TRANSPORTATION SCIENCES
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VERIDIAN REMOTE SIDE IMPACT AIR BAG NON-DEPLOYMENT INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 02-02-069A

VEHICLE - 2001 VOLVO S40

LOCATION - STATE OF NEW YORK

CRASH DATE - AUGUST 2002

Contract No. DTNH22-01-C-17002

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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 remote investigation focused on the non-deployment of the Side Impact Protection System (SIPS) in a 2001 Volvo S40. The safety system included a seat back mounted side impact air bag and roof side rail mounted side impact curtain air bag. The 2001 Volvo S40 was also equipped with dual stage frontal air bags, safety belt retractor pretensioners and a Whiplash Protection System (WHIPS) for the front occupants. The Volvo was occupied by a restrained 57-year-old female driver. The Volvo was involved in a severe intersection crash with a 1998 Ford Econoline van. The Ford Econoline was a chassis/cab with a moving van body. The front of the 1998 Ford impacted the left side of the Volvo. The impact displaced the Volvo off-road where it impacted a cable guardrail system with its right side and roof respectively. The impact with 1998 Ford Econoline deployed the Volvo's front right airbag and fired the driver's safety belt pretensioner; however, the left SIPS did not deploy. The driver was transported by ambulance to a local hospital where she was admitted for treatment of her injuries. She expired four days post-crash. The driver sustained two posterior scalp abrasions, left abdomen contusion, left upper extremity contusion, left pelvis fracture, anterior pelvis fracture, inferior diaphragm laceration, posterior scalp contusion/subgaleal hematoma, left upper extremity abrasion, left spleen laceration, inferior colon laceration, fractures (unspecified region), and a cerebrum contusion (unspecified region). The driver of the Ford sustained police reported minor injuries and the front right occupant was reported as not injured.

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BACKGROUND

This remote investigation focused on the non-deployment of the Side Impact Protection System (SIPS) in a 2001 Volvo S40. The safety system included a seat back mounted side impact air bag and roof side rail mounted side impact curtain air bag. The 2001 Volvo S40 was also equipped with dual stage frontal air bags, safety belt retractor pretensioners and a Whiplash Protection System (WHIPS) for the front occupants. The Volvo was occupied by a restrained 57-year-old female driver. The Volvo **(Figure 1)** was involved in a severe intersection crash with a 1998 Ford Econoline van. The Ford Econoline was a chassis/cab with a moving van body. The front of the 1998 Ford impacted the left side of the Volvo. The impact displaced the Volvo off-road where it impacted a cable guardrail system with its right side and roof respectively. The impact with 1998 Ford Econoline deployed the Volvo's front right airbag and fired the driver's safety belt pretensioner; however, the left SIPS did not deploy. The driver was transported by ambulance to a local hospital where she was admitted for treatment of her injuries. She expired four days post-crash. The driver sustained two posterior scalp abrasions, left abdomen contusion, left upper extremity contusion, left pelvis fracture, anterior pelvis fracture, inferior diaphragm laceration, posterior scalp contusion/subgaleal hematoma, left upper extremity abrasion, left spleen laceration, inferior colon laceration, rib fractures (unspecified region), and a cerebrum contusion (unspecified region). The driver of the Ford sustained police reported minor injuries and the front right occupant was reported as not injured.

Figure 1. Volvo S40

This crash was identified by the National Automotive Sampling System (NASS) PSU 02 during the weekly sampling of Police Accident Reports (PARs). This crash was selected as CDS Case No. 02-02-069A. The NASS PSU performed the vehicle and scene inspections. The NASS researcher due to the owner not allowing permission did not inspect the Ford Econoline. Due to the non-deployment of the SIPS and the fatal injuries sustained by the driver, NHTSA assigned the tasks of case review and report preparation to the Veridian SCI team.

