Advanced Occupant Protection System Crash Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS02020
2003 Toyota Corolla CE four door
Washington
August, 2002

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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 be 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 Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient Catalog No.
DS02020		

4. Title and Subtitle	5. Report Date
Advanced Occupant Protection System Crash Investigation	October 8, 2003
	6. Performing Organization Report No.

7. Author(s)	8. Performing Organization Report No.
Dynamic Science, Inc.	

9. Performing Organization name and Address	10. Work Unit No. (TRAIS)
Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401	11. Contract or Grant no. DTNH22-94-D-27058

12. Sponsoring Agency Name and Address	13. Type of report and period Covered [Report Month, Year]
U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590	14. Sponsoring Agency Code

15. Supplemental Notes

16. Abstract

This two-vehicle crash occurred in August, 2002 at 1609 hours. The crash occurred on a straight portion of a four-lane roadway exiting/entering an interstate interchange. The road surface is bituminous and the weather was clear and dry. The posted speed limit for the four-lane undivided roadway is 48 km/h (30 mph). The case vehicle is an Advanced Occupant Protection System equipped 2003 Toyota Corolla four-door that was being driven by a properly restrained 23-year-old female. The driver was wearing metal framed sunglasses and contact lenses. She was seated in a fabric covered bucket seat that was adjusted to the forward most track position. The case vehicle was traveling westbound in the second lane from the right of the four-lane roadway. This vehicle had just exited from the northbound freeway. The case vehicle was equipped with multi-stage driver and front right passenger air bags, and front seat belt pretensioners with force limiters. The other vehicle is a 1992 Nissan Pathfinder 4x4 driven by a restrained 37-year-old female. The front right seat was occupied by a restrained 48-year-old male. This vehicle had also just exited the northbound freeway and was traveling westbound. The driver had missed her turn and needed to return to the freeway. She began a left hand U turn to travel east. At this time she encroached into the path of the case vehicle. The front of the case vehicle struck the left side of the other vehicle. Both frontal air bags and seat belt pretensioners deployed at this time.

The driver of the case vehicle sustained contusions to both knees, her abdomen, and center chest (AIS=1). The knee contusions were a result of contact with the lower instrument panel. The contusions to her chest and abdomen were related to her seat belt usage. She was assisted from the vehicle by other drivers. She was transported by ground ambulance to a local hospital for treatment. The contusion to her right knee was more serious than the one on her left knee. At the time of the interview (two months post-crash), she was still undergoing physical therapy.

17. Key Words	18. Distribution Statement
Air bag, deployment, injury, AOPS, multistage, EDR	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price

Dynamic Science, Inc.
Accident Investigation
Case Number: DS02020

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BACKGROUND:

Description:	This Advanced Occupant Protection System (AOPS) case was selected by the NHTSA in their weekly General Estimates System review. DSI was notified of this potential AOPS case by NHTSA on September 27, 2002. DSI located and obtained permission to inspect the case vehicle on October 4, 2002. On October 7, 2002 the vehicle's current owners were provided with a permission slip that allows DSI to remove the electronic control unit and return it to the owner at some later date. DSI was assigned the case on October 8, 2002. Field work was completed on October 10, 2002.
Investigation Type:	On-scene
Crash Location:	Washington
Crash Date:	August, 2002
Assigned Date:	October 8, 2002
Field Work Completed:	October 10, 2002

SUMMARY:

Figure 1. Approach to area of impact (leaving interstate)

This two-vehicle crash occurred in August, 2002 at 1609 hours. The crash occurred on a straight portion of a four-lane roadway exiting/entering an interstate interchange. For westbound travel, the roadway is comprised of a right hand curved southbound interstate off-ramp leading into the right lane of the roadway and a left hand curved northbound interstate off-ramp leading into the second westbound travel lane. For eastbound travel, the roadway is comprised of two eastbound travel lanes that split into a single on-ramp for the northbound interstate and two on-ramps for the southbound interstate. The west and eastbound travels lanes are separated by double yellow lines. The road surface is bituminous and the weather was clear and dry. The posted speed limit for the four-lane undivided roadway is 48 km/h (30 mph).

The case vehicle is a 2003 Toyota Corolla four-door that was being driven by a properly restrained 23-year-old female (152 cm/60 in, 54 kg/120 lbs). The driver was wearing metal framed sunglasses and contact lenses. She was seated in a fabric covered bucket seat that was adjusted to the forward most track position. The case vehicle was traveling westbound in the second lane from the right of the four-lane roadway. This vehicle had just exited from the northbound freeway. The case vehicle was equipped with multi-stage driver and front right passenger air bags, and front seat belt pretensioners with force limiters.

