CRASH DATA RESEARCH CENTER

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REDESIGNED AIR BAG SPECIAL STUDY (RABSS)
SCI TECHNICAL SUMMARY REPORT

NASS CDS CASE NO. 1999-41-026J

RABSS VEHICLE - 1998 TOYOTA CELICA GT CONVERTIBLE

LOCATION - STATE OF FLORIDA

CRASH DATE - FEBRUARY, 1999

Contract No. DTNH22-94-D-07058

Prepared for:

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National Highway Traffic Safety Administration
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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. *Abstract* This investigation focused on a single vehicle crash involving a 1998 Toyota Celica GT convertible equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of a frontal collision with a building. The driver of the Toyota Celica was operating the vehicle westbound on a 2-lane urban roadway when she allowed the vehicle to depart the right (north) pavement edge in a forward tracking mode. As the Toyota exited the right pavement edge, the front right area impacted a signpost resulting in minor damage. The vehicle re-entered the roadway in a counterclockwise yaw and subsequently exited the left (south) pavement edge where the front right area struck a building resulting in moderate damage. The Toyota rebounded as the right side surface made final contact to a parked vehicle which resulted in minor damage. At impact with the building, the unrestrained 53 year old female driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the knee bolster and deployed redesigned driver air bag. Loading of the knee bolster resulted in bilateral thigh contusions and associated right femur fractures. She also sustained multiple lacerations to the forehead and anterior scalp from contact to the windshield and header. The driver was transported to a local trauma center for treatment and admitted for 6 days.			
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BACKGROUND

This investigation focused on a single vehicle crash involving a 1998 Toyota Celica GT convertible equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of a frontal collision with a building. The driver of the Toyota Celica was operating the vehicle westbound on a 2-lane urban roadway when she allowed the vehicle to depart the right (north) pavement edge in a forward tracking mode. As the Toyota exited the right pavement edge, the front right area impacted a signpost resulting in minor damage. The vehicle re-entered the roadway in a counterclockwise yaw and subsequently exited the left (south) pavement edge where the front right area struck a building resulting in moderate damage. The Toyota rebounded as the right side surface made final contact to a parked vehicle which resulted in minor damage. At impact with the building, the unrestrained 53 year old female driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the knee bolster and deployed redesigned driver air bag. Loading of the knee bolster resulted in bilateral thigh contusions and associated right femur fractures. She also sustained multiple lacerations to the forehead and anterior scalp from contact to the windshield and header. The driver was transported to a local trauma center for treatment and admitted for 6 days.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 1999-41-026J and also included in the Redesigned Air Bag Special Study. The Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) assigned the Special Crash Investigation (SCI) team at Veridian the task of case review and final report preparation.

SUMMARY

Crash Site

This single vehicle crash occurred during the late evening hours of February, 1999. At the time of the crash, it was dark (street lighted) with no adverse conditions as the road was dry. The crash occurred off the north pavement edge of a (straight/level) urban 2-lane east/west roadway **(see Figure 7 - page 6)**. The asphalt roadway was bordered by a grassy area to the north and residential buildings to the south. No traffic control was present at the scene which had a posted speed limit of 56 km/h (35 mph).

Pre-Crash

The 53 year old female driver of the 1998 Toyota Celica GT was operating the vehicle westbound **(Figure 1)** when she allowed the vehicle to depart the right (north) pavement edge in a forward tracking mode. The vehicle traveled approximately 76.5 meters (251.0 feet) alongside the north pavement edge prior to the first impact. The police reported no brake marks at the scene indicative of driver avoidance maneuvers.

Figure 1. Westbound approach for the 1998 Toyota Celica GT convertible.

