ALASKA LEGISLATURE COMMITTEE FILES 1987-1988 8672
5561 SSTA HB 167 (file 1)

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Seating location: Bench 3, extreme left
Sex: M
Age: 17
Height: 5 feet 7 inches
Weight: 180
Seated height: 34 inches
Restraint used: None
Proper use? NA

This man was not wearing the static lap belt available at his seat position. The Safety Board's examination of the area forward of this position revealed the uppermost framework of the second bench seatback was displaced forward several inches, with a further bow reaching an additional 3 1/2 inches at top center. The lower tubular supports for the second bench were bent forward, 3 inches on the left side and 3 3/4 inches at the right side. The framework beneath the third bench was bent forward, 4 inches on the left side and 6 1/2 inches at the right side. The right front base support anchor beneath this seat was found to be separated from the lower seat framework.

Injuries	AIS	Probable Source
Fracture, left distal radius	2	Bench 2 seatback
Mild concussion	2	Bench 2 seatback
Abrasion, lower right leg	1	Bench 2 lower frame
Abrasion, lower left leg	1	Bench 2 lower frame

He was treated and released at a hospital. He stated that almost 1 month of work was lost as a result of the accident injuries.

Containment worked again at this position, as the forces acting upon this man were allowed to dissipate over the major bulk of his body rather than be concentrated at narrow body areas.

Seating location: Bench 3, center
Sex: M
Age: 17
Height: 6 feet
Weight: 143
Seated Height: 37 inches
Restraint used: None
Proper use? NA

This man was not wearing the static lap belt available at his position. The top of the second bench seatback was displaced forward several inches in front of this man, with a 3 1/2-inch bow found in the top center tubular framework. The lower supports for the second bench were bent forward, 3 inches on the left side and 3 3/4 inches on the right side. The tubular supports of the third bench were bent forward, 4 inches on the left side and 6 1/2 inches on the right side. He said he was leaning over the seatback of the bench in front of him (second bench) following the crash.

Injuries	AIS	Probable Source
Contusion, nose	1	Bench 2 center occupant
Abrasion, right lower leg	1	Bench 2 lower frame
Unspecified right hip injury	0	Bench 2 seatback
Abrasion, right knee	1	Bench 2 seatback
Unspecified injury, medial lower left thigh	0	Bench 2 seatback
Unspecified injury, medial lower right thigh	0	Bench 2 seatback

He was treated and released at a hospital. He said he was able to return to work immediately.

Containment also worked for this occupant.

Seating location: Bench 3, extreme right
Sex: M
Age: 20
Height: 5 feet 10 inches
Weight: 175
Restraint used: None
Proper use? NA

This man was not wearing the static lap belt available at his position. The Safety Board's examination of the forward area for this position revealed the top portion of the second bench seatback was displaced forward several inches in the crash. The right side tubular framework supports for the second bench were bent forward 3 3/4 inches, and the right side back cushion framework was broken at its junction with the lower cushion frame. The right side tubular framework supports for the third bench, directly below this position, were bent forward 6 1/2 inches. The front base support on the right side of the third bench was separated from the body of the seat. This occupant recalled being thrown into the right side floor area.

Injuries	AIS	Probable Source
Contusion, right shoulder	2	Vehicle interior side
Contusion, right thigh	1	Vehicle interior side
Laceration, right shoulder	1	Vehicle interior side
Abrasions, back of neck	1	Exit through broken side glass

He was treated and released at a hospital and reported no loss of work as a result of his injuries.

Although this man was displaced from his seating position, the major impact forces probably were dissipated through contacts of his upper body and leg with the second bench seatback as he was leaving his seat. This prevented serious injury.

Seating location: Bench 4, extreme left
Sex: M
Age: 17
Height: 5 feet 5 inches
Weight: 150
Restraint used: None
Proper use? NA

This man was not wearing the static lap belt available at his seating position. The top framework of the third bench seatback, located forward of his position, was displaced forward several inches. The lower tubular support posts for the third bench were bent forward 4 inches, and the top center framework was bowed forward 1 1/2 inches. The tubular support posts for the fourth bench, directly below this occupant, were undeformed. With the seatback cushion of the third bench bent forward, the bolt heads and metal plates used for attaching the belt webbing for the third bench were exposed on the rearmost lower cushion framework.

Injuries	AIS	Probable Source
Closed head injury	2	Bench 3 seatback
Fracture, right scapula	2	Bench 3 seatback
Laceration, right lower leg (victim stated 6 inches)	1	Bench 3 lower frame
Contusion, left lower leg	1	Bench 3 lower frame
Contusion, right ankle	1	Bench 3 lower frame
Contusion, central chest	1	Bench 3 seatback
Contusion, right eye	1	Bench 3 seatback

He was treated and released at a hospital. He said he lost about 1 week of work.

This unrestrained man's forward movement was contained by the seatback of the third bench; like the unrestrained man at the third bench, extreme left, he sustained only minor to moderate injuries. The containment effect allowed him to ride down the severe Delta V with dissipation over a large body area.

Seating location: Bench 4, right center
Sex: M
Age: 17
Height: 5 feet 10 inches
Weight: 135
Restraint used: Lap belt (static)
Proper use? Probably

This man was wearing a static lap belt with a cinching type of latchplate, adjustable on a 53-inch length of floor-anchored webbing, and a pushbutton release type of buckle. The buckle webbing, 34 inches long, was also floor-anchored, and both portions of webbing for the system passed through the junction of the upper and lower seat cushions. The belt anchoring method caused lateral separation of 40 inches between the two floor anchor points. The seatback of the third bench, directly forward of this position, was deformed forward several inches at its uppermost edge. One of the seat cushion stiffeners was also

deformed forward. Further examination of this position found the spare tire of the vehicle unattached, lying directly below this seating position (14), on the cargo floor.

Injuries	AIS	Probable Source
Fractured left radius	2	Bench 3 seatback
Fractured left fibula	2	Bench 3 lower frame and unsecured spare tire
Fractured left tibia	2	Bench 3 lower frame and unsecured spare tire
Lacerations to arms	1	Postcrash vehicle exit
Abrasions to arms	1	Postcrash vehicle exit
Numerous abrasions to face	1	Bench 3 seatback, postcrash vehicle exit
Numerous lacerations to face	1	Bench 3 seatback, postcrash vehicle exit
Unspecified urinary tract injury	7	Lap belt

This man said that following the crash a friend helped him get out of the vehicle through a broken side window. He rolled and tumbled down a 45° embankment for about 15 feet. This man was in a hospital for 1 week, followed by an extended period of followup. He said that 4 months of recovery time was required before he could return to work.

The facial injuries sustained by this lap belted occupant were less severe than those of the lap belted men on the first and second benches, probably due to the less rigid contact surface furnished by the center area of the third bench upper seatback, and/or to the fact that he attempted to brace himself.

The injury mechanism of his lower leg injuries was the unsecured spare tire, which moved forward during the crash and struck his legs. Had the spare tire been secured properly, it is unlikely that the extreme lower fractures could have occurred.

Had this occupant not been restrained, it could be assumed that his injury level would have been similar to that sustained by other center seated occupants--i.e., minor to moderate. (However, this assumption does not consider the unsecured spare tire.)

Seating location: Bench 4, extreme right
Sex: M
Age: 20
Height: 5 feet 6 inches
Weight: 128
Restraint used: Lap belt (static)
Proper use? Probably not

This man was wearing a static lap belt with a cinching type of latchplate, adjustable on a 45-inch length of webbing, and a pushbutton release type of buckle attached to a 44-inch length of webbing. Both webbing sections entered the seat position area by passing between the junction of the seat cushions. He said that his lap belt tension was snug but could not state the position about his body.