SUMMARY

Crash Site

This two-vehicle crash occurred during the daylight hours of August 2002 in the state of New York. At the time of the crash, there were no adverse weather conditions and the asphalt road surface was dry. The crash occurred at a "T" intersection of a north/south roadway that intersected an east/west roadway. The north/south roadway was configured with two travel lanes in each direction that were separated by a double-yellow centerline. The roadway curved right for southbound travel with an uphill grade. The north/south roadway was bordered with a cable guardrail system on the west road edge. The southbound lane of the roadway curved right prior to the intersection and had an uphill grade. The east/west roadway was bordered with a white fog line on the north road edge and cable guardrail on the south road edge. The westbound lane had a right turn lane that entered the north/south roadway. The westbound approach to the intersection curved slightly to the left and was level. Traffic flow through the intersection was controlled by a stop sign for southbound travel and no traffic controls were present for east/west travel. The posted speed limit for the north/south roadway was 64 km/h (40 mph) and 89 km/h (55 mph) for the east/west roadway. The NASS scene schematic is included as **Figure 13** of this report.

VEHICLE DATA – 2001 Volvo S40

The 2001 Volvo S40 was identified by the Vehicle Identification Number (VIN): YV1VS29511F (production sequence omitted). The odometer reading was unknown due to lack of power to the vehicle at the time of the inspection. The vehicle was a four-door sedan that was equipped with a 1.9-liter turbo charged, 4-cylinder engine, with front wheel drive and a 4-speed automatic transmission. The Volvo was also equipped with 4-wheel disc brakes with ABS and OEM alloy wheels. The tires on the Volvo were Michelin MXV4 radials, size P195/60R15. The 2001 Volvo was configured with front bucket seats with height adjustable head restraints. The second row was configured with a bench seat, which folded forward for cargo and height adjustable head restraints. The driver's seat was equipped with manual adjustments for seat track and recline adjustments.

Crash Sequence

Pre-Crash

The 57-year-old female driver of the 2001 Volvo S40 was operating the vehicle southbound on approach to the "T" intersection **(Figure 2)**. The driver of the 1998 Ford Econoline was operating the vehicle westbound on approach to the "T" intersection **(Figure 3)**. It was unknown if the driver of the Volvo came to a complete stop before entering the intersection. No pre-impact evidence was found at the crash site for the Volvo. Based on physical evidence documented at the scene by the NASS researcher, the driver of the Ford Econoline attempted to avoid the Volvo by steering left and braking with sufficient force to lock-up the front wheels of the van. The researcher documented 13.5m (44.3') of pre-impact skidmarks for the Ford.

Figure 2. Volvo approach to intersection.

Figure 3. Ford approach to intersection.

Crash

The frontal area of the Ford van impacted the left front side area of the Volvo. Resultant directions of force were 10 o'clock for the struck Volvo and within the 1 o'clock sector for the Ford van. The Barrier Equivalent Speed computed by the WinSMASH program was 41.0 km/h (25.4 mph) for the Volvo. The lateral crash to the Volvo deployed the front right passenger air bag and fired the driver's safety belt retractor pretensioner. The left side impact air bag system did not deploy.

The impact displaced the Ford laterally left as its momentum allowed the vehicle to continue forward. The vehicles remained engaged as they traversed the mouth of the intersection. The vehicles departed the south road edge west of the intersection. The physical evidence at the crash site yielded 19.5 m (63.9') of post-crash skid marks from the Ford van. A 3.2 m (10.5') lateral right front tire scuff from the Volvo was documented by the NASS researcher.

As the Volvo was carried off-road, the right side of the Volvo impacted a cable guardrail system. Two guardrail posts were deflected by the impact, which allowed the Volvo to penetrate under the cable system. The cable contacted the roof area of the Volvo as the vehicle came to rest under the guardrail **(Figure 5)**.

Figure 4. Area of impact.

