CRASH DATA RESEARCH CENTER

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

CASE NO: CA04-031

VEHICLE: 2004 TOYOTA CAMRY

LOCATION: GEORGIA

CRASH DATE: MAY 2004

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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TABLE OF CONTENTS

CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION
SCI CASE NO: CA04-031
SUBJECT VEHICLE – 2004 TOYOTA CAMRY
LOCATION - STATE OF GEORGIA
CRASH DATE – MAY 2004

BACKGROUND

This on-site investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2004 Toyota Camry **(Figure 1)**. The manufacturer of this vehicle has certified that this 2004 Toyota Camry meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The safety system included dual stage frontal air bags, seat track position sensors for the front seats, safety belt retractor pretensioners and buckle switches, and an occupant detection sensor for the front right position. The Toyota was equipped with an air bag control module for the CAC safety system, which had event data recording capabilities. The air bag control module was removed from the vehicle during the SCI investigation and forwarded to NHTSA for download by Toyota. The air bag control module output is summarized in this report. The Toyota was occupied by a restrained 25-year old female driver. The Toyota was involved in a multiple impact collision on an interstate roadway with a 2003 Volvo tractor-trailer, 1998 Ford Expedition, and an extended height Jersey median barrier. The barrier collision resulted in the deployment of the driver's frontal air bag and the driver's safety belt retractor pretensioner. The driver sustained police reported minor air bag abrasions and was treated at the scene. The Camry was towed from the scene of the crash and transferred to an insurance salvage yard where it was inspected.

Figure 1. Subject 2004 Toyota Camry.

This crash was identified from a list of claims provided by an insurance company to the National Highway Traffic Safety Administration (NHTSA) that identified Certified Advanced 208-Compliant (CAC) vehicles that had been involved in crashes. NHTSA forwarded a list of vehicles to the Calspan Special Crash Investigations (SCI) team for follow-up investigation. The Toyota was located and cooperation was established with the salvage facility and the insurance claims representative. The case was assigned to the Calspan SCI team on July 9, 2004, and the Toyota was inspected on July 16, 2004.

SUMMARY

Crash Site

This interstate crash occurred during the daytime hours of May 2004. At the time of the crash, the weather was clear with no adverse conditions. This crash occurred on the inboard northbound travel lanes of a divided north/south interstate. The northbound lanes

were configured with four through traffic lanes and a High Occupancy Vehicle (HOV) lane. The interstate was delineated by an extended height Jersey median barrier. The roadway was surfaced with asphalt and was bordered by asphalt shoulders. The posted speed limit for the northbound traffic was 105 km/h (65 mph). The scene schematic is included as **(Figure 11)** of this report.

Vehicle Data – 2004 Toyota Camry

The 2004 Toyota Camry was identified by the Vehicle Identification Number (VIN): 4T1BE32K74 (production sequence omitted). The odometer reading at the time of the inspection was unknown due to the vehicle having no power. The vehicle was a four-door sedan that was equipped with a 2.4-liter, four-cylinder engine, 4-speed automatic transmission, front-wheel drive, power-front and rear disc brakes with anti-lock and electronic brake-force distribution, aftermarket alloy wheels, daytime running lights, power-steering, tilt steering wheel, and aftermarket window tint. The Toyota was equipped with Bridgestone Turanza ER33 tires, size P215/60R16. The maximum pressure for these tires was 303 kPa (44 PSI). The manufacturer recommended tire pressure for this vehicle was 200 kPa (29 PSI). The specific tire data was follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
LF	0 kPa	6 mm (7/32”)	6 cm (2.5”) sidewall cut
LR	214 kPa (31 PSI)	7 mm (9/32”)	None
RF	210 kPa (30.5 PSI)	6 mm (7/32”)	None
RR	162 kPa (23.5 PSI)	7 mm (9/32”)	None

The Toyota’s seating positions consisted of front buckets seats with height adjustable head restraints. The front head restraints were adjusted between the mid-to-full down positions at the time of the vehicle inspection. The second row was configured with a three-passenger split bench seat (60/40) and height adjustable head restraints for the outboard seating positions. The rear head restraints were adjusted to the full-down positions.

