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CALSPAN REMOTE AIR BAG DEPLOYMENT CRASH INVESTIGATION

CALSPAN CASE NO. CA97-015

VEHICLE #1 - 1994 PLYMOUTH GRAND VOYAGER

VEHICLE #2 - 1984 MERCURY GRAND MARQUIS

VEHICLE #3 - 1985 BUICK REGAL

LOCATION - STATE OF FLORIDA

JANUARY, 1997

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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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15. <i>Supplementary Notes</i> Remote investigation of a three vehicle chain reaction crash between a 1994 Plymouth Grand Voyager (Vehicle #1), a 1984 Mercury Grand Marquis (Vehicle #2), and a 1985 Buick Regal (Vehicle #3) which the right front occupant in 1994 Plymouth Grand Voyager suffered head trauma, and abrasions of the face and neck from contact with the expanding front right air bag.			
16. <i>Abstract</i> <p>The crash occurred after the Buick entered the eastbound roadway from an intersecting roadway and subsequently stopped in the left lane to make a left turn at the next intersection. The Mercury which was traveling eastbound in the left lane applied the brakes in a reportedly quick stopping maneuver. Due to the bright sunlight from the setting sun, the driver of the Plymouth did not detect the Mercury's brake lights until he was too close. The frontal plane of the Plymouth struck the rear plane of the Mercury which subsequently struck the rear plane of the Buick.</p> <p>Vehicle #1 sustained minor damage with an assigned Collision Deformation Classification (CDC) code of 12-FDEW-1. The SMASH program computed the delta V as 20 km/h (12 mph) which was sufficient to deploy the Supplemental Restraint System (SRS). Driver #1, a 59 year old male who was 189.2 cm (74.5") tall, was reportedly using the three point manual lap and shoulder belt at the time of the crash. He sustained abrasions of the left forearm and hand from the deploying front left air bag.</p> <p>The right front passenger in the Plymouth, a ten year old male who was 154.9 cm (61.0") tall and weighed 54.4 kg (120.0 lb), was reportedly restrained by the lap and torso belt at the time of the crash. The deploying front right air bag contacted his facial and neck areas which resulted in severe abrasions of the forehead, nose, chin with denuding over both cheeks. The boy was transported via ambulance to a nearby medical treatment facility where he was admitted for overnight observation and released the following day.</p> <p>A third occupant in the Plymouth, a 9 year old male who was restrained by the restraint belt in the right seat of the second row, was not injured in the crash. The 33 year old female driver in the Mercury was not injured in the crash. The 18 year old female driver in the Buick was not injured in the crash.</p>			
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TABLE OF CONTENTS

Background 1
Summary 1
Vehicle #1 Damage 3
Supplemental Restraint System (SRS) 3
Vehicle Velocity Estimates 4
Collision Sequence 4
Human Factors/Occupant Data 5
Injury Data 5
Occupant Kinematics 7

CALSPAN AIR BAG DEPLOYMENT INVESTIGATION

CALSPAN CASE NO. CA97-015

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VEHICLE #3 - 1985 BUICK REGAL

LOCATION - STATE OF FLORIDA

JANUARY, 1997

BACKGROUND

This crash came to the attention of the Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) after it was discovered on a news wire service. It was reported that a ten year old boy sustained burns of the face from the passenger side air bag during the deployment sequence in a 1994 Plymouth Grand Voyager. Calspan was notified of the crash by the NHTSA and directed to ascertain the type and related cause of the facial burn described in the news article. This investigation was conducted as a remote effort.

SUMMARY

An investigation was conducted into a three vehicle chain reaction crash which occurred in the month of January, 1997 in the late afternoon hours in the State of Florida on a straight, four lane, undivided, dry roadway that had a posted speed limit of 64 km/h (40 mph). The weather at the time of the crash was dry with setting sunlight. The vehicles involved were a 1994 Plymouth Grand Voyager (Vehicle #1) which was equipped with dual front air bags, a 1984 Mercury Grand Marquis (Vehicle #2), and a 1985 Buick Regal (Vehicle #3).

