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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-06-023
LOCATION - TEXAS
VEHICLE - 2005 TOYOTA SEQUOIA
CRASH DATE - June 2006

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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

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On-site air bag deployment investigation involving a 2005 Toyota Sequoia with manual safety belts and manufacturer certified advanced 208-compliant front air bag system.

16. *Abstract*
This report covers an on-site investigation of an air bag deployment crash that involved a 2005 Toyota Sequoia (case vehicle), which ran-off-road and impacted a luminaire pole. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, as well as an Event Data Recorder (EDR), and the case vehicle's driver (38-year-old, female) sustained a police reported “B” (non-incapacitating-evident) injury as a result of the crash. In addition, the manufacturer of this vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case vehicle was traveling west on a multi-lane, divided city street in the inside through lane. The case vehicle drifted left and ran onto the raised, concrete median. The front of the case vehicle then impacted a metal luminaire pole causing the driver’s air bag to deploy. After impacting the luminaire pole, the case vehicle rotated counterclockwise and came to final rest facing southwest. The case vehicle’s driver was restrained by her manual, three-point, lap-and-shoulder safety belt system. She was transported by ambulance to a hospital and treated and released. The front right and back center passengers were also restrained by their three-point, lap-and-shoulder safety belt system. They sustained minor injury and were not transported to a hospital.

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This on-site investigation was brought to NHTSA's attention on or before July 21, 2006 by NASS CDS/GES sampling activities. This crash involved a 2005 Toyota Sequoia SR5 (case vehicle), which ran-off-road and impacted a luminaire pole located in the median. The crash occurred in June, 2006 at 11:07 p.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, as well as an Event Data Recorder (EDR), and the case vehicle's driver [38-year-old, White (Hispanic) female] sustained a police reported "B" (non-incapacitating-evident) injury as a result of the crash. In addition, the manufacturer of this vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. This contractor inspected the case vehicle on August 14, 2006, inspected the crash scene on August 15, 2006 and interviewed the driver on September 28, 2006. Permission to harvest the case vehicle's Electronic Control Unit (ECU), which contains the EDR was denied by the insurance company. This report is based on the police crash report, scene and vehicle inspections, an interview with the case vehicle's driver, case vehicle driver's medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling west on a multi-lane, divided city street in the inside through lane. The case vehicle driver's attention was diverted from the roadway when she briefly looked at her purse, which was sitting on the console. The case vehicle drifted left and ran onto the raised, concrete median. The front of the case vehicle then impacted a metal luminaire pole causing the driver's air bag to deploy. The front right passenger's air bag did not deploy. The 12-year-old male passenger's slumped seating position most likely displaced enough of his weight away from the seat's weight sensor that the air bag system suppressed deployment of the front right air bag. After impacting the luminaire pole, the case vehicle rotated counterclockwise and came to final rest facing southwest. The impact broke the luminaire pole off its base. At the time of the crash the light condition was daylight, the weather was clear, and the roadway pavement was dry, traveled concrete.

The CDC for the case vehicle was determined to be: **12-FYEN-3** (**0** degrees) for the front impact. The case vehicle's residual maximum front crush was 77 centimeters (30.3 inches) occurring at C_2. Yielding object impacts are out-of-scope for the WinSMASH reconstruction program; therefore, the program could not be used to determine the case vehicle's Delta Vs. However, the WinSMASH program was used to determine a Barrier Equivalent Speed (BES) based on the case vehicle's front crush. The BES was calculated as 33.6 km.p.h (20.9 m.p.h.). The case vehicle was towed due to damage.

The case vehicle's driver was restrained by her three-point, lap-and-shoulder safety belt system. She sustained an abrasion to her left wrist due to contact with her deploying air bag. She also sustained a fractured left clavicle from loading her safety belt, a lacerated right foot, which was pinned under the brake pedal, and a fractured left foot due to loading the intruding toe pan.

She was transported by ambulance to a hospital and treated and released. The deployment of the driver's advanced air bag system and the driver's use of her safety belt system prevented her from impacting the steering wheel and possibly sustaining serious injury.

