

Real-time Vehicle Dynamics for Ride Comfort Analysis

Simulations of ground vehicles are used extensively by military and commercial vehicle developers to aid in the design process. Realtime Technologies, Inc. (RTI) has recently demonstrated the ability to use high fidelity multi-body simulation to perform ride and comfort testing in an operator-in-the-loop environment. The key to this success is Realtime Technologies' SimCreator® modeling environment.

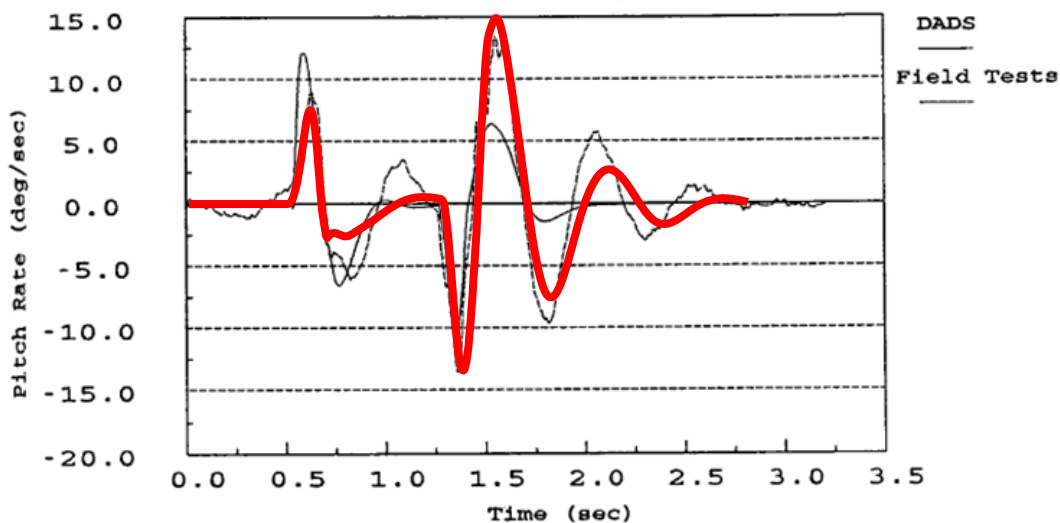


SimCreator was used to make an advanced real-time model of the U.S. Army's High-Mobility Multipurpose Wheeled Vehicle (HMMWV) shown left. The model includes over twenty-two independent bodies that represent control arms, spindles, anti-roll bars, and steering linkages. Since the model captures the actual suspension geometry including the suspension attachment points, it was easy to introduce shock and spring data including non-linear effects. Results from physical tests of the vehicle's shocks and springs were implemented in the model based on look up tables of force versus the shock or spring's position and velocity.

For ride comfort analysis it is important that the tire model capture the undulating features of the terrain. Therefore a "multi-disk" tire model was implemented in SimCreator that models the tire as a set of

concentric disks. A two dimensional volume analysis is performed with each disk and the polygons that represent the terrain. The total volume that the tire is compressed is calculated by summing the volume of the set of disks for each particular tire. In addition, the direction of tire compression is also calculated. This ensures that the forces acting on the tires are applied appropriately. For example if a tire runs into a curb the forces act to push the vehicle up and to slow the vehicle down.

Due to the exceptional performance of SimCreator, the HMMWV model could execute at an update frequency of 2000 Hz in real-time. It is important to have a very high execution rate when performing ride comfort analysis so that interactions with small undulations in the terrain can be appropriately captured. At 100 km/h with an update rate of 2000 Hz, interactions with objects as small as 2.5 centimeters in length can be appropriately captured.

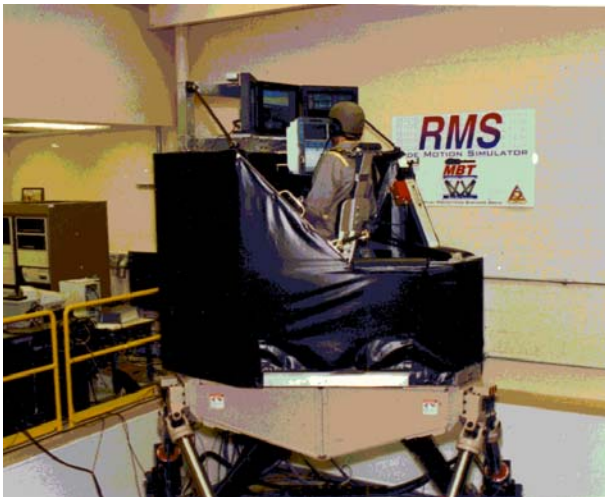


The chart above shows the pitch rate of the SimCreator HMMWV driving over a four inch half-round obstacle at 10 miles per hour. The pitch rate is compared with test data collected in the field. Half rounds of various sizes are one of the standard obstacles used by the U.S. Army to assess ride comfort both in the field and in simulation.

Since SimCreator's ride comfort models can run in real-time the driver can be placed in the loop. This adds an important aspect to any ride comfort analysis. Drivers will adjust their speed selection based on the type of road conditions encountered and the type of vehicle being driven. To assess the impact of vehicle design on driver comfort it is important to capture the resulting behavior of the driver. On some surfaces faster speeds can actually lead to smoother driving. In addition, active suspension systems may also lead to deferring driver behavior. Real-time high-fidelity dynamics is the key to a successful evaluation.

A critical piece for real-time ride comfort analysis is the selection of a motion base that can generate the required motions and accelerations. Realtime Technologies has experience with a variety of motion base manufacturers. In addition, Realtime Technologies develops a motion drive algorithm, OverTilt®, which translates the modeled vehicle accelerations into appropriate motion base movements.

The purpose of a motion drive algorithm is to cause a simulator motion base to move in a manner that feels realistic to the person experiencing the simulation. The motion base, with its simulated vehicle cab, sits in one place and is constrained in its envelope of movement. Yet it must replicate the experience of traveling several miles on-road, or off-road. Therefore, the software that controls the motion base requires an algorithm that calculates motion position commands, ensuring that the simulated experience feels realistic while keeping the motion base within its given constraints.



RTI has implemented the vehicle dynamics and motion drive algorithm of ride comfort simulators for the U.S. Army as shown above. A similar unit has been adopted by Johnson Controls, Inc. as shown below.



The U.S. Army's Ride Motion Simulator has a bandwidth of 40 Hz with accelerations as high as 2.5 g's providing ample ability to evaluate ride comfort issues. A range of motion base solutions are possible including small displacement low cost systems.

Finally Realtime Technologies is currently developing conversion tools that allow models developed using non-real-time multi-body dynamics packages to be converted into SimCreator. This will allow easy import of existing vehicle models for use in a ride comfort simulator environment.

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