CRASH DATA RESEARCH CENTER
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CALSPAN ON-SITE CHILD SAFETY SEAT INVESTIGATION
EVENFLO CHASE DELUXE CHILD SAFETY SEAT
SCI CASE NO: CA08028

VEHICLE: 2008 MAZDA 6
LOCATION: ALABAMA
CRASH DATE: MAY 2008

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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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16. Abstract This investigation focused on the injury and injury source of 2 year old male restrained within a forward facing child safety seat (CSS) in the right rear position of a 2008 Mazda 6. The Mazda departed the inboard lane of an interstate, impacted a W-beam guardrail with its front plane and subsequently rolled over. The vehicle came to rest on its roof in the center median. The Mazda 6 was equipped with Certified Advanced 208 Compliant frontal air bags, front seat back mounted side impact air bags, and inflatable side curtains mounted in the roof rails. The vehicle's manufacturer certified that the frontal air bags met the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No: 208. The driver air bag deployed as a result of the guardrail impact. The Mazda was driven by an unrestrained 23 year old female and occupied by the 2 year old male in the CSS. The driver/mother indicated that she had installed the CSS by using the automatic locking mode of the vehicle's switchable safety belt retractor. The vehicle was traveling southbound in the inboard lane of a divided two lane interstate highway at the time of the crash. Reportedly, the driver became distracted while checking for traffic to her right and checking on the child. During her distraction, she allowed the vehicle to drift off the left shoulder of the road precipitating the crash. The occupants of the Mazda sustained minor soft tissue injuries and were transported to a local hospital, treated and released.			
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BACKGROUND

This investigation focused on the injury and injury source of 2 year old male restrained within a forward facing child safety seat (CSS) in the right rear position of a 2008 Mazda 6. The Mazda departed the inboard lane of an interstate, impacted a W-beam guardrail with its front plane and subsequently rolled over. The vehicle came to rest on its roof in the center median. The Mazda 6 was equipped with Certified Advanced 208 Compliant frontal air bags, front seat back mounted side impact air bags, and inflatable side curtains mounted in the roof rails. The vehicle's manufacturer certified that the frontal air bags met the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No: 208. The driver air bag deployed as a result of the guardrail impact. The Mazda was driven by an unrestrained 23 year old female and occupied by the 2 year old male in the CSS. The driver/mother indicated that she had installed the CSS by using the automatic locking mode of the vehicle's switchable safety belt retractor. The vehicle was traveling southbound in the inboard lane of a divided two lane interstate highway at the time of the crash. Reportedly, the driver became distracted while checking for traffic to her right and checking on the child. During her distraction, she allowed the vehicle to drift off the left shoulder of the road precipitating the crash. The occupants of the Mazda sustained minor soft tissue injuries and were transported to a local hospital, treated and released.

Figure 1: Left oblique view of the Mazda 6.

This crash was identified by the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) and notification was sent to the Calspan Special Crash Investigations (SCI) team on July 3, 2008. Calspan SCI initiated a follow-up investigation and established cooperation with the vehicle's insurance carrier and the driver. The vehicle was declared a total loss by the insurance company and was available for inspection at a salvage yard. The child safety seat was in the driver's possession and still being used. The agency assigned an on-site investigation of the crash to the SCI team due its on-going interest in child safety seats and child passenger safety. The on-site portion of the investigation took place on July 23 and 24, 2008.

SUMMARY

VEHICLE DATA

The 2008 Mazda 6 was identified by the Vehicle Identification Number (VIN): 1YVHP80C085 (production sequence deleted). The four-door sedan was equipped with a 2.3 liter, I4 engine linked to a five-speed automatic transmission. The service brakes were a four-wheel disc system was anti-lock (ABS). The manual restraint system consisted of three-point lap and shoulder belts in the five seat positions. The front safety belts were equipped with retractor pretensioners. The Mazda was equipped with CAC frontal air bags, front seat back mounted side impact air bags and roof rail mounted inflatable curtains. The Mazda was equipped with Michelin MXM4 P215/50R17 tires mounted on OEM alloy rims and a Tire Pressure Monitoring System (TPMS). The vehicle manufacturer's recommended cold tire pressure was 221 kPa (32 PSI) front and rear. The specific measured tire data and the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	Tire Flat	7 mm (9/32 in)	No	None
LR	214 kPa (31 PSI)	6 mm (8/32 in)	No	None
RF	Tire Flat	7 mm (9/32 in)	No	Sidewall cut
RR	48 kPa (7 PSI)	6 mm (8/32 in)	No	None