The front right passenger (12-year-old, male) and back center passenger (9-year-old, male) were both restrained by their three-point, lap-and-shoulder safety belt systems. They sustained only minor injuries and were not transported to a hospital for treatment. The front right passenger and back center passenger's use of their safety belt system prevented them from impacting the case vehicle's interior components and mitigated their injury potential.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a five-lane, divided, city street, traversing in an east and west direction and formed an intersection with another city street. The eastbound and westbound roadways each had two through lanes and a left turn lane. On the case vehicle's approach roadway, the outside through lane was 3.7 meters (12 feet) in width, the inside through lane was 3.5 meters (11.5 feet) in width, and the left turn lane was 2.9 meters (9.5 feet) in width. The roadways were bordered by barrier curbs and divided by a raised, curbed, concrete median 1.2 meters (3.9 feet) in width. Roadway pavement markings consisted of a broken white lane line and "Bots Dots" delineating the left turn lane. The case vehicle's approach roadway was slightly curved right and the vertical alignment was approximately 3% negative on the approach to impact. The speed limit was 48 km.p.h. (30 m.p.h.). There was no regulatory speed limit sign near the crash site. At the time of the crash the light condition was daylight, the weather was clear, and the roadway pavement was dry, traveled concrete with an estimated coefficient of friction of 0.68. Traffic density at the time of the crash was unknown, and the site of the crash was residential. See the Crash Diagram at the end of this report.

Pre-Crash: The case vehicle was traveling west in a slight right curve (**Figure 1**) in the inside through lane at a driver estimated speed of approximately 56 km.p.h. (35 m.p.h.). The case vehicle's driver was intending to continue westbound. The driver indicated that she briefly took her eyes off the roadway to look at her purse, which was sitting on the console. Due to this distraction, the case vehicle drifted left as it was traversing through the intersection and ran onto the raised concrete median. The driver took no avoidance actions prior to the crash, which occurred in the median.

Figure 1: Case vehicle approach westbound toward intersection, arrow shows point of impact with luminaire pole

Crash: The front of the case vehicle (**Figure 2** below) impacted a metal luminaire pole (**Figure 3** below), causing the case vehicle driver's air bag to deploy. It is not known if the second stage of the dual stage air bag deployed. The front right

passenger's air bag did not deploy. The 12-year-old male passenger was reportedly seated in a slumped position with his buttocks on the front edge of the seat and his back against the seat back. The passenger's position on the seat most likely displaced enough of his weight away from the case vehicle's weight sensor that the sensor determined the weight on the seat was below the air bag system's threshold and suppressed deployment of the front right air bag.

Figure 2: Overview of damage to front of case vehicle from impact with luminaire pole

Figure 3: Arrow shows location of impacted luminaire pole, which has been replaced

Post-Crash: After impacting the luminaire pole, the case vehicle rotated counterclockwise slightly and came to final rest facing southwest. The impact broke the luminaire pole off its base.

CASE VEHICLE

The 2005 Toyota Sequoia SR5 was a rear wheel drive, four-door, sport utility vehicle (VIN: 5TDZT34AX5S------) equipped with a 4.7L, V8 engine; five-speed automatic transmission, four wheel anti-lock brakes with electronic brake force distribution, electronic stability control and traction control. The front seating row was equipped with bucket seats with adjustable head restraints and seat track position sensors, driver and front right passenger dual stage air bags, seat back-mounted side impact air bags; driver and front right passenger manual, three-point, lap-and-shoulder safety belts with adjustable upper anchors, pretensioners, energy management features and usage sensors. The second seating row was equipped with a split bench seat with folding backs, adjustable head restraints and three-point, lap-and-shoulder safety belts. The third seating row was equipped with a split bench seat with folding backs; three-point, lap-and-shoulder safety belts and adjustable head restraints in the outboard positions. The case vehicle was also equipped with side curtain air bags and an occupant weight sensor in the front right seat cushion. In addition, the manufacturer of this vehicle has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Finally, the case vehicle's specification wheelbase was 300 centimeters (118.1 inches). The odometer reading at the time of the case vehicle inspection was unknown because the case vehicle was equipped with an electronic odometer. The case vehicle's driver estimated the case vehicle's mileage at the time of the crash at approximately 32,186 kilometers (20,00 miles).