Vehicle Data – 1998 Ford Expedition

The 1998 Ford Expedition was driven from the crash site and was repaired prior to this on-site investigation. The Police Accident Report (PAR) listed the VIN for this vehicle as 1FMRU17LXWL (production number deleted). The vehicle was powered by a 5.4 liter V-8 engine linked to an automatic transmission with rear wheel drive.

Vehicle Data – 2003 Volvo VNL Tractor Trailer

The 2003 Volvo VNL tractor-trailer was driven from the crash site. The PAR listed the VIN for this vehicle as 4V4NC9TJ93N (production sequence omitted). It was registered to an Iowa trucking company and was used for nationwide transport. This vehicle was not inspected during the SCI investigation.

Crash Sequence

Pre-Crash

The restrained 25-year-old female driver of the 2004 Toyota Camry was operating the vehicle northbound on the five-lane roadway on the inboard through lane, right of the HOV lane. The driver of the Ford was operating the vehicle northbound on the same roadway in the adjacent lane. The driver of the Volvo tractor-trailer was operating the vehicle northbound adjacent to the Ford. As the vehicles continued northbound, the driver of the Volvo attempted to change lanes from the center lane to the second inboard lane. The driver of the Ford avoided the encroaching tractor-trailer and entered the left through lane. The driver of Toyota steered left in order to avoid the Ford. As a result of this steering maneuver, the driver of the Toyota lost directional control of the vehicle. The Toyota entered the west shoulder and then re-entered the roadway in a northeast trajectory towards the Volvo tractor-trailer.

Crash

The Toyota traveled into the Volvo's travel lane where the front of the Toyota underrode the trailer portion of the Volvo **(Figure 2)**. The left side of the trailer struck the top surface of the Toyota's hood. The resulting direction of force for the Toyota was non-horizontal. Consequently, the damage was out of the scope of the WINSMASH program, therefore a delta V was not calculated for this impact.

Figure 2. North approach for all the vehicles and area of impact.

Following the initial impact, the Toyota began to rotate counterclockwise (CCW). The lower edge of the trailer impacted the upper right A-, B-, and C-pillars of the Toyota. The direction of force was within the 3 o'clock sector for the Toyota. The Toyota and the Volvo remained engaged and began a northbound trajectory while in contact. The left rear tires of the trailer impacted the rear right aspect of the Toyota's bumper fascia resulting in a 6 o'clock impact force to the Camry. This corner impact damage was outside the scope of the WINSMASH program.

The Toyota deflected left and departed the west road edge where the front of the vehicle impacted an extended height Jersey median barrier. The resultant direction of force for this impact was within the 1 o'clock sector. Three crush profiles were documented for this impact; however, the bumper beam crush measurements were utilized to calculate the delta V. The WINSMASH Barrier Equivalent algorithm was used to calculate a delta V for this impact. The total calculated delta V was 37 km/h (23 mph). The longitudinal and lateral components were -35 km/h (-21.7 mph) and -13 km/h (-8.1 mph), respectively. The EDR recorded a delta-V of 39 km/h (24.3 mph) for this event. The Event counter listed this event as number 4. Although the EDR did not link the deployment of the driver's air bag to an event, the air bag probably deployed as a result of the Jersey barrier impact.

As a result of the impact with the extended height Jersey median barrier, the Toyota continued its CCW rotation and traveled rearward into the HOV lane. The front of the Ford impacted the left rear side aspect of the Toyota in a 12/9 o'clock impact configuration. The impact resulted in minor damage to both vehicles. The WINSMASH Missing Vehicle algorithm was used to calculate the delta V for this impact. The total delta V for the Toyota was 4 km/h (2.5 mph). The longitudinal and lateral components were 0 km/h (1.3 mph) and 4 km/h (2.5 mph), respectively. The total delta V for the Ford was 3 km/h (1.9 mph). The longitudinal and lateral components were -3 km/h (-1.9 mph) and 0 km/h, respectively.