Figure 2. Overview of impact area (other vehicle approaches from ramp to the right)

Figure 3. Front right, case vehicle

The other vehicle is a 1992 Nissan Pathfinder 4x4 driven by a restrained 37-year-old female. The front right seat was occupied by a restrained 48-year-old male. This vehicle had also just exited the northbound freeway and was traveling westbound. The driver had missed her turn and needed to return to the freeway. She began a left hand U turn to travel east. At this time she encroached into the path of the case vehicle. The front of the case vehicle (81FDEW2–incremented for shift) struck the left side of the other vehicle. The total velocity change calculated by the Missing Vehicle algorithm of the WINSMASH collision model[1] was 37 km/h (23.0 mph). The longitudinal and lateral delta V components were -32 km/h (-19.9 mph) and -18.5 km/h (-11.5 mph), respectively. Both frontal air bags deployed and seat belt pretensioners actuated at this time.

The driver of the case vehicle sustained contusions to both knees, her abdomen, and center chest (AIS=1). The knee contusions were a result of contact to the lower instrument panel. The contusions to her chest and abdomen were related to her seat belt usage. She was assisted from the vehicle by other drivers. She was transported by ground ambulance to a local hospital for treatment. The

[1]Calculated using stiffness values derived from NCAP test 2859

contusion to her right knee was more significant than the one on her left knee. At the time of the interview (two months post-crash), she was still undergoing physical therapy.

It was reported that the driver of the other vehicle was transported to a local hospital for treatment. It is not known if there were any injuries.

Both vehicles were towed from the scene due to damage. The case vehicle was later declared a total loss by the insurance company.

The air bag control module ECU (Toyota part number 89170-02190) was harvested from the case vehicle and sent through NHTSA to the manufacturer for possible interpretation. As of the time of this report, the interpretation has yet to be provided to the Agency. When/if the interpretation is provided to the Agency, it will be included as an addendum to this report.

