TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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

NASS RABSS CASE NO. 1998-12-806E

RABSS VEHICLE - 1999 CHEVROLET CORVETTE

LOCATION - STATE OF MICHIGAN

CRASH DATE - OCTOBER, 1998

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* 98-12-806E	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Redesigned Air Bag Special Study (RABSS) RABSS Vehicle - 1999 Chevrolet Corvette Location - State of Michigan		5. *Report Date*: December, 1999 6. *Performing Organization Code*	
7. *Author(s)* Crash Research Section		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Sciences Crash Research Section Veridian Engineering (Calspan Operations) P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0238.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. *Type of Report and Period Covered* Technical Summary Report Crash Date: October, 1998 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* NASS investigation of a frontal collision (into a fixed object) that involved a 1999 Chevrolet Corvette with redesigned frontal air bags.			
16. *Abstract* This investigation focused on a single vehicle crash involving a 1999 Chevrolet Corvette convertible. The Chevrolet Corvette was equipped with redesigned frontal air bags that deployed as a result of a frontal collision with a large diameter tree. The driver was operating the Corvette eastbound on a rural two lane roadway and negotiating a left curve when the vehicle began a counterclockwise rotation and subsequently departed the left (north) pavement edge. As the Corvette exited the north pavement edge, the front right area struck a large diameter tree resulting in moderately severe damage. The vehicle rotated clockwise and impacted a bush before coming to rest facing southeast. The 54 year old male driver of the Chevrolet Corvette was unrestrained (3-point manual lap and shoulder belt system available) and seated in an upright posture. At impact, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed redesigned driver air bag resulting in multiple soft tissue injuries to the facial area. His lower extremities contacted the knee bolster which resulted in bilateral femur fractures. Loading of the brake pedal resulted in fractures of the left tibia/fibula. He continued the kinematic response pattern into the center instrument panel and windshield area resulting in fractures of the right radius/ulna and additional soft tissue injuries to the forehead/scalp. The 48 year old female front right passenger was also unrestrained and initiated a forward trajectory in response to the 1 o'clock impact force. She loaded the redesigned passenger air bag which resulted in a contusion to the posterior aspect of the left hand. She also sustained a fracture of the left tibia from contact to the glove compartment door. Both occupants were transported by ambulance to a local trauma center and admitted for five days.			
17. *Key Words* Redesigned frontal air bag system Collision Deformation Classification (CDC): 01-FREE-3 Bilateral femur fractures		18. *Distribution Statement* General Public	
19. *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 8	22. *Price*

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CRASH DATE - OCTOBER, 1998

BACKGROUND

This investigation focused on a single vehicle crash involving a 1999 Chevrolet Corvette convertible. The Chevrolet Corvette was equipped with redesigned frontal air bags that deployed as a result of a frontal collision with a large diameter tree. The driver was operating the Corvette eastbound on a rural two lane roadway and negotiating a left curve when the vehicle began a counterclockwise rotation and subsequently departed the left (north) pavement edge. As the Corvette exited the north pavement edge, the front right area struck a large diameter tree resulting in moderately severe damage. The vehicle rotated clockwise and impacted a bush before coming to rest facing southeast. The 54 year old male driver of the Chevrolet Corvette was unrestrained (3-point manual lap and shoulder belt system available) and seated in an upright posture. At impact, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed redesigned driver air bag resulting in multiple soft tissue injuries to the facial area. His lower extremities contacted the knee bolster which resulted in bilateral femur fractures. Loading of the brake pedal resulted in fractures of the left tibia/fibula. He continued the kinematic response pattern into the center instrument panel and windshield area resulting in fractures of the right radius/ulna and additional soft tissue injuries to the forehead/scalp. The 48 year old female front right passenger was also unrestrained and initiated a forward trajectory in response to the 1 o'clock impact force. She loaded the redesigned passenger air bag which resulted in a contusion to the posterior aspect of the left hand. She also sustained a fracture of the left tibia from contact to the glove compartment door. Both occupants were transported by ambulance to a local trauma center and admitted for five days.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as case number 98-12-806E for 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/Calspan the task of case review and final report preparation.

