slip phenomena are incorporated into CarSim with user-selected tire models. As different suspension types and linkage geometry are included in CarSim models, any suspension behavior can be replicated in feedback to the dynamometer during launch. The capability to simulate tire slip along with dynamic load transfer effects during start-up are essential elements in the laboratory development of traction controls.

Shift quality of a powertrain can be evaluated at many levels. With wheel slip and compliances captured in CarSim, dynamometer loading at the transmission or at the wheels of a full powertrain system can provide a first level shift evaluation in the lab, allowing some transmission tuning prior to on-road testing.

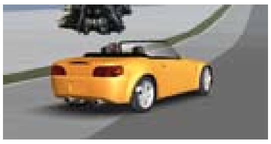
The complexity of powertrain performance and tuning has grown with the advent of electronically controlled clutches in transfer cases, and differentials used in new traction and stability controls. There is unprecedented pressure for all vehicles to have electronic stability control as a result of performance regulations like FMVSS 126. Whether based on torque vectoring or brake controls, powertrain behavior plays a major role. Evaluating powertrain interactions with stability control systems can only be accomplished in the laboratory with a complete vehicle dynamic model.

Development of race car powertrains often involves dynamometers mounted on pitch-and-roll actuator systems to reproduce accelerations that may adversely effect fuel and lubrication system performance. Controlling these systems with CarSim adds enhancements to fidelity and utility. Road data files of accelerations are not required because these can be replicated in CarSim models operating on actual race track topology. Longitudinal accelerations are duplicated in conjunction with full aerodynamic effects for pitch control. The effects of lateral accelerations and vehicle roll response can be duplicated in simulation for roll control of the dyno platform.

Another advance in the powertrain development process can be achieved by augmenting dyno labs with driving simulators. Cost-effective simulators are now available with hexapod motion bases. With CarSim, enabling engineers to 'drive' powertrain hardware with a virtual vehicle-in-the-loop facilitates concurrent development and reduces the product timing cycle. Electronic stability control performance can be evaluated in diverse maneuvers over a wide range of road conditions, capitalizing on the economy of test setup and test conditions available in the simulation world.



AN ENGINE DYNAMOMETER LABORATORY IN ACTION



ROAD TEST CONDITIONS SUCH AS SPLIT-μ (ICE) ARE EASILY DUPLICATED IN SIMULATIONS

LOOKING FOR MORE?

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