Crash

As the Toyota departed the right (north) pavement edge, the front right area made initial contact to a small diameter signpost resulting in minor damage. The signpost was uprooted and struck the right hood, A-pillar, and windshield as it fell to the ground which resulted in minor (non-horizontal) damage. At this point, the driver steered left/braked as the vehicle re-entered the roadway in a counterclockwise yaw as evidenced by the yaw marks noted in the NASS scene images **(Figure 2)**. The Toyota continued in a southwesterly direction approximately 44.7 meters (146.7 feet), traversed a connecting roadway, and subsequently exited the left (south) pavement edge where the front right area impacted the northeast corner of a building **(Figure 3)** resulting in moderate damage. The WinSMASH reconstruction program computed a *(SCI revised)* velocity change of 46.4 km/h (28.8 mph) with a longitudinal component of -45.7 km/h (-28.4 mph). The impact induced deceleration was sufficient to deploy the Toyota's redesigned frontal air bag system. The vehicle rebounded 4.1 meters (13.5 feet) where the right side surface made final contact to a parked vehicle (facing east in the west lot) resulting in minor damage. The Toyota came to rest against the parked vehicle facing southeast. *It should be noted that SCI analysis of the vehicle damage and collision dynamics necessitated revisions to the chain of events depicted in the NASS case file.*

Figure 2. Southwest trajectory as the vehicle re-enters the roadway.

Figure 3. Struck building (impact #3).

Post-Crash

The driver was removed by rescue personnel due to perceived serious injury and was subsequently transported by ambulance to a local trauma center for treatment and admitted for 6 days. The vehicle was towed from the crash site due to disabling damage.

RABSS VEHICLE

The 1998 Toyota Celica GT was identified by the vehicle identification number (VIN): 2T1BR12E0WC (production number deleted). ***A discrepancy existed between the VIN listed on the police report and the VIN recorded during the NASS vehicle inspection, however, this could not be resolved as no vehicle identifiers were provided in the case file.*** The police report listed the driver as the owner of the vehicle. The vehicle was a 2-door convertible equipped with front-wheel drive and a 2.0 liter, 4-cylinder engine. At the time of the crash, the odometer had recorded 4,764 km (2,960 miles). The seating was configured with front bucket and rear bench seats (with folding backs). The NASS interview was not obtained, therefore, previous crashes or maintenance on the Toyota's frontal air bag system were unknown.

VEHICLE DAMAGE

Exterior

The 1998 Toyota Celica GT sustained moderate frontal damage as a result of the impact with the building **(Figure 4)**. *Erroneous field documentation necessitated SCI revisions to the crush profile and deformation classification.* The direct contact damage began at the front right bumper corner and extended approximately 45.0 cm (17.7 in) inboard. The impact deformed the entire front end width resulting in a combined direct and induced damage length (Field L) of 140.0 cm (55.1 in). Six crush measurements were documented at the level of the lower radiator *(bumper reinforcement bar and fascia separation)*: C1= 0 cm, C2= 2.0 cm (0.8 in), C3= 9.0 cm (3.5 in), C4= 34.0 cm (13.4 in), C5= 78.0 cm (30.7 in), C6= 47.0 cm (18.5 in). The Collision Deformation Classification (CDC) for this impact to the Toyota was 12-FZEW-3 with a principal direction of force of (+)10 degrees. The windshield was fractured from (exterior) impact forces and (interior) occupant contact. The hood was deformed up and rearward from engagement against the building. The right fender was displaced rearward which jammed the right door and restricted the right front wheel/tire. Reduction in the right side wheelbase measured 19.0 cm (7.5 in). Lateral and rearward displacement of the left fender jammed the left door and restricted the left front wheel/tire. Pry marks were noted to the left door (removed) frame from driver extrication activities post-crash.

Figure 4. Front right damage to the 1998 Toyota Celica GT Convertible.

Direct contact damage was also identified to the front right area from the initial signpost impact. The direct damage began approximately 15.0 cm (5.9 in) to the right of the vehicle centerline and extended 10.0 cm (3.9 in) outboard. Although classified as overlapping damage, this minor impact probably did not produce any bumper displacement, nor invalidate any WinSMASH outputs for the highest Delta-V event. The CDC for this impact was 12-FCEN-1. Additional contact damage was noted to the right hood, A-pillar and windshield area attributed to the signpost as it fell to the ground. The CDC for this minor (secondary) non-horizontal impact was 00-TYZW-1. Minor surface scratching and light pocketing were noted to the right passenger door attributed to the final impact with the parked vehicle. The estimated CDC for this final impact was 03-RPEN-1.