CRASH SITE

This single vehicle run-off road crash occurred during the daylight hours of May 2008. At the time of the crash, the weather was clear and the asphalt road was dry. Due to the passage of time between the May crash date and the July crash notification, any physical evidence at the scene had eroded. The crash occurred on the southbound lanes of a two-lane divided highway in a rural area. **Figure 2** is a trajectory view of the Mazda in the area of the road side departure taken during the SCI scene inspection. The travel lanes measured 3.7 m (12 ft) wide and were bordered by asphalt shoulders. The width of the outboard shoulder measured 3 m (10 ft). The inboard shoulder measured 1 m (3 ft) in width. A rumble strip was incorporated into the inboard shoulder. A 12.8 m (42 ft) wide depressed grass median separated the opposing lanes of the interstate. Two concrete columns were located within the median providing support for an east/west roadway overpass. A W-beam guardrail ran parallel to the southbound lane and protected errant vehicles from contact with the columns. The beginning of the guardrail was located 28.3 m (93 ft) north of the north-most column and 5.5 m (18 ft) east of the pavement edge. The guardrail end treatment was the point of the frontal impact. The end of the guardrail was mounted to two 15 cm (6 in) square wood posts spaced 1.8 m (6 ft) apart. The frontal impact fractured both posts at ground level and the guardrail deformed to the south in a V-shape. **Figure 3** is an image of the damaged guardrail taken several days post-crash. Downstream of the impact, the guardrail tapered toward the

Figure 2: Southbound trajectory view in the area of the roadside departure.

southbound lanes and was located 3.7 m (12 ft) east of the inboard shoulder. The Mazda subsequently rolled over in the median and came to rest on its roof near the base of the column in **Figure 4**. The speed limit of the interstate was 113 km/h (70 mph). A schematic of the crash site is attached to the end of this narrative report as **Figure 10**.

Figure 3: View of the damaged guardrail.

Figure 4: South view at the crash site depicting the guardrail impact and roll trajectory. The Mazda came to rest at the base of the pillar.

C*RASH SEQUENCE*

Pre-Crash

The 23 year old female driver of the Mazda was the owner of the Mazda and had purchased the vehicle new approximately two weeks prior to the crash. She was travelling south on the inboard lane at a driver reported speed of 113 to 121 km/h (70 to 75 mph). The traffic volume was reported as medium. The driver turned to her right to check traffic in the outboard lane before initiating a lane change and allowed the vehicle to drift to the left. She also thought that she may have been checking on her son seated in the right rear position. The 2 year old male was restrained within a forward facing child safety seat and was asleep. When the driver returned her attention to straight ahead, she realized she was entering the center median. The guardrail was directly in front of her. She applied the brakes and braced herself against the steering wheel rim.

Crash

The front plane of the Mazda impacted the end-treatment of the guardrail. The force of the impact caused the driver air bag to deploy. The impact fractured two 15 cm (6 in) wooden posts securing the guardrail and a 3 m (10 ft) length of the W-beam deformed. The Mazda rode through the yielding object continuing its southeast trajectory through the median and began to rotate counterclockwise. The right rear bumper corner swiped against the guardrail as evidenced by a 46 cm (18 in) long horizontal abrasion to the rear fascia. The left front tire of the vehicle began to climb the back side of the median slope resulting in a weight shift to the right rear. The right rear tire furrowed into the soft earth and tripped the vehicle into a right side leading rollover. The Mazda rolled two quarter turns and impacted the ground with its roof. This impact resulted in approximately 10 cm (4 in) of vertical roof deformation at the left aspect of the windshield header. The Mazda continued to roll an additional four quarter turns and came to rest on its roof at the base of the concrete overpass column facing north east. The approximate roll distance was 20 m (65 ft).

Post-Crash

The unrestrained driver came to rest on the roof and crawled out of the vehicle's front right window. Her first instinct was to locate her child and she opened the right rear door. Her son was restrained within the CSS suspended upside down. The driver supported the child, unbuckled the harness retainer clip and harness straps, and removed the child from the vehicle. The child's only injury was a small neck abrasion attributed to the harness straps. Concurrent to the driver's actions multiple passers-by stopped to render assistance. The police and ambulance personnel responded to the scene. The driver and child passenger were transported by ground ambulance to a local hospital and examined. Both individuals were treated for soft tissue injuries and released approximately 2.5 hours post-crash.