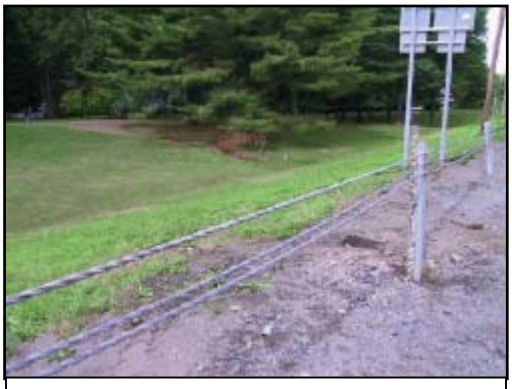

Figure 5. Volvo guardrail rail impact.

Post-Crash

The Ford came to rest against the left side of the Volvo off-road near the guardrail. The Volvo came to rest off-road engaged under the guardrail and against the Ford. The front left door was jammed closed from damage. Rescue personnel arrived on scene and cut the B-pillar and pried open the front left door of the Volvo to extricate the driver. She was transported by ambulance to a local hospital where she was admitted for treatment of her injuries. The driver succumbed to her injuries four days post-crash. The driver of the Ford sustained police reported visible injuries, however, he was transported. The front right passenger of the Ford Econoline was not injured.

VEHICLE DAMAGE

Exterior Damage - 2001 Volvo S40

The 2001 Volvo S40 sustained severe left side damage as a result of the impact with the 1998 Ford **(Figure 6)**. The left side damage involved a fractured left front axle, left front fender, hood, and both left side doors. The windshield was in place and holed from impact damage. The left front glazing was disintegrated from impact damage; however, it's not known if the left rear glazing was disintegrated by impact or rescue efforts. The left side damage began at the left front bumper corner and extended 282.0 cm (110.0") rearward and terminated 22.0 cm (8.6") forward of the left rear axle. The maximum crush was 37.0 cm (14.6"). The combined direct and induced damage was 306.0cm (120.5") in length. Six crush measurements were documented along the left side at the mid door level and were as follows: C1= 0.0 cm (0.0") C2= 10 cm (3.9") C3= 26 cm (10.2") C4= 26 cm (10.2") C5= 37 cm (14.6") C6= 9.0cm (3.5"). The Collision Deformation Classification for the left side impact to the Volvo was 10-LYAW-3.

Figure 6. Front left oblique.

The damage from the guardrail post on the right side was minor and was documented by the NASS researcher as being 22.0 cm (8.6") in length and located on the sill at the B-pillar area. No crush measurements were obtained by the NASS researcher. The Collision Deformation Classification for the post impact was 09-RPLN1. The damage from the guardrail cable was located on the right side of the Volvo beginning at the right A-pillar extending to the left roof. The damaged consisted of scuffs and the roof being crushed vertically approximately 10.2 cm (4.0"). The Collision Deformation Classification for this impact was 03-RYHW5

Interior Damage – 2001 Volvo S40

The 2001 Volvo S40 sustained moderate interior damage **(Figure 7)** as a result of the crash. The damage consisted of intrusion associated with exterior deformation and occupant contacts. The intrusions documented by the NASS researcher are identified in the following table:

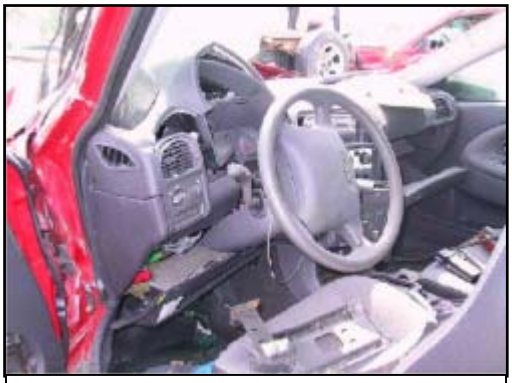

Figure 7. Interior damage from intrusion.