The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity and driver and front right passenger safety belt usage to determine the front air bag inflation level appropriate for the severity of the

crash. For the front right seat position, an occupant weight sensor in the seat cushion determines if an occupant is on the seat and enables or suppresses deployment of the air bag based on the amount of weight on the seat.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's contact with the luminaire pole involved the front plane. The front bumper, bumper fascia, grille, radiator, and hood were directly damaged and crushed rearward. The case vehicle's front bumper had been broken off the vehicle and was not present at the inspection. Therefore, measurements were made in relation to the lower sheet metal panel located behind the bumper and adjusted for the missing bumper. The direct damage began 63 centimeters (39 inches) left of the right end of the lower sheet metal panel and extended approximately 30 centimeters (11.8 inches) along the front of the vehicle. Crush measurements were taken along the lower sheet metal panel, and the residual maximum crush was determined to be 77 centimeters (30.3 inches) occurring at C_2. The table below shows the case vehicle's front crush profile.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	31	77	92	61	77	26	17	13	11	-33	0
in		12.2	30.3	36.2	24.0	30.3	10.2	6.7	5.1	4.3	-13.0	0.0

The left side wheelbase was reduced 19 centimeters (7.5 inches) while the right side wheelbase was extended 5 centimeters (2 inches). Induced damage involved the hood, both front headlamp and turn signal assemblies, both fenders, left front wheel, and the windshield was cracked. There was no other induced damage noted to the remainder of the case vehicle's exterior.

The case vehicle's recommended tire size was P265/65R17, and the case vehicle was equipped with tires of this size. The case vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	0	0	221	32	7	9	Unknown, driven into back of wheel house	Yes	Yes
RF	207	30	221	32	6	8	None	No	No
LR	207	30	221	32	6	8	None	No	No

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
RR	207	30	221	32	6	8	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior (**Figure 4**) revealed no evidence of occupant contact to any interior surfaces or components. Intrusions were noted at the left and right toe pans, which were intruded longitudinally 7 and 5 centimeters (2.8 and 2 inches), respectively. There was no evidence of compression of the energy absorbing steering column or deformation of the steering wheel rim (**Figure 5**).

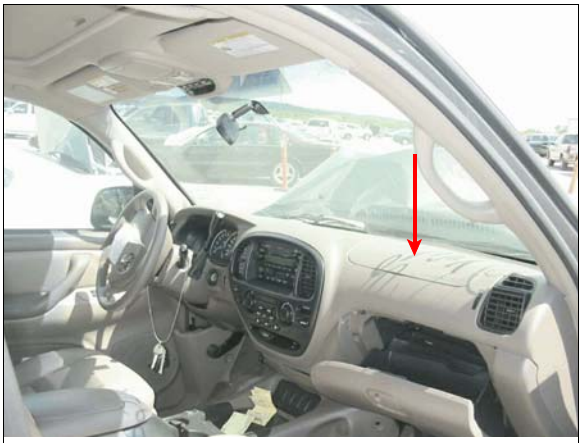


Figure 4: Case vehicle's instrument panel, windshield and steering wheel, arrow shows location of front right passenger air bag

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FYEN-3** (**0** degrees) for the front impact. Yielding object impacts are out-of-scope for the WinSMASH reconstruction program; therefore, the program could not be used to determine the case vehicle's Delta Vs. However, the WinSMASH program was used to determine a Barrier Equivalent Speed (BES) based on the case vehicle's front crush. The BES was calculated as 33.6 km.p.h (20.9 m.p.h.). The case vehicle was towed due to damage.

Figure 5: Left side view of case vehicle's steering wheel and steering column showing lack of deformation

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a manufacturer certified advanced 208-compliant front air bag system. The driver's air bag deployed in this crash. The front right passenger air bag did not deploy.