2008 MAZDA 6

Exterior Damage

The Mazda sustained exterior damage to its front, top and side planes consistent with the dynamics of the crash. The front bumper fascia separated during the impact with the guardrail exposing the deformed bumper reinforcement bar. The reinforcement bar deformed into a U-shaped pattern. The direct contact damage was limited to the center zone of the front plane and was 20 cm (8 in) in width. The reinforcement bar deformed rearward into the radiator and engine block. The residual crush documented across the bar was as follows: C1 = 0 cm (0 in), C2 = 15 cm (5.9 in), C3 = 34 cm (13.4 in), C4 = 33 cm (13.0 in), C5 = 18 cm (7.1 in), C6 = 5 cm (2.0 in). Refer to **Figure 5**. The Collision Deformation Classification (CDC) was 12-FCEN2.

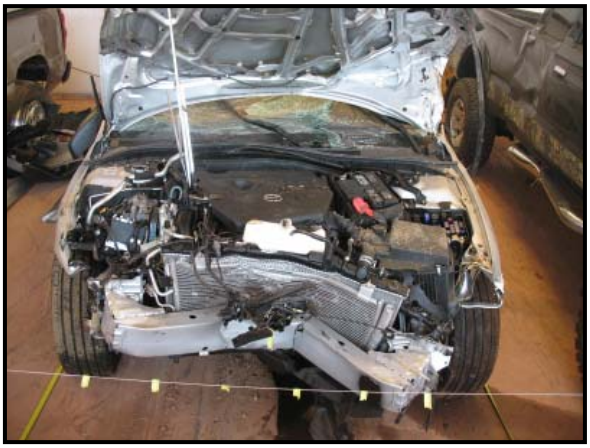

Figure 5: Front view of the Mazda.

The side and top planes exhibited body panel abrasions and deformation consistent with a right side leading, six-quarter turn tripped rollover. Grass, dirt and debris were embedded in the beads of both right side tires indicative of the furrow trip. The left side of the roof deformed down in a shallow V-pattern over the driver's position. The maximum vertical deformation was located on the windshield header 15 cm (6 in) inboard of the left A-pillar, **Figure 6**. The maximum deformation measured 10 cm (4.1 in). There was no lateral deformation of the roof structure. The CDC of the rollover was 00-TDDO3.

Figure 6: Maximum vertical deformation.

The left front door was jammed shut. The left rear and both right side doors remained closed during the crash sequence and were operational post-crash. The glazings of the left front and right front windows disintegrated. The windshield was fractured and the bond separated along the left A-pillar. The separation resulted a triangular shaped void that measured 53 cm x 76 cm (21 in x 30 in), width by height. The sunroof was intact.

Interior Damage

The interior damage to the Mazda consisted of the deployment of the driver air bag and the moderate intrusion of the windshield header and roof into the driver's compartment. The vertical intrusion of the Mazda is listed in the following table:

Position	***Component***	***Magnitude***
Row 1 Left	Left A-Pillar	3 cm (1.2 in)
Row 1 Left	Windshield Header	14 cm (5.5 in)
Row 1 Left	Roof	20 cm (7.9 in)
Row 1 Right	Left A-Pillar	2 cm (0.8 in)
Row 1 Right	Windshield Header	5 cm (2.0 in)
Row 1 Right	Roof	5 cm (2.0 in)
Row 2 Left	Roof	7 cm (2.8 cm)
Row 2 Right	Roof	5 cm (2.0 in)

The six-way powered driver seat was adjusted to a mid-track position at the time of the inspection. The seat could not be moved due to a lack of electrical power. The position of the seat was measured relative to the manual front right seat and was located 8 cm (3 in) aft of full forward. The seat back was reclined 35 degrees aft of vertical. The head restraint was adjusted full down. The horizontal distance from the seat back to the center of the steering wheel rim measured 61 cm (24 in). This distance was measured 48 cm (19 in) above the seat bight. There was no deformation of the steering wheel rim and there was no displacement of the steering column shear capsules. A 10 cm (4 in) vertical scuff was noted to the left aspect of the bolster that was attributed to contact from the driver's left lower extremity. The Mazda was equipped with a sunroof and a shade. The shade was in the closed position. Numerous scuff marks were noted to the shade; however, it could not be determined if the scuffs resulted from driver contact or resulted from post-crash handling of the vehicle.

