D6 Crash Test Verification of Offset Rear-Impact Accident Reconstruction and Crashworthiness-Design Concepts

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After attending this presentation, attendees will be presented with a vehicle-to-vehicle crash test methodology for validating physics-based reconstruction of offset rear-impact override crush accidents, with verifications of occupant injury analysis, a demonstration of safer available alterative vehicle designs, and the benefits of using basic, accepted crashworthiness-design concepts.

This presentation will impact the forensic science community by explaining how the crash test method provides a means for scientifically verifying accident reconstructions with correlation of injury measures, as well as demonstrating safety improvements and reduced injury risks related to following well-established, good crashworthiness-design concepts.

In this study, a physics-based accident reconstruction was performed on a rear-impacted, four-door sedan vehicle that was struck off-set to the right rear half by a Sports Utility Vehicle (SUV) that over-rode the rear bumper and trunk floor structure. This allowed the sedan's weaker sheet-metal fender material to easily crush and allow displacement of the rear shock tower structure into the right-rear occupant space. The sedan had two average-size males in the front and three smaller rear seat occupants. During the crash, the occupied front seats yielded rearward into rear occupant space. Simultaneously, intrusion of the right-rear occupant space by the shock-tower structure shoved the right rear 13-year-old forward toward the rearward collapsing front seat and occupant. As a result of the above occupant space violations, the right-rear occupant received a severe disabling head injury. In contrast, the front occupants and other two rear occupants, who were located farther from the right-rear penetration, did not receive any permanent injuries. In order to understand the engineering parameters that led to the injury of only the right-rear occupant, a reconstruction of the accident was performed by using energy and momentum balance principles. The reconstruction analysis (see Figure 1 diagram) indicated that the SUV impacted into the stationary sedan right-rear at 54kph.

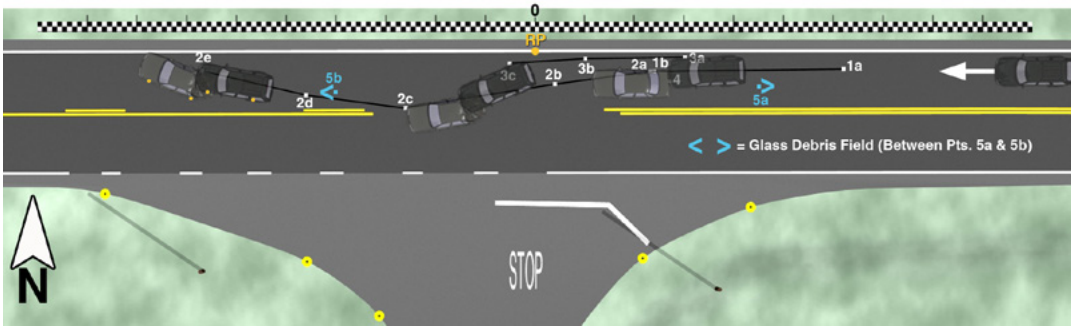

Figure 1: Reconstruction Diagram of Right Rear 50% Off-Set Overlap Rear Impact of SUV into 4-Door Sedan.

A vehicle-to-vehicle confirmation crash test, with instrumented surrogates, was run to verify the reconstruction impact speed and show consistency of surrogate injury measures with accident occupant-injury levels as further proof of the analysis. Figure 2 shows a comparison of the actual accident vehicle damage with the sedan used in this crash test. Figure 3 shows the pre-test positions of the rear seated surrogates and also a photo clip from the high-speed interior camera recorded at 173 milliseconds after impact. The 173ms clip shows the left side of the right-rear surrogate head (red chalked) turned toward the right and striking the back of the right-front surrogate head (blue chalked), and the front seat headrest, due to the inertial rearward loading of the front occupant while the right-rear surrogate was being shoved forward from the rear intrusion. The Head Injury Criteria (HIC) measures of this test, like the accident, indicated that only the right-rear surrogate received a severe HIC level of 1,217.4 (i.e., in violation of the National Highway Traffic Safety Administration (NHTSA) injury level), with a dangerously high-peak G resultant head load of 281 G's.

In addition to the above reconstruction confirmation test, two other tests were also run with the SUV impacting offset into the right-rear half of a four-door sedan at 54kph. One test was run with a crashworthy modified exemplar of the accident vehicle to demonstrate how good crashworthiness redesign of the O**riginal Equipment Manufacturer** (OEM) vehicle could have been utilized, with state-of-the-art concepts recommended in the 1960s and 1970s, to eliminate the right-rear occupant head injury caused by the space-intrusion dangers of the accident vehicle design.[1-4] Another repeat 54kph test was also run, but in this test the struck accident vehicle design was replaced by a different commercially available model year OEM European designed four-door sedan, which demonstrated how a vehicle with well-designed barrier resistance and stronger less-rearward yielding front seats could have also eliminated the injury sustained by the right-rear teenager. In both of these tests, the front and rear intrusion, and violation of the rear-seated occupant safety zone, was reduced such that none of the rear-seated surrogates had injurious head contact with the front seats or front occupants.

Figure 2: Comparison of Accident Vehicle Right Side Damage (Blue Vehicle) with Confirmation Test Vehicle.

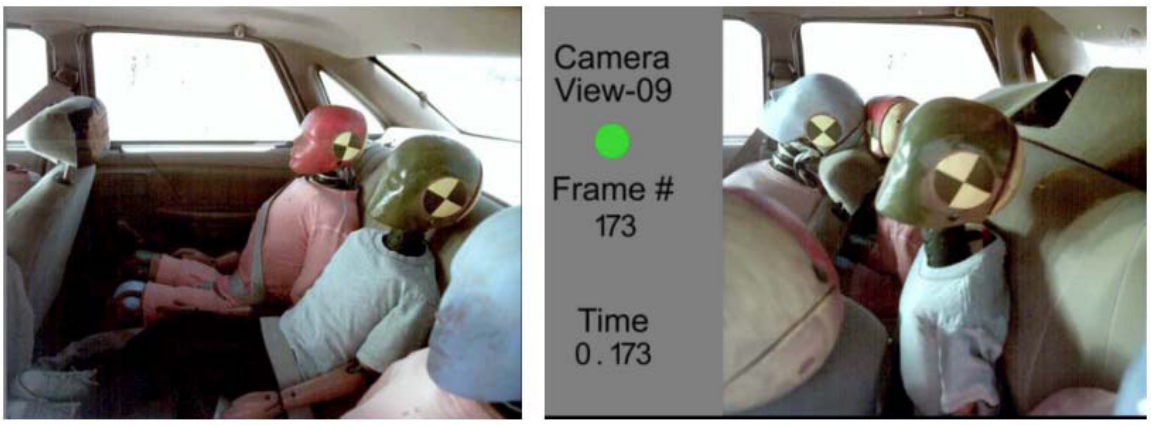

Figure 3: Pre-Test Surrogate Positions (Left Side Photo) and Confirmation Test Impact Intrusion Photo at 173ms.

References:

1. D. Severy, et al., "Vehicle Design for Passenger Protection from High-Speed Rear-End Collisions", *SA*E 680774, 1968.
2. E. Francini (Fiat), "The Crash Survival Space", *SAE* 690005, 1969.
3. R. Danial (Ford), "Vehicle Interior Safety Constraint Systems", *SAE* 700423, 1970.
4. D. Burland (Ford Ltd), "Occupant Protection in Rear Impact", *5th ESV Conference*, London, England, 1974.

Accident Reconstruction, Crash Testing, Crashworthiness Design