SUMMARY

Crash Site

This single vehicle crash occurred during the late evening hours of October, 1998. At the time of the crash, it was dark (street not lighted) with intermittent rain conditions as the roads were wet. The crash occurred off the north pavement edge of a level two lane east/west asphalt roadway **(see Figure 8 - page 8)** which curved left for eastbound traffic. No traffic control was present at the scene which had a posted speed limit of 40 km/h (25 mph). The roadside environment featured various trees and shrubbery, residential driveways and mailboxes.

Pre-Crash

The 54 year old male driver of the 1999 Chevrolet Corvette was operating the vehicle eastbound and negotiating a left curve **(Figure 1)** on wet pavement (direction of travel/collision dynamics identified incorrectly in the NASS case file). The intermittent rain resulted in hazardous conditions as puddles and leaves were collecting about the residential roadway. As the vehicle reached the apex of the curve, it encountered a puddle and hydroplaned initiating a slight counterclockwise rotation. Upon recognition of the impending harmful event, the driver steered left and braked in avoidance, subsequently exiting the left (north) pavement edge.

Figure 1. Overview of crash site looking west (struck tree to the right in image).

Figure 2. East view of struck tree.

Crash

As the Chevrolet Corvette exited the north pavement edge of the rural two lane roadway, the front right area struck a large diameter tree **(Figure 2)** resulting in moderately severe damage. Initial contact involved the extreme front right corner area which displaced the bumper and leading edge of the right fender. The continued forward motion of the vehicle resulted in engagement of the right front wheel/tire against the tree. This was the first significant structural contact, therefore, the air bag system probably deployed at this time, late in the crash sequence. The impact induced deceleration was sufficient to deploy the Chevrolet's redesigned frontal air bag system. The damage algorithm of the WinSMASH program computed a (barrier equivalent) velocity change of 35.6 km/h (22.1 mph). The specific longitudinal component was -33.5 km/h (-20.8 mph). The Collision Deformation Classification (CDC) for this initial impact to the Chevrolet Corvette was 01-FREE-3. At this point, the Corvette rotated clockwise approximately 40 degrees as the front left area impacted a bush (adjacent to the tree) resulting in superficial damage. The CDC for this second and final impact to the Corvette was 11-FYEW-1. The Chevrolet Corvette came to rest off the north pavement edge facing southeast.

Post-Crash

Both occupants were removed from the vehicle by rescue personnel with perceived serious injuries. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMT). Both occupants were transported by ambulance to a local trauma center and admitted for five days. The vehicle was towed from the scene due to disabling damage.

RABSS VEHICLE

The 1999 Chevrolet Corvette convertible was identified by the Vehicle Identification Number (VIN): 1G1YY32G6X5 (production sequence deleted). The vehicle was a 2-door convertible equipped with rear wheel drive and a 5.7 liter, V-8 engine. The vehicle's odometer reading was unknown at the time of the crash. The police report did not identify the owner of the vehicle. The seating was configured with front bucket seats. The surrogate reported no previous crashes or maintenance on the air bag system (original equipment). It was unknown if a cell phone was present or in-use at the time of the collision.

VEHICLE DAMAGE

Exterior Damage

The 1999 Chevrolet Corvette sustained moderately severe frontal damage as a result of the impact with the tree **(Figures 3 & 4)**. The direct contact damage began at the front right bumper corner and extended 36.0 cm (14.2 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 95.0 cm (37.4 in). Six crush measurements were documented at the level of the bumper: C1= 13.0 cm (5.1 in), C2= 18.0 cm (7.1 in), C3= 26.0 cm (10.2 in), C4= 35.0 cm (13.8 in), C5= 41.0 cm(16.1 in), C6= 54.0 cm (21.3 in). The contact damage extended rearward down the right side surface which deformed the fender and deflated/restricted the right front wheel/tire. Lateral displacement of the hood was noted from engagement against the tree. Superficial scratches were documented along the remainder of the bumper fascia from the bush impact. Reduction in the right side wheelbase measured 37.0 cm (14.6 in). Reduction in the left side wheelbase measured 4.0 cm (1.6 in). The windshield fractured at the right A-pillar from exterior impact forces and center mid-windshield area from (interior) occupant contact.

