CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD SAFETY SEAT INVESTIGATION

SCI CASE NO. – CA05-023

SUBJECT VEHICLE – 2001 MITSUBISHI MONTERO

LOCATION – FLORIDA

CRASH DATE – APRIL 2005

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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BACKGROUND

This on-site investigative effort focused on the performance of two child safety seats and the resulting injuries to the child occupants of a 2001 Mitsubishi Montero **(Figure 1)**. The Mitsubishi was involved in a multiple impact collision with a 2003 Volvo tractor/1999 Lufkin trailer, and a 1995 Ford Econoline cargo van. A restrained 29-year-old female driver, a 2-year-old male who was seated in the rear left in a forward facing child safety seat, restrained by the integrated 5-point harness system, and a 7-month-old male who was seated in the rear right that was restrained in a rear facing child safety seat, occupied the Mitsubishi. The driver of the Mitsubishi was traveling northbound on a divided interstate roadway where she departed the left side of the road and crossed a depressed grass median. The Mitsubishi entered the southbound lanes where the left side of the Mitsubishi impacted the left side of the Lufkin trailer and continued southbound and struck the Ford in an offset, head-on collision. The driver and child occupants were removed from the Mitsubishi and airlifted to a local trauma center. The 29-year-old female driver sustained severe injuries and was hospitalized for 14 days. The 2-year-old male was transported by helicopter to a local trauma center where he was treated for approximately 90 minutes and was transferred to a second trauma center where he expired. The 7-month-old male rear right occupant was treated at the trauma center and expired approximately 70 minutes post-crash.

Figure 1. Subject vehicle 2001 Mitsubishi Montero.

This crash was identified by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) through an Internet news article. Due to the use of child safety seats and the resultant injuries to the child occupants, NHTSA forwarded the article to the Calspan Special Crash Investigations (SCI) team for follow-up investigation. The Mitsubishi and the forward facing child safety seat (CSS) were located at a local tow yard where cooperation was established and permission was granted to inspect the vehicle and child safety seat. The infant CSS was not with the vehicle during this on-site investigation. The infant CSS was inspected during a subsequent investigation to the region. The case was assigned to the Calspan SCI team on April 19, 2005 as an on-site investigative effort. The vehicles, forward facing CSS, and the crash site were inspected during the week of April 20, 2005.

SUMMARY

Crash Site

This multiple vehicle crash occurred during the daylight hours of April 2005. At the time of the crash, the weather was cloudy and the roadway was dry. The crash occurred on the southbound lanes of a north/south interstate. The interstate was configured with two travel lanes in each direction, which were delineated by broken white lane lines. The north/southbound lanes were separated by a depressed grass median and bordered by asphalt shoulders. The roadside adjacent to the west shoulder consisted of grass and a tree line. The posted speed limit for the roadway was 113 km/h (70 mph). **Figure 2** is an overall view of the roadway. The scene schematic is included as **Figure 21** of this report.

Figure 2. Overall view of the crash from the southbound travel lanes.

Vehicle Data – 2001 Mitsubishi Montero

The 2001 Mitsubishi Montero was identified by the Vehicle Identification Number (VIN): JA4MW31R41 (production sequence omitted). The odometer reading at the time of the inspection was unknown due to lack of power. The vehicle was a four-door sport utility vehicle that was equipped with a 3.5-liter, V6 engine, a 4-speed automatic transmission, four-wheel drive, power-front and rear disc brakes with anti-lock, power steering, and a tilt steering wheel. The Mitsubishi was configured with Uniroyal Laredo tires, size P265/70R16. The manufacturer recommended front and rear tire pressure was 200 and 241 kPa (29 and 35 PSI), respectively. The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	9 mm (11/32)	Yes	Cut sidewall
LR	207 kPa (30 PSI)	8 mm (10/32)	No	None
RF	0 kPa	9 mm (11/32)	Yes	De-beaded
RR	207 kPa (30 PSI)	8 mm (10/32)	No	None

The seating positions in the Mitsubishi were configured with cloth upholstered front bucket seats with height adjustable head restraints. The left head restraint was adjusted to the top third position and the right was adjusted to the lower third position at the time of the SCI inspection. The second row was configured with a three-passenger split-bench seat (60/40) with height adjustable head restraints for the outboard seats. The left head restraint was in the full down position and the right was 2 cm (0.8”) above the full-down position at the time of the SCI inspection. The Mitsubishi was equipped with a two-

passenger third row seat, which was removed prior to the crash and was not available for the SCI inspection.

