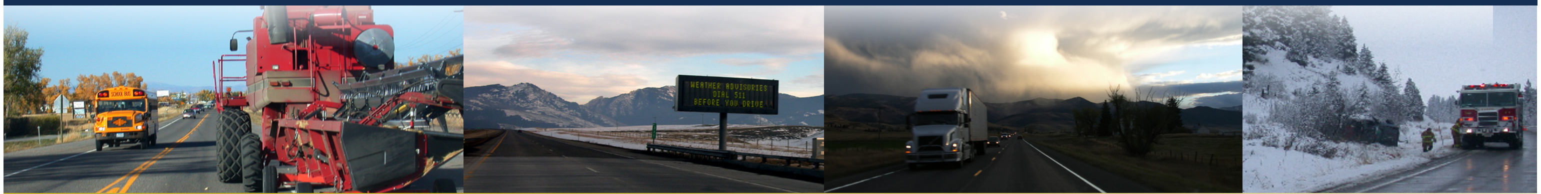

WTI Human Factors Research Facilities

Driving Simulator Optimization: Optimizing Sound and Vibration Cues for Realistic Motion of Advanced Driving Simulator

WTI has embarked on a systematic program to optimize and tune its advanced driving simulator so that it provides a realistic research and testing environment capable of yielding results that are transferable to the real world. This tuning and optimization work was completed by Dr. Erwin R. Boer (Entropy Control Inc.) who is an international expert in modeling and optimizing perceptual cues in driving simulators. This involved comparing the response of the simulator including its motion base to driver input (steering, throttle, and braking) with the response of an instrumented vehicle that matched the type of vehicle used to develop the simulator dynamic model (Chevrolet Impala). This press release summarizes the sound an vibration component of this systematic process completed with the WTI Advanced Driving Simulator (WADS).

The WTI driving simulator is capable of reproducing realistic driving behavior across all driving maneuvers ranging from high speed highway driving to low speed parking. The simulator consist of a full Chevrolet Impala car body with all the original controls mounted on a 6-DOF motion platform placed in the center of a curved surround projection screens and speakers. The simulator provider is Realtime Technologies Inc. (RTI). To elicit realistic driving behavior, it is necessary to provide the driver with a sensory experience that closely matches reality.

The sound system in most simulators is severely underdeveloped as was the case in the simulator prior to optimization. To bring the sound quality up to the high level of the rest of the system, a 2-hour test drive was performed with the instrumented Impala during which we drove on many different road surfaces at different speeds and also performed acceleration and deceleration at different rates including a braking to a stop with squealing tires. The sound was recorded with a high end audio recording unit during the entire period.

To obtain realistic road and wind noise, wav-files were cut out of the full 2hour wav file when the car was driving on a highway at different constant speed with the fans off. Figure 1 clearly show that the overall sound levels at all frequencies increases with speed. The amplitude and pitch of the wav file sounds are scaled with car speed and RPM. To provide drivers with clear feedback on engine response, a separate pure engine sound file was used and its pitch and amplitude scaled with RPM to add a clear engine firing sound into the mix. The result is a realistic sound experience with fast feedback on changes in RPM as caused by accelerating and automatic down shifting.

The goal for the simulator is to separate road, engine, and wind noise because those sounds will be played through different speakers. The road rumble will be played mostly through the woofer speaker in the seat and was also used as vibration input to the motion base. The engine noise will be played through speakers mounted under the hood. The wind noise will be played together with the noise of other cars through the surround speakers outside the cab