Post-Crash

The driver of the Toyota sustained police reported minor air bag abrasions and was treated at the scene. The Toyota sustained disabling damage and was towed from the crash site and deemed a total loss by the insurance company. The Ford and the Volvo sustained minor damage and were driven from the crash site.

Vehicle Damage

Exterior Damage – 2004 Toyota Camry

The Toyota sustained minor severity damage to the hood as a result of the initial impact with the Volvo's trailer **(Figure 3)**. The damage consisted of a vertically deformed hood with diagonally oriented creases. The damage length was 98 cm (38.5") and 148 cm (58.3") in width. A crush profile was not documented for this non-horizontal impact. The Collision Deformation Classification (CDC) for this impact was 00-TFDW-6.

Figure 3. Damage to the top surface of the hood.

Figure 3. Right side damage from the impact with the lower edge of the

The Toyota sustained minor severity right side damage as a result of the secondary impact with the Volvo's trailer **(Figure 4)**. The damage consisted of lateral deformation to the right upper A-, B-, and C-pillars and disintegrated right side glazing. The damage to the right A-pillar began 10 cm (4.0") above the beltline and extended upward 18 cm (7.0"). The maximum crush measured 2 cm (0.9") at the A-pillar. The B-pillar sustained minor lateral deformation. The direct damage on the C-pillar measured 67 cm (26.5") and the maximum crush was 3 cm (1.3"). The CDC for this impact was 03-RDGW-2.

The third impact event resulted in moderate severity damage to the rear right aspect as a result of the impact with the left side tires of the Volvo's trailer **(Figure 5)**. The trailer tires impacted the bumper fascia corner and continued onto the quarter panel. The direct damage began 67 cm (26.4") right of the rear centerline and extended to the right rear corner of the bumper fascia. The deformation area was outboard of the bumper beam, which yielded no residual crush to the bumper beam. The damage extended 116 cm (45.5") forward onto the quarter panel terminating 20 cm (8") forward of the right rear axle. The CDC for this impact was 06-BRES-4.

Figure 5. Rear damage from the impact with the trailer wheels.

Figure 6. Frontal damage from the extended height Jersey barrier. View of the three crush profiles documented for this impact.

The Toyota sustained moderate severity frontal damage as a result of the impact with the extended height Jersey median barrier **(Figure 6)**. The damage consisted of longitudinal deformation to the front structural components. Three crush profiles were utilized to document the damage. These involved a profile at the lower radiator support, bumper support, and upper radiator support levels. The direct damage began 41 cm (16") left of the centerline and extended 57 cm (22.5") to the outboard corner of the frontal sheet metal. Six crush measurements were documented using a combined direct and induced damage width of 86.4 cm (34.0") at the lower radiator support and were as follows: C1 = 41 cm (16.2"), C2 = 31 cm (12.2"), C3 = 24 cm (9.8"), C4 = 20 cm (7.9"), C5 = 14 cm (5.4"), C6 = 7 cm (2.8").

The crush at the bumper beam was documented using a combined direct and induced damage width of 96.0 cm (37.8"). Six crush measurements were utilized to obtain a crush profile of the residual damage, and were as follows: C1 = 40 (15.7"), C2 = 37 cm (14.6"), C3 = 40 cm (15.7"), C4 = 41 cm (16.1"), C5 = 34 cm (13.4"), C6 = 3 cm (1.2").

The crush at the upper radiator support was measured using a combined direct and induced damage width of 146 cm (57.3"). Six crush measurements were documented as follows: C1 = 13 cm (5.2"), C2 = 22 cm (8.7"), C3 = 31 cm (12.2"), C4 = 22 cm (8.7"), C5 = 20 cm (7.9"), C6 = 0 cm. The CDC for this impact was 01-FDEW-2.

Although three crush profiles were documented, the bumper beam crush profile yielded the greatest depth of crush; therefore it was used to calculate the delta V for this barrier impact.