1995 Ford Econoline

The 1995 Ford Econoline was identified by the VIN: 1FDEE14N7S (production sequence deleted). The odometer reading was not obtained at the time of the inspection due to lack of power. The vehicle was a large cargo van that was equipped with a 5.0-liter, V8 engine, 4-speed automatic transmission, rear-wheel drive, and power steering. The Ford was configured with Mastercraft Courser HTR tires size, P235/75R15. At the time of the SCI inspection the specific tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	283 kPa (41 PSI)	6 mm (8/32)	No	None
LR	255 kPa (37 PSI)	6 mm (7/32)	No	None
RF	0 kPa	5 mm (6/32)	No	Tear on outer sidewall
RR	0 kPa	5 mm (6/32)	No	Tear on inner sidewall

2003 Volvo Tractor and 1999 Lufkin Trailer

The 2003 Volvo tractor and 1999 Lufkin trailer sustained minor damage and were driven from the crash scene and were not located during this SCI investigation.

Crash Sequence

Pre-Crash

The restrained 29-year-old female driver was operating the 2001 Mitsubishi Montero northbound on the inboard lane of the interstate **(Figure 3)**. A non-contact vehicle was traveling northbound adjacent to the Mitsubishi. A 46-year-old male operated the 1995 Ford Econoline, which was towing a trailer southbound on the outboard lane. Based on the on-scene police images, the trailer appeared to contain landscape tools and machinery. A 45-year-old male was operating the 2003 Volvo tractor with a 1999 Lufkin trailer southbound ahead of the Ford. Reportedly, the driver of the Mitsubishi either attempted a lane change maneuver from left to right or drifted into the right lane. The lane change action resulted in the driver that occupied the northbound right lane to activate the horn to alert the driver of the Mitsubishi of its presence. This caused the driver of the Mitsubishi to steer left in order to avoid a potential impact. As a result, the Mitsubishi traveled across the inboard

Figure 3. Mitsubishi's northbound travel.

shoulder and center grass median in a northeast direction and entered the southbound travel lanes.

Crash

As the Mitsubishi entered the outboard southbound lane, the left passenger compartment area impacted the left rear corner of the Lufkin trailer. The direct contact damage began forward of the left B-pillar and extended 236 cm (93") rearward to the left D-pillar. This impact resulted in a slight clockwise rotation; therefore the Mitsubishi began to travel in a northbound direction on the inboard southbound lane. The Volvo tractor and Lufkin trailer continued southbound and came to rest on the right shoulder. **Figure 4** is an overall view of the area of impact and final rest. Note: The tow operator stated to the SCI investigator that another crash occurred at the same location, therefore there's overlapping physical evidence at the crash site.

Figure 4. Area of impact and final rest from the southbound lanes.

The front left area of the Mitsubishi impacted the front left area of the Ford in an offset head-on collision. The resultant directions of force were within the 12 o'clock sector for both vehicles. The Ford was towing a trailer, which altered the weight and stiffness of the vehicle; consequently this articulated combination was outside the scope of the WINSMASH program. The barrier equivalent algorithm of the WINSMASH program was used to calculate a delta-V for the Mitsubishi. The barrier equivalent delta-V was 29 km/h (18.0 mph). The longitudinal and lateral components were -19 km/h (-12.2 mph) and 4 km/h (2.2 mph), respectively. The actual delta-V was higher than calculated; however, the standard algorithm could not be used due to the altered weight and stiffness of the Ford.

As the vehicles crushed to maximum engagement, the Mitsubishi began a counterclockwise (CCW) rotation and overrode the frontal plane of the Ford. The override resulted in direct contact between the Mitsubishi's front right bumper and the windshield header of the Ford. Subsequent to the frontal impact, the cargo in the trailer of the Ford was displaced forward and impacted the rear of the Ford. The Ford was deflected to its right and began a southwest travel direction as it drove through the impact. The Mitsubishi continued its CCW rotation and the right rear tire impacted the left side area of the Ford.

Additionally, a small fire ensued in the engine compartment of the Mitsubishi. The fire was extinguished prior to spreading to the interior of the vehicle.

The Mitsubishi came to rest straddling both southbound travel lanes, facing in an easterly direction. The Ford traveled in a southwest direction and departed the right side of the road and came to rest on the grass roadside, facing in a westerly direction.

Post-Crash

Police and EMS responded to the crash site. The 29-year-old female driver of the Mitsubishi sustained severe injuries and was transported by helicopter to a trauma center where she was hospitalized for 14 days. The 2-year-old male was transported by helicopter to a local trauma center where he was treated for approximately 90 minutes and transferred to a second trauma center where he expired. The 7-month-old male rear right occupant was transported by ambulance to a trauma center where he expired approximately 70 minutes post crash. The driver and front right occupant of the Ford van were fatally injured as a result of the crash.

Vehicle Damage

Exterior Damage – 2001 Mitsubishi Montero

The 2001 Mitsubishi Montero sustained severe left side damage as a result of the initial impact with the Lufkin trailer **(Figure 5)**. The direct contact damage began on the left door window frame and extended 274 cm (108.0”) rearward, which included a 107 cm (42.0”) section of the quarter panel that was torn from the vehicle. Additionally, the direct contact damage on the left side rail measured 236 cm (93.0”) and extended from the A-pillar to the D-pillar. Due to the torn sheet metal, a crush profile could not be obtained along the left side plane of the vehicle. Therefore, the lateral crush was documented at the side rail for this impact at each pillar location. The crush at the A-pillar measured 3 cm (1.2”), B-pillar 10 cm (4.0”), C-pillar 25 cm (10.0”), and D-pillar 25 cm (10.0”). The Collision Deformation Classification (CDC) for this impact was 11-LDAW-3.