The seatback of the third bench was displaced forward several inches directly forward of this occupant's position. The extreme right side of the third bench was directly forward of the approximate longitudinal center of his position. On the cargo floor, directly forward of him, a raised tire well is located adjacent to the interior sidewall. The fourth bench tubular support posts at the extreme right were bent forward 5 inches. There was no deformation noted at the back cushion of the fourth bench.

Injuries	AIS	Probable Source
Torn sigmoid colon	5	Lap belt
Torn mesentery	4	Lap belt
Torn serosa of jejunum	4	Lap belt
Fracture, 5th lumbar vertebra	3	Lap belt
Cauda equina (nerve root) injury	3	Lap belt
Contusion, right ankle	1	Cargo floor tire well
Fracture, left 1st rib	1	Right side, bench 3 seatback

Only major injuries were noted in detail on this man's hospital records. No detailed information was supplied as to contusions and abrasions about his body. It was noted, however, on the emergency room reports, that he was tender in the left upper quadrant of the abdomen.

He spent 2 months in a hospital. Following discharge, he required outpatient care about once a month. Seven months after the accident, he had not returned to work and stated that he was on disability.

The critical abdominal injuries sustained by this man can be attributed directly to the lap belt he was wearing. His kinematics can be easily traced by the nature and location of his injuries. The forward travel of his upper body resulted in a fracture of the T-1 left side rib as that body area struck the extreme right side of the third bench seatback. (That seatback is offset inboard from the right approximately 12 inches to allow a passageway.) With the reactive travel forward and slightly to the right, this man's upper body was not contained, and a jackknife action over the lap belt resulted. His entire deceleration was into the 2-inch-wide lap belt. The nature of his internal abdominal injuries and the fracture at the L5 vertebra indicate abdominal penetration by the restraint webbing.

The belt webbing at this seating position was anchored to the cargo floor, 19 inches below and 4 inches behind the undeformed junction of the seat cushion. Anchored in this manner, the webbing would have provided a downward force as it was loaded by his body during the crash. If the lap belt had been positioned below this man's iliac crests, the nature of the system's anchors and routing over the metal framework of the lower cushion probably would have prevented it from riding up. Thus, the lap belt probably was above the top of the long iliac crests prior to the deceleration forces.

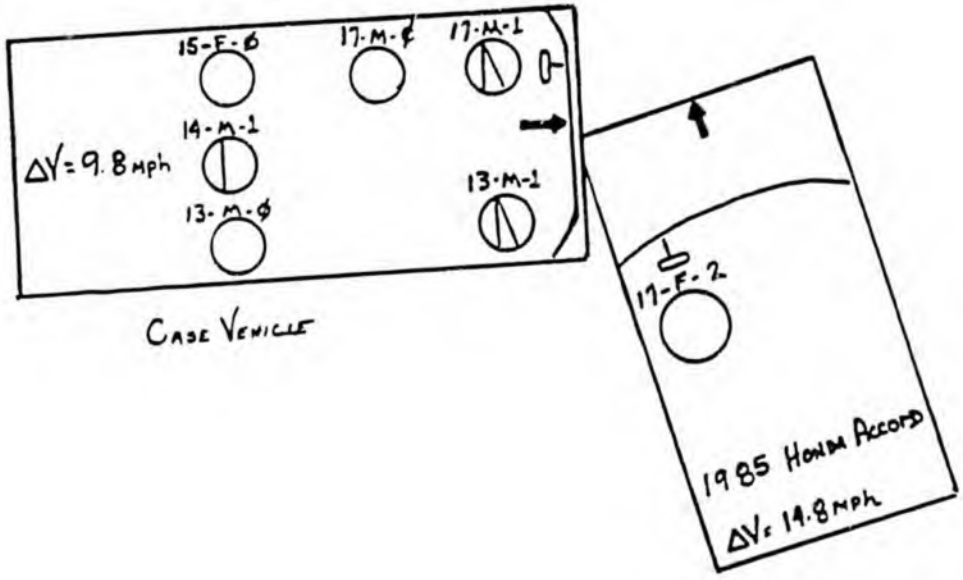
Another factor which probably affected this man's injury severity was the lateral separation between the latchplate and buckle webbing anchors, along with the placement of those anchors in relation to the longitudinal centerline of the seating position. It seems that, under severe force loads, the belt webbing would generate a lateral compression force. As forward loading of the belt webbing increases, the lateral compressive forces into an occupant's abdomen would also increase. With the left side webbing routed out and around the occupant's left side, the maximum compressive forces would occur on that side. A check of his hospital records verify that speculation: his most severe abdominal injuries were located in the lower left quadrant.

An analysis of probable results had this man not been wearing the lap belt is difficult. There would have been little containment provided by the third bench seatback forward of him, due to the 12-inch inboard offset. This passenger's body mass would have been thrown forward and partially contained on the left side. The twisting effect of this deceleration probably would have resulted in various fractures of his extremities, specifically to his lower legs. Fractures of his right side extremities also could have occurred, due to forceful contact with the cargo floor and tire well.

If this man had been restrained in a lap/shoulder belt, he probably would have sustained only minor to moderate injuries.

CASE 5 (FTW-85-H-OR31)

Case vehicle: 1976 Volkswagen Van
Case vehicle weight: 4,000 pounds
Case vehicle Delta V: 9.8 mph



Circumstances

A 1976 VW Van struck, front center, a 1985 Honda Accord on the left front corner. The van was driven by a 17-year-old boy wearing the available static lap/shoulder belt. There were 5 other occupants of the van: a 13-year-old boy in the right front, restrained by a static lap/shoulder belt; a 15-year-old girl in the left rear, unrestrained; a 14-year-old boy in the center rear, with a static lap belt around him; a 13-year-old boy in the right rear, unrestrained; and a passenger riding on the cargo area floor of the van. Damage was substantial to both vehicles and both required towaway removal from the accident scene.

The collision resulted in moderate injuries to the unrestrained driver of the Honda. The restrained driver of the van, although misusing his restraint by wearing the shoulder belt portion routed under his left arm, sustained only minor injuries, as did the lap/shoulder belted right front passenger. The boy riding in the center rear seat with a lap belt received minor injuries also, apparently due to disconnection of the buckle at impact. The remaining occupants, all unrestrained, were not injured.

Restraint and Injury

Seating location: Driver
Sex: M
Age: 17
Height: 6 feet 2 inches
Weight: 175
Seated height: 35 inches
Restraint used: Lap/shoulder belt
Proper use? No

This boy was wearing a lap/shoulder belt with two separate lengths of webbing, joined by a cinching adjustment device, that formed an adjustable length, continuous loop belt, with free sliding latchplate. The latchplate coupled with a rigid stalk-mounted buckle attached to the seat pedestal framework. At the time of the impact, he was wearing the shoulder strap improperly routed under his left arm. The steering assembly was displaced forward approximately 2 inches.

Injuries	AIS	Probable Source
Fractured metacarpal (left)	2	Steering wheel rim
Soreness in upper right shoulder without contusion	0	Impact forces

He attributed his left hand injury to his attempt at bracing against the impact forces. He sought medical attention for this injury, was treated and released.