Scene Diagram

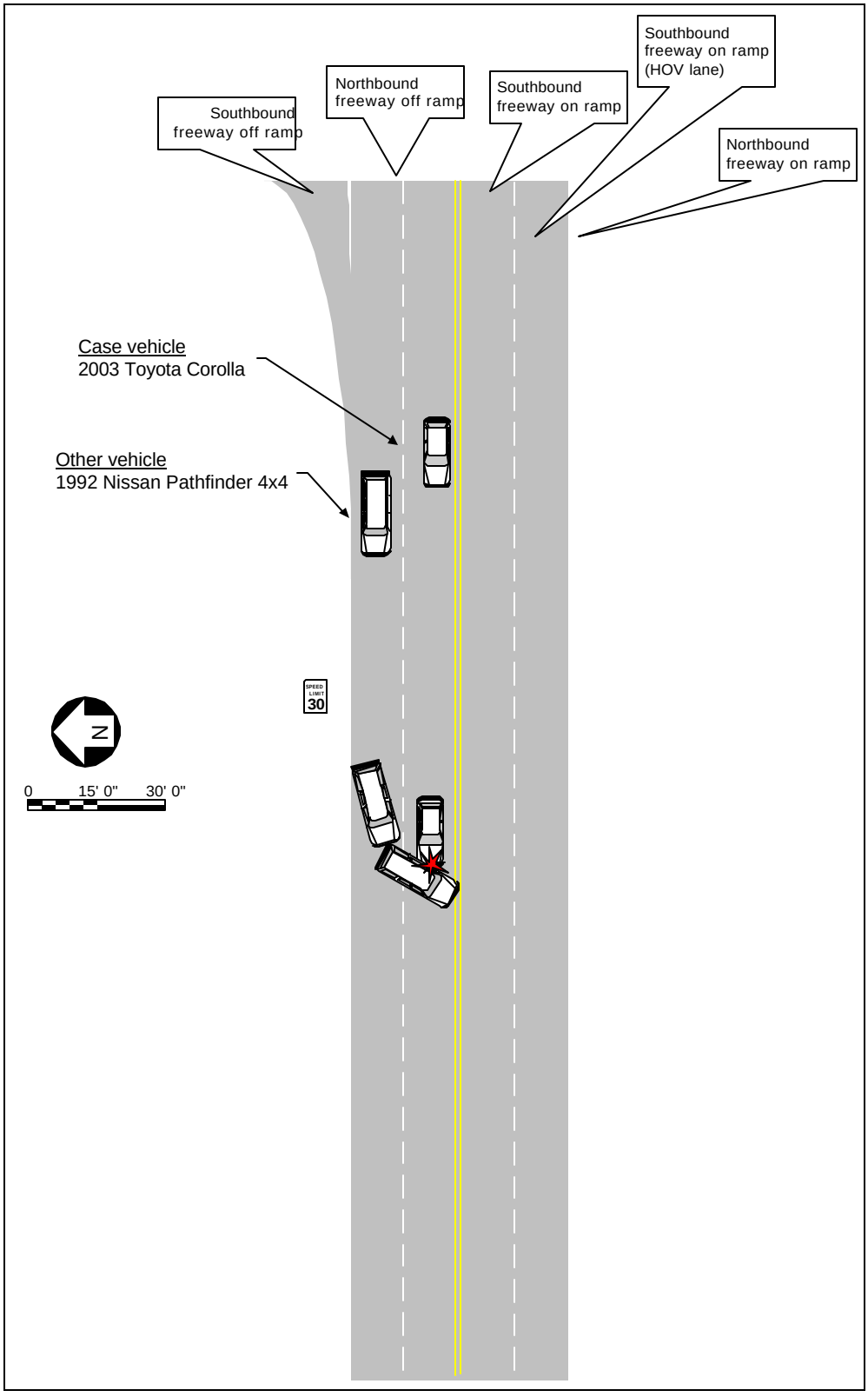

Figure 4. Scene diagram

DETAILED INFORMATION

Vehicles

Case vehicle		
Description:	2003 Toyota Corolla CE four door	
VIN:	1NXBR32EX3Zxxxxxx	
Odometer:	Unknown, electronic display	
Engine:	1.8 L, 4 cylinder	
Reported Defects:	None	
Cargo:	None	
Damage Description:	Bumper fascia and reinforcement bar, the radiator supports, hood, and both fenders. Towed from the scene due to damage. Vehicle declared a total loss by insurance company.	
CDC:	81FDEW2	
Delta V:	Total	37 km/h (23 mph)
	Longitudinal	-32.0 km/h (-19.9 mph)
	Latitudinal	-18.5 km/h (-11.5 mph)
	Energy	31,260 joules (23,056 ft-lbs)

The case vehicle sustained 118 cm (46.5 in) of direct contact damage that started at the front right and extended to the left. The residual crush measured along the bumper reinforcement bar was as follows: C1=12.0 cm (4.7 in), C2=15.0 cm (5.9 in), C3=21.5 cm (8.5 in), and C4=27.5 cm (10.8 in). The maximum crush was located at C4. The reinforcement bar had been shifted to the left by approximately 30 cm (11.8 in). The principle direction of force was within the 1 o'clock sector and was an estimated 30 degrees. The impact energy was managed by the forward structures of the vehicle. The damaged components included the bumper fascia and reinforcement bar, the radiator supports, hood, and both fenders. The right wheelbase had been shortened by 1 cm (0.4 in). There was a single fracture to the right side of the windshield that occurred as a result of the front right air bag deployment. The right rear door was jammed shut. The right front door and left doors all remained closed and operational.

Figure 5. Front, case vehicle

Figure 6. Right side, crush depth

AOPS/Safety Systems Discussion

The driver's manual restraint system consisted of a continuous loop 3-point lap and shoulder belt with a sliding latch. The emergency locking retractor was located in the B-pillar. The front seat belts were equipped with pretensioners and force limiters, in addition to adjustable shoulder anchors. Both pretensioners actuated during the crash. The driver's seatbelt was locked in the extended position. The front right passenger seatbelt was locked in the stowed position. The front right seat and all rear seat positions were equipped with switchable automatic/emergency locking retractors.

Figure 7. Driver's seated position showing deployed air bags

The case vehicle was also equipped with multi-stage driver and front right passenger air bags.

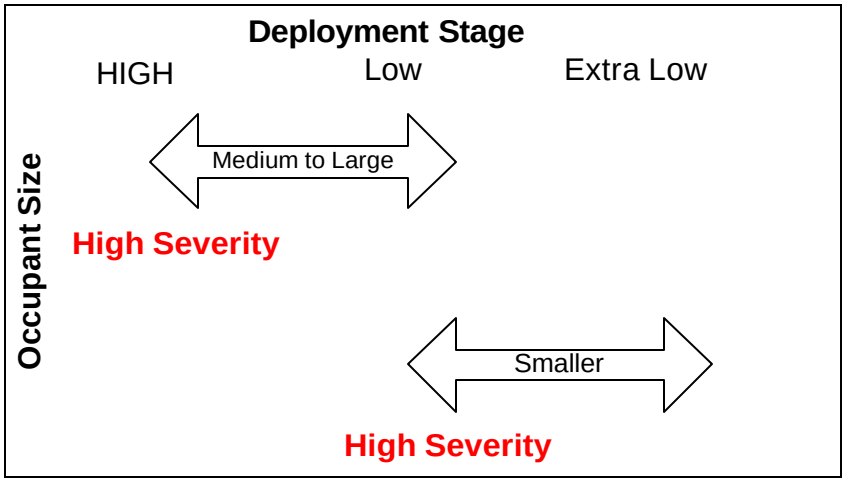

Figure 8. Driver's air bag deployment logic

The driver's air bag has a three-stage deployment sequence based on impact severity and the position of the driver seat. A seat position sensor judges the size of the occupant based on the seat position. The driver's air bag will deploy at a faster rate (high stage) or slower rate (low stage) for medium and large size occupants, depending on impact severity. The driver's air bag will deploy at low stage, or extra-low stage for smaller occupants, depending on impact severity. Based on the known seat track position (fully forward), the air bag should have deployed at a low or extra low stage with the latter being the most likely.