Intruded Component	Magnitude	Intrusion Direction
Front Right A-Pillar	16.0 cm (6.3”)	Vertical
Front Right Roof	3.0 cm to 8.0 cm (1.2” to 3.1”)	Vertical
Front Right Roof Side Rail	6.0 cm (2.4”)	Vertical
Front Right Windshield Header	10.0 cm (3.9”)	Vertical
Front Middle Roof	3.0 cm to 8.0 cm (1.2” to 3.1”)	Vertical
Front Middle Windshield Header	8.0 cm (3.1”)	Vertical
Front Left A-Pillar	9.0 cm (3.5”)	Lateral
Instrument Panel Left	8.0cm (3.1”)	Vertical
Front Left Door Panel	12.0cm (4.7”)	Lateral
Left B-Pillar	6.0cm (2.4”)	Lateral
Left Rear Door Panel	5.0cm (2.0”)	Lateral
Front Left Sill	6.0cm (2.4”)	Lateral
Front Left Side Panel Forward of A-Pillar	6.0 cm (2.4”)	Lateral
Rear Left Roof Side Rail	1.0cm (0.4”)	Lateral
Rear Left Roof	1.0cm (0.4”)	Vertical

As a result of the driver responding to the 10 o’clock direction of force, her upper and lower torso contacted the interior of the left door resulting in the occupant contact damage to the interior door panel. The damage consisted of denting, cracking and scuffing to the door panel **(Figure 8)**. The driver’s left knee also contacted and scuffed the left knee bolster.

Figure 8. Interior door panel occupant contacts.

Exterior Damage – 1998 Ford Econoline
The 1998 Ford Econoline chassis/cab with a moving van body was not located for inspection.

***MANUAL RESTRAINT SYSTEMS – 2001* Volvo S40**
The 2001 Volvo S40 was equipped with manual 3-point lap and shoulder belts for all five positions. The front safety belts were equipped with retractor-mounted pretensioners. The driver's safety belt was configured with a sliding latch plate and a belt-sensitive Emergency Locking Retractor (ELR). The driver's lap and shoulder belt was cut by rescue. The upper aspect of the driver's safety belt was restricted in the retractor by the fired pretensioner. The latch plate was buckled and the cut segments of the lap and shoulder belt webbing was located on the seat cushion. The front right safety belt pretensioner did not fire. The remaining safety belts were configured with sliding latch plates and belt-sensitive switchable ELR/Automatic Locking Retractors (ALR).

Side Impact Air Bag System - 2001 Volvo S40
The 2001 Volvo S40 was equipped with a Side Impact Protection System (SIPS) that consisted of front seat back mounted side impact air bags **(Figure 9)** and roof side rail mounted side curtains **(Figure 10)**. The SIPS did not deploy in this crash. The SIPS impact sensors were located in the lower B- and C-pillars. The inflatable curtain utilized stored gas cylinders located in the C-pillars to provide inflation. The NASS researcher pulled back the roof side rail trim cover allowing the inflatable curtain to be visible in its original non-deployed state.

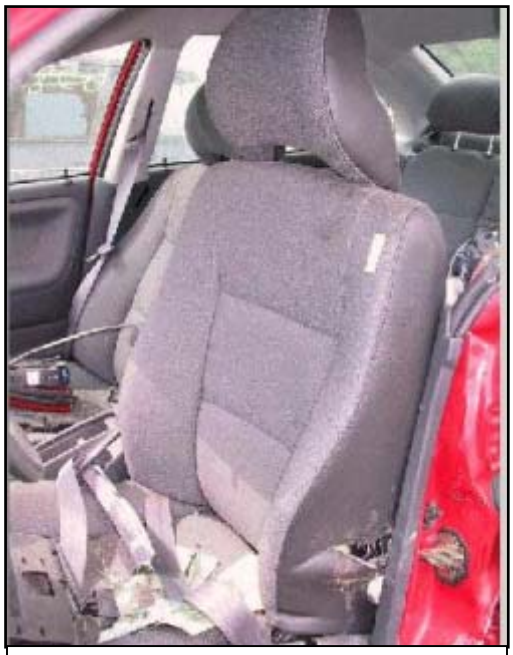

Figure 9. Driver safety belt cut by rescue.

Figure 10. Non-deployed curtain in left roof side rail.

