TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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

NASS RABSS CASE NO. 1998-45-802G

RABSS VEHICLE - 1998 SATURN SL2

LOCATION - STATE OF TENNESSEE

CRASH DATE - JULY, 1998

Contract No. DTNH22-94-D-07058

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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 two vehicle crash involving a 1998 Saturn SL2 4-door sedan (subject vehicle) and a 1989 White conventional tractor-trailer. The Saturn was equipped with redesigned frontal air bags for the driver and right passenger positions that deployed as a result of an oblique angle collision with the White tractor-trailer. The driver of the tractor-trailer made an abrupt lane change (to the right) across the path of the Saturn where the right side surface of the tractor portion impacted the left side surface of the Saturn resulting in minor damage to both vehicles. At this point, the Saturn was dragged for a short distance before separation occurred. The Saturn rotated counterclockwise across the path of the truck as the front left area struck the trailer portion resulting in moderate damage. The Saturn came to rest on the median shoulder facing southeast. The tractor-trailer came to a controlled stop in the westbound lanes facing west. The restrained 29 year old male driver of the Saturn initiated a forward trajectory in response to the *secondary* 11 o'clock impact force as the expanding air bag contacted the anterior aspect of his left wrist resulting in a small abrasion. The expanding air bag propelled his arm forward into the windshield which resulted in multiple small lacerations to the posterior aspect of the left forearm (air bag related "fling" injury). The restrained 53 year old female front right passenger also initiated a forward trajectory in response to the secondary 11 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Contact to the passenger air bag resulted in a sprained left wrist with no other injury reported. The front seated occupants of the Saturn refused treatment. The rear left and right seating positions were occupied by a 77 year old female and 82 year old male who were reported by police as uninjured.			
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BACKGROUND

This investigation focused on a two vehicle crash involving a 1998 Saturn SL2 4-door sedan (subject vehicle) and a 1989 White conventional tractor-trailer. The Saturn was equipped with redesigned frontal air bags for the driver and right passenger positions that deployed as a result of an oblique angle collision with the White tractor-trailer. The driver of the tractor-trailer made an abrupt lane change (to the right) across the path of the Saturn where the right side surface of the tractor portion impacted the left side surface of the Saturn resulting in minor damage to both vehicles. At this point, the Saturn was dragged for a short distance before separation occurred. The Saturn rotated counterclockwise across the path of the truck as the front left area struck the trailer portion resulting in moderate damage. The Saturn came to rest on the median shoulder facing southeast. The tractor-trailer came to a controlled stop in the westbound lanes facing west. The restrained 29 year old male driver of the Saturn initiated a forward trajectory in response to the *secondary* 11 o'clock impact force as the expanding air bag contacted the anterior aspect of his left wrist resulting in a small abrasion. The expanding air bag propelled his arm forward into the windshield which resulted in multiple small lacerations to the posterior aspect of the left forearm (air bag related "fling" injury). The restrained 53 year old female front right passenger also initiated a forward trajectory in response to the secondary 11 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Contact to the passenger air bag resulted in a sprained left wrist with no other injury reported. The front seated occupants of the Saturn refused treatment. The rear left and right seating positions were occupied by a 77 year old female and 82 year old male who were reported by police as uninjured.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as case number 98-45-802G 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 the task of case review and final report preparation.

SUMMARY

Crash Site

This two vehicle crash occurred during the afternoon hours of July, 1998. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred in the westbound lanes of a straight (asphalt) 8-lane east/west interstate highway which was bordered by paved shoulders and divided by a raised concrete barrier **(see Figure 7 - page 6)**. No traffic control was present at the scene which had a posted speed limit of 89 km/h (55 mph).

Pre-Crash

The 28 year old male driver of the White tractor-trailer was operating the vehicle westbound in the #2 inboard lane **(Figure 1)** when he changed lanes to the right. The 29 year old male driver of the 1998 Saturn SL2 was operating the vehicle westbound in the #2 outboard lane at a (driver reported) speed of 89 km/h (55 mph) and proceeding straight when he observed the truck encroach into his lane of travel. The driver of the Saturn reported no avoidance maneuvers.