The case vehicle's driver air bag was located in the steering wheel hub. The air bag module cover consisted of asymmetrical, essentially, "H"-configuration cover flaps made of pliable vinyl. The upper flap was 13 centimeters in width and 8 centimeters in height. The lower flap was trapezoidal-shaped and was 13 centimeters (5.1 inches) in width along the horizontal tear seam, 5 centimeters (2 inches) in width at the bottom and 7.5 centimeters (3 inches) in height. An inspection of the air bag module cover flaps (**Figure 6** below) and the air bag fabric revealed that

the cover flaps opened at the designated tear points. There was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each approximately 10 centimeters (3.9 inches) in width. The deployed driver's air bag (**Figure 7**) was round with a diameter of 60 centimeters (23.6 inches) and had two vent ports (**Figure 8**), each measuring 5 centimeters (2 inches) in length and 1 centimeter (0.4 inches) wide, located at approximately the 11 and 1 o'clock positions. The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection (i.e., seat at middle track position, seat back slightly reclined), and the front surface of the air bag's fabric at approximate full excursion was 28 centimeters (11 inches). An inspection of the driver's air bag fabric revealed no evidence of occupant contact on the front of the air bag.

Figure 6: Case vehicle's driver air bag cover flaps, each stripe on rod is 5 cm (2 in)

Figure 7: Case vehicle's driver's air bag.

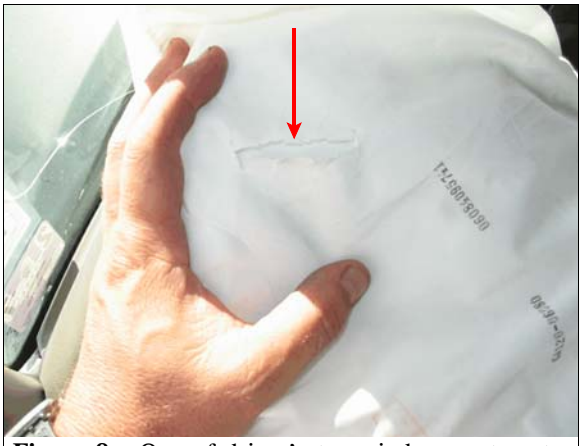


Figure 8: One of driver's two air bag vent ports (arrow)

The front right passenger's air bag was located in the middle of the instrument panel (**Figure 4** above). This air bag did not deploy. The 12-year-old male passenger was reportedly seated in a slumped position with his buttocks on the front edge of the seat and his back against the seat back. His position on the seat most likely displaced enough of his weight away from the case vehicle's weight sensor that the sensor determined the weight on the seat was below the air bag system's threshold and suppressed deployment of the front right air bag.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash, the case vehicle's driver [38-year-old, White (non-Hispanic) female; 168 centimeters and 59 kilograms (66 inches and 130 pounds] was seated in an upright driving position. She had her left hand on the steering wheel at the 10 o'clock position and was looking down to her right with her right hand on her purse, which was on the console. Her left foot was on the floor and her right foot was on the accelerator. Based on the vehicle inspection, the case vehicle driver's seat track was located in the approximate middle track position. The driver's seat back appeared to have been slightly reclined prior to the crash, and

remained in that position after the crash. The tilt steering column was located in its center position.