The unoccupied front right passenger seat was adjusted to a full forward track position. The seat track travel measured 23 cm (9.0 in). The seat back was reclined 25 degrees. The horizontal distance from the seat back to the face of the instrument panel measured 69 cm (27.3 in). The rear seat was a 60/40 split fold-down bench (left side wide). There was no damage or occupant contact points identified in the rear seat area.

Manual Restraint Systems

The driver's manual three-point restraint consisted of a continuous loop webbing, a sliding latch plate, an adjustable D-ring and an Emergency Locking Retractor (ELR). The retractor was equipped with a pretensioner that actuated as a result of the frontal impact. The pretensioner actuated with the webbing stowed on the retractor in the unused position. The webbing was taut

and under tension. The stowed condition of the restraint and the actuated pretensioner indicated the driver was not unrestrained at the time of the crash.

Figure 7: Rear right safety belt.

The manual restraint in the rear right position consisted of a continuous loop webbing, sliding latch plate, and a switchable Automatic Locking Retractor/Emergency Locking Retractor (ALR/ELR). The retractor had been switched to the locking mode by the driver/mother during the CSS installation. During the SCI inspection, the webbing was found in the extended and locked in the used position. The shoulder portion of the webbing was captured between the folding seat back and the outboard bolster of the seat. Refer to **Figure 7**. The length of the captured webbing measured 150 cm (59 in). The webbing was creased 28 cm (11 in) above the seat bight from its interaction with the belt path of the CSS. A second crease was noted 58 cm (23 in) above the seat bight in the area of the latch plate. Subtle abrasions were noted to the friction surface of the latch plate.

Air Bag Systems

The Certified Advanced 208-Compliant (CAC) frontal air bag consisted of advanced dual stage air bags for the driver and front right passenger, seat track position sensors, front safety belt buckle switch sensors, safety belt retractor pretensioners and a front right occupant detection sensor. The CAC air bag system was certified by the vehicle's manufacturer to have met the advanced air bag requirements of the Federal Motor Vehicle Safety Standard No. 208.

The driver air bag deployed from a tri-fold module located in the center hub of the steering wheel rim. The cover flaps were asymmetrical. The upper flap incorporated the Mazda logo design and measured 12 cm x 9 cm (4.8 in x 3.5 in) width by height, respectively. The two lower flaps separated along a vertical seam and were captured in the open position by contact with the steering wheel rim. The flaps were not damaged. The deployed driver air bag measured 58 cm (23 in) in its deflated state. It was not tethered and was vented by two 4 cm (1.5 in) diameter ports located in the 11/1 o'clock sectors. Black deployment scuffs were noted in the 3 and 9 o'clock sectors. The face of the bag was soiled from post-crash handling. There was no residual evidence of occupant contact noted on the face of the air bag.

The front right passenger air bag was a top-mount design located in the right aspect of the instrument panel. The deployment of this air bag was suppressed by the occupant presence detection system in the unoccupied seat.

The Mazda was also equipped with front seat back mounted side air bags and roof rail mounted inflatable curtains. These components were not commanded to deploy in this multiple event crash.

CHILD SAFETY SEAT DATA

Figure 8: View of the Evenflo CSS.

The 2 year old child was restrained in a forward facing manner in an Evenflo Chase Deluxe Child Safety Seat (CSS) that was manufactured on July 21, 2006 and was identified by the model number: 3251692L1. **Figure 8** is a view of the CSS. The seat was designed for use in a forward facing mode with the five-point harness or as a belt positioning booster seat (no harness) dependant on the weight and height of the child. The five-point harness installation was for use by a child weighting 9 to 18 kg (20 to 40 lb) with a height between 74 and 109 cm (29 and 43 in). The belt positioning booster installation was designed for children weighing 13.6 kg to 45.3 kg (40 to 100 lb) with a height less than 137 cm (54 in). At the time of the crash, the CSS was restrained by the vehicle's three-point lap and shoulder belt routed through the forward facing belt path. The mother reported that she had the switchable retractor in the automatic locking mode. The child was secured in the CSS by the five-point harness system. He had a reported height and weight of 14 kg (30 lb) and 76 cm (31 in). She stated that the harness straps were adjusted "snug" on the child. The harness retainer clip was adjusted to the arm pit level. The child was asleep at the time of the crash.