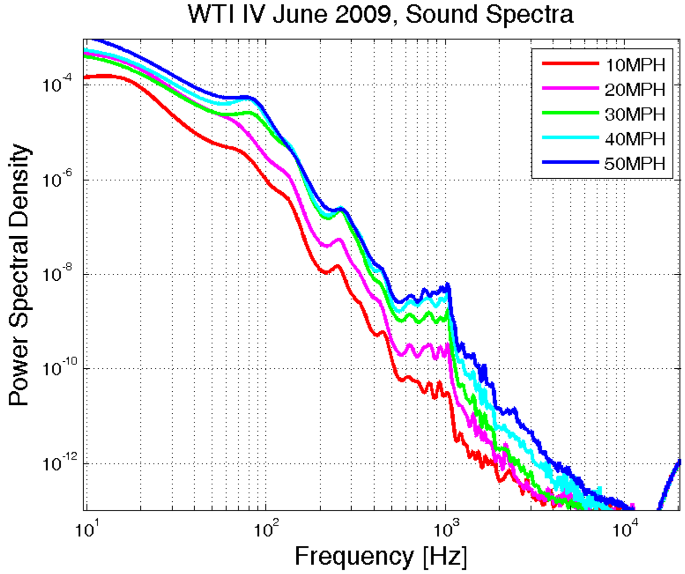

Figure 1. Sound spectra of the Instrumented Impala at five different speeds on a highway with the air-conditioning fan turned off.

To generate the vibrations, the vertical vibration spectrum was obtained from the 1-DOF accelerometers mounted on the CAB above the front wheels on the instrumented vehicle. The vertical cab acceleration spectrum of the real Impala at speed ranging from 17 to 23 m/s is shown in Figure 2. This spatial vibration spectrum is created in the simulator as a function of distance traveled. As the driver speeds up and slows down the experienced temporal frequencies increase and decrease respectively. This results in a very realistic sense of driving over small bumps. Since the vibrations are vibrations of the cab on the road the vibration commands that are sent to the motion base are not compensated for. This assures that the driver's head bounces relative to the visual road surface as in reality. The adopted approach to provide vibration feedback is a computationally efficient and realistic approach. The chosen sound and vibration implementation is expected to contribute to driver's speed perception and also to provide quick non-visual feedback for speed changes.

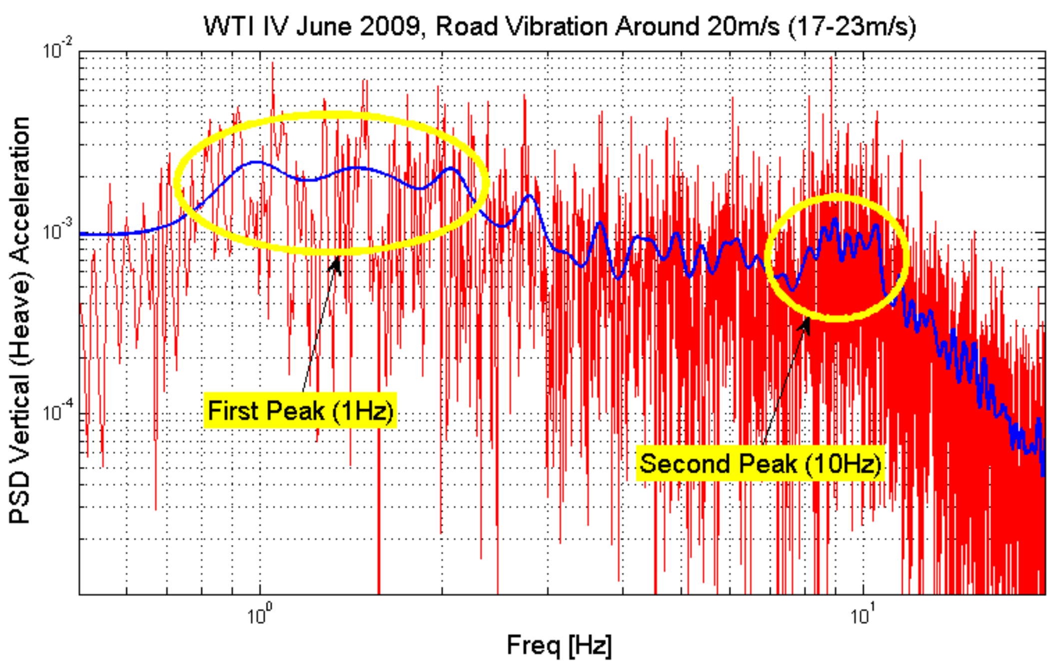

Figure 2. Vertical vibration spectrum of the instrumented impala driving on a highway between 17 and 23m/s.

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