The Toyota sustained minor severity left side damage as a result of the impact with the Ford Expedition. The direct and induced damage and began at the left rear bumper corner and extended 138 cm (54.3") forward. The damaged components consisted of the rear left door, left quarter panel, and the left side of the bumper fascia. Six crush measurements were used to document this crush and were as follows: C1 = 0 cm, C2 = 0 cm, C3 = 0 cm, C4 = 0 cm, C5 = 1 cm (0.5"), C6 = 0 cm. The CDC for this impact is 09-LZEW-1.

The left side doors remained closed and operational post-crash. The right side doors remained closed during the crash; however, they were jammed closed post-crash from the lateral displacement of the upper pillars and the longitudinal deformation of the right rear door. The windshield was fractured from contact with the rear right edge of the hood. The side and rear glazing exhibited aftermarket tint. The right side glazing was disintegrated as result of the impact with the Volvo's trailer.

Interior Damage – 2004 Toyota Camry

The interior of the 2004 Toyota Camry sustained no damage as a result of occupant contact points or exterior deformation. The vehicle sustained minor interior damage due to passenger compartment intrusion. The right A-pillar intruded laterally 3 cm (1") from the impact with the Volvo's trailer. **Figure 7** is an overall of the driver's area.

Figure 7. Overall view of the driver's area.

Figure 8. Front right air bag indicator light and safety belt minder light.

Certified Advanced 208-Compliant Safety System – 2004 Toyota Camry

The 2004 Toyota Camry was equipped with a Certified Advanced 208-Compliant (CAC) safety system. The manufacturer of this vehicle has certified that this 2004 Toyota Camry meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The system consisted of dual stage frontal air bags, seat track positioning sensors for the front seats, an occupant presence sensor for the front right seat, and front safety belt retractor pretensioners and buckle switches. The system

also consisted of a passenger air bag indicator light **(Figure 8)**, which notifies the occupants of the on/off status of the front right air bag. An air bag control module monitors the system and measures and predicts crash severity, and then deploys the appropriate safety systems based on seat track position, belt status, and front right occupant presence. The air bag control module had Event Data Recording (EDR) capabilities. The air bag control module was removed from the Toyota by the SCI investigator and forward to NHTSA for download by Toyota. The output is summarized in the section that follows.

The driver's frontal air bag deployed at impact with the extended height Jersey median barrier. The driver's air bag was located in the center of the steering wheel hub **(Figure 9)**. The air bag module consisted of a triangular cover flap configuration with a horizontal tear seam. The top cover flap measured 15 cm (5.9") in width and 8 cm (3") in height. The two lower flaps were symmetrical and measured 8 cm (3") at the horizontal tear seam, 6 cm (2.3") at the vertical tear seam, and 9 cm (3.3") at the outboard hinges. The air bag membrane was 64 cm (25.3") in diameter in its deflated state. No occupant contact points were noted on the air bag. The air bag contained two wide band tethers that were 11 cm (4.5") in width. The tethers were sewn to a 22 cm (8.8") diameter tether stitching on the face of the air bag. The air bag was vented by two 3 cm (1") diameter vent ports that were located 7 cm (2.6") forward of the peripheral seam at the 11 and 1 o'clock positions. The driver's bag was identified by the following nomenclature that was stamped on the top surface of the air bag membrane:

Figure 9. Deployed driver's frontal air bag.

0552305442
GA120-05520

The front right passenger air bag was a top-mount design in the right instrument panel. The air bag module was located 9 cm (3.5") forward of the front instrument panel edge. The cover flap was of a rectangular design which measured 20 cm (8") in width and 10 cm (3.8") in height. The front right seating position was not occupied during the crash, therefore the air bag control module did not warrant the deployment of the front right air bag or the firing of the retractor pretensioner.

Event Data Recorder – 2004 Toyota Camry

The 2004 Toyota Camry was equipped with an air bag control module that had Event Data Recording (EDR) capabilities. The air bag control module was removed from the Camry with insurance company approval by the SCI investigator and forwarded to NHTSA for download by Toyota. The module output is summarized as follows:

The EDR recorded the driver's belt status as Buckled and the driver's seat adjusted to the rearward position. The front right seat was unoccupied and the passenger belt status was Unbuckled. The EDR recorded four events; however, the EDR file included three, Events 1, 3 and 4. The first event recorded a maximum delta-V of 20 km/h (12.2 mph) at 150 ms. The time recording from the previous event was listed as 5000 ms.