Frontal Air Bag System-2001 Volvo S40

The 2001 Volvo S40 was equipped with dual-stage frontal air bags for the driver and front right passenger positions. The driver's frontal air bag did not deploy as a result of the impact with the Ford **(Figure 11)**, however, the front right airbag deployed **(Figure 12)**. Due to the lack of Electronic Data Recorder (EDR) data, the deployment stage was unknown. The front right air bag deployed from the top of the right instrument panel. The front right air bag measured 46.0 cm (18.1") in height and 37.0 cm (14.6") in width. The air bag module had two cover flaps. The top flap measured 32.0 cm (12.6") in width and 9.0 cm (3.5") in height. The bottom flap measured 32.0 cm (12.6") in width and 6.0 cm (2.4") in height. The air bag was vented by two ports at the 9 and 3 o'clock positions on the lateral aspects of the air bag. The air bag was not tethered.

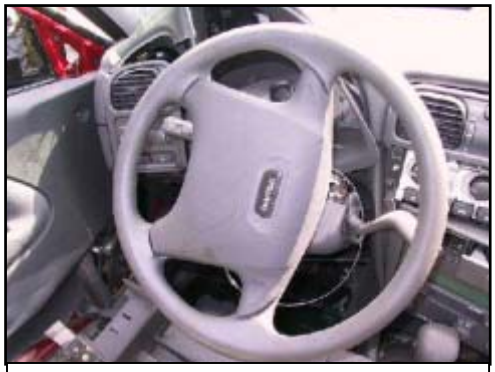

Figure 11. Non-deployed driver's frontal air bag.

Figure 12. Deployed front right air bag.

OCCUPANT DEMOGRAPHICS – 2001 Volvo S40

Driver

Age/Sex:	57-year-old female
Height:	152 cm (60")
Weight:	59 kg (130 lb)
Seat Track Position:	Between forward and mid track
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a hospital, admitted for treatment, and expired four days post crash

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Inferior diaphragm laceration [OIS grade II through IV (left diaphragm rupture)]	Serious (440604.3,8)	Left side door panel
Cerebrum contusion (unspecified region)	Serious (140602.3,9)	Unknown
Left pelvis fracture, NFS	Moderate (852600.2,2)	Left side door panel / armrest
Anterior pelvis fracture, NFS	Moderate (852600.2,5)	Left side door panel / armrest
Left spleen laceration, minor	Moderate (544222.2,2)	Left side door panel
Inferior colon laceration, NFS	Moderate (540820.2,8)	Left side door panel / armrest
Rib fractures (unspecified region)	Moderate (450220.2,9)	Unknown
Posterior scalp abrasion	Minor (190202.1,6)	Head restraint
Left abdomen contusion	Minor (590402.1,2)	Left side door panel / armrest
Left upper extremity laceration, NFS	Minor (790600.1,2)	Left side door panel / armrest
Posterior Scalp contusion/subgaleal hematoma	Minor (190402.1,6)	Head restraint
Left upper extremity abrasion	Minor (790202.1,2)	Left side door panel / armrest

Injury source: Emergency Room Records, Post-ER Records

Driver Kinematics and Injuries

The 57-year-old female driver of the 2001 Volvo S40 was seated in a presumed upright posture and restrained by the manual 3-point lap and shoulder belt. The seat was adjusted to a forward track position. At impact, the front right air bag deployed and the driver's safety belt pretensioner fired. The restrained driver initiated a lateral left and forward trajectory to the 10 o'clock impact force from the impact with the Ford. The driver was displaced into the intruding left door panel and loaded the plastic panel that resulted in the left abdomen contusion, left upper extremity laceration, left pelvis fracture, and left upper extremity abrasion. The loading also resulted in the left spleen laceration, anterior pelvis fracture, inferior colon laceration, and an inferior diaphragm laceration. The driver rebounded into the head restraint, which resulted in the posterior scalp abrasion and posterior scalp contusion/subgaleal hematoma. She also sustained rib fractures (unspecified region) and a cerebrum contusion (unspecified region) from unknown sources. The driver was transported by ambulance to a hospital where she was admitted however; she expired from her injuries four days post-crash.

Figure 13. NASS Scene Schematic