Figure 1. Westbound approach for the 1989 White conventional tractor-trailer.

Crash

As the tractor-trailer changed lanes to the right, the right side surface of the tractor portion impacted the left side surface of the Saturn resulting in minor damage to both vehicles. The Collision Deformation Classification (CDC) for this initial impact to the Saturn was 09-LZAW-2. The tractor-trailer braked which allowed the Saturn to pass and rotate counterclockwise across its path of travel where the front left area of the Saturn struck the left side surface of the trailer portion resulting in moderate damage. At this point, the Saturn underrode the side surface of the trailer which penetrated the upper left windshield area. The impact induced deceleration was sufficient to deploy the Saturn's redesigned frontal air bag system. Although the impact with the tractor-trailer was classified as out of scope, the damage algorithm of the WinSMASH program computed a (barrier equivalent) velocity change of 11.4 km/h (7.1 mph) for the subject vehicle. The specific longitudinal component was -9.8 km/h (-6.1 mph). The CDC for this second and final impact to the Saturn was 11-FYAA-7. The Saturn continued rotating counterclockwise and came to rest on the median shoulder facing southeast. The tractor-trailer was driven to a controlled stop in the westbound lanes facing west.

Post-Crash

All occupants exited the vehicle under their own power. No ambulance was summoned to the crash site. The Saturn was towed from the scene due to disabling damage while the White tractor-trailer was driven from the scene.

RABSS VEHICLE

The 1998 Saturn SL2 was identified by the Vehicle Identification Number (VIN): 1G8ZK5276WZ (production sequence deleted). The vehicle was a 4-door sedan equipped with front wheel drive and a 1.9 liter, 4 cylinder engine. The vehicle's odometer reading was 11,401 km (7,084 miles) at the time of the crash. The driver's parents were listed on the police report as the owners of the vehicle. The seating was configured with front bucket and rear (folding back) bench seats. The driver reported no previous crashes or maintenance on the air bag system (original equipment). No cell phone was present or in-use at the time of the collision.

VEHICLE DAMAGE

Exterior Damage

The 1998 Saturn SL2 sustained moderate frontal damage as a result of the impact with the tractor-trailer **(Figures 2 & 3)**. The (secondary) direct contact damage began at the front left bumper corner and extended 67.0 cm (26.4 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 110.0 cm (43.3 in). Six crush measurements were documented at the level of the reinforcement bar (bumper cover separation): C1= 10.0 cm (3.9 in), C2= 9.0 cm (3.5 in), C3= 5.0 cm (2.0 in), C4= 2.0 cm (0.8 in), C5= 0 cm, C6= 0 cm. The left fender was displaced rearward and to the right which restricted the left front wheel/tire (not deflated). Underride damage consisted of an imprint to the hood surface from the trailer portion of the truck which extended rearward to the windshield header. A puncture hole was identified to the upper left windshield area and measured 20.0 cm x 10.0 cm (7.9 in x 3.9 in). Surface scratching was documented rearward along the left side surface attributed to the initial impact with the tractor portion. This damage pattern began 52.0 cm (20.5 in) aft of the left front axle and extended 301.0 cm (118.5 in) rearward. The front and rear bumper cover fascia separated from the vehicle during the crash sequence. All tempered glazing remained intact.

Figure 2. Frontal damage to the 1998 Saturn SL2.

Figure 3. Left and rear damage.

Interior Damage

Interior damage to the Saturn identified through the NASS vehicle inspection was minimal and was attributed to occupant contact **(Figure 4)**. A spider-web fracture pattern was documented to the left lower windshield. Scuff marks were found on the left side interior door surfaces and left knee bolster (rigid plastic type). A longitudinal windshield (and opposing vehicle) intrusion measured 3.0 cm (1.2 in). No deformation was noted to the steering wheel hub/rim (tilt column placed to the center position).