The crash occurred after Vehicle #3 entered the eastbound roadway from an intersecting roadway and subsequently stopped in the left lane to make a left turn at the next intersection. Vehicle #2 which was traveling eastbound in the left lane applied the brakes in a reportedly quick stopping maneuver to avoid contact with the rear plane of Vehicle #3. Due to the bright sunlight from the setting sun, Driver #1 did not detect Vehicle #2's brake lights until he was too close to the rear plane of Vehicle #2. The frontal plane of Vehicle #1 struck the rear plane of Vehicle #2. Vehicle #2 was pushed forward and struck the rear of vehicle #3.



Figure 1
Frontal view of Vehicle #1

Vehicle #1 sustained minor damage with an assigned Collision Deformation Classification (CDC) code of 12-FDEW-1. The frontal area of the vehicle sustained damage to the front bumper, headlight mounting brackets, grille, and hood area. Bumper crush was estimated from a photograph at 3.8 cm (1.5") at the left corner and 5.1 cm (2.0") at the right corner as shown in **Figure #1**. The "Missing Vehicle" algorithm of the SMASH speed reconstruction program computed the delta V for Vehicle #1 as 20 km/h (12 mph) and 24 km/h (15 mph) for Vehicle #2.

During the first crash sequence event, the Supplemental Restraint System (SRS) in Vehicle #1 deployed as designed. Driver #1, a 59 year old male who was 189.2 cm (74.5") tall, was reportedly using the three point manual lap and shoulder belt at the time of the crash. He described his seat position as being adjusted in the full rear position.

Driver #1 indicated that after the deployment of the SRS, his breathing was impaired by the air bag generant inside the vehicle. The effect of the generant according to the driver was reduced due to the fact that the windows were open at the time of the crash. The outside temperature was reportedly at 24 degrees Celsius (76 degrees F).

During the SRS deployment sequence, the driver's left forearm and hand came in contact with the deploying front left air bag which resulted in abrasions of both areas. Although the driver described these lesions as chemical burns with "bubbling" of the skin, this lesion was more than likely the result of friction between the expanding air bag and his forearm/hand. He was not treated at a medical treatment facility following the crash. The police listed his injury severity as "not injured".

Driver #1 indicated that his titanium glass frames were bent as the result of the crash. This damage could have been the result of the driver's head moving forward during the crash sequence and contacting the inflated front left air bag. He reportedly did not sustain any lesion of the facial area.

The right front passenger in Vehicle #1, the driver's ten year old grandson who was 154.9 cm (61.0") tall and weighed 54.4 kg (120.0 lb), was reportedly restrained by the lap and torso belt at the time of the crash. This information was provided by the driver, the boy's mother, the police crash report, and medical records. Prior to the crash, the driver may have attempted to brake which would have resulted in the forward movement of the boy's upper body.

The boy was wearing corrective lenses for near sightedness at the time of the crash. As the boy's upper body moved into the air bag expansion zone, the expanding front right air bag contacted the glasses which resulted in a twisted broken frame. A vertical abrasion which began above the left eye lid and extended vertically onto the forehead was attributed to the fractured frame. The air bag contacted his facial area which resulted in severe abrasions of the forehead, nose, and chin with denuding over both cheeks. The air bag then contacted the anterior surface of his neck which resulted in multiple abrasions.

The boy rebounded back into the seat where he came to final rest.

The boy was transported via ambulance to a nearby medical treatment facility where he arrived thirty minutes after the crash. He was admitted for overnight observation and released the following day. He was seen three days later by a plastic surgeon where it was determined that reconstructive surgery was not warranted. His facial lesions were cleaned and he was seen again four days later where his condition had greatly improved. The boy was counseled by the doctor to use sun screen with a high SPF to prevent hyperpigmentation and demarcation of the adjacent non-injured area. Additional follow-up appointments with the physician were not required.

A third occupant in Vehicle #1, a 9 year old male who was restrained by the restraint belt in the right seat of the second row, was not injured in the crash. The boy weighed 25.4 kg (56.0 lb.) and was the brother of the right front occupant.

Vehicle #2 sustained a police estimated damage of \$1,000 and was driven from the scene. The 33 year old female driver, who was reportedly using the restraint belt, was not injured in the crash. There were no other occupants in this vehicle.

