CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE CERTIFIED ADVANCED-208 COMPLIANT VEHICLE CRASH INVESTIGATION

SCI CASE NO. – CA06-012

SUBJECT VEHICLE – 2006 TOYOTA COROLLA

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE – MARCH 2006

Contract No. DTNH22-01-C-17002

Prepared for:

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

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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. CA06-012	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Calspan On-Site Certified Advanced 208-Compliant Vehicle Crash Investigation Vehicle: 2006 Toyota Corolla Location: State of Pennsylvania		*5. Report Date*: October 2006 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Transportation Sciences Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* C00410.0000.0351 *11. Contract or Grant No.* DTNH22-01-C-17002	
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 Report Crash Date: March 2006 *14. Sponsoring Agency Code*	
15. Supplementary Note This on-site investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in a 2006 Toyota Corolla.			
16. Abstract This on-site investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in a 2006 Toyota Corolla. A CAC vehicle is certified by the manufacturer to be compliant to Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVCC) No. 208. The safety system included dual stage frontal air bags, safety belt buckle switch sensors, safety belt retractor pretensioners, and an occupant detection sensor for the front right seat. The Toyota also utilized an Air bag Control Module (ACM), which had Event Data Recording (EDR) capabilities. The EDR module was removed from the vehicle with insurance company approval and was forwarded to NHTSA for download by Toyota. The EDR data is summarized in the Event Data Recorder section of this report. The Toyota was occupied by an unrestrained 28-year-old male driver and was involved in a front-to-rear collision with a legally parked 2001 GMC 5500 step van. The front plane of the Toyota impacted the rear of the GMC. This collision resulted in the deployment of the driver's frontal air bag and the firing the driver's retractor pretensioner. The driver of the Toyota sustained evident injuries and transported to a local hospital where he was treated and released.			
17. Key Words Frontal Air Bag Deployment Certified Advanced 208-Compliant Safety System		*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*

TABLE OF CONTENTS

CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION
SCI CASE NO. – CA06-012
SUBJECT VEHICLE – 2006 TOYOTA COROLLA
LOCATION - STATE OF PENNSYLVANIA
CRASH DATE – MARCH 2006

BACKGROUND

This on-site investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in a 2006 Toyota Corolla **(Figure 1)**. A CAC vehicle is certified by the manufacturer to be compliant to Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVCC) No. 208. The safety system included dual stage frontal air bags, safety belt buckle switch sensors, safety belt retractor pretensioners, and an occupant detection sensor for the front right seat. The Toyota also utilized an Air bag Control Module (ACM), which had Event Data Recording (EDR) capabilities. The EDR module was removed from the vehicle with insurance company approval and was forwarded to NHTSA for download by Toyota. The EDR data is summarized in the Event Data Recorder section of this report. The Toyota was occupied by an unrestrained 28-year-old male driver and was involved in a front-to-rear collision with a legally parked 2001 GMC 5500 step van. The front plane of the Toyota impacted the rear of the GMC. This collision resulted in the deployment of the driver's frontal air bag and the firing the driver's retractor pretensioner. The driver of the Toyota sustained evident injuries and transported to a local hospital where he was treated and released.

Figure 1. 2006 Toyota Corolla subject vehicle.

This crash was identified by the National Highway Traffic Safety Administration (NHTSA) through the review of Police Accident Reports (PAR's) that were submitted by the General Estimate System (GES). The PAR identified the Certified Advanced 208-Compliant Toyota that had been involved in a crash. The PAR was forwarded to the Calspan Special Crash Investigations (SCI) team for follow-up investigation. The Toyota was located at an insurance auction facility and cooperation was established with the facility to inspect the vehicle and remove the ACM. An on-site investigation was assigned to the Calspan SCI team on May 17, 2006. The vehicle and crash site were inspected on May 23, 2006.