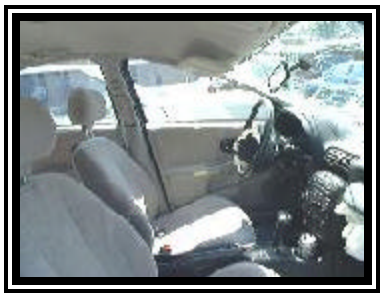

Figure 4. Interior view of the 1998 Saturn SL2.

REDESIGNED AIR BAG SYSTEM

The 1998 Saturn SL2 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). Although no contact evidence was identified on the exterior surface of the module cover flaps, an orange fabric transfer was documented to the lower left quadrant along with blood spattering to the lower right quadrant of the air bag. The flaps were symmetrical in shape and measured 9.0 cm (3.5 in) in width and 13.0 cm (5.1 in) in height. The NASS researcher measured the diameter of the driver air bag at 42.0 cm (16.5 in) in its deflated state **(Figure 5)**. The bag was tethered by four 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 mid-instrument panel area with a single cover flap design hinged at the top 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 30.0 cm (11.8 in) in width and 12.0 cm (4.7 in) in height. The NASS researcher measured the passenger air bag at 70.0 cm (27.6 in) in width and 50.0 cm (19.7 in) in height in its deflated state **(Figure 6)**. No internal tether straps or vent ports were present. No cutoff switch was reported for the front right redesigned passenger air bag.

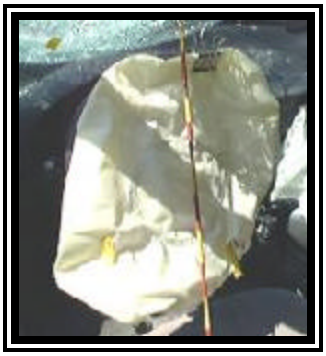

Figure 5. 1998 Saturn SL2 redesigned driver air bag.

Figure 6. 1998 Saturn SL2 redesigned passenger air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	29 year old male
Height:	191 cm (75 in)
Weight:	102 kg (225 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	NASS vehicle inspection, driver interview, police report
Eyeware:	Prescription glasses
Type of Medical Treatment:	Refused treatment

Driver Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
Abrasion left anterior wrist (golf ball size)	Minor (790202.1,2)	Expanding front left air bag
Laceration left posterior forearm (multiple/small)	Minor (790602.1,2)	Windshield (air bag related "fling" injury)

Driver Kinematics

The 29 year old male driver of the 1998 Saturn SL2 was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the full rearward position. His hands were placed at the 10 o'clock and 2 o'clock positions on the steering wheel rim. Belt usage was confirmed by the lack of significant interior contacts and injury. At first impact with the tractor-trailer, he initiated a lateral trajectory in response to the 9 o'clock impact force and loaded the door panel as evidenced by the scuff marks documented to this component, with no resulting injury reported. At second impact with the tractor-trailer, the driver initiated a forward trajectory in response to the 11 o'clock impact force as the expanding air bag contacted the anterior aspect of his left forearm resulting in a small abrasion, evidenced by the size and location of the injury relative to the pre-crash placement of the hands on the steering wheel rim. The expanding air bag propelled the left forearm forward into the windshield which resulted in multiple/small lacerations *(air bag related "fling" injury)*. This trajectory was evidenced by the type of injury sustained in conjunction with the spider-web type fracture identified to the lower left windshield area. The driver refused treatment. The combination of restraint options provided protection against further contact to the steering wheel hub/rim and potential serious injury.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	53 year old female
Height:	165 cm (65 in)
Weight:	82 kg (180 lb)
Seat Track Position:	Middle position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	NASS vehicle inspection, driver interview, police report
Eyeware:	Prescription glasses
Type of Medical Treatment:	Refused treatment

Front Right Passenger Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
(No codable injuries)	N/A	N/A

Front Right Passenger Kinematics

The 53 year old female front right passenger of the 1998 Saturn SL2 was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the middle position. Belt usage was confirmed by the lack of significant interior contacts and injury. At first impact with the tractor-trailer, she initiated a lateral trajectory in response to the 9 o'clock impact force (no associated injury reported). At second impact with the tractor-trailer, she initiated a forward trajectory in response to the 11 o'clock impact force and loaded the manual restraint and deployed redesigned passenger air bag. Contact to the deployed air bag resulted in a sprained left wrist. The front right passenger refused treatment. The combination of restraint options provided protection against further contact to the instrument panel area and potential serious injury.

