C7 Multiple Vector Impact Crashworthiness Affecting Restrained Vehicle Occupants: Ejection Caused by Predictable Seat Belt and Seat Failure

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After attending this presentation, attendees will learn the science and engineering involved in investigating at-scene and vehicle evidence in determining the foregoing failures in a foreseeable multi-impact collision, as well as how static and dynamic testing of the vehicle also demonstrated the predictability of the ensuing severe injuries in what should have been a readily survivable collision.

This presentation will impact the forensic science community by demonstrating the significant safety hazards affecting millions of motorists under similar impact conditions. This study especially highlights the emerging safety issues of second- and third-row seating in utility vehicles, as well as the unreliability of various occupant protection systems.

Vehicle frontal and side-impact protection is required by federal law. Technological advancements of seat belts, airbags, and other forms of frontal and side-impact protection have been achieved in response to these requirements. Despite decades of proposed rulemaking and published research on how and why there is a need to provide vehicle crashworthiness in dynamic rear and rollover collisions, there are no effective U.S. government or auto industry occupant protection requirements for rear impact or rollover. Consequently, there has been far less advancement made in the crashworthiness of most production vehicle seats, seat belts, and structures to insure occupant-protection in such collisions. It is common for foreseeable multi-impact collisions to occur, such as frontal impact followed by rear impact followed by rollover. Vehicle occupant restraints, such as seat belts and seats, must function properly to reduce interior contact and prevent ejection, not only during frontal and side impact, but also during rear impact and rollover; however, the latter two are not dynamically evaluated during normal vehicle development or safety testing. During rear and rollover impacts, various predictable seat belt and seat safety defects can cause vehicle occupants to be extremely vulnerable to ejection and injury.

This is a case study involving accident reconstruction, biomechanical analysis, vehicle design, and crashworthiness evaluation, as well as static and dynamic testing, to prove how and why ejection and injury of a belted occupant occurred in a minor to moderate multi-vector collision, and how it would have been prevented utilizing existing technology. A utility vehicle containing three restrained occupants incurred a moderate frontal impact with airbag deployment, followed by a low to moderate rear impact, followed by a partial rollover onto one side of the vehicle. There was no loss of occupant survival space as a result of any impact. The driver and left rear occupant escaped without significant injury, because they were protected by their restraints in the frontal impact, and their seats generally remained upright, sufficient to prevent ejection during the rear impact and rollover. The initially restrained center rear occupant loaded the belt, had no detectable crash injuries, and made no detectable injurious contact with the vehicle interior during the frontal impact, but was ejected from the belt and seat and was severely injured due to contact with the road surface as a result of the rear impact and rollover. There were predictable failures of the rear seat and seat belt during the rear impact and rollover which affected occupant retention and protection. There was multiple evidence of seat belt usage, as well as catastrophic failure of the seat belt and seat during the rear impact. Static and dynamic tests were utilized to validate vehicle and occupant dynamics and to evaluate rear seats, head restraints, and belts under controlled scientific conditions. Production seats and belts were compared with alternative design seats, with and without belts. Seats repeatedly showed catastrophic failure that precisely matched the forensic evidence in the subject vehicle. Belt buckle failure and slackening have been demonstrated in dynamic testing and real-world collisions, and have been published in the technical literature since the 1960s.

Rear Impact and Rollover, Seat and Belt Failure, Occupant Ejection

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