Figure 5. Left side damage to the Mitsubishi from the impact with the Lifkin trailer.

Figure 6. Frontal damage to the Mitsubishi from the impact with the Ford.

The Mitsubishi sustained moderate frontal damage as a result of the impact with the front of the Ford **(Figure 6)**. The direct contact damage measured 130 cm (51.2”), and extended to the front left bumper. The maximum crush measured 45 cm (17.7”) and was located at the left corner of the bumper support. A crush profile was documented across the full width of the bumper support of 130 cm (51.2”) and was as

follows: C1 = 45 cm (17.7”), C2 = 22 cm (8.6”), C3 = 11 cm (4.3”), C4 = 4 cm (1.6”), C5 = 0.0, C6 = 0.0. The CDC assigned to this impact was 12-FDEW-2.

The Mitsubishi sustained minor right side damage as a result of the secondary impact with the Ford **(Figure 7)**. The direct contact damage began aft of the forward edge of the right front door and extended forward and measured 117 cm (46.0”). The maximum crush measured 6 cm (2.4”) and was located on the front right fender. The crush profile was documented at the mid-door level for this impact was as follows: C1 = 3 cm (1.2”), C2 = 3 cm (1.2”), C3 = 6 cm (2.4”), C4 = 5 cm (2.0”), C5 = 6 cm (2.4”), C6 = 3 cm (1.2”). The assigned CDC for this event was 03-RFEW-1.

Figure 7. Right side damage to the Montero from the secondary impact with the Ford

The Mitsubishi sustained minor damage to the engine compartment from the ensuing fire. The ignition source could not be identified; additionally the fire was contained within the engine compartment of the vehicle.

Interior Damage – 2001 Mitsubishi Montero

The 2001 Mitsubishi Montero sustained severe interior damage as a result of occupant contacts, air bag deployment, and passenger compartment intrusion. The driver loaded the seat cushion as she responded to the crash forces. The loading deformed the seat track mounting brackets inward, which allowed the cushion to travel downward and forward. Also noted on the seat cushion was a red cloth transfer and frictional abrasions. Deformation and body fluid were noted to the left knee bolster. The lower aspect of the steering wheel rim was deflected 6 cm (2.4”) forward. There was complete separation of the shear capsules. **Figures 8 and 9** are an overall view of the damage to the left instrument panel and driver’s seat cushion.

Figure 8. Interior damage to the first row of the Montero.

The Lufkin trailer penetrated the passenger compartment during the initial impact. The penetration occurred at the second row where the rear left corner of the trailer contacted the outboard aspect of the rear left seatback resulting in a vertical tear approximately 8 cm (3.1") in height. A double stroller that weighed approximately 14 kgs (30 lbs) was located in the rear cargo area of the vehicle. At impact, the stroller loaded the rear of the second row seatback, which resulted in four tears to the cloth, and forward displacement of the seatback **(Figures 10 and 11)**. The longitudinal distance between the front left seat back and the left rear CSS seatback was 27 cm (10.6") and the front seatback to the CSS cushion was 9 cm (3.5"). The second row center and right seatbacks were also displaced forward. The infant CSS was not with the vehicle at the time of the SCI inspection, therefore the longitudinal distance between the CSS and front right seatback was unknown. The passenger compartment intrusions are listed in the table below:

Figure 9. Overhead view of the Mitsubishi's driver's seat cushion and frictional

Seat Position	Intruded Component	Magnitude	Direction
Front Left	Toe Pan	15 cm (5.9")	Longitudinal
Front Left	Floor	2 cm (0.8")	Vertical
Front Left	Roof Rail	2 cm (0.8")	Lateral
Front Left	B-Pillar	10 cm (3.9")	Lateral
Front Right	Toe Pan	8 cm (3.1")	Longitudinal
Rear Left	Lufkin semi-trailer	15-30 cm (6-12")	Lateral
Rear Left	Roof Rail	4 cm (1.6")	Lateral
Rear Left	Roof	3 cm (1.2")	Vertical
Rear Left	C-Pillar	14 cm (5.5")	Lateral
3rd Row Left	Roof Rail	18 cm (7.1")	Lateral
3rd Row Left	Roof	9 cm (3.5")	Vertical
3rd Row Left	D-pillar	6 cm (2.4")	Lateral

Figure 10. Stroller to the rear of the second row seatbacks of the Montero.

Figure 11. Forward deformation of the second row seatbacks of the Mitsubishi and left seatback contact from the Lufkin trailer.