REAR OCCUPANT DEMOGRAPHICS / INJURIES

The unrestrained 77 year old female passenger of the 1998 Saturn SL2 was seated in an upright posture in the rear left position. The NASS interview revealed she was unrestrained, further evidenced by the police report data. At first impact with the tractor-trailer, she initiated a lateral trajectory in response to the 9 o'clock impact force and loaded the door panel as evidenced by the scuff marks documented to this component, with no resulting injury reported. At second impact with the tractor-trailer, the passenger initiated a forward trajectory in response to the 11 o'clock impact force and loaded the front left seat back as evidenced by the scuff mark documented to this component; with no resulting injury reported. She sustained multiple/small lacerations to the posterior aspect of the left hand from flying glass (windshield glazing), evidenced by the location of the injury relative to the lack of disintegrated tempered glazing in the vehicle. The passenger refused treatment.

The unrestrained 82 year old male passenger of the 1998 Saturn SL2 was seated in an upright posture in the rear right position. The NASS interview revealed he was unrestrained, further evidenced by the police report data. At first impact with the tractor-trailer, he initiated a lateral trajectory in response to the 9 o'clock impact force (no associated injury reported). At second impact with the tractor-trailer, he initiated a forward trajectory in response to the 11 o'clock impact force (no associated injury reported). The passenger was uninjured in the collision.

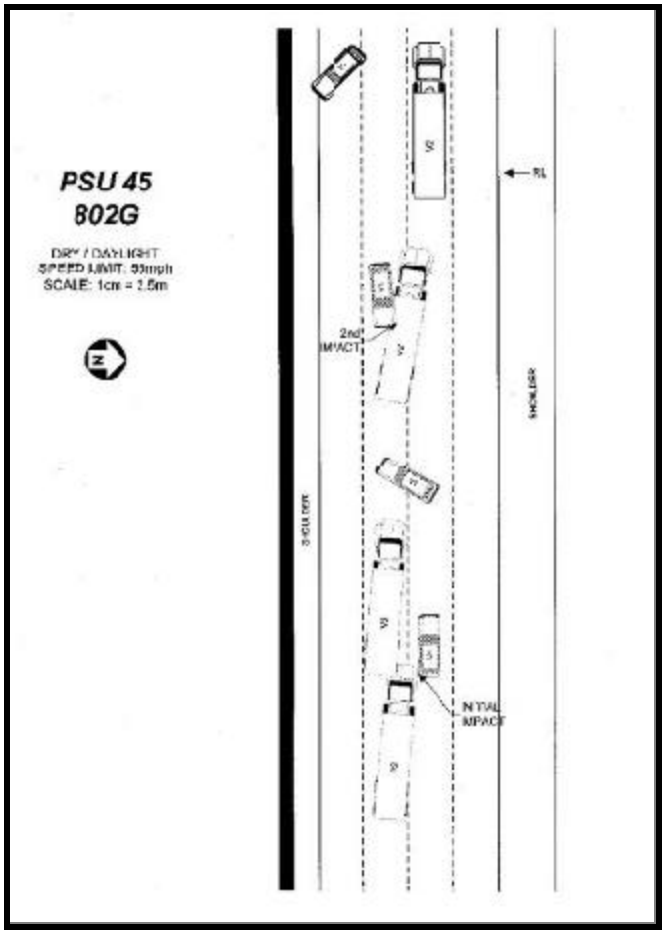

Figure 7. NASS Scene Diagram.