Vehicle #3 sustained a police estimated damage of \$300 and was also driven from the scene. The 18 year old female driver, who was reportedly using the restraint belt, was not injured in the crash. There were no other occupants in this vehicle.

VEHICLE DAMAGE

Vehicle #1 - Exterior:

Direct contact damage to Vehicle #1 involved the entire frontal plane which was estimated at 151.0 cm (59.4"). The maximum crush was estimated at 5.1 cm (2.0") and was located 35.5 cm (14.0") left of the right front bumper corner (refer to **Figure 1**). Components damaged in the crash included the front bumper, the both front headlight assemblies, the grille, and hood.

The assigned CDC for Vehicle #1 was 12-FDEW-1.

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

The dual front air bag supplemental restraint system (SRS) in the 1994 Plymouth Grand Voyager deployed during the impact sequence with Vehicle #2. There were no photographs available of the vehicle interior to determine occupant contact evidence.

The front left air bag (based on other case investigations of a similar vehicle) was a nontethered air bag with two vent ports located in the upper portion of the air bag. The front right air bag was a top mount design which incorporated a single flap. The air bag was tethered with no visible vent ports. The

driver indicated that the instrument panels sustained damage as the result of the air bag deployment. It was not known whether there were artifacts visible on the air bag surface or other interior components from occupant contact.

Based on photographs of the right front occupant in Vehicle #1 and the medical description of his facial and neck injuries, it was theorized that the boy's facial area was within the expansion zone of the air bag during the SRS deployment cycle. The driver may have attempted to avoid the crash by applying the brakes which would have resulted in the forward movement of the boy's upper torso and placed it within the air bag expansion zone at the time of deployment.

VEHICLE VELOCITY ESTIMATES

The "Missing Vehicle" algorithm of the SMASH speed reconstruction program computed the delta V for Vehicle #1 as 20 km/h (12 mph) and 24 km/h (15 mph) for Vehicle #2. Vehicle damage inputs were based on a visual estimate of frontal damage as shown in **Figure 1**. The crush estimated at the left front bumper corner was 3.8 cm (1.5") and 5.1 cm (2.0") at the right front corner.

	Vehicle #1	Vehicle #2
Total ΔV :	20.0 km/h (11.0 mph)	24.0 km/h (15.0 mph)
Longitudinal ΔV :	-20.0 km/h (-11.0 mph)	15.0 km/h (15.0 mph)
Lateral ΔV :	0 km/h (0 mph)	0 km/h (0 mph)
Energy Absorption:	16,461 joules (12,139 ft-lb)	41,289 joules (30,449 ft-lb)

COLLISION SEQUENCE

Pre-Crash:

Vehicle #3 made a right turn at a four leg intersection and proceeded a short distance eastbound in the left lane of a four lane undivided roadway when the driver stopped to make a left turn into a local roadway. Vehicle #2 was traveling in the left eastbound travel lane and had just passed through the green traffic control light when it encountered Vehicle #3. The sudden action of Vehicle #3 resulted in a quick braking response from Driver #2 in order to avoid striking the rear plane of this vehicle.

Vehicle #1 was traveling behind Vehicle #2 and due to the low setting sun did not see Vehicle #2's brake lights in time to avoid the crash. Driver #1 indicated that he had stopped at the traffic light and had just accelerated to an estimated speed of 40 km/h (25 mph) after the light turned green when he realized that Vehicle #2 had stopped. He was not sure whether he had applied the brakes prior to the crash.

Crash:

The front plane of Vehicle #1 struck the rear plane of Vehicle #2 which actuated the SRS deployment sequence. Vehicle #2 was subsequently pushed forward and struck the rear of Vehicle #3.

Post Crash:

Final Rest -The three vehicles came to rest in the left eastbound travel lane.

Police Activities - The local police department arrived on-scene within four minutes of the crash notification.

Rescue Activities - EMT personnel arrived and transported the boy in Vehicle #1 via ambulance to a local medical treatment facility where he arrived thirty minutes after the reported time of the crash. The right front occupant was admitted overnight for treatment and observation and discharged the next day.

