## C10 Repeatable Rollover Testing for Injury Analysis

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The goal of this presentation is to help the audience better understand relationships between roof crush and cervical spine injury in vehicle rollovers, and to learn about a unique new dynamic rollover test device.

The presentation will impact the forensic science community by demonstrating how the Jordan Rollover System (JRS) is a valuable research tool for analyzing the effect of roof crush shape and magnitude on occupant head and neck injury.

The device is known as the Jordan Rollover System (JRS), developed by Acen Jordan and operated by the non-profit Center for Injury Research. Additionally, a case study will be presented for which the JRS was used – producing both comparable damage and dummy body motion to the real world crash.

Over 10,000 occupants of motor vehicles are killed each year in rollovers and more than that are paralyzed. Rather than the number of fatal injuries going down every year, as is the trend in other crash modes, fatalities are increasing in rollovers. Part of the problem is the popularity of less stable vehicles such as SUV's and light weight trucks. However, the situation is exacerbated by the lack of adequate standards for roof strength. In the last 30 years, no new standards for roof strength have been instituted. No dynamic strength tests are required by the National Highway Traffic Safety Administration for vehicle certification. One of the reasons given for the lack of dynamic testing is that rollovers are not repeatable, that is, roof impacts in a rollover are unpredictable and random. This reason is no longer valid. Impacts to the roof using the JRS are repeatable and can replicate the first two roof impacts in a rollover.

In the JRS, the vehicle is elevated above a track and rotated about its longitudinal axis to a specified rpm. A platform representing the roadway is accelerated down the track. The rotating vehicle is then dropped onto the moving platform such that the roof of the vehicle impacts the platform. Once the vehicle clears the platform, it is caught so that no other impacts can occur. The system is designed such that vehicle drop height, yaw, roll rate, pitch, and contact angle can be specified. In effect, the system has the rolling vehicle striking a horizontally moving roadway that approximates a rollover crash in which the vehicle roof impacts as the vehicle rolls over a stationary surface. The laws of motion related to impact force allow such a comparison,

and are commonly analogized by an impact of a ball thrown against the wall. The impact is the same whether the wall is moving into the ball or the ball is moving into the wall, provided the closing velocity is the same. Impact forces are the same, only the reference frames used in the equations that gov- ern the impact are different.

Using the JRS, instrumented anthropomorphic dummies are placed in the vehicles to measure head acceleration and neck loads. The vehicle accelerations and roof displacement are measured and the platform is instrumented. High-speed video cameras record the interior and exterior impact dynamics. When the JRS is used to study an actual injury event, the roof crush produced is compared to the actual crush. When produced damage correlates with actual damage, the dummy response measures are compared to injuries sustained.

In a case study rollover injury event, the driver sustained a C5 disloca- tion resulting in quadriplegia. A left forward roof rail ground contact produced a longitudinal roof buckle above the driver's head. Marks on the headliner showed the driver's head contacted the roof just to the left of max- imum buckle intrusion. The same shape buckle and dummy head impact was produced on the JRS. The measured dummy neck compression of 9,960 N exceeded human neck injury thresholds and correlated with the actual cervical injury sustained. Although a one-to-one relationship between dummy neck forces and human neck forces cannot be made due to the dummy neck's lack of biofidelity, conversion relationships exist. This ap- proximation of a rollover injury event using the JRS revealed valuable new information about the impact that produced the driver's paralyzing injury and also how the injury could have been prevented by lessoning the roof intrusion. The system provided a valuable research tool for analyzing the effect of roof crush shape and magnitude on occupant head and neck injury.

**Rollover, Cervical Injury, Jordan Rollover System (JRS)**

 ** Presenting Author*