## C19 Forensic Analysis of a Seat-Belted Occupant Ejection in a Rollover Collision

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The goal of this presentation is to illustrate to the forensic community that vehicle occupants wearing seat belts are still at risk of ejection and injury during a rollover collision.

This presentation will impact the forensic science community by illustrating the apparent risk of injury and/or ejection while wearing a seat belt in a rollover collision.

**Introduction:** Seat belts are the primary occupant restraint system in passenger cars, light trucks, and sport utility vehicles. In the event of a rollover collision, three-point lap and shoulder belts help to reduce the risk of injury due to impacts with interior components or ejection. However, it has been observed that complete ejection of seat-belted occupants can and does occur in rollover crashes.[1] This case study will detail the physical evidence supporting seat belt use at the time of collision and the subsequent forensic analysis of the occupant compartment as it relates to the ejected passenger.

**Collision Sequence Overview:** A 2001 model year SUV with driver and right front passenger was traveling on a highway with a posted speed limit of 70mph. A left rear tire tread belt separation caused vehicle oversteer characteristics and the SUV entered a clockwise yaw on the highway for approximately 160ft.[2] Upon entering the dirt shoulder, the vehicle continued to yaw for another 52ft before it overturned, driver's side leading. The vehicle rolled approximately 147ft and came to rest on its wheels. The right front passenger was ejected during the rollover event.

Based on stress marks observed on the driver's seat belt webbing, investigators concluded the driver was wearing the seat belt. The right front seat belt was found still buckled at the scene (Photograph 1), and the webbing did not reveal any type of stress marks. Although the investigators agreed the right front occupant was ejected, they concluded this occupant was either not wearing the seat belt properly, or was not wearing the seat belt at all.

**Incident Vehicle Examination:** Significant roof crush and corresponding occupant compartment intrusion is consistent with a driver's side leading rollover event (Photograph 2).[3] The left rear tire was examined and showed a near complete tread belt separation. Localized damage was observed around the left rear wheel well, on the rear bumper fascia, and exhaust system. Part of the tread belt was found still wrapped around the rear axle.

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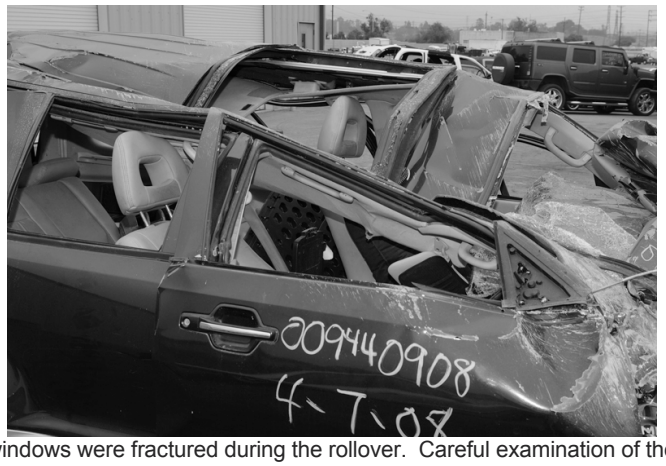
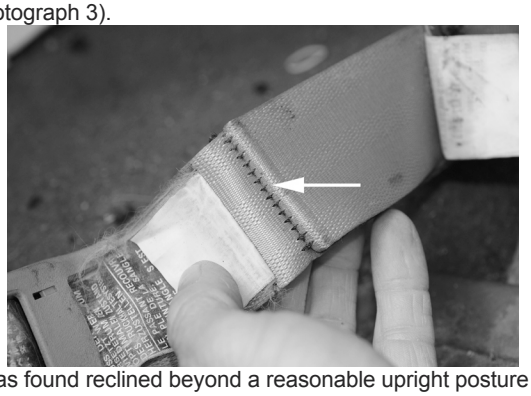



All of the vehicle's windows were fractured during the rollover. Careful examination of the right front seat belt showed approximately 15in of webbing with cut fibers consistent with interaction with fractured glass fragments. However, these fiber disturbances were found on an area of the webbing that would not be exposed to the vehicle's interior if the seat belt was stowed.

Artifacts aligned longitudinally with the webbing were found to correspond to faint striations on the plastic coating of the latch plate load surface.

The right front seat belt features an expansion loop concealed under a rubber-like sleeve approximately 10in long.[4] Close examination of the first row of stitches revealed these stitches were under tension applied during occupant restraining forces (Photograph 3).



The right front seat back was found reclined beyond a reasonable upright posture such that the head restraint is in contact with the right roof rail within the right rear door opening. A courtesy light is installed on the interior upholstered right roof rail. The lens of the courtesy light exhibits linear scratches with plastic flow in an orientation directed toward the window and to the outside of the vehicle. The potential ejection portal was identified to be the right rear window opening.

Upon further examination, the seat back assembly was found to recline without much effort. That is, the seat back recline mechanism was not locked. The seat back recline angle adjuster is on the outboard side of the seat cushion. Pulling the lever upward allows the seat back to recline. This recline lever was found to be substantially deformed (Photograph 4).

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When the right front seat belt is stowed, the webbing is nearly vertical, but when fastened the expansion loop sleeve rotates forward about the lower outboard anchor bolt. It was discovered that the rubber-like expansion loop sleeve will cause the potential for the seat belt webbing to route under the seat back recline lever (Photograph 5).

**Exemplar Vehicle Examination:** A similar model year exemplar vehicle was located by random selection. The right front seat cushion position of the incident vehicle was duplicated in the exemplar vehicle. When a right front occupant fastened the exemplar seat belt, the webbing caught on the tip of the recline lever. Remarkably, after the retractor was manually locked and the right front occupant rose up from the seat to put the lap belt in tension, the recline lever was actuated and the right front seat back unexpectedly reclined. The exemplar vehicle demonstration helped explain the chain of events that led to the seat-belted occupant ejection in a rollover collision.

**References:**


1. David A. Renfroe, "Rollover Ejection While Wearing Lap and Shoulder Harness: The Role of the Retractor," SAE Paper No. 960096.
2. Charles P. Dickerson, Mark W. Arndt, and Stephen M. Arndt, "Vehicle Handling with Tire Tread Separation," SAE Paper No. 1999-01-0450.
3. Ian S. Jones and Lawrence A. Wilson, "Techniques for the Reconstruction of Rollover Accident Involving Sport Utility Vehicles, Light Trucks and Minivans," SAE Paper No. 2000-01-0851.
4. Kurt D. Weiss, "Forensic Testing and the Characteristics of Seat Belt Webbing Force Limiting Expansion Loops," *Proceedings of the American Academy of Forensic Sciences*, 57th Annual Meeting, New Orleans, February 21-26, 2005, 133-134.


**SUV Tread Separation, Rollover Ejection, Seat Belt**

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