Scene Clearance - Vehicle #1 was towed from the scene due to damage while Vehicle #2 and Vehicle #3 were driven from the scene.

HUMAN FACTORS/OCCUPANT DATA

Vehicle #1	Driver	Right Front	Right Second Row
Age/Sex	59 year old male	10 year old male	9 year old male
Height:	189.2 cm (74.5")	154.9 cm (61.0")	Unknown
Weight:	Unknown	54.4 kg (120.0 lb.)	25.4 kg (56.0 lb.)
Manual Restraint System Usage:	Three point lap and torso restraint belt	Three point lap and torso restraint belt	Three point lap and torso restraint belt
Usage Source:	Police report, interviewee	Police report, interviewee, medical records	Police report
Eyewear:	Corrective lenses	Corrective lenses	Unknown
Vehicle Familiarity:	Familiar		
Route Familiarity:	Unknown		

Type of Medical Treatment:	Not transported to medical facility	Transported to medical facility and admitted for overnight observation, two follow-up treatment sessions with a private physician	Not injured
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INJURY DATA

Following the crash, the right front occupant in Vehicle #1 was transported to a medical facility where he was admitted overnight for treatment and observation. The patient had abrasions of the facial area and anterior neck and head trauma. Driver #1 reportedly suffered abrasions of the left forearm and hand, but was not treated. The following table identifies the type of injury, the related AIS-90 injury code, and the injury source:

VEHICLE #1 DRIVER INJURIES	INJURY SEVERITY AIS-90	INJURY SOURCE
1. Abrasion of the left forearm and hand	790202.12	Front left air bag

VEHICLE #1 RIGHT FRONT OCCUPANT INJURIES	INJURY SEVERITY AIS-90	INJURY SOURCE
1-3. Severe facial abrasions with denuding of both cheek areas.	290099.10 290800.11 290800.12	Front right air bag
4. Abrasion of the left eyelid	297202.12	Front right air bag
5. Abrasion of the forehead	290202.17	Fractured eye glass frame
6. Multiple abrasions of the anterior neck	390202.10	Front right air bag

VEHICLE #1 RIGHT FRONT OCCUPANT INJURIES	INJURY SEVERITY AIS-90	INJURY SOURCE
<p><i>Supplemental discussion:</i> Anterior surface of most of the child's face showed severe abrasions with denuding of most of the skin of his face, especially the cheeks. All of the lesions, however, appear to be only involving the epidermis and maybe just the top portion of the dermis. In the emergency room, a CT scan did not show increased intracranial pressure, but it was somewhat suspicious and the child had some evidence of waxing and waning level of consciousness in the emergency room and as a result he was admitted.</p>		
7. Amnesia, no loss of consciousness, GCS-15, does not remember accident	160410.20	Front right air bag

Driver#1 and the boy's mother indicated that the child had sustained chemical burns to the face. Medical records from the medical treatment facility indicated the child had sustained severe abrasions of the facial area with no mention of burn type lesions. Post discharge physician's office records indicated the following: "The patient has what appears to be 1st and 2nd degree burns of the entire face including the forehead, cheeks, nose, lips and chin. There is heavy crust of non-debrided tissue and caked on antibiotic ointment which requires removal by debridement and cleansing."

OCCUPANT KINEMATICS

Driver #1 indicated to police that his 10 year old grandson seated in the front seat was restrained by the manual three point lap and torso restraint belt at the time of the crash. The boy's injury pattern, however, indicated that the child's upper torso was within the expansion zone of the deploying front air bag.

During the pre-impact phase of the crash, the Driver #1 may have reacted to the sudden stop of Vehicle #2 and applied the brakes. This braking action would have resulted in the forward movement of the child's upper torso toward the instrument panel. The lap and shoulder belt would have limited the travel distance of his upper torso and probably resulted in a forward pitching of his head. The expanding front right air bag then contacted the boy's facial area resulting in severe abrasions of the face with denuding of both cheeks and head trauma. As the air bag continued to expand, it contacted the anterior surface of the child's neck. He rebounded and came to rest in the right front seat.