The output for Event 3 listed a maximum delta-V of -4 km/h (-2.4 mph) at 110 ms of the 150 ms recording. The time recording from the previous event was 1500 ms.

The output for Event 4 recorded a total delta-V of 39 km/h (24.3 mph) at 150 ms of the recording. This event was listed as occurring at 1580 ms of the previous event. Based on the severity of the crash and the resultant direction of force, the driver's frontal air bag and retractor pretensioner deployed during the impact with the Jersey barrier. The deployment stage and timing of the deployment was not recorded.

Manual Restraint Systems – 2004 Toyota Camry

The 2004 Toyota Camry was equipped with continuous loop manual 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, and a retractor pretensioner with force limiters. The adjustable D-ring was adjusted 2 cm (0.8") above the full-down position at the time of the SCI inspection. The adjustable D-ring had 9 cm (3.5") of vertical travel. Historical usage evidence was present on the latch plate which consisted of minor abrasions to the latch plate. The driver utilized her safety belt in the crash, which was evidenced by the lack of occupant contact points and the fired status of the retractor pretensioner **(Figure 10)**. The driver's safety belt was found in the used position with 159 cm (62.5") of webbing locked and extended from the D-ring by the fired pretensioner. No crash related evidence such as loading was present on the safety belt webbing or hardware components.

Figure 10. Driver's safety belt restricted in used position due to the fired pretensioner.

The front right safety belt was configured with a sliding latch plate, switchable ELR/Automatic Locking Retractor (ALR), height adjustable D-ring, and a retractor pretensioner with force limiters. The front right D-ring was adjusted to 7 cm (2.8") above the full-down position at the time of the SCI inspection. The front right seat was not occupied, therefore the pretensioner did not deploy in the subject crash.

The rear safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractor's (ALR).

Occupant Demographics – 2004 Toyota Camry

Driver

Age/Sex:	25-year-old/ Female
Height:	Not available
Weight:	Not available
Seat Track Position:	7 cm (2.6") forward of full-rear [23.8 cm (9.4") of track travel]
Manual Restraint Use:	3-point manual lap and shoulder safety belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Police reported minor air bag abrasions. She was treated at the scene and was not transported.

Driver Injuries

Injury	Injury Severity	Injury Source
Skin abrasions, NFS	Minor (990200.1,9)	Driver's air bag

Source – Police Accident Report

Driver Kinematics

The 25-year-old female driver of the 2004 Toyota Camry was seated in a presumed upright posture and was restrained by the manual 3-point lap and shoulder safety belt. The driver's seat was adjusted to a rear track position and the head restraint was adjusted to the mid-to-full down position. Safety belt use was supported by the locked position of the belt webbing due to the fired retractor pretensioner. There was no belt loading evidence on the webbing or system hardware.

At impact with the Volvo's trailer, the driver of the Toyota was not significantly displaced due to the minor impact forces. The Toyota subsequently rotated CCW and the upper right upper A-, B-, and C-pillars and right side glazing was impacted by the lower edge of the trailer. This impact was minor which probably resulted in minimal displacement of the driver.

The Toyota began to travel in a northwest direction and departed the west road edge where the front of the vehicle impacted an extended height Jersey barrier. At impact, the driver's frontal air bag deployed and the safety belt retractor pretensioner fired. The driver initiated a forward trajectory and loaded the belt system and the deployed air bag. She sustained police reported minor air bag abrasions. The combination of safety belt usage and air bag deployment prevented her from potential contact with frontal components and possible serious injury.

The Toyota was impacted on the left side as it rotated CCW to final rest. The frontal area of the Ford impacted the left rear side aspect of the Toyota. This impact was minor in severity and probably did not displace the driver.