Given the configuration of the van's interior in front of the driver, it is probable that some degree of injury would have been sustained even if the shoulder strap had been routed properly While the underarm strap routing contributed to an excessive slack in the webbing, there was also simply not enough clear space forward of the driver to avoid a contact with the steering assembly. Although this boy suffered no reported abdominal or chest injuries, the steering assembly displacement must have come about through some contact from his body. It is unlikely that the wheel displacement came about through his attempt to brace himself with his left arm. A 175-pound boy almost certainly could not

hold himself back from the steering assembly with one arm while decelerating through a vehicle speed change of approximately 10 mph, especially when very little upper torso restraint was provided by the improperly routed shoulder strap.

Had this boy been unrestrained, a moderate level of injury could have been expected in this crash.

Seating location: Right front
Sex: M
Age: 13
Height: 5 feet 8 inches
Weight: 135
Restraint used: Lap/shoulder belt
Proper use? Yes

This boy was wearing a lap/shoulder restraint made up of two lengths of webbing, joined by a cinching type of adjustment device, that formed an adjustable length, continuous loop, system with free-sliding latchplate. The latchplate coupled with a rigid stalk- mounted buckle that extended up and forward from its seat pedestal attachment point. This boy's description of system adjustment indicated proper routing and belt tension. The front interior forward of this occupant was collapsed rearward approximately 10 inches, substantially reducing the clear space available. The vehicle's windshield was also displaced from its framework, leaving the unfinished framework edges open to possible occupant contact.

Injuries	AIS	Probable Source
Contusion, upper right shoulder and chest	1	Shoulder strap
Contusion, lower right leg just above ankle	1	Collapsed frontal interior

This boy did not require treatment for his injuries. The lower leg contusion he suffered resulted from interior compression directly in front of him. In a vehicle with collapsible front components other than sheetmetal, this leg injury almost certainly would not have occurred.

Had he not been restrained, even with the relatively low Delta V of this crash, it is very likely that serious injuries would have resulted. Since the windshield was displaced from its framework, it would have been quite possible for him to have been ejected, or partially ejected, through this space (see the right front occupant in Case 4). Even without ejection, severe contacts with the blunt windshield framework would have occurred. This boy's lack of serious, life-threatening injuries can be attributed directly to his (proper) use of and the good performance of the lap/shoulder belt at his position.

Seating location: Rear center
Sex: M
Age: 14
Height: 5 feet 11 inches
Weight: 170
Restraint used: Lap belt (static)
Proper use? Probably not

Before the accident, this boy was wearing a static lap belt. His description of precrash belt adjustment was that the webbing was loosely positioned low on his hips, resting on top of his thighs. He said that immediately after the crash, he found himself on the cargo floor of the van. He could not recall with certainty, but thought that the belt was still routed around him. There were several items lying unsecured in the cargo area, including a 5-gallon plastic bucket.

Injuries	AIS	Probable Source
Small laceration in right eybrow line	1	Interior loose cargo
Abrasion to right knee	1	Cargo floor area

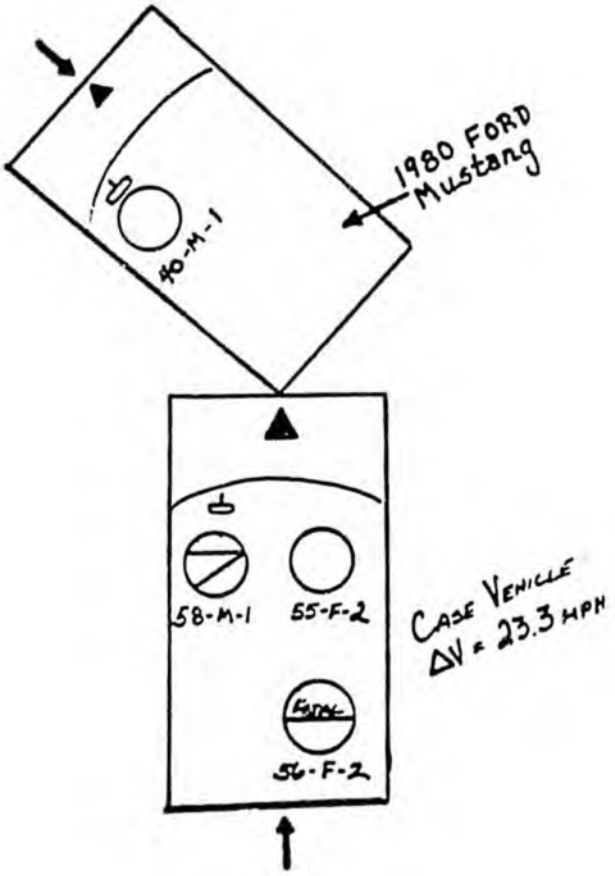
He visited a local emergency clinic for treatment of his minor injuries.

Postcrash webbing measurements showed that the total webbing length of this lap belt could not have allowed the boy to end up on the floor with the latchplate still coupled into the buckle. It is clear that the buckle/latchplate connection must have failed, but it is not readily apparent why it failed. Safety Board investigators were able to secure the connection, postcrash, with no visible defects. Of course, it was not possible to apply force loads similar to those which occurred at the impact, but it is clear that a load of more than 450 pounds did not cause the separation. The absence of load marks on the webbing indicates that the connection failed before or at the very beginning of the imposition of crash loads. It is possible that the connection was not securely fastened by the occupant in the first place.

There were three other young people riding in the rear of the van. A 15-year-old girl was riding unrestrained at the left rear seat position and was not injured. A 13-year-old boy was riding unrestrained at the right rear position and was uninjured. A 17-year-old boy sitting unrestrained on the floor was not injured.

CASE 6 (NYC-84-H-OR05)

Case vehicle: 1983 Chevrolet Malibu, 4-door
Case vehicle weight: 3,690 pounds
Case vehicle Delta V: 23.3 mph



Circumstances

A 1983 Chevrolet Malibu was struck in the front center by the left rear corner of an out-of-control 1980 Ford Mustang. The Chevrolet was occupied by 3 adults, 2 of whom were wearing seat belts: the driver, a 58-year-old man, was wearing a lap/shoulder belt; the right rear passenger, a 56-year-old woman, was wearing a lapbelt. The right front passenger, a 55-year-old woman, was unrestrained.

As a result of the crash, the unrestrained Mustang driver and the front seat occupants of the Chevrolet received minor injuries. The lap belted woman in the right rear of the Chevrolet died soon after arriving at the hospital.

Restraint and Injury

Seating location: Driver
Sex: M
Age: 58
Height: 6 feet
Weight: 270
Restraint used: Lap/shoulder belt (ELR)
Proper use? Yes

The Chevrolet driver was wearing a continuous loop, lap-shoulder belt with a locking latchplate and windowshade type of tension relief device. The ELR was vehicle sensitive.

Injuries	AIS	Probable Source
Chest pain along shoulder belt line	0	Shoulder belt
Mild neck strain	1	Flexion
Contusion, front lower left leg	1	Contact with hardware
Contusion, front lower right leg	1	Under dashboard

This man was examined and released at a hospital.

Seating location: Right front
Sex: F
Age: 55
Height: 5 feet 6 inches
Weight: 160
Restraint used: None

Injuries	AIS	Injury Source
Laceration (2 inch), left temple	2	Rear view mirror
Neck strain	1	Rearward flexion when head struck windshield moulding and visor
Contusion, forehead, both eyes, cheekbone below eye	1	Contact with upper windshield moulding and visor
Soreness above left breast	0	Unknown
Multiple abrasions, discoloration left arm	1	Steering wheel, gear shift, instrument panel instrument panel
Multiple abrasions and discoloration both legs	1	Dashboard, glove compartment
Sprained ankle	1	Floorboard

This woman was treated and released at a hospital.