Exterior – 1995 Ford Econoline

The 1995 Ford Econoline sustained severe frontal damage as a result of the frontal impact with the Mitsubishi **(Figure 12)**. The direct contact damage measured 122 cm (48.0”) and extended from the front left bumper corner to the front right bumper corner. The maximum crush at the bumper measured 61 cm (24.0”) and was located 48 cm (18.9”) inboard of the left corner. The maximum crush at the upper radiator support measured 105 cm (41.3”) and was located 48 cm (18.9”) inboard of the left corner. Due to the Mitsubishi overriding the frontal plane of the Ford, the crush was documented at the bumper, upper radiator support, and windshield header. The crush measurements were documented using a combined direct and induced damage width of 122 cm (48.0”). The crush at the bumper was as follows: C1 = 0.0 cm, C2 = 27 cm (10.6”), C3 = 61 cm (24.0”), C4 = 55 cm (21.6”), C5 = 28 cm (11.0”), C6 = 2.0 cm (0.8”). The crush at the upper radiator support was as follows: C1 = 77 cm (30.3”), C2 = 85 cm (33.5”), C3 = 105 cm (41.3”), C4 = 101 cm (39.7”), C5 = 94 cm (37.0”), C6 = 72 cm (28.3”). The CDC for this impact was 12-FDAW-6.

Figure 12. Frontal damage to the Ford from the impact with the Mitsubishi.

Figure 13. Ford’s windshield header damage and crush profile.

As a result of the override impact, the front of the Mitsubishi contacted the windshield header of the Ford **(Figure 13)**. A damage profile was measured to represent the deformation to this area and was as follows: C1 = 22 cm (8.6”), C2 = 20 cm (7.8”), C3 = 5 cm (2.0”), C4 = 0 cm, C5 = 0 cm, C6 = 8 cm (3.1”).

Figure 14. Left side damage to the Ford from the impact with the Mitsubishi's right rear tire.

As the Ford and the Mitsubishi disengaged, the vehicles rotated which resulted in a secondary impact. The impact involved the right rear tire of the Mitsubishi contacting the left side of the Ford **(Figure 14)**. The direct contact damage consisted of a rotating tire scuffmark on the quarter panel rear of the B-pillar. The crush on the left side of the Ford was as follows: C1 = 1 cm (0.4”), C2 = 4 cm (1.6”), C3 = 8 cm (3.1”), C4 = 6 cm (2.4”), C5 = 4 cm (1.6”), C6 = 0 cm. The CDC for this impact was 09-LPEW-1.

The Ford sustained minor severity damage as a result of the cargo impacting the back plane. The direct contact damage measured 149.8 cm (59.0”) and began the rear right bumper corner and extended left. Six equidistant measurements were used to document the crush at the rear bumper and were as follows: C1 = 0 cm, C2 = 11 cm (4.3”), C3 = 29 cm (11.4”), C4 = 23 cm (9.1”), C5 = 14 cm (5.5”), C6 = 9 cm (3.5”). The CDC for this impact was 06-BDEW-2.

Frontal Air Bag System – 2001 Mitsubishi Montero

The 2001 Mitsubishi Montero was equipped with a redesigned frontal air bag system that deployed as result of the frontal impact with the Ford **(Figure 15)**. The driver’s air bag was conventionally located in the center of the steering wheel hub. Two A-symmetrical cover flaps concealed the air bag. The top cover flap measured 14 cm (5.5”) in height and 14 cm (5.5”) in width at the center tear seam. The lower cover flap measured 3 cm (1.2”) in height and 14 cm (5.5”) in width. The air bag membrane was 60 cm (23.6”) in diameter in its deflated state and was vented by two ports that were located on the rear aspect of the air bag at the 11 and 1 o’clock positions. Two wide band tethers at the 9 and 3 o’clock positions tethered the driver’s air bag. There were no occupant contact points present on the air bag membrane; however, dirt and body fluid were present on the air bag face.

Figure 15. Mitsubishi’s deployed frontal air bag system.

The front right passenger air bag was a top-mount design in the right instrument panel. The front right air was concealed by a single cover flap and vented by two ports located on the side panels at the 9 and 3 o'clock positions. The air bag membrane measured 87 cm (34.3") in height and 70 cm (27.6") in width. Dirt and body fluid were present on the air bag membrane.

Side Impact Air Bags – 2001 Mitsubishi Montero

The 2001 Mitsubishi Montero was equipped with seatback mounted side impact air bags for the front seating positions. The side impact air bags did not deploy during this crash.

Manual Restraint Systems – 2001 Mitsubishi Montero

The 2001 Mitsubishi Montero was equipped with manual 3-point lap and shoulder safety belts for the outboard seating positions. The rear center was configured with a 2-point manual lap belt. The driver's safety belt was configured with a sliding latch plate, an Emergency Locking Retractor (ELR), and an energy management loop. The driver utilized her safety belt in the crash, which was evidenced by the abrasions on the latch plate and deployed energy management loop **(Figure 16)**.

Figure 16. Mitsubishi's driver's lap belt with deployed energy management loop.