Figure 3. Frontal damage to the 1999 Chevrolet Corvette.

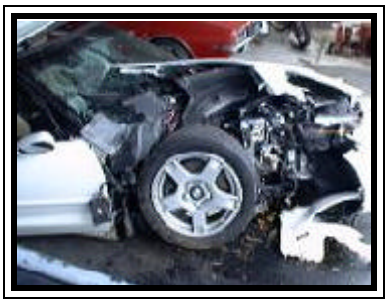

Figure 4. Right side view.

Interior Damage

Interior damage to the Corvette identified through the NASS vehicle inspection was moderate and was attributed to occupant contact **(Figure 5)**. A scuff mark was noted to the left knee bolster (padded type) along with an indentation to the glove compartment door. The upper portion of the steering wheel rim was deformed 6.0 cm (2.4 in). A spider-web type fracture was documented to the center windshield area with rear view mirror separation (unknown if

Figure 5. Interior view.

damaged). Indentations were found along the center instrument trim panels with the vents and radio out of place. The right front glazing was found adjacent to the vehicle (intact) with hair strands attached. A door failure was identified at the right latch/stryker assembly. Longitudinal intrusions into the front right passenger space included 17.0 cm (6.7 in) of toepan intrusion and 11.0 cm (4.3 in) of windshield header intrusion.

REDESIGNED AIR BAG SYSTEM

The 1999 Chevrolet Corvette was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags had deployed as a result of the crash. The driver air bag was housed in the center of the steering wheel with a vertically oriented flap tear seam (I-configuration). The flaps were symmetrical in shape and measured 8.0 cm (3.1 in) in width and 13.0 cm (5.1 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, blood spattering was documented to the (front/back) lower section of the air bag. The NASS researcher measured the diameter of the driver air bag at 56.0 cm (22.0 in) in its deflated state **(Figure 6)**. The bag was tethered by two internal straps and vented by two ports located at the 11 o'clock and 1 o'clock sectors on the rear aspect of the air bag.

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. The cover flap was rectangular in shape and measured 27.0 cm (10.6 in) in width and 18.0 cm (7.1 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flap, blood spattering was documented to the lower right quadrant of the air bag. The NASS researcher measured the passenger air bag at 38.0 cm (15.0 in) in width and 50.0 cm (19.7 in) in height in its deflated state **(Figure 7)**. No internal tether straps or vent ports were present. No cutoff switch was reported for the front right redesigned passenger air bag.

Figure 6. 1999 Chevrolet Corvette redesigned driver air bag.

Figure 7. 1999 Chevrolet Corvette redesigned passenger air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	54 year old male
Height:	180 cm (71 in)
Weight:	95 kg (210 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	None
Usage Source:	NASS vehicle inspection, medical report, police report
Eyeware:	Prescription glasses
Type of Medical Treatment:	Transported to a local hospital and admitted (5 days)

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
Fracture right radius (mid-shaft: mildly comminuted and displaced)	Serious (752804.3,1)	Center instrument panel
Fracture right ulna	Serious (753204.3,1)	Center instrument panel
Fracture right femur (intertrochanteric)	Serious (851810.3,1)	Knee bolster (indirect contact injury)
Fracture right femur (subtrochanteric)	Serious (851818.3,1)	Knee bolster (indirect contact injury)
Fracture left femur (condylar)	Serious (851804.3,2)	Knee bolster (indirect contact injury)
Fracture left fibula (bimalleolar)	Moderate (851612.2,2)	Brake pedal (indirect contact injury)
Fracture left tibia (shaft)	Moderate (853420.2,2)	Brake pedal (indirect contact injury)
Contusion scalp	Minor (190402.1,5)	Rear view mirror
Laceration mid-upper forehead (4.0 cm - with glass embedded)	Minor (290602.1,7)	Windshield
Contusion forehead	Minor (290402.1,7)	Windshield
Abrasion right upper forehead (multiple - linear)	Minor (290202.1,7)	Windshield
Contusion right eyelid	Minor (297402.1,1)	Front left air bag