Since the Chevrolet experienced sudden deceleration and clockwise rotation at impact, the occupants (due to inertia) moved forward and left. This unrestrained woman crashed into the car's interior and received the minor to moderate injuries noted above. If she had worn (properly) the available lap/shoulder belt, she probably would have escaped much of this injury. However, this woman stated that, except for occasional use on a long trip if she is driving, she does not wear seat belts because they are "uncomfortable."

Seating location: Right rear
Sex: F
Age: 56
Height: 5 feet 8 inches
Weight: 155
Restraint used: Lap belt (ALR)
Proper use? Yes

This woman was wearing a lap belt with an ALR. At impact, she also was thrown forward. The lap belt pressed into her abdomen, restraining her pelvis while her upper torso jackknifed over the belt. Her head and legs hit the back of the right front seat, but much of the deceleration force was concentrated at her abdomen by the belt, apparently causing serious intra-abdominal injuries. Since no autopsy was performed, however, the precise nature of her internal injuries was not determined. Circumstantial evidence, however, indicates that she probably suffered internal abdominal injuries that caused severe hemorrhaging and led to her death. The emergency personnel reported that this woman complained of stomach pain, nausea, tingling sensation in the extremities, and difficulty in breathing. At the scene, and en route to the hospital, the emergency technicians encountered difficulty in getting a blood pressure reading--it was weak and

hard to find. They also noted that her abdomen was very swollen. The emergency room physician said he believed this swelling was due to internal hemorrhaging, consistent with the tingling sensation in the extremities and the difficulty in getting blood pressure readings.

The woman died within minutes of arriving at the hospital.

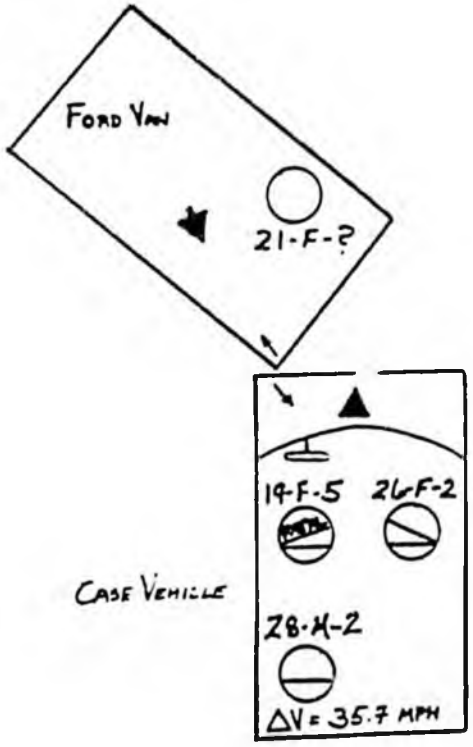
Injuries	AIS	Injury Source
Fracture (probable), nose	1	Front seatback
Contusion, left eye	1	Front seatback
Distended abdomen, with 3-inch bruise along lap belt line, about 2 inches below umbilicus, extending from iliac crests	2	Lap belt
Pelvis, rib pain	7	Unknown

The woman's fatal injuries cannot be attributed to improper belt use or improper belt fit, the Safety Board believes, because the location of the belt contusions on her abdomen indicate that the belt was on the iliac crests at the moment of loading--thus, considered to be within the proper fit zone. Given the level of injuries sustained by the unrestrained front seat passenger, it is reasonable to believe that this rear seated woman would have fared much better if she had not been wearing her lap belt, or if she had been restrained by a lap/shoulder belt.

This case is of special interest because it offers an opportunity to compare the crash outcomes for three persons experiencing similar crash forces but each representing a different restraint situation: the lap/shoulder belt, the lap belt, and unrestrained. Furthermore, the crash was of only moderate severity, and the unrestrained woman and the lap belted woman were of closely similar size. The unrestrained woman was also seated in a more hostile position than the lap belted woman. It is thus important to note the substantial discrepancy between the level of injuries sustained by the right front, unrestrained woman and the lap belted woman sitting in the rear seat behind her. Not surprisingly, the lap/shoulder belted driver fared relatively well; surprisingly, the unrestrained front passenger also fared much better than the lap belted rear passenger.

CASE 7 (CHI-85-H-OR02)

Case vehicle: 1984 Chevrolet Celebrity, 4-door
Case vehicle weight: 3,172 pounds
Case vehicle Delta V: 35.7 mph



Circumstances

A 1984 Chevrolet Celebrity was struck on the left front corner by the right front corner of a 1984 Ford van. The Chevrolet was driven by a 19-year-old woman; a 26-year-old woman was in the right front, and a 28-year-old man was in the left rear. Both front seat occupants were restrained by 3-point lap/shoulder belts, while the rear seat passenger was wearing a lap belt. Both vehicles received substantial front structural damage.

The crash caused critical head injuries to the Chevrolet driver as the front structure collapsed rearward into the driver's space. The driver was pronounced dead 7 1/2 hours after the crash without regaining consciousness. The right front passenger and left rear passenger both sustained multiple moderate to serious injuries.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 19
Height: 5 feet 5 inches
Weight: 122
Seated Height: 27 inches
Restraint used: Lap/shoulder belt (ELR)
Proper use? Yes

This woman was wearing a 3-point, continuous loop, lap/shoulder belt with a vehicle motion sensitive ELR, a cinching type of latchplate, and a pushbutton release type of buckle mounted to a flexible stalk. The restraint system also had a windowshade type of tension relief device, operational only with the position door closed.

The A pillar, instrument panel, and steering assembly were collapsed rearward several inches forward of this seating position; in fact, extrication tools were required to remove this occupant from the crushed interior. The driver's seat was in full foward position.

This collision was probably not survivable for the Celebrity driver, due to the compression of her seating position. The impact forces resulted in several inches of rearward displacement to the steering assembly and B pillar. Had the principal impact area not been located to the left side of the major structural components, the fatal injuries should not have occurred, since the injury-producing contact points would not have been reachable by a fully-restrained driver.

Injuries	AIS	Probable Source
Loss of consciousness (1-24 hours) with neurologic defect	5	Transmitted force, head contact with A pillar
Laceration (2 inches), left parietal scalp	2	A pillar
Laceration (1 1/2 inches), left supraorbital	1	A pillar
Depressed skull fracture, left frontal area	3	A pillar
Traumatic subarachnoid hemorrhage	3	Transmitted forces
Cerebral contusion	3	Transmitted forces
Depressed maxillary fracture	2	A pillar
Abrasions, multiple, left eyelid	1	A pillar
Fracture, right sternum at junction with ribs	2	Steering assembly
Abrasions, left pectoral chest	1	Door side-glass
Contusion, right lower abdomen	1	Steering wheel and/or lap belt
Contusion, junction of abdomen and right thigh	1	Steering wheel and/or lap belt
Closed fracture, right femur	3	Transmitted force from instrument panel
Closed fracture, left femur	3	Transmitted force from instrument panel
Contusion, right thigh	2	Steering assembly
Contusion, posterior surface, left knee	1	Instrument panel and below, collapsed lower A pillar, interior sidewall
Abrasion, left mid-tibial region	1	Instrument panel and below, collapsed lower A pillar, interior sidewall
Contusion, left mid-tibial region	1	Instrument panel and below, collapsed lower A pillar, interior sidewall

This driver reportedly did not regain consciousness following the accident. She was transported to two different hospitals before being pronounced dead approximately 2 1/2 hours later. The official cause of death was multiple injuries with diagnosis of acute craniocerebral injury.