The front right safety belt was configured with a sliding latch plate, a switchable ELR/Automatic Locking Retractor (ALR), and an energy management loop. The front right position was not occupied therefore; the safety belt was not used during the crash. The rear outboard safety belts were configured with sliding latch plates and switchable ELR/ALR. The left rear safety belt was used to restrain a child safety seat (CSS) that was occupied by the 2-year-old male occupant. Usage was supported by the loading marks and black plastic transfers on the webbing from the CSS **(Figure 17)**. The rear center lap belt was not used in this crash. The rear right safety belt was used to restrain an infant CSS that was occupied by the 7-month-old male occupant. The safety belt exhibited usage evidence that consisted of gray plastic transfers from the CSS **(Figure 18)**.

Figure 17. Loading evidence on left rear safety belt of the Monteror.

Figure 18. Loading evidence on right rear safety belt of the Monteror.

Child Safety Seats – 2001 Mitsubishi Montero

Two CSS's were used in the rear of the Mitsubishi during the crash. The rear left CSS was a Century Select Breverra Classic Model No. 4865MAL01 and was manufactured on 8/2/2000 **(Figure 19)**. The seat was designed to be used as a forward facing CSS with the 5-point harness for children weighing between 13.6-18.1 kg (30-40 lbs), or as a belt-positioning booster for children weighing between 13.6-36.3 kg (30-80 lbs). The seat was used as a forward facing CSS with the 5-point harness system by the 2-year-old male. The vehicle's lap and shoulder belt was routed through the rear belt path to restrain the CSS. This was supported by the loading abrasions that were noted on the belt path and plastic transfers on the safety belt. The harness system was routed through the top slots at the time of the SCI inspection. Additionally, the harness system displayed minor usage evidence that consisted of curling to the harness straps from the child occupant. A 1.0 cm (0.4") tear was noted to the right harness strap and several areas on both straps contained body fluid. Located on cloth seat cushion were body fluid, brain matter, and hair. No damage was noted to the CSS structure.

Figure 19. Rear left forward facing Century CSS.

The rear right CSS was a Graco Lite Rider Model No. 7426CUB that was manufactured on 6/29/2002 **(Figure 20)**. The CSS consisted of a child safety seat with an integral five-point harness system, a pivoting carrying handle, and a detachable base. Additionally, the base was equipped with an adjustable foot that was extended to the lowest of three positions. The CSS was designed as an infant restraint for children that weigh 9.1 kg (20 lbs) or less and height of 66.0 cm (26.0") or less. The 7-month-old male that occupied the CSS was 69 cm (27") in length and weighed 8 kgs (18 lbs). His height was beyond the manufacturer's recommended height of limits (26.0") 66 cm; consequently the CSS was misused according to the manufacturer specifications. Minor stress marks were noted to the front and rear of the top aspect of the shell and to the cushion area of the shell. Stress marks were noted at the base of the shell where the integral harness system was routed through from left to right side indicative of loading to the harness system. Additionally, stress marks were noted to the reinforcements that were located on the outboards aspects of the shell adjacent to the crarrying handle. The

Figure 20. Right rear Graco infant CSS.

base exhibited stress marks on the left side due to contact from the shell reinforcements. The harness system was located in the lower slots at the time of the SCI inspection. In the fastened position, the retainer clip was approximately 2.5 cm (1.0") lower on the left harness strap. There was no damage to the harness system; however, the left harness strap was folded longitudinally at the left hip area.

Occupant Demographics – 2001 Mitsubishi Montero

Driver

Age/Sex:	29-year-old/Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Rear track
Manual Restraint Use:	3-point manual lap and shoulder safety belt
Usage Source:	Vehicle inspection
Eyewear:	Not currently available
Type of Medical Treatment:	Transported to a local trauma center where she was hospitalized for 14 days

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Fractured right orbital floor, NFS	Moderate (251200.2,1)	Left instrument panel
Left hip dislocation	Moderate (850610.2,2)	Knee bolster
Dislocation of the left elbow	Minor (750630.1,2)	Left A-pillar
Comminuted fracture of the left olecranon process	Serious (753204.3,2)	Left A-pillar
Complex laceration of the right knee (with exposed patella) including the quadriceps tendon	Moderate (850818.2,1)	Knee bolster
Grade II open fracture of the right talar neck	Moderate (853200.2,1)	Intruding toe pan
Right subtalar subluxation	Minor (851203.1,1)	Intruding toe pan
Closed left fibula shaft fracture	Moderate (851606.2,2)	Knee bolster
Closed left tibia shaft fracture	Moderate (853420.2,2)	Knee bolster
Perineal laceration, (NFS)	Minor (543220.1,8)	Seat cushion
3.8 cm (1.5") laceration of the right lateral malleoli	Minor (890602.1,1)	Toe pan/foot controls

Injury Data Source = Discharge summary

Driver Kinematics

The 29-year-old female driver of the 2001 Mitsubishi Montero was seated in a presumed upright posture with the seat track adjusted to a rear track position. The driver utilized the manual 3-point lap and shoulder safety belt in the crash, which was evidenced by the minor loading on the safety belt webbing. At impact with the Lufkin trailer, the driver

was probably slightly displaced forward and left as a result of the 11 o'clock direction of force. The Mitsubishi continued its forward travel where the front of the vehicle impacted the front of the Ford van. At impact, the driver's frontal air bag deployed and the driver initiated a forward trajectory in response to the 12 o'clock direction of force. The frontal air bag deployment expanded against the driver's left arm. Her hand separated from the steering wheel and her arm contacted the left instrument panel resulting in the dislocation of the left elbow, and comminuted fracture of the left olecranon process.