Interior

Interior damage to the Toyota Celica identified through the vehicle inspection was moderate and was attributed to occupant contact and component intrusion. A spider-web fracture pattern was documented to the upper centered portion of the windshield along with hair strands to the header. The rear view mirror separated from the header mount. Scuff marks and indentations were identified on the left knee bolster. The radio and climate control cluster was pushed inward as the surrounding trim panel was fractured. Longitudinal intrusions into the front occupant space involved 13.0 cm (5.1 in) of right instrument panel and 8.0 cm (3.1 in) of center instrument panel intrusion.

REDESIGNED AIR BAG SYSTEM

The 1998 Toyota Celica GT was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags deployed as a result of the crash. The driver air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The flaps were symmetrical in shape and measured 13.5 cm (5.3 in) in width and 12.0 cm (4.7 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, an unspecified transfer was noted to the upper right quadrant of the air bag face. The NASS researcher measured the diameter of the driver air bag at 62.0 cm (24.4 in) in its deflated state **(Figure 5)**. The bag was tethered by two internal straps and vented by two ports not located on the rear aspect by the NASS researcher.

The front right passenger air bag deployed from the right top instrument panel area with a single cover flap design hinged at the forward aspect. No contact evidence was identified on the air bag or exterior surface of the module cover flap. The cover flap was rectangular in shape and measured 35.0 cm (13.8 in) in width and 6.0 cm (2.4 in) in height. No air bag dimensions or port locations were provided by the NASS researcher **(Figure 6)**. No internal tether straps were reportedly present.

Figure 5. 1998 Toyota Celica GT deployed redesigned driver air bag.

Figure 6. 1998 Toyota Celica GT deployed passenger air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	53 year old female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Mid-to-forward position
Manual Restraint Use:	None
Usage Source:	NASS vehicle inspection, police report
Eyeware:	Unknown
Type of Medical Treatment:	Transported to a local trauma center and admitted (6 days)

Driver Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
*Fracture right femur (mid-shaft open/comminuted)	Serious (851814.3,1)	Left knee bolster
*Fracture right femur (supra condylar-comminuted)	Serious (851822.3,1)	Left knee bolster
*Laceration anterior/front scalp (8cm)	Minor (190602.1,5)	Windshield header
*Laceration lower middle forehead (lateral eyebrow on right, side to mid-left eyebrow, and right mid-forehead)	Minor (290602.1,7)	Windshield
*Laceration right thigh (associated with femur fracture)	Minor (890602.1,1)	Left knee bolster
+Contusion bilateral anterior (distal) thighs	Minor (890402.1,3)	Left knee bolster

sources - discharge summary/ER report+*

Driver Kinematics

The unrestrained 53 year old female driver of the 1998 Toyota Celica GT convertible was presumed to be seated in an upright posture with the seat track adjusted to a mid-to-forward position. The lack of belt usage was determined by the extent of interior contact points relative to the type of injuries sustained. At impact with the signpost, the driver probably remained in her pre-impact posture as this minor impact offered no resistance to the vehicle nor produce any occupant kinematic response. At impact with the building, she initiated a forward trajectory in response to the 12 o'clock impact force and loaded the knee bolster and deployed redesigned driver air bag. Loading of the knee bolster resulted in bilateral anterior (distal) thigh contusions and open/comminuted fractures of the right femur, evidenced by the indentations and scuff marks documented to this component. Contact to the deployed driver air bag was confirmed by the unspecified transfer documented to the upper right quadrant of the air bag face. She continued the kinematic trajectory into the windshield and header which resulted in multiple lacerations to the middle (lower) forehead and anterior scalp area. This injury mechanism was evidenced by the spider-web fracture pattern on the upper (centered) windshield and hair strands identified on the header. Deformation to the center instrument panel (radio and climate controls) may have been a result of further loading by the right anterior thigh during continued kinematic travel into the windshield header area, however, the damage pattern suggests this was probably from right hand/arm contact producing soft tissue injury not captured in the medical report. Following the crash, the driver was removed from the vehicle by rescue personnel due to perceived serious injury and transported by ambulance to a local trauma center for treatment and admitted for 6 days.