SUMMARY

Crash Site

This crash occurred during the daylight hours of March 2006. At the time of the crash, the weather was clear with no adverse conditions. The crash occurred on the shoulder of a local east/west roadway. The east and westbound lanes were configured with two through traffic lanes, a center left turn lane, and asphalt shoulders. The travel lanes were separated by a raised grass median with barrier curbs. Mountable curbs that were intersected by driveways bordered the roadway. The posted speed limit for the roadway was 64 km/h (40 mph). The scene schematic is included as **(Figure 11)** of this report.

Vehicle Data – 2006 Toyota Corolla

The 2006 Toyota Corolla was identified by the Vehicle Identification Number (VIN): 1NXBR32E75 (production sequence omitted). The odometer reading at the time of the inspection was unknown due to the expended vehicle battery. The vehicle was a four-door sedan that was equipped with a 1.8-liter, four-cylinder engine, 4-speed automatic transmission, front-wheel drive, power front disc and rear drum brakes, OEM steel wheels with plastic wheel covers, power steering, and a tilt steering wheel. The Toyota was configured with GoodYear Integrity tires, size P185/65R15. The manufacturer recommended front and rear tire pressure was 207 kPa (30 PSI). The specific tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	248 kPa (36 PSI)	6 mm (8/32)	No	No
LR	262 kPa (38 PSI)	7 mm (9/32)	No	No
RF	248 kPa (36 PSI)	6 mm (8/32)	No	No
RR	262 kPa (38 PSI)	7 mm (9/32)	No	No

The seating positions in the Toyota were configured with cloth upholstered front bucket seats with height adjustable head restraints. The front seat head restraints were adjusted to the full-down position at the time of the vehicle inspection. The second row was configured with a cloth upholstered three-passenger split bench seat (60/40) and height adjustable head restraints. The rear right and center head restraints were adjusted to full-down position. The rear left head restraint was removed and located on the floor in the rear of the vehicle.

2001 GMC 5500 Step Van

The 2001 GMC 5500 step van was located at a repair facility where the repairs were nearly complete. Due to the repair status of this vehicle, the GMC was not inspected during this on-site investigation.

Crash Sequence

Pre-Crash

The restrained 28-year-old male driver of the 2006 Toyota Corolla was operating the vehicle westbound on the two-lane roadway **(Figure 2)**. Witnesses to the crash reported to the police that the driver of the Toyota was weaving in and out of the travel lanes and the shoulder at a high rate of speed. The 2001 GMC was legally parked on the shoulder and was unoccupied. As the driver continued to operate the Toyota in this manor, he entered the shoulder and failed to detect the parked GMC.

Figure 2. Pre-crash travel direction for the Toyota.

Figure 3. Area of impact with the parked GMC.

Crash

The front of the Toyota impacted the rear of the parked GMC on the shoulder **(Figure 3)**. Due to the height of the GMC, the Toyota pitched downward as the vehicle crushed. This impact produced an underride damage pattern to the front of the Toyota. The resulting directions of force were 12 o'clock for the Toyota and 6 o'clock for the GMC. The GMC was beyond the scope of the WINSMASH program; therefore, the WINSMASH program's barrier equivalent algorithm was used to calculate a delta-V for the Toyota. The total delta-V for the Toyota was 30.0 km/h (18.6 mph). The longitudinal and lateral components were -30.0 (-18.6 mph) and 0 km/h, respectively. The Toyota's EDR maximum recorded delta-V was 42 km/h (26.1 mph) at 153.6 milliseconds, which was consistent with the damage to the vehicle. Due to the combination of the underride crash dynamics, averaged crush values, and the barrier equivalent algorithm, the WINSMASH calculated delta-V was underestimated. The Toyota's driver's frontal air bag deployed due to the severity of deceleration sustained during the impact.

Post-Crash

Police and emergency medical personnel responded to the crash site. The driver of the Toyota sustained evident injuries and was transported by ambulance to a local hospital where he was treated and released. The Toyota sustained moderate severity damage and was towed from the crash site and was subsequently deemed a total loss by the insurance company.

Vehicle Damage

Exterior Damage – 2006 Toyota Corolla

The 2006 Toyota Corolla sustained moderate severity frontal damage as a result of the impact with the GMC **(Figure 4)**. The damage consisted of longitudinal deformation to the frontal structure that included the bumper fascia and support, upper radiator support, radiator, A/C condenser, hood, and the right front fender. Additionally, the hood contacted and fractured the windshield.