Since the time of the crash, the mother had been using the CSS in her replacement Mazda 6. At the time of the SCI inspection, it was located in the rear right position of her vehicle, **Figure 9**. Examination of the installation revealed the CSS moved side to side approximately 5 cm (2 in) at the belt path. The mother reported that the installation of this CSS was similar to the CSS installation at the time of the crash. She was not familiar with the Child Seat Checkpoints and learned how to install the seat by reading the instruction manual. She stated that she placed her knee in the seat and compressed the seat cushion, set the retractor to the locking mode and then back-fed the webbing into the retractor. Although the CSS was designed with Lower Anchors and Tethers for CHildren (LATCH), she was not familiar with the use of that system.

Figure 9: View of the CSS installed in the replacement Mazda 6.

Examination of the CSS was unremarkable for crash related evidence. Inspection of the forward facing belt path identified minor abrasions consistent with safety belt use. The harness straps of the seat were adjusted to the middle slots. The straps were in good condition and were not roped or twisted. There was no evidence of loading to the straps.

Occupant Demographics:

	Driver	Rear Right Passenger
Age/Sex:	23 year old / Female	2 year old / Male
Height:	155 cm (61 in)	79 cm (31 in)
Weight:	48 kg (105 lb)	14 kg (30 lb)
Seat Position:	Mid-track	Not adjustable
Manual Restraint Usage:	Unrestrained	Five-point harness in a CSS
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Treated and released	Treated and released

Driver Injury

Injury	***Injury Severity (AIS Update 98)***	***Injury Source***
Sourced from medical records		
Left forehead contusion above eye, NFS	Minor (290402.1,7)	Driver air bag
Left forehead abrasions, NFS	Minor (290202.1,7)	Driver air bag
Left forehead laceration, NFS	Minor (290600.1,7)	Flying glass
Abrasions to hands (bilateral), NFS	Minor (790202.1,3)	Driver air bag
Sprained right ankle	Minor (850206.1,1)	Foot controls
Sourced through driver interview		
Left shoulder contusion, NFS	Minor (790402.1,2)	Driver air bag
Left chest contusion, NFS	Minor (490402.1,2)	Driver air bag
Abrasion to central abdomen, NFS	Minor (590402.1,4)	Driver air bag
Left wrist/forearm and 4th finger laceration, NFS	Minor (790600.1,2)	Flying glass
Multiple left lower extremity contusions, NFS	Minor (890402.1,1)	Knee bolster

Source – Emergency Room records and Driver Interview.

Driver Kinematics

The 23 year old female driver was seated in a mid track position and was unrestrained. She was operating the vehicle southbound in the inboard lane. She reported that traffic volume was medium and noticed an approaching non-contact vehicle in her rear view mirror. The driver turned her attention to the right in order to check traffic and to check on her son sleeping in the

right rear position. The driver allowed the Mazda to depart the travel lane to the left. Upon returning her attention to straight ahead, the vehicle was in the center median approaching the guardrail. The driver braced and applied the brakes in an attempt to avoid the crash.

Upon impact with the guardrail, the driver's air bag deployed. The driver initiated a forward trajectory in response to the 12 o'clock direction of force and her face and chest contacted the deploying air bag. This contact resulted in the soft tissue injuries to her face, shoulder, chest and abdomen. Her foot likely slipped off the brake pedal contributing to her ankle sprain. During her forward trajectory, her left lower extremity contacted the knee booster resulting in the identified contusions. As the vehicle tripped and rolled over, the driver was displaced from the seat in an unknown manner. She came to rest on the roof and exited the vehicle through the front right window. The driver then opened the right rear door and removed her son from the CSS. She was transported to a local hospital, treated and released approximately 2.5 hours post-crash.

Rear Right Passenger Injury

Injury	***Injury Severity (AIS Update 98)***	***Injury Source***
Right neck abrasion, NFS	Minor (390202.1,1)	CSS harness strap

Source – Emergency Room records.

Rear Right Passenger Kinematics

The 2 year old male child was restrained by the five-point harness of the child safety seat in the rear right position of the Mazda. The harness straps were reportedly snug and the harness retainer clip was adjusted to the arm pit level. The driver/mother reported that the child was asleep.