The passenger air bag has a two-stage deployment sequence based on the severity of the impact. This provides either a "faster" or a "slower" deployment as deemed appropriate.

Both front air bags deployed during the crash. The circular driver's front air bag was mounted in the

steering wheel hub and measured 60 cm (24 in) in diameter. The air bag was equipped with two vents ports–located at the 10 and 2 o'clock positions-- and one tether. The "Y" type module cover opened at the designed tear points and there was no damage to the cover. There was no damage to the air bag nor any occupant contacts found. There was no steering wheel rim deformation nor any steering column movement.

The rectangular front right air bag was mounted in the top of the instrument panel and measured 42 cm (17 in) wide by 53 cm (21 in) high. The air bag was equipped with two vents–located at the 3 and 9 o'clock positions. The dual module cover flaps opened at the designed tear points and there was no damage to the covers. There was no damage to the air bag nor any occupant contacts found.

Figure 9. Scuffing to driver's seatbelt

Other vehicle

Description:	1992 Nissan Pathfinder 4x4 utility vehicle	
VIN:	JN8HD17Y0NWxxxxxxx	
Odometer:	Unknown	
Engine:	3.0L, V6	
Reported Defects:	None	
Cargo:	Unknown	
Damage Description:	Per police report, moderate damage to left side from the driver's door rearward. Vehicle towed from the scene due to damage.	
CDC:	Unknown	
Delta V:	Total	22.0 km/h (13.7 mph)
	Longitudinal	-7.5 km/h (-4.7 mph)
	Latitudinal	20.7 km/h (12.8 mph)
	Energy	98,711 joules (72,806 ft lbs)

Occupants

Case vehicle	Occupant 1
Age/Sex:	23/Female
Seated Position:	Front left
Seat Type:	Fabric covered bucket seat. Seat adjusted to forward most track position. Seat back slightly reclined.
Height:	152 cm (60 in)
Weight:	54 kg (120 lbs)
Occupation:	Student
Pre-existing Medical Condition:	None
Alcohol/Drug Involvement:	None
Driving Experience:	5-6 years
Body Posture:	Normal, upright
Hand Position:	Both hands on wheel.
Foot Position:	Right foot on brake, left on floorboard
Restraint Usage:	Lap and shoulder belt, used. Pretensioner actuated.
Air bag:	Steering wheel mounted air bag, deployed. Low or extra low stage.

Other vehicle	Occupant 1	Occupant 2
Age/Sex:	37/Female	48/Male
Seated Position:	Front left	Front right
Seat Type:	Unknown	Unknown
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	Unknown	Unknown
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report	Lap and shoulder belt used, per police report

Injuries and Injury Mechanisms

Case vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Bilateral knee contusions	890402.1,1 890402.1,2	924.11 924.11	Left instrument panel
	Chest contusion	490402.1,4	922.1	Seat belt
	Middle abdomen contusion	590402.1,4	922.2	Seat belt

Other vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Contusions, unknown location	990200.1,9	924.9	Unknown
Front right occupant:	Contusions, unknown location	990200.1,9	924.9	Unknown

Occupant Kinematics

The 23-year-old female driver of the case vehicle was seated in a fabric covered bucket seat that had been adjusted to the forward most track position. She was seated in a normal, upright fashion, and was facing straight ahead with her hands at the 10 and 2 o'clock positions on the steering wheel rim. She was using the available lap and shoulder belts with the shoulder belt upper anchorage adjustment in the full down position. She was wearing metal framed sunglasses and contact lenses. Prior to impact, the driver began braking and steering to the left. The braking motion likely began loading the seatbelt. Upon impact, both front pretensioners actuated and the frontal air bags deployed. The driver responded to the 1 o'clock direction of force by exhibiting a forward and slightly right trajectory and loading the pretensioned and locked manual restraint system. Her upper torso contacted the deployed driver air bag and her knees contacted the lower instrument panel. The driver sustained contusions to both knees from the instrument panel contact. She also sustained chest and middle abdomen contusions from contact with the seatbelt.

Figure 10. Driver's seated area

Figure 11. Knee contact (scuff)