The driver loaded the manual lap and shoulder belt, which resulted in the deployment of the energy management loop. Her upper torso loaded through the deployed air bag and engaged the steering wheel rim, which deformed the steering wheel rim and compressed the steering column. There was complete separation of the shear capsules. The deployment of the energy management loop allowed the driver's lower body to travel forward. As the vehicles reached maximum engagement, the Mitsubishi began to override the front of the Van; the driver loaded the seat cushion compressing it against the frame. The seat cushion loading was noted by the red clothing transfer, deformed seat track brackets, longitudinally and vertical displaced seat cushion, and frictional abrasions to the cushion. The loading to the seat cushion resulted in the perineal laceration.

As the vehicle continued to crush, the toe pan subsequently intruded into the passenger compartment, resulting in the grade II open fracture of the right talar neck and the subtalar subluxation. The driver's lower extremities contacted and loaded the knee bolster which resulted in the closed left tibia shaft fracture, a closed left fibula shaft fracture, a complex laceration of the right knee (with exposed patella) including the quadriceps tendon, and the left hip dislocation. The 4 cm (1.5") laceration of the lateral malleoli result from contact from the intruding toe pan and foot controls.

As the vehicles continued forward, the lower front right aspect of the Mitsubishi impacted the left aspect of the windshield header. This impact displaced the driver's head in a forward and downward motion allowing her to contact the instrument panel causing the fracture to the right orbital floor.

The driver was transported by helicopter to a local trauma center where she was admitted for treatment. The treatment included surgical repair of the right knee, right ankle, left elbow and left tibia. She was discharged 14 days post crash.

Rear Left Occupant

Age/Sex:	2-year-old/Male
Height:	102 cm (40”)
Weight:	18 kgs (39 lbs)
Seat Track Position:	Not adjustable
Manual Restraint Use:	5-point harness system in a forward facing CSS
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Transported by helicopter to local trauma center where he was treated for approximately 90 minutes and was then transferred to a second trauma center where he expired

Rear Left Occupant Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Anterior forehead and scalp avulsion/laceration 15.0 cm (5.9”) rear of hairline from right temporal scalp to left supraobital forehead	Minor (190802.1,5) Minor (290802.1,7)	Lufkin semi-trailer
Bilateral subarachnoid hemorrhage superior and lateral cerebral hemispheres	Serious (140684.3,1) Serious (140684.3,2)	Lufkin semi-trailer
Intraventrical hemorrhage	Severe (140678.4,9)	Lufkin semi-trailer
Pneumocephalus	Serious (140682.3,9)	Lufkin semi-trailer
Bilateral subdural hematoma	Critical (140654.5,3)	Lufkin semi-trailer
Edema and diffuse swelling of the cerebral gyri, NFS	Serious (140660.3,9)	Lufkin semi-trailer
Right orbit fracture	Moderate (251200.2,1)	Lufkin semi-trailer
Basilar fracture through orbital roof anterolaterally (extension of the orbit fracture)	Serious (150200.3,8)	Lufkin semi-trailer
Right sinus fracture	Moderate (250800.2,1)	Lufkin semi-trailer
Nasal fracture	Minor (251000.1,4)	Lufkin semi-trailer
Diastatic sagittal suture fracture	Moderate (150402.2,5)	Lufkin semi-trailer
Left thigh abrasion	Minor (890202.1,2)	5-point harness
Multiple forehead and face abrasions	Minor (290202.1,0)	Flying glass
Right periorbital hematoma	Minor (297402.1,1)	Lufkin semi-trailer

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Multiple abrasions to the upper extremities, (NFS)	Minor (790202.1,3)	Child safety seat
Multiple forehead and face contusions	Minor (290402.1,0)	Lufkin semi-trailer
Superficial incised wounds over both legs (lacerations)	Minor (890602.1,3)	Flying glass
Red contusions anterior both legs	Minor (890402.1,3)	Rear of front left seatback

Injury Data Source = Emergency room records and Autopsy

Rear Left Occupant Kinematics

The 2-year-old male was seated in the rear left position of the Mitsubishi in a Century Select Breverra Classic forward facing child safety seat and was restrained by the integrated 5-point harness system. The CSS was restrained to the vehicle by the 3-point lap and shoulder belt. However, the CSS was removed from the belt system prior to the SCI inspection, therefore it was unknown if the retractor was set in the ALR mode