Seating location: Right front
Sex: F
Age: 28
Height: 5 feet 5 inches
Weight: 130
Seated height: 27 1/2 inches
Restraint used: Lap/shoulder belt
Proper use? Yes

This woman was wearing a 3-point, continuous loop, lap/shoulder belt similar to the driver's. Her seat was in full forward position. Though the instrument panel was pushed rearward at this location, the amount of compartment compression was not nearly as great as that which occurred forward of the driver.

This occupant probably rode down the crash forces as well as could be expected. Due to the angular force line, she came from behind the shoulder strap and struck either the steering assembly or the instrument panel with her head. This movement from behind the shoulder strap has been found in other cases involving angular force lines and probably should not be considered a failure with a Delta V of almost 36 mph acting at approximately 40° to 50° from the vehicle's precrash longitudinal travel path.

Injuries	AIS	Probable Source
Laceration, left eyelid	1	Instrument panel or steering wheel
Fractured nose	1	Instrument panel or steering wheel
Contusion, right shoulder to left abdomen	2	Shoulder belt webbing
Contusions, hips and abdomen	1	Lap belt webbing
Abrasion, left hip	1	Buckle and stalk
Fractured pelvis	2	Lap belt
Laceration (4 inch) with avulsed tissue, left lateral thigh	2	Instrument panel parts
Contusion, left lateral ankle	1	Collapsed underpanel
Contusion, right shin	1	Collapsed underpanel
Laceration, left heel	1	Collapsed underpanel
Scratches, right hand	1	Windshield

This passenger was in a hospital for 6 1/2 days and was off work for 1 month.

Seating location: Left rear
Sex: M
Age: 28
Height: 5 feet 7 inches
Weight: 145
Seated height: 30 inches
Restraint used: Lap belt (ALR)
Proper use? Yes

This man was restrained by a lap belt with an ALR, a sewn-in latchplate attached to the retractor webbing, and a sewn-in pushbutton release type of buckle attached to a short length of webbing. The buckle webbing entered the seating area by passing between the seat cushion junction; the latchplate webbing passed over the outboard edge of the lower seat cushion approximately 2 to 3 inches forward of the seat cushion junction.

There was a slight compartment compression at this seating position due to the rearward displacement of the left side B pillar, along with rearward displacement of the lower outboard driver's seat.

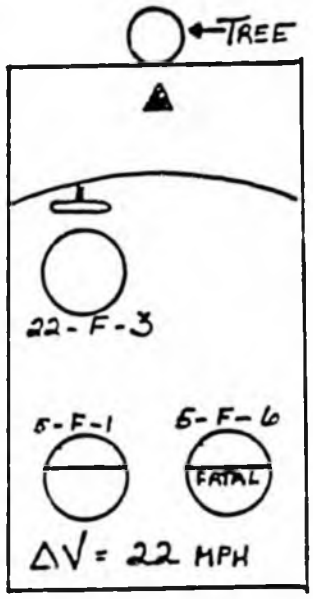
Due to the angular force line, this passenger was subjected to a 33-mph longitudinal Delta V out of the total Delta V 35.7 mph. The lateral speed change component allowed his deceleration to be somewhat contained by the left interior sidewall and B pillar instead of entirely into the 2-inch-wide lap belt webbing. Had he been subjected to an actual 12 o'clock force line and undergone the entire Delta V 35.7 mph longitudinally, the lap belt would have been his major deceleration point. This could very easily have resulted in major internal injuries, since little containment would have been provided by the fully forward driver's seat. It would be extremely difficult to speculate a lesser degree of injury had he not been lap belted, since his travel path to the most severe injuries would have been very similar.

Injuries	AIS	Probable Source
Laceration (3 inch), above left eye	2	B pillar, side-glass
Lacerations (two 1 1/2 inch each), below left eye	2	B pillar, side-glass
Lacerations (two), above right eye	1	B pillar, side-glass
Contusion, large, left side face	2	B pillar, side-glass
Fracture, left mandible	2	B pillar, side-glass
Fracture, left zygoma	2	B pillar, side-glass
Contusion, left parietal scalp	1	B pillar, side-glass
Laceration, left parietal scalp	1	B pillar, side-glass
Abrasions, left shoulder	1	B pillar, side-glass
Lacerations (superficial), left shoulder	1	Side-glass
Contusion, abdominal	2	Lap belt
Laceration, small, left finger	1	Side-glass

He was in a hospital for 8 1/2 days. He was off work for 2 months.

CASE 8 (CHI-85-H-OR19)

Case vehicle: 1977 Chevette, 2-door hatchback
Case vehicle weight: 2,261 pounds
Case vehicle Delta V: 22 mph



Circumstances

A 1977 Chevrolet Chevette sedan, driven by an unrestrained 22-year-old woman with two lap belted 5-year-old girls in the rear seat, ran off the road and hit a tree center front. Following this moderate crash, the three ocupants were transported to a hospital by ambulance. The unrestrained driver received serious injuries, and the lap belted child in the left rear had minor injuries. The lap belted child in the right rear was fatally injured.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 22
Height: 5 feet 6 inches
Weight: 160
Restraint used: None

Injuries	AIS	Injury Source
Fractured right femur	3	Instrument panel
Contusion, right lung	2	Steering assembly
Abrasion, sternum	1	Steering assembly
Fractured pubic bone	2	Steering assembly
Laceration, left knee	1	Instrument panel
Laceration, right knee	1	Instrument panel
Laceration, scalp	2	Windshield
Contusion, right side face	1	Unknown
Abrasion, left elbow	1	Unknown
Abrasion, left shoulder	1	Unknown

Seating location: Left rear
Sex: F
Age: 5
Height: 43 inches
Weight: 41
Seated height: 19 inches
Restraint used: Lap belt (ALR)
Proper use? Perhaps too high

Injuries	AIS	Injury Source
Abrasion, right side forehead	1	Driver's seatback
Abrasion, right upper lip	1	Driver's seatback
Abrasion, left thigh	1	Lap belt
Abrasion across lower abdomen at umbilicus	1	Lap belt

This child was admitted to a hospital only for observation. Although a witness stated that the lap belt worn by this child was tightly adjusted and worn low on the hips, which indicates proper fit and position, the abrasion across the abdomen at the umbilicus suggests that the belt may have been too high.

(See discussion below regarding this child's kinematics.)

Seating location: Right rear
Sex: F
Age: 5
Height: 43 inches
Weight: 41
Seated height: 19 inches
Restraint used: Lap belt (ALR)
Proper use? Probably

Injuries	AIS	Injury Source
Disarticulation of skull from spinal cord (2 cm separation of head from spinal column with torn ligaments; no vertebrae fractures)	6	Impact force
Deep purple bruise at right iliac crest and lower abdomen below umbilicus	1	Lap belt
Bruise of head and face	1	Victim's legs, or seat cushion
Bruise over right eye	1	Victim's legs or seat cushion
Small bruise, left chest	1	Legs, or CPR

This child was found unconscious in the right rear seat by a passing motorist who was first on the scene. He said that the child was wearing a lap belt which he described as fitting tight and positioned low on the hips. He unbuckled the child and removed her from the car. He placed her on the side of the road and administered CPR. When she was removed to the hospital, she was put on a life support system, but never regained consciousness. She was pronounced dead about 18 hours after the crash. No autopsy was performed. The cause of death was listed as severe spinal cord injury with head injury.

Based on the statement of the first person on the scene, and the bruises to the iliac crest and lower abdomen, it is believed that the lap belt was worn within the proper fit zone, if at the upper limit.