Figure 4. Overall view of the frontal damage.

Figure 5. Overhead view of the residual crush to the frontal structure.

The direct contact damage began 5 cm (2.0”) left of the centerline and extended 66 cm (26.0”) to the right front fender. The total direct contact damage width measured 71 cm (28.0”). The impact resulted in an underride damage pattern; therefore, two crush profiles were documented at the bumper beam and the upper radiator support. The maximum crush at the bumper beam was 2 cm (0.8”) and was located 67 cm (26.4”) inboard of the left corner. The crush profile was documented across the full width of the bumper beam of 112 cm (44.0”) and were as follows: C1 = 0 cm, C2 = 0 cm, C3 = 2 cm (0.8”), C4 = 2 cm (0.8”), C5 = 2 cm (0.8”), C6 = 0 cm.

The maximum crush at the upper radiator support was 57 cm (22.4”) and was located 45 cm (17.6”) inboard of the right end. The residual crush at the upper radiator support was as follows: C1 = 0 cm, C2 = 17 cm (6.7”), C3 = 43 cm (16.9”), C4 = 57 cm (22.4”), C5 = 45 cm (17.7”), C6 = 53 cm (20.9”). An additional crush measurement was taken at the leading edge of the right fender, which yielded 45 cm (18.7”) of crush. **Figure 5** is overhead view of the crush to the frontal structure. The Collision Deformation Classification (CDC) for this impact was 12-FZEW-3.

Interior Damage – 2006 Toyota Corolla

The interior of the Corolla sustained moderated severity damage that was attributed to occupant contact points. The occupant contact points consisted of two knee strikes to the knee bolster that resulted in approximately 3 cm (1.0”) of longitudinal deformation. These contacts to the knee bolster resulted in deformation to the center stack, which dislodged the trim panels for the HVAC, center vents, and the radio.

Although the driver contacted the deployed air bag, no contact evidence was present on the air bag. He loaded through the air bag resulting in 1 cm (0.4") of deformation to the steering wheel rim and compression of the steering column. Due to the deformation of the knee bolster, the panel could not be removed to allow for an inspection of the shear capsules. To document the steering column compression, a measurement was taken from the top aspect of the steering wheel rim to the top of the left instrument panel. The steering column compression was 5 cm (2.1").

The driver also contacted the sun visor with his head, which fractured the vanity mirror that was located on the inboard aspect of the sun visor. Additionally, the driver's right hand contacted and displaced the rearview mirror downward and forward.

Damage was noted to the right front air bag cover flap that was mounted on the top of the instrument panel. This damage resulted from the hood crushing rearward which engaged the windshield. The hood and windshield continued rearward and contacted the cover flap deforming it downward into the air bag module. The total deformation was approximately 3 cm (1.0") at the lower left corner of the air bag cover flap. There was no passenger compartment intrusion. **Figure 6** is an overall view of the driver's contact points.

Figure 6. Overall view of the driver's contact points.

Certified Advanced 208-Compliant Safety System – 2006 Toyota Corolla

The 2006 Toyota Corolla was equipped with a Certified Advanced 208-Compliant (CAC) safety system. A CAC vehicle is certified by the manufacturer to be compliant to Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVCC) No. 208. The safety system included dual stage frontal air bags, safety belt buckle switch sensors, safety belt retractor pretensioners, and an occupant detection sensor for the front right seat. An Air bag Control Module (ACM) controlled the system. The ACM measures and predicts crash severity and monitors belt status, and occupant presence to deploy the appropriate safety system. In this crash, the module commanded the deployment of the driver frontal air bag and firing of the driver's retractor pretensioner. Additionally, the ACM had Event Data Recording (EDR) capabilities. This ACM was removed from the vehicle with permission from the insurance company and was forwarded to NHTSA for download by Toyota. The EDR output is summarized in this report.