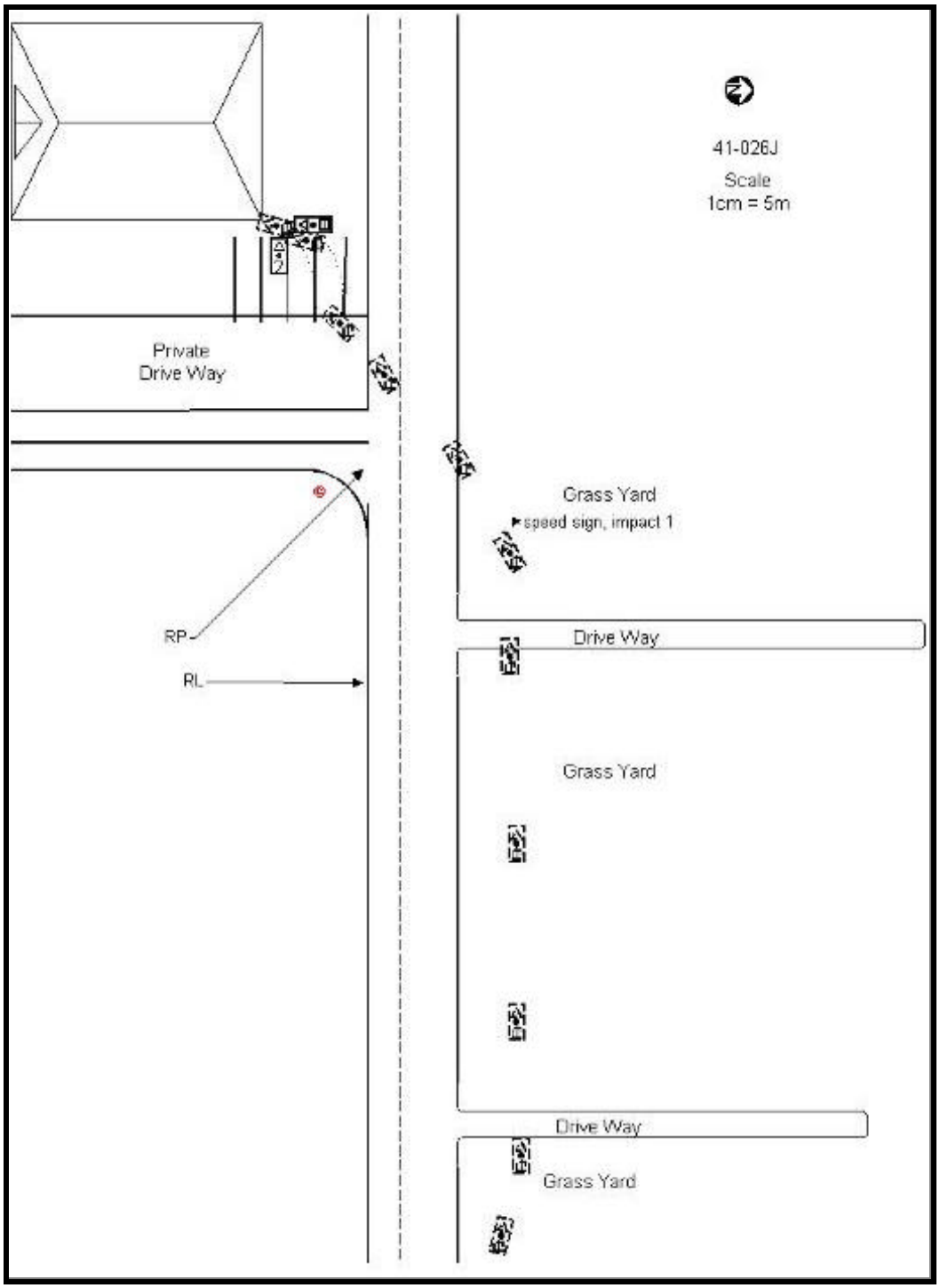

Figure 7. NASS Scene Diagram (physical evidence not plotted, physical plant and collision dynamics incorrectly plotted by researcher) .