Abrasion right cornea	Minor (240602.1,1)	Front left air bag
Abrasion left cheek	Minor (290202.1,2)	Front left air bag
Abrasion chin	Minor (290202.1,8)	Front left air bag
Contusion right forearm (posterior)	Minor (790402.1,1)	Center instrument panel
Abrasion bilateral lower legs (anterior - proximal to knees)	Minor (890202.1,3)	Knee bolster
Contusion left lower leg (anterior - proximal to knee)	Minor (890402.1,2)	Knee bolster

Driver Kinematics

The unrestrained 54 year old male driver of the 1999 Chevrolet Corvette was presumed to be seated in an upright posture with the seat back slightly reclined and the seat track adjusted to the full rearward position. Lack of belt usage was confirmed by the type of injuries sustained and contact points within the vehicle. At impact with the tree, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed redesigned driver air bag which resulted in multiple soft tissue injuries to the facial area. His lower extremities contacted the knee bolster resulting in bilateral abrasions to the knees/shins, a fracture of the left femur (condylar segment) and fractures of the right femur (intertrochanteric and subtrochanteric areas). This mechanism was evidenced by the type and location of the injuries sustained in conjunction with the scuff marks documented to the knee bolster. The driver's placement of the left foot on the brake pedal during pre-crash avoidance maneuvers resulted in a fracture of the tibia/fibula.

At this point, the driver bottomed out the top portion of the air bag (confirmed by the 6.0 cm of upper rim deformation), traveled up and over the steering wheel rim and continued the kinematic response pattern into the center instrument panel and windshield area. The right forearm struck the center instrument panel resulting in a contusion and fractures of the radius/ulna, evidenced by the indentations and displacement of the center instrument panel components. His head contacted the rear view mirror which resulted in a contusion as evidenced by the location of the injury and separation of the mirror from the windshield. He contacted the windshield resulting in additional soft tissue injury to the forehead and scalp, evidenced by the spider web type fracture to the windshield and subsequent removal of glass fragments during the driver's treatment at a local trauma center. No injury was attributed to the subsequent bush impact. The driver was transported by ambulance to a local trauma center and admitted for five days. The medical report stated his blood alcohol level was .107. *Please note that many injury sources were identified incorrectly in the NASS case file, however, the correct sources were listed in this report.*

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	48 year old female
Height:	165 cm (65 in)
Weight:	57 kg (125 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	None
Usage Source:	NASS vehicle inspection
Eyeware:	Unknown
Type of Medical Treatment:	Transported to a local hospital and admitted (5 days)

Front Right Passenger Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Fracture left tibia - plateau (comminuted)	Serious (853408.3,2)	Glove compartment door
Contusion left lower leg (anterior-proximal to knee)	Minor (890402.1,2)	Glove compartment door
Contusion posterior left hand	Minor (790402.1,2)	Front right air bag

Front Right Passenger Kinematics

The unrestrained 48 year old female front right passenger of the 1999 Chevrolet Corvette was presumed to be seated in an upright posture with the seat back slightly reclined and the seat track adjusted to the full rearward position. Lack of belt usage was confirmed by the type of injuries sustained relative to the occupants height and pre-crash seat track position. At impact with the tree, she initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed redesigned passenger air bag resulting in a 10.2 cm (4.0 in) contusion to the posterior aspect of the left hand (injury source identified as the center instrument panel in the case file). This mechanism was evidenced by the location of the injury in conjunction with the kinematic pattern and rearward extent of the fully deployed air bag. Her lower extremities loaded the glove compartment door which resulted in a contusion to the left knee and (comminuted) fracture of the left tibia, evidenced by the indentations noted to this component. No injury was attributed to the subsequent bush impact. The front right passenger was transported by ambulance to a local trauma center and admitted for five days.