Upon impact with the guardrail, the child responded to the 12 o'clock direction of force by initiating a forward trajectory. During his forward trajectory the right aspect of his neck contacted the right harness strap and was abraded. The child's shoulders and chest contacted the harness straps and he began to ride down the force of the impact. As the vehicle tripped and began to rollover, the child continued to load the harness straps and road down the forces of the rollover. The child came to rest upside down, restrained within the CSS. The driver exited the vehicle through the front right window and opened the right rear door. She removed the child from the CSS and waited for the police and EMS personnel to respond. The child was transported to a local hospital, treated and released.

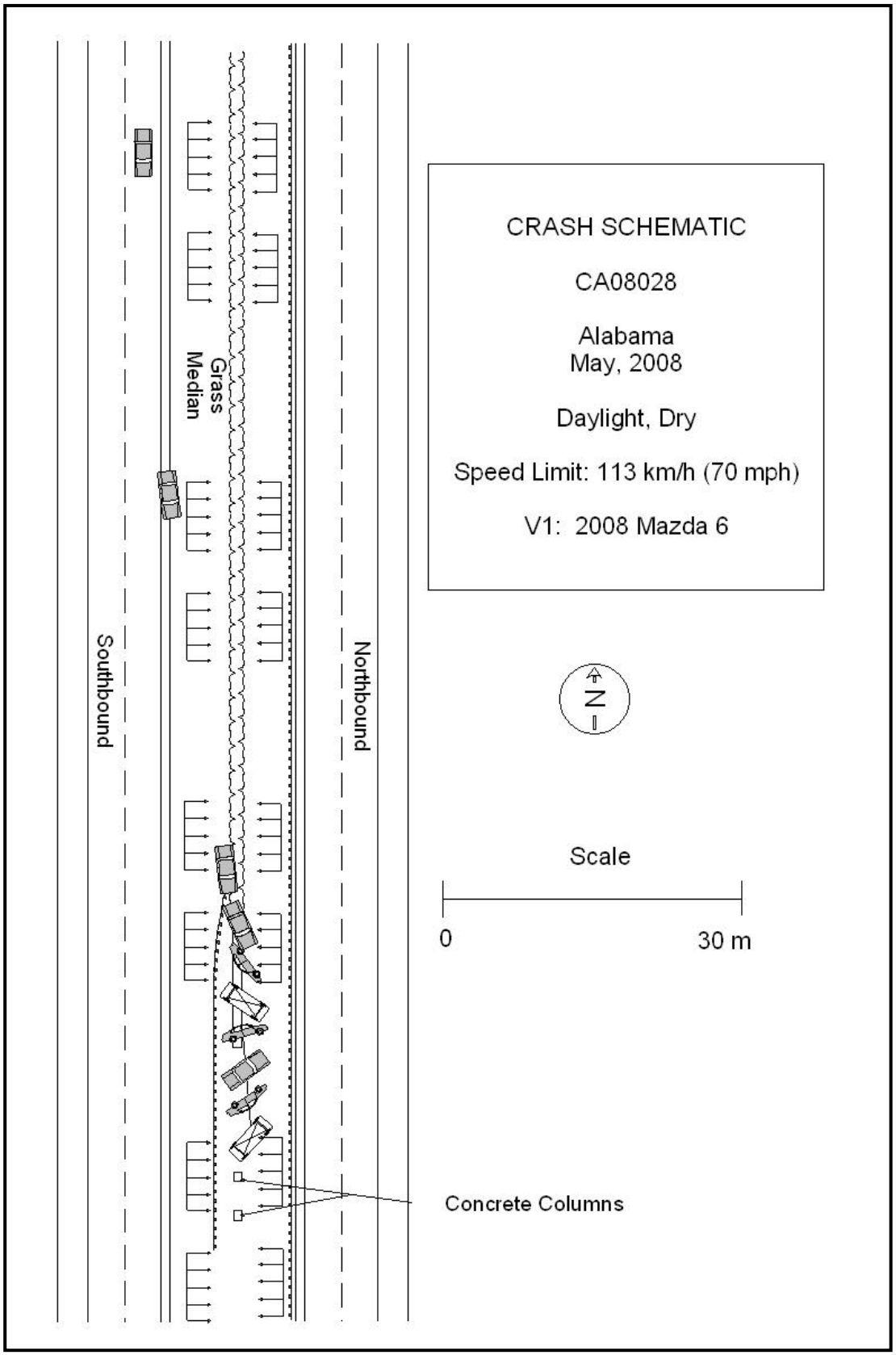

Figure 10: Crash Schematic.