Since no autopsy was performed on the fatally injured child, the disarticulation of the skull cannot be certainly attributed to hyperextension (overstretching) or hyperflexion (overbending); it could have been either. Initially, the Safety Board investigation surmised that, during impact, both lap belted children in the rear seat jackknifed forward over their lap belts and struck their heads on the seatbacks in front of them. According to this analysis, the great dissimilarity in the two girls' injuries resulted from the difference in the track adjustment of the seats in front of them--since the right front seatback was

5 inches further forward than the left front seatback, the right rear seat passenger's neck stretched before her head struck the rear seat, causing the fatal injury. However, though this scenario may be possible, on further analysis, the Board concludes the available evidence does not convincingly support it.

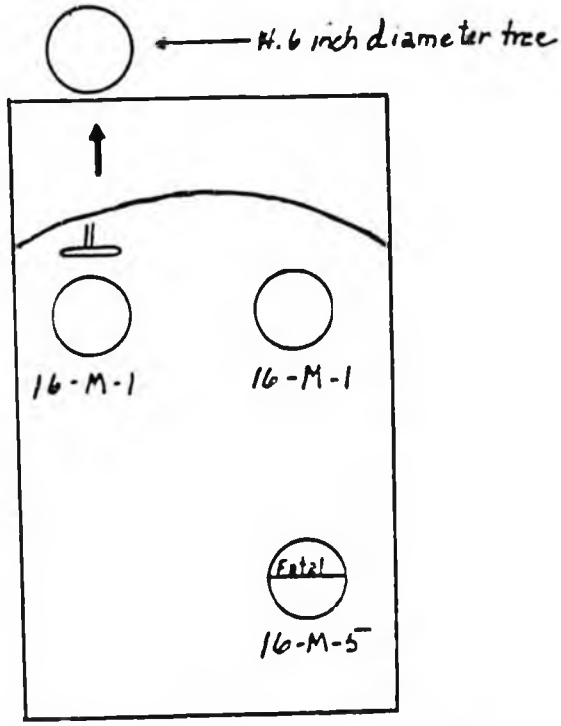
Rather, it is probable, based on the children's 19-inch seated height, their facial injuries, and the location of the clear contact point on the backs of the front seats, that neither child's head struck the seatback in front of her. Since both children were only 43 inches tall, it is likely that, when belted into the car's rear seat, their lower legs did not flex down over the front edge of their seat cushion, but projected straight out. When the car crashed into the tree, the children's bodies moved straight forward and, if anything, their shoes contacted the backs of the front seats while their upper torsos jackknifed over their lap belts and their heads came face down onto their legs or the seat cushion they were seated on, or both. The degree of injury resulting from this type of kinematic is not predictable and likely depends on head attitude combined with leg orientation. (Similar kinematics were involved in bringing about the fatal spinal cord injuries in the similar size boy wearing a lap belt in Case 10.) However, we can be certain that if the children had been lap/shoulder belted they would not have jackknifed forward, and both would have survived. Their survival would not have been left to chance.

This case illustrates an important type of lap belt related injury: head and cervical spine injury resulting from jackknifing forward over the lap belt. Young children may be more vulnerable to this type of injury than are adults.

Finally, although it was clearly evident from the case facts that the fatally injured child was not ejected from the car, both the ambulance and hospital records stated that this child was thrown from the vehicle into a ditch. While it is uncertain what effect this erroneous information had on the evaluation and treatment of the child's injuries, it is vital that emergency room physicians be provided with accurate information regarding the injury-producing mechanics, particularly with unconscious crash victims, to assist them in evaluating the injuries so that treatment will be prompt and appropriate.

CASE 9 (ATL-84-H-OR29)

Case vehicle: 1977 Pontiac Trans Am
Case vehicle weight: 3,940 pounds
Case vehicle Delta V: 26.4 mph



Circumstances

A 1977 Pontiac Trans Am struck a 14.6-inch-diameter tree head-on but left of center. The impact caused front structural collapse of 25 inches on the car. The car was occupied by an unrestrained 16-year-old male driver, an unrestrained 16-year-old boy in the right front, and a 16-year-old boy in the right rear. This boy was restrained by the latchplate webbing of his seating position coupled into the buckle assembly of the seat to his left.

The crash resulted in minor injuries to the front seated occupants. The right rear passenger sustained serious, and ultimately fatal, intra-abdominal and spinal injuries. All occupants were transported to a hospital, where the driver and right front passenger were treated and released. The right rear passenger was admitted to the hospital and received treatment for 25 days before he died.

Restraint and Injury

Seating location: Driver
Sex: M
Age: 16
Height: 5 feet 10 inches
Weight: '60
Restraint used: None
Proper use? NA

Injuries	AIS	Probable Source
Mild abrasion to left side of chest	1	Steering assembly
Hematoma, left lower mandible	1	Steering assembly

Seating location: Right front
Sex: M
Age: 16
Height: 6 feet 1 inch
Weight: 175
Restraint used: None
Proper use? NA

Injuries	AIS	Probable Source
Perineal tear	1	Impact forces

Seating location: Right rear
Sex: M
Age: 16
Height: 5 feet 11 inches
Weight: 150
Restraint used: Lap belt (ALR)
Proper use? No

This boy was wearing a lap belt combination which used the latchplate webbing system furnished for the right rear seat and the buckle system provided for the left rear seating position. It had an ALR for the latchplate webbing and a pushbutton release type of buckle mounted to a short length of webbing passing through the seat cushion junction. His use of the left side buckle assembly was necessary due to the inaccessibility of the right position assembly, but it introduced several inches of lateral separation between the restraint anchor points.

Following is a list of the injuries sustained by this occupant:

Injuries	AIS	Probable Source
Fracture/dislocation of thoracic spine at T-11, T-12	2	Lap belt
Total transection of spinal cord at T-11, T-12	5	Lap belt
Ruptured spleen	4	Lap belt
Ruptured left kidney	5	Lap belt
Ruptured duodenum	5	Lap belt
Ruptured head of pancreas	5	Lap belt
45 mm fracture of right kidney	5	Lap belt
1 to 2 cm contusion on liver	3	Lap belt
Abdominal contusions, upper	1	Lap belt
Left ankle abrasions	1	Front seat assembly
Right knee abrasions	1	Front seat assembly

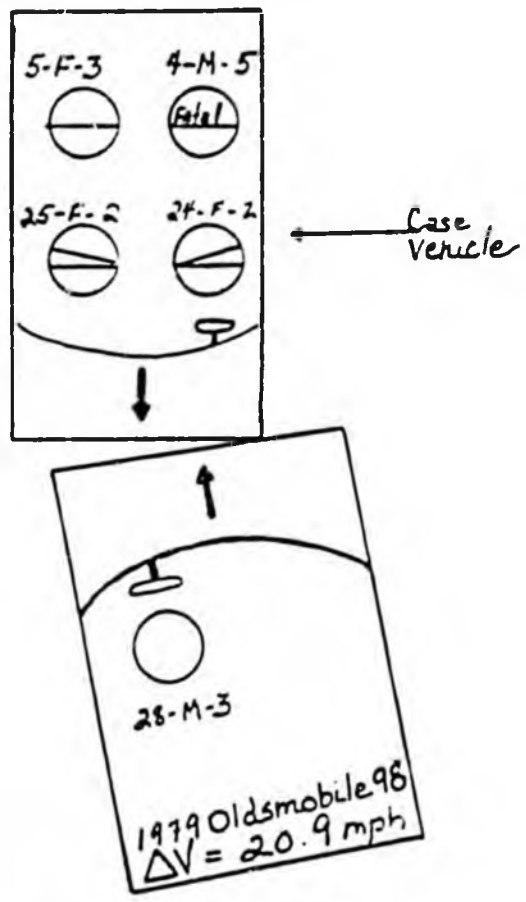
It seems apparent from reviewing the medical records that the major restraining force of the lap belt was concentrated in the upper abdominal area of the victim. The hospital records indicate contusions to the upper abdomen without mention of injuries in the lower area of proper belt routing. In addition to the upper abdominal contusions, all major organ damage was concentrated in the upper area of the abdominal cavity.