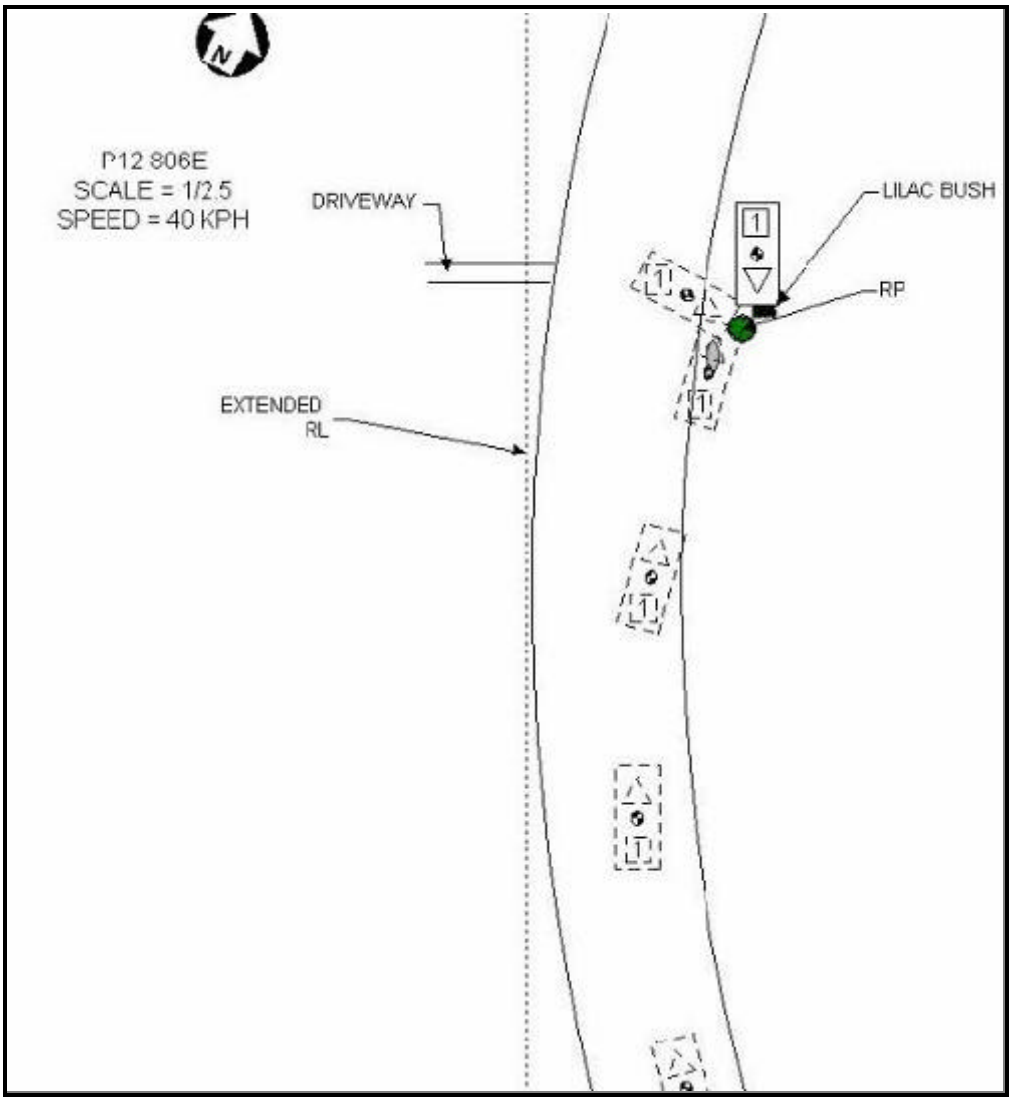

Figure 8. NASS Scene Diagram (direction of travel identified incorrectly).