At impact with the Lufkin semi-trailer, the left side glass disintegrated and the child occupant was displaced forward and laterally left. As the Mitsubishi continued its forward trajectory, the Lufkin semi-trailer penetrated the passenger compartment beyond the left B-pillar. The combination of the occupant displacement and the trailer penetration resulted in the 2-year-old contacting the trailer with his head. This contact consequently resulted in the anterior forehead and scalp avulsion/laceration 15 cm (5.9”) rear of hairline from right temporal scalp to left supraobital forehead, bilateral subarachnoid hemorrhage superior and lateral cerebral hemispheres, pneumocephalus, intraventrical hemorrhage, bilateral subdural hematoma, right orbit fracture, basilar fracture through orbital roof anterolaterally (extension of the orbit fracture), right sinus fracture, nasal fracture, diastatic sagittal suture fracture, multiple forehead and face abrasions, right periorbital hematoma, multiple forehead and face contusions.

The occupant loaded the 5-point harness system during the forward displacement, which resulted in the left thigh abrasion. Additionally, he contacted the sides of the child safety seat due to the multiple impacts. This contact resulted in the multiple abrasions to his upper extremities. Also noted were the superficial incised wounds over both legs (lacerations), which were sustained from contact with glass fragments. The red contusions to the anterior of both legs were a result of contact with the rear of the front left seatback.

The 2-year-old male was transported by helicopter to a local trauma center where he was treated for approximately 90 minutes and transferred to a second trauma center where he expired.

Rear Right Occupant

Age/Sex:	7-month-old/Male
Height:	69 cm (27”)
Weight:	8 kgs (18 lbs)
Seat Track Position:	Not adjustable
Manual Restraint Use:	5-point harness system in rear facing CSS
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Fatally injured

Rear Right Occupant Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Large subdural hemorrhage approx 75 ml	Critical (140656.5,9)	Front right seat back
Large diffuse subarachnoid hemorrhage	Serious (140684.3,9)	Front right seat back
Linear basilar skull fracture through right posterior cranial fossa	Serious (150200.3,8)	Front right seat back
C2 fracture at multiple sites, NFS	Moderate (650216.2,6)	Front right seat back
C4-C5 level fracture at multiple sites, NFS	Moderate (650216.2,6)	Front right seat back
T2-T3 level fractures at multiple sites, NFS	Moderate (650418.2,7)	Front right seat back
1.0 cm (0.5”) laceration to the posterior scalp	Minor (190602.1,6)	Front right seat back
Large subgaleal hemorrhage	Minor (190402.1,9)	Front right seat back
Right lung contusion at the periphery; hemothoracies (right 130 ml and left 20 ml)	Serious (441406.3,1)	3-point harness
Forehead and face punctate abrasions	Minor (190202.1,0)	Glass
Right lower thigh and upper leg punctate abrasions	Minor (890202.1,1)	Glass

Injury data source = Emergency room records and Autopsy

Rear Right Occupant Kinematics

The 7-month-old male was seated in the rear right position in the Mitsubishi and was restrained in a Graco infant rear-facing child safety seat. The CSS was designed as an infant restraint for children that weigh 9 kg (20 lb) or less and height of 66 cm (26.0”) or less. The 7-month-old male was 69 cm (27”) in length and weighed 8 kg (18 lb). His height was beyond the manufacturers height limit of the CSS.

The CSS was installed in the vehicle with the detachable base unit. The vehicle's three-point lap and shoulder belt system was routed through the belt path of the base; however, it was unknown if the seat belt retractor was set to the ALR mode. This probably resulted in a loose installation of the CSS. The child was restrained within the CSS by the integral 5-point harness system. A chest retainer clip was present on the harness straps; however, the adjustment of the harness straps and the position of the retainer clip were unknown at the time of the crash. This CSS was inspected at a later date and was not available for repositioning in the Mitsubishi during the on-site SCI investigation.

At impact with the Lufkin semi-trailer, the left side glass disintegrated and scattered throughout the interior of the vehicle. The glass fragments contacted the infant resulting in the forehead and face punctate abrasions and the right lower thigh and upper leg punctate abrasions. Furthermore, this impact probably resulted in minimal displacement of the 7-month-old male.

At impact with the Ford, the child and CSS responded to the frontal crash forces by moving forward. The base of the CSS likely moved forward on the seat cushion, which was allowed by the inherent slack in the vehicle's belt system. The ELR locked which prevented additional spool-out of the belt webbing. As the belt path loaded the safety belt webbing, the plastic transferred onto the webbing, which supported use of the safety belt system.