The Safety Board concludes that the improper latchplate/buckle coupling was not solely responsible for this boy's injuries. The additional 6 to 8 inches of lateral separation resulting from connecting the right position latchplate into the left position buckle assembly should not, by itself, cause a properly routed lap belt to ride up several inches. The most probable explanation of the injuries is that a combination of three factors contributed: the improper coupling; a lap belt routing which placed the webbing well above the iliac crest; submarining of the occupant which forced the restraint webbing toward the upper area of the abdominal cavity.

In any case, given the nature and severity of the injuries sustained by the front occupants, it seems clear that this boy could have survived with minor or no injury if he had not been wearing a lap belt or had been wearing a properly fitted lap/shoulder belt.

CASE 10 (NYC-85-H-OR09)

Case vehicle: 1982 Subaru station wagon
Case vehicle weight: 2,715 pounds
Case vehicle Delta V: 32.3 mph



Circumstances

A 1982 Subaru station wagon was struck head-on by a 1979 Oldsmobile 98. At impact, the Subaru was stopped and pushed backward; the Delta V was 32.3 mph. The four Subaru occupants were restrained by seat belts. The two adults in the front seat (24-year-old woman driving and 25-year-old woman in right front) were wearing lap/shoulder belts. The two children in the rear seat (a 4-year-old boy in the left rear and a 5-year-old girl in the right rear) were both wearing lap belts.

The rescue squad and ambulances arrived soon after the collision and transported the occupants of both cars to a hospital. The Subaru driver and front seat passenger received moderate injuries, the lap belted 5-year-old in the right rear seat was seriously injured, and the lap belted 4-year-old in the left rear was fatally injured. The unrestrained 28-year-old man driving the Oldsmobile, the vehicle's sole occupant, was seriously injured.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 24
Height: 5 feet 6 inches
Weight: 135
Restraint used: Lap/shoulder belt (ALR)
Proper use? Yes

This woman was wearing a continuous loop, lap/shoulder belt that had a free-sliding latchplate and a vehicle-sensitive ALR.

Injuries	AIS	Probable Source
Lacerated lip	1	Steering wheel
Laceration, right knee	2	Instrument panel
Fractured, right tibial plateau	2	Instrument panel
Fracture and dislocation of right foot	2	Foot control
Laceration, left elbow	1	Driver's door
Abrasion of lower abdomen	1	Steering wheel and/or lap belt

This woman was 12 to 13 weeks pregnant, but she was unaware of it. Her condition was discovered during the postcrash hospital examination. No sign of life was found in the fetus and it was aborted. She was released from the hospital 9 days after the accident.

Seating location: Right front
Sex: F
Age: 25
Height: 5 feet 7 inches
Weight: 130
Restraint used: Lap/shoulder belt
Proper use? Yes

This woman was wearing a lap/shoulder belt similar to the driver's. She suffered the following injuries:

Injuries	AIS	Probable Source
Laceration of left eyelid	1	Unknown
Contusion lower abdomen	1	Lap belt
Fractured, left tibia	2	Dash panel
Contusion, right leg	1	Unknown
Contusion, left thigh	1	Unknown
Contusion, left hip	1	Lap belt

This woman also spent 9 days in the hospital.

Seating location: Right rear
Sex: F
Age: 5
Height: 40 inches
Weight: 35
Restraint used: Lap belt (ALR)
Proper use? Yes

This child sustained the following serious injuries, all induced by the lap belt:

Injuries	AIS	Probable Source
Abrasion, lower abdomen	1	Lap belt
Hematoma, small bowel	3	Lap belt
Retroperitoneal hematoma of lower left abdominal area	3	Lap belt
Mesenteric tear, sigmoid colon	3	Lap belt
Hematoma, sigmoid colon	3	Lap belt
Bilateral fracture of L4	2	Lap belt
Hematoma of the conus medularis (cone-shaped lower end of spinal cord)	7	Lap belt

Her severe abdominal and lumbar spine injuries occurred despite the fact that she seems to have been wearing the lap belt in the proper location. A laparotomy was performed on this girl 2 days after the crash. She was transferred to two other hospitals before being released about 4 months later. She now wears leg braces and must use a "walker" for mobility.

Seating location: Left rear
Sex: M
Age: 4
Height: 40 inches
Weight: 38
Restraint used: Lap belt (ALR)
Proper use? Yes

This child was found unconscious after the crash, and remained unconscious until he was pronounced dead 2 days later. The cause of death was listed as cerebral edema with anoxic changes (changes from lack of oxygen in the brain) and severe contusion of the spinal cord from subluxation of the cervical spine.

Injuries	AIS	Probable Source
Abrasion, right side of forehead	1	Unknown
Severe contusion of cervical spinal cord	3	Unknown
Subluxation of cervical spine (C2-C3)	3	Unknown
Fracture, thoracic spine (T-2)	2	Unknown
Abrasion of thorax at sternum cleft	1	Unknown
Abrasion, right shoulder	1	Unknown
Abrasion, left shoulder	1	Unknown
Brain edema	3	Unknown
Hematoma on back at T-2	1	Unknown
Abrasion, left iliac crest	1	Lap belt
Abrasion, right iliac crest	1	Lap belt
Unconscious more than 24 hours	5	Unknown

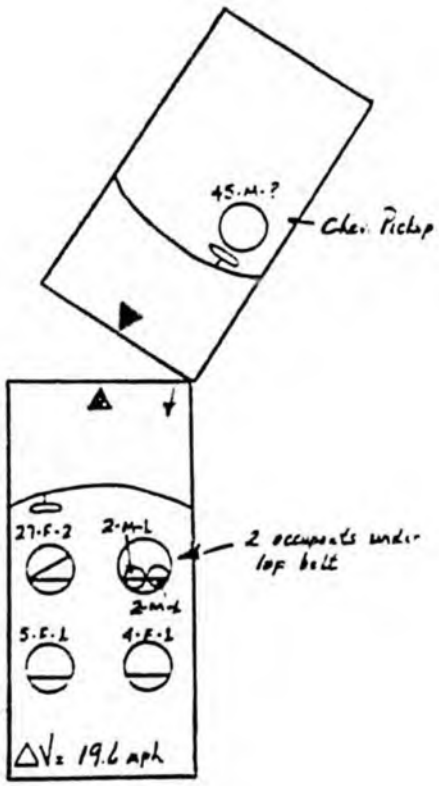
The medical examiner's report on this child's death states that he was appar[illegible] wearing a seat belt but that it might have been loose and that the boy wa[illegible] within the car." These statements are examples of the poor understanding [illegible] medical personnel of motor vehicle crash injury causation. They illustrate how uninformed but official statements have contributed to continued dismissal of lap belt injuries as being caused solely by inappropriate use of the belt.