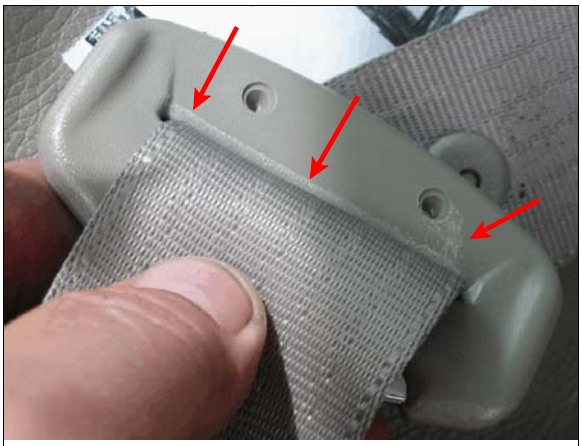


Figure 9: Arrows show load abrasions on driver's sliding latch plate

Based on this contractor's vehicle inspection and supported by the driver's interview, the case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder safety belt system. There were load abrasions on the sliding latch plate (**Figure 9**) and D-ring, and the driver sustained a fracture to her left collar bone from loading the shoulder belt. In addition, the safety belt was equipped with a retractor-mounted pretensioner and force load limiter housed within the B-pillar. The driver's safety belt was found spooled out of the retractor and would not retract, indicating actuation of the pretensioner and usage of the safety belt in the crash.

The case vehicle's driver made no avoidance maneuvers. As a result, her body position did not change prior to impact. As the case vehicle ran over the curb just prior to the impact, the driver's safety belt retractor most likely locked. The case vehicle's front impact with the luminaire pole then caused the driver's pretensioner to actuate and the driver to continue forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. She loaded her safety belt fracturing her left clavicle. Her left wrist contacted her deploying air bag causing an abrasion to her left wrist. Her face and upper chest also most likely contacted her deployed air bag. Her right foot impacted the brake pedal causing an irregular laceration approximately 8 to 10 centimeters (3 to 4 inches) in length extending from her ankle toward her toes. The bottom of her left foot also loaded the intruding toe pan causing a hairline fracture to the ball of her foot. The driver most likely rebounded off her air bag back into her seat. The driver's right foot became trapped between the intruded toe pan and brake pedal during the impact. Rescue personnel had to be bend the pedal upward to facilitate her exit from the vehicle. The deployment of the driver's advanced air bag system and the driver's use of her safety belt system prevented her from impacting the steering wheel and possibly sustaining serious injury.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver sustained a police reported "B" (non-incapacitating-evident) injury. The driver was transported to a hospital by ambulance and was treated and released. The driver indicated she received follow-up treatment for her clavicle fracture and lost 10 work days as a result of the crash. The table below shows the case vehicle driver's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fracture, closed, displaced, mid-shaft left clavicle	moderate 752200.2,2	Torso portion of safety belt system	Certain	Emergency room records
2	Abrasion, small, anterior left wrist	minor 790202.1,2	Air bag, driver's	Certain	Interviewee (driver)
3	Contusions, not further specified	minor 990400.1,9	Unknown contact mechanism	Unknown	Emergency room records
4	Laceration, 7.6 - 10.2 cm (3-4 in), dorsal {top} right foot	minor 890602.1,1	Floor, foot controls	Certain	Emergency room records
5	Fracture, hairline, plantar {ball} aspect of left foot	moderate 852200.2,2	Floor, including toe pan	Certain	Interviewee (driver)

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's front right passenger [12-year-old, White (non-Hispanic) male; 152 centimeters and 40 kilograms (60 inches and 88 pounds] was seated in an slouched position with his buttocks at the front edge of the seat cushion and his back against the seat back. He was holding a book with both hands. His seat track was located in the center position and the seat back was slightly reclined, which remained in the same position after the crash.

Based on this contractor's vehicle inspection, the case vehicle's front right passenger was restrained by his manual, three-point, lap-and-shoulder safety belt system. Load abrasions were observed on the sliding latch plate and D-ring (**Figure 10**). In addition, the safety belt system was equipped with a retractor-mounted pretensioner and force load limiter housed within the "B"-pillar. The front right passenger's safety belt was found spooled out of the retractor and would not retract, indicating actuation of the pretensioner and usage of the safety belt in the crash.