The driver's air bag was conventionally located in the center of the steering wheel hub **(Figure 7)**. Three T-shaped cover flaps were used to conceal the air bag. The top cover flap measured 15 cm (6.0") in width and 9 cm (3.4") in height. The lower cover flaps measured 7 cm (2.8) in width and 5 cm (1.8) in height. The air bag membrane measured 60 cm (23.5") in diameter in its deflated state. The driver's air bag was tethered by two wide band tethers that were located at the 9 and 3 o'clock positions on the face of the air

bag and measured 11 cm (4.3”). Two vent ports vented the airbag at the 11 and 1 o’clock positions on the rear panel. The maximum excursion of the air bag membrane at the tethers measured 36 cm (14.0”). Although the driver contacted the air bag, no occupant contacts were present on the air bag membrane. The following identifiers were printed on the face of the air bag:

312266 420d

Figure 7. Deployed driver's frontal air bag. Note the steering wheel was turned slightly left.

The front right passenger air bag was a top-mount design in the right instrument panel. The front right seating position was not occupied; therefore, the CAC system did not warrant the deployment of the front right air bag.

Event Data Recorder – 2006 Toyota Corolla

The 2006 Toyota Corolla was equipped with an Air Bag Control Module (ACM) that had Event Data Recorder (EDR) capabilities. The ACM was located forward of the center console at the base of the center instrument panel. The ACM was removed from the vehicle and was forwarded to NHTSA for download by Toyota. It should be noted that the insurance company authorized the removal of the module. Technical representatives from Toyota Motor Company in–turn sent a text copy of the downloaded data to the NHTSA. A summary of that text data is included below.

The EDR output indicated that the deployment stage for the driver’s air bag was Low (1st stage) and was commanded to deploy at 39 milliseconds after Algorithm Enable (AE). Additionally, the EDR data showed that both frontal safety belts were unbuckled. This EDR did not record pre-crash data such as speed, brake status, or engine RPM. The EDR maximum recorded delta-V was 42 km/h (26.1 mph) at 153.6 milliseconds of AE.

The EDR data also included two additional banks of saved data. However, analysis of the text data indicated that the event probably occurred prior to the crash and was unrelated.

Manual Restraint Systems – 2006 Toyota Corolla

The 2006 Toyota Corolla was equipped with manual continuous loop 3-point lap and shoulder safety belts for the five seating positions. The driver’s safety belt was configured with a sliding latch plate, Emergency Locking Retractor (ELR), height adjustable D-ring that was in the full-up position, and a retractor pretensioner. The driver did not use the safety belt in the crash, which was supported by the occupant contact points and the fired pretensioner that restricted the safety belt in the stowed position.

The safety belts for the remaining four seating positions were configured with continuous loop webbing with sliding latch plates that retracted onto switchable ELR/Automatic

Locking Retractor's (ALR). The front right safety belt was equipped with a retractor pretesnioner; however, the front right seat was not occupied during the crash, therefore the pretensioner did not fire.

Occupant Demographics – 2008 Toyota Corolla

Driver

Age/Sex:	28-year-old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Rear-track
Manual Restraint Use:	Manual 3-point lap and shoulder safety belt
Usage Source:	Vehicle inspection
Eyewear:	Not currently available
Type of Medical Treatment:	Transported to a hospital, treated and released.

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Unknown	Unknown	Unknown

Driver Kinematics

The 28-year-old male driver of the 2006 Toyota Corolla was seated in a presumed upright posture and was not restrained by the manual 3-point lap and shoulder safety belt. At impact with the GMC, the frontal air bag deployed and the safety belt pretensioner fired. The driver's right hand was probably positioned on the steering wheel, which was displaced by the deploying air bag. His right hand contacted the rear view mirror, which repositioned it forward and downward. The driver initiated a forward trajectory in response to the 12 o'clock direction of force. He contacted and loaded through the deployed air bag, which resulted in the deformation of the steering wheel rim and compression of the steering column. The driver's knees struck and deformed the knee bolster. As the vehicle continued to crush the front pitched downward and his continued forward motion allowed him to contact the sun visor with his head. The fractured mirror in the sun visor supported this contact. The driver sustained evident injury and was transported to a local hospital where he was treated for his injuries and released. The driver could not be located for an interview. Furthermore, the medical facility would not release the injury information.