The driver unbuckled the manual belt system and exited the vehicle post-crash. She was treated at the scene for minor severity air bag related abrasions.

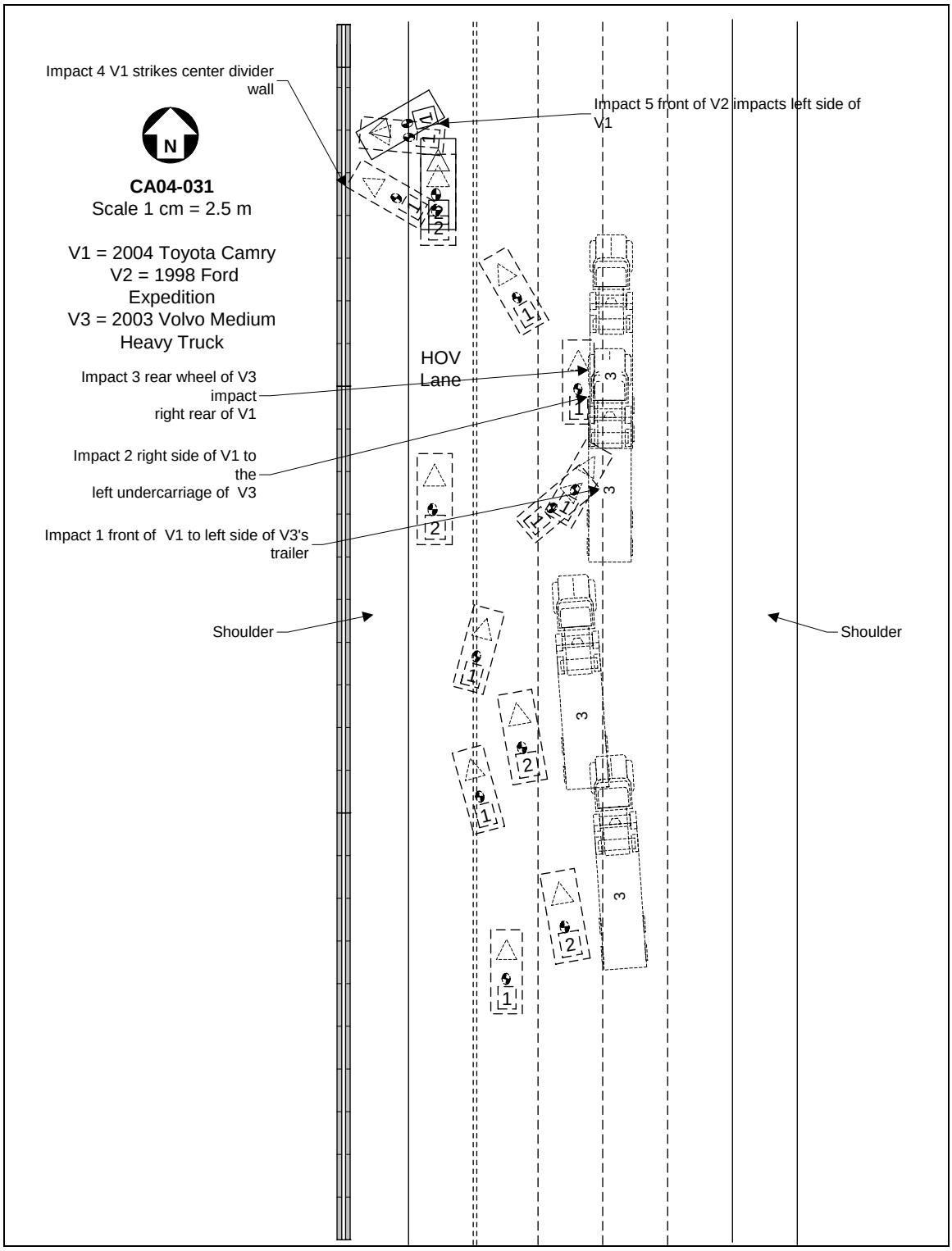

Figure 11. Scene Schematic