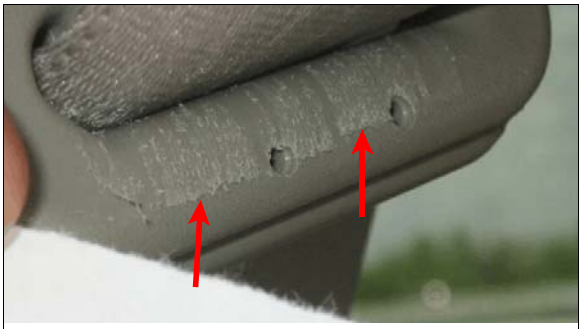


Figure 10: Load abrasions on front right passenger's "D"-ring

The case vehicle's driver made no avoidance maneuvers. As a result, the front right passenger's body position did not change prior to impact. As the case vehicle ran over the curb just prior to the impact, the passenger's safety belt retractor most likely locked. The case vehicle's frontal impact with the luminaire pole then caused the front right passenger's pretensioner to actuate and the passenger to continue forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated and he loaded his safety belt. His interaction with the safety belt caused an approximate 10 centimeter (4 inch)

abrasion on the right side of his neck. The case vehicle then continued to move slightly forward and rotated counterclockwise, and he remained in a forward position against his shoulder belt and moved slightly to the right. This passenger then rebounded back into his seat. He exited the case vehicle under his own power. The front right passenger's use of his three-point, lap-and-shoulder safety belt system prevented him from impacting the case vehicle's instrument panel and mitigated his injury potential.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The case vehicle's front right passenger did not sustain any police reported injuries. The driver indicated that the passenger sustained no treatment subsequent to the crash for his neck abrasion. The table below shows the front right passenger's interviewee reported injury and injury mechanism.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion, 10.2 cm (4 in) right side of neck	minor 390202.1,1	Torso portion of safety belt system	Probable	Interviewee (driver)

CASE VEHICLE BACK CENTER PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's back center passenger [9-year-old, White (non-Hispanic) male; 137 centimeters and 27 kilograms (54 inches and 60 pounds] was seated in an upright position, with his feet on the floor and his hands in his lap. Both the seat track and seat back were non-adjustable.

Based on the police crash report and a statement from the driver, the case vehicle's back center passenger was restrained by his manual, three-point, lap-and-shoulder safety belt system. No obvious loading evidence was noted on his safety belt. However, the driver stated he sustained an abrasion extending from his chest to the left side of his neck, as well as contusions to both of his hips, indicating usage of the safety belt in the crash.