As the forward movement of the CSS was restricted by the safety belt system, the leading edge of the CSS pitched downward. The infant continued forward, restrained in the CSS by the loosely applied harness system. (This was presumed based on his resultant motion, loading and injury.) Due to his height, the close proximity of the rear-facing CSS in relation to the front seat back, and the forward motion of the CSS and the infant, the top of the infant's head extended forward of the CSS shell and loaded the back of the front right seat back resulting in a 1 cm (0.5") laceration to the posterior scalp, a large subgaleal hemorrhage, a large subdural hemorrhage of approximately 75 ml, large diffuse subarachnoid hemorrhage and a linear basilar skull fracture through right posterior cranial fossa. As the infant's body continued forward, axial loading with compression of his neck and spinal column occurred, which resulted in the C2 fracture at multiple sites, C4-C5 level fracture at multiple sites, and T2-T3 level fractures at multiple sites.

The 7-month old male loaded the harness system of the CSS, which resulted in the right lung contusion at the periphery and bilateral hemothoracies (right 130 ml and left 20 ml). The 7-month-old male was transported by helicopter to a local trauma center where he expired approximately 70 minutes post-crash. An autopsy was performed which provided the detail of these injuries.

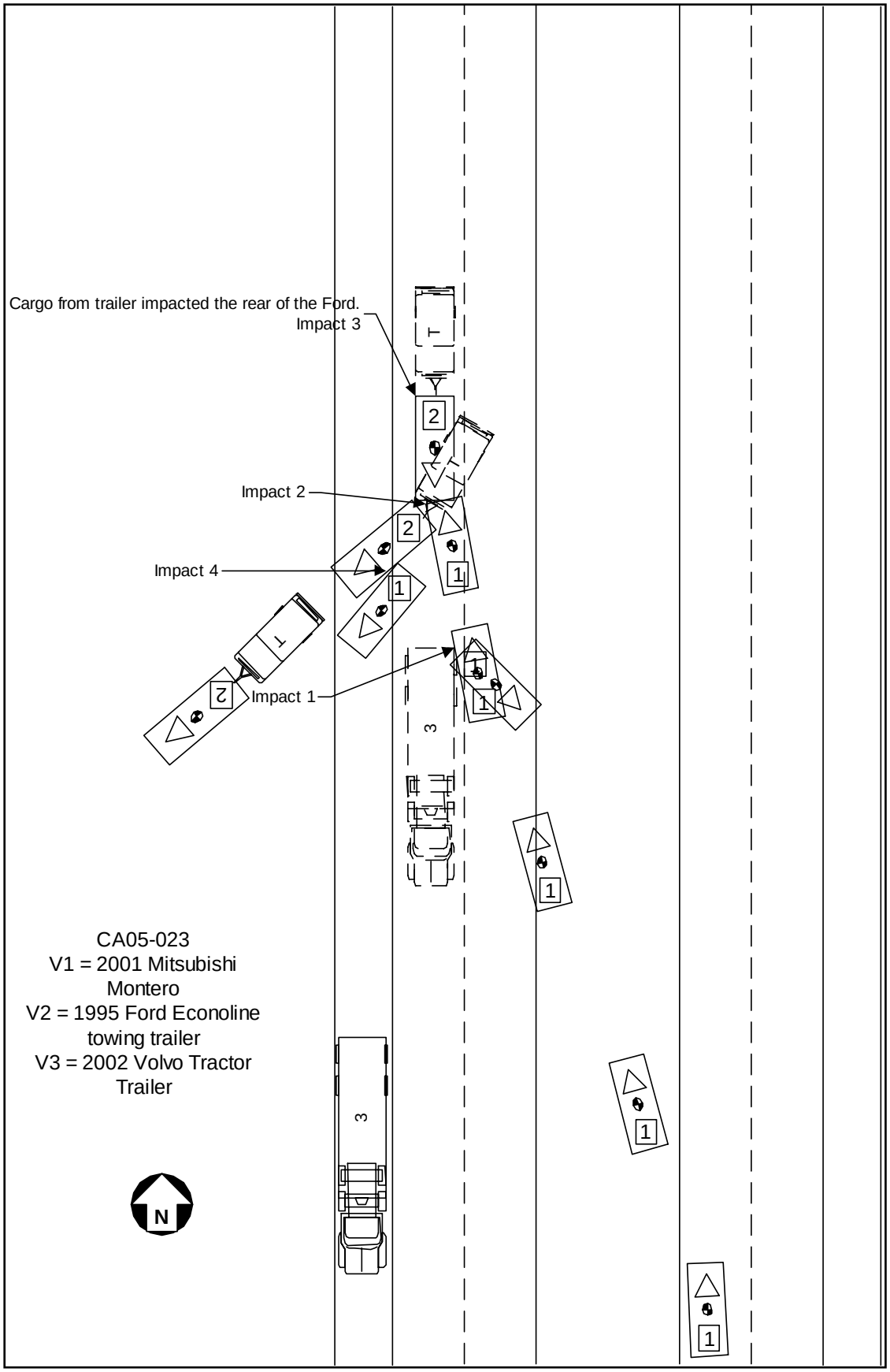

Figure 21. Scene schematic