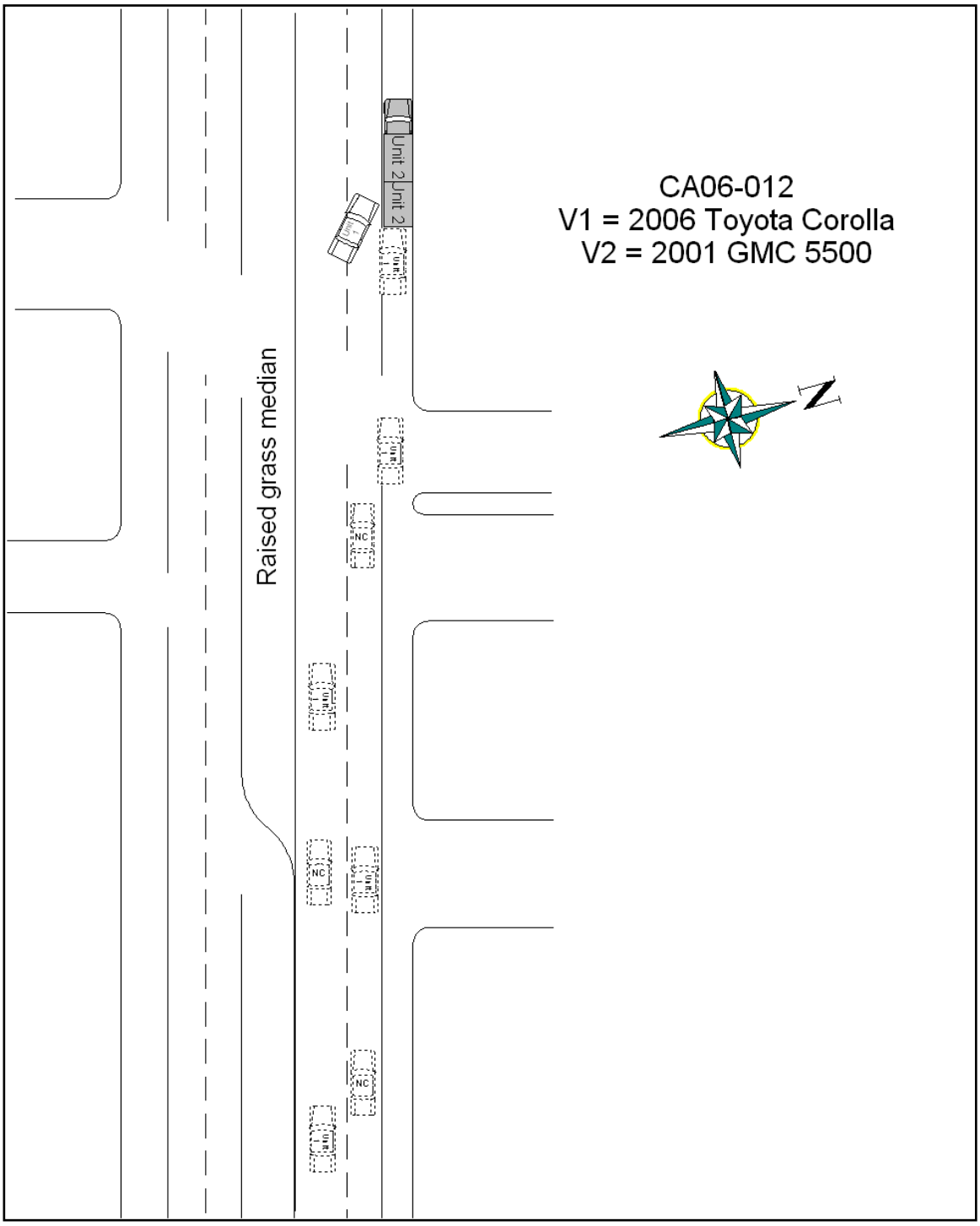

Figure 8. Scene schematic