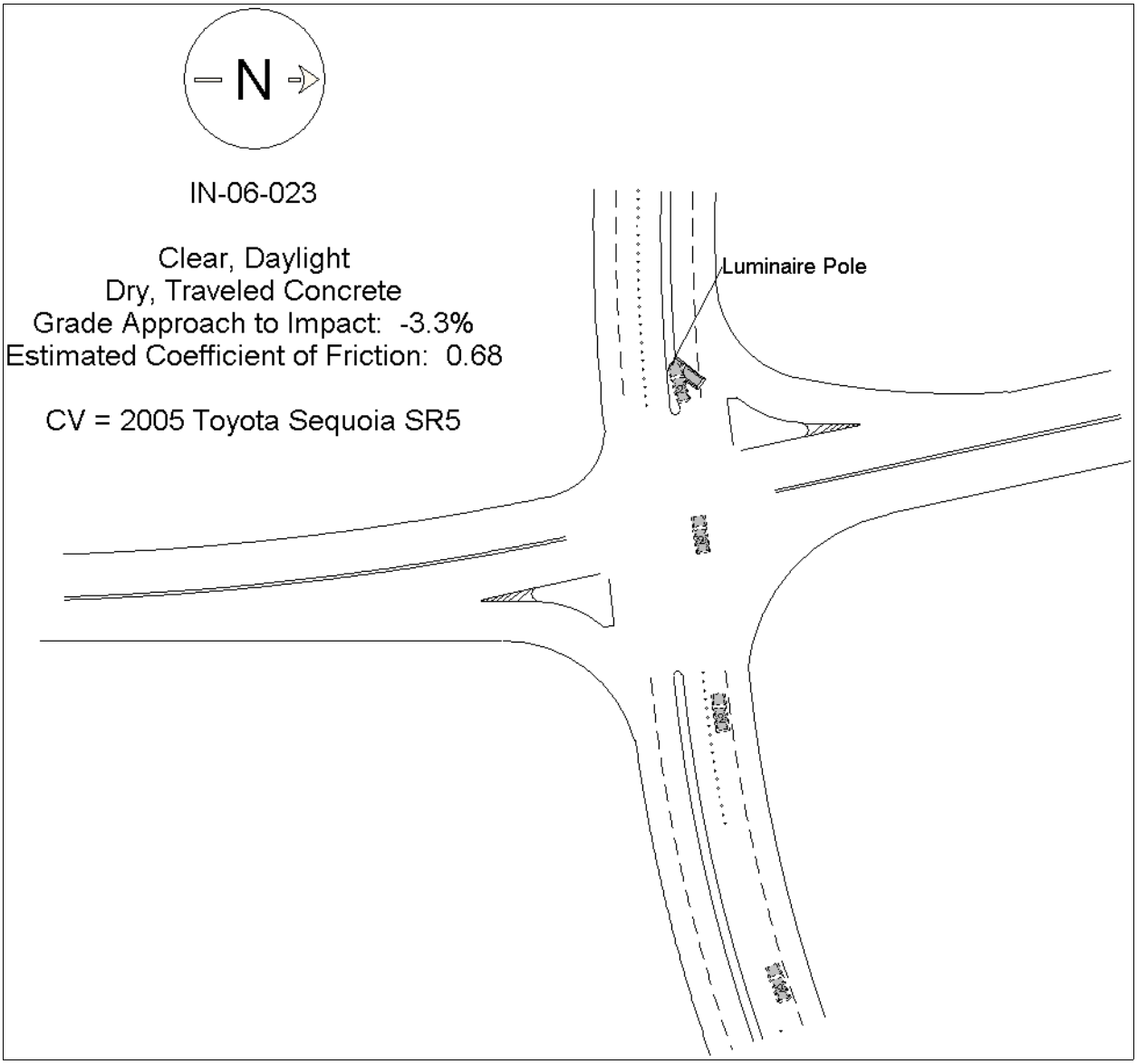
The case vehicle's driver made no avoidance maneuvers. As a result, the back center passenger's body position did not change prior to impact. As the case vehicle ran over the curb just prior to the impact, the passenger's safety belt retractor most likely locked. The case vehicle's front impact with the luminaire pole then caused the passenger to continue forward along a path opposite the case vehicle's 0 degree direction of principal force as the vehicle decelerated and he loaded his safety belt. His interaction with the safety belt caused an abrasion approximately 10 centimeters (4 inches) in length extending from his chest to the left side of his neck, as well as an approximate 5 centimeter (2 inches) contusion on both of his hips. The case vehicle then continued to move slightly forward and rotated counterclockwise, and he remained in a forward position against his shoulder belt and moved slightly to the right. This passenger then rebounded back into his seat. He exited the case vehicle under his own power. The back center

passenger's use of his three-point, lap-and-shoulder safety belt system prevented him from possibly being projected forward between the front seats and into the instrument panel or windshield and mitigated his injury potential.

CASE VEHICLE BACK CENTER PASSENGER INJURIES

The case vehicle's back center passenger did not sustain any police reported injuries and was not transported to a medical facility. The driver indicated that the passenger sustained no treatment subsequent to the crash for the chest abrasion and hip contusions. The table below shows the back center passenger's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion {bruise} left side of neck, not further specified	minor 390402.1,2	Torso portion of safety belt system	Probable	Interviewee (driver)
2	Contusion {bruise} chest, not further specified	minor 490402.1,4	Torso portion of safety belt system	Probable	Interviewee (driver)
3	Contusion {bruise} across lower abdomen and hips	minor 590402.1,8	Lap portion of safety belt system	Probable	Interviewee (driver)


N
IN-06-023
Clear, Daylight
Dry, Traveled Concrete
Grade Approach to Impact: -3.3%
Estimated Coefficient of Friction: 0.68
CV = 2005 Toyota Sequoia SR5
Luminaire Pole