There is no support for the medical examiner's statements in this case. The facts indicate that the boy was wearing the lap belt in the proper way, that it was snug, and that it fit him in the way lap belts are supposed to fit. The belt is fitted with an automatic locking retractor which is tension loaded and automatically takes up any belt slack and locks the belt in place. Thus, it is highly unlikely that it could have been worn "loosely." There were abrasions on the boy's left and right iliac crests, which indicate that the pelvic area was restrained at impact and that the lap belt was worn within the zone considered to be proper. It appears that the belt performed as designed: it retained the pelvic area and permitted the unrestrained upper torso to jackknife forward over the lap belt. Based on his injuries, the Safety Board surmises that when the boy's upper body jackknifed over the belt, his shoulders struck his legs and his head went down between his knees, causing the spinal cord, spine, and shoulder injuries. (There were similar kinematics involved in causing the fatal cervical spine injuries in the 5-year-old girl wearing a lap belt in Case 8.) Finally, the boy was found lap belted and leaning over on the child in the right rear seat; no interior evidence of contact suggests that the boy was "bounced within the car."

The Safety Board concludes that both these children would have sustained substantially less severe injuries and both would have survived had their upper bodies been restrained along with their pelvises, by the proper use of rear seat lap/shoulder belts.

CASE 11 (ATL-85-H-OR14)

Case vehicle: 1977 Plymouth Arrow, 2-door
Case vehicle weight: 2,395 pounds
Case vehicle Delta V: 19.6 mph



Circumstances

A 1977 Plymouth Arrow struck a 1985 Chevrolet S-10 pickup, right front into left front. The longitudinal Delta V for the car was 14 to 17 mph; the total Delta V was 19.6 mph. The car was occupied by a lap/shoulder belt restrained 27-year-old female driver, 4- and 5-year-old girls in the rear who were lap belt restrained, and two 2-year-old boys seated under a lap belt at the right front.

This moderate crash resulted in moderate injuries to the restrained driver of the Plymouth and minor injuries to all four lap belted children. All were transported to a hospital where they were treated and released. The Plymouth driver required further care from a private physician for treatment of a knee injury and was unable to work for 2 weeks. No visible injury was reported by the unrestrained driver of the Chevrolet pickup.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 27
Height: 5 feet 11 inches
Weight: 110
Restraint used: Lap/shoulder belt (ELR)
Proper use? Yes

The Plymouth driver was wearing a 3-point, continuous loop, lap/shoulder belt with an ELR sensitive to webbing travel, a free-sliding latchplate, and a pushbutton release type of buckle attached to a flexible stalk. A force load mark from the free-sliding latchplate was found 36 inches above the lower outboard webbing anchor. There were no force loading scars on the D-ring area webbing.

An inspection of the driver's interior compartment revealed no compression of the occupiable space. A white area of fabric abrasion was found on the left side of the steering column, just rearward of the lower surface of the instrument panel. The driver related that, at the time of the crash, she was wearing white jeans.

The restraint system adjustment at this position was described as snug with the webbing positioned across the abdomen. The shoulder strap webbing placement was shown by injury photographs to be above the right side of the mid-chest area and the driver indicated the strap to be without excessive slack.

Injuries	AIS	Probable Source
Major contusion, lower abdomen	2	Lap belt
Cervical strain	1	Transmitted forces
Contusion, left clavicle area	1	Shoulder strap
Contusion, mid right chest	1	Shoulder strap
Contusion, left knee,	1	Steering column
Contusion, right knee, medial	1	Steering column
Abrasion, right lower arm	1	Steering wheel rim
Abrasion, medial left ankle	1	Foot pedal controls

Seating location: Right front, inboard
Sex: M
Age: 2
Height: 36 1/2 inches
Weight: 35
Seated height: 20 inches
Restraint used: Lap belt
Proper use? No

This toddler boy was riding on the inboard portion of the right front bucket seat alongside another 2-year-old boy. They were both restrained by the lap belt webbing of a continuous loop, lap/shoulder restraint with the shoulder strap routed behind their backs. The belt system was similar to the driver's.

The driver said that the lap belt was positioned low across the children's hips and snug. There was a 3-inch-long force loading scar at the latchplate adjustment position. The webbing was found folded over itself at the point where it passed through the free-sliding latchplate. There was no loading mark from the D-ring.

Inspection of the right front passenger compartment revealed a depressed area of the vinyl padded instrument panel, just above the upper left corner of the glove compartment door. Light colored hair was embedded in the damaged vinyl surface.

Injuries	AIS	Probable Source
Laceration (1/2 inch), right forehead	1	Instrument panel
Abrasion, right forehead	1	Instrument panel
Abrasion, right eyelid	1	Instrument panel
Contusion, lower right abdomen	1	Lap belt
Contusion, lower right abdomen	1	Lap belt

This boy was treated and released from a hospital.

Seating location: Right front, outboard
Sex: M
Age: 2
Height: 37 1/2 inches
Weight: 25
Seated height: 20 inches
Restraint used: Lap belt
Proper use? No

This child was riding on the outboard portion of the right front bucket seat, restrained with another 2-year-old boy under the lap belt webbing of a 3-point restraint system with the shoulder strap webbing routed behind their backs. (For description of restraint system, adjustment, and position compartment examination, see information on right front inboard passenger.)

Injuries	AIS	Probable Source
Laceration (5 stitches), right parietal scalp	1	Instrument panel
Abrasion, right temporal to right zygomatic	1	Instrument panel

The two small boys were improperly restrained in the right front bucket seat. Both were seated under the lap belt with the shoulder strap routed behind their backs. There was an excessive amount of webbing between the lower outboard anchor and the latchplate; either the lap belt was positioned around them with this excess slack or the excess was crash induced. The boys must have traveled forward and inboard several inches to make the contact with the instrument panel at the point documented by the investigation. There was probably little restraint provided by the lap belt at this position. A large portion of the crash energy acting on these occupants was probably dissipated by the interbelt contact between their bodies and the head strikes into the deeply padded instrument panel. A comparison between the lap belt induced abdominal bruising of these boys and those of the driver clearly show a large difference in restraining effect.

The absence of lap belt related abdominal bruising on the outboard seated child indicates that his body probably loaded the inboard seated child into the belt's webbing. The fact that the inboard occupant received abdominal bruising to both the right and left side reinforce this indication.

Seating location: Left rear
Sex: F
Age: 5
Height: 44 inches
Weight: 40
Seated height: 22 inches
Restraint used: Lap belt (ELR)
Proper use? Yes

This girl was sitting on the rear bench seat, restrained by a lap belt with an emergency locking retractor, a latchplate integrated into the retractor, and a pushbutton release type of buckle. There was no apparent interior compartment deformation nor webbing scars due to force loading of the lap belt.

Injuries	AIS	Probable Source
Contusion, mid to lower left abdomen	1	Lap belt and retractor
Contusion, upper left thigh	1	Lap belt and retractor
Contusion, lower right abdomen	1	Lap belt
Extended period of soreness in abdomen	0	Lap belt

This occupant's lap belt was probably positioned low, across the top of her hips with a snug fit afforded by the retractor tensioning. There were no apparent contact points between the occupant and vehicle interior but it is highly probable, given the resultant force lines due to rotation, that the left side of the girl's head made contact with the vehicle interior sidewall. Her upper body probably hit her lower extremities, due to the jackknifing motion over the lap belt. This jackknife motion is well illustrated by the retractor induced contusions on her left upper thigh and lower left abdomen; these occurred as her body folded over the large retractor assembly. The angular forward motion of her upper body allowed the upper body contact with the lower extremities to occur over the upper surface of her left leg, preventing the head and neck injuries seen in similar crashes due to the head's travel downward between the lower extremities.

Seating location: Right rear
Sex: F
Age: 4
Height: 45 inches
Weight: 35
Seated height: 22 inches
Restraint used: Lap belt (ELR)
Proper use? Yes

This child was restrained in a manner similar to her seatmate in the left rear. There was no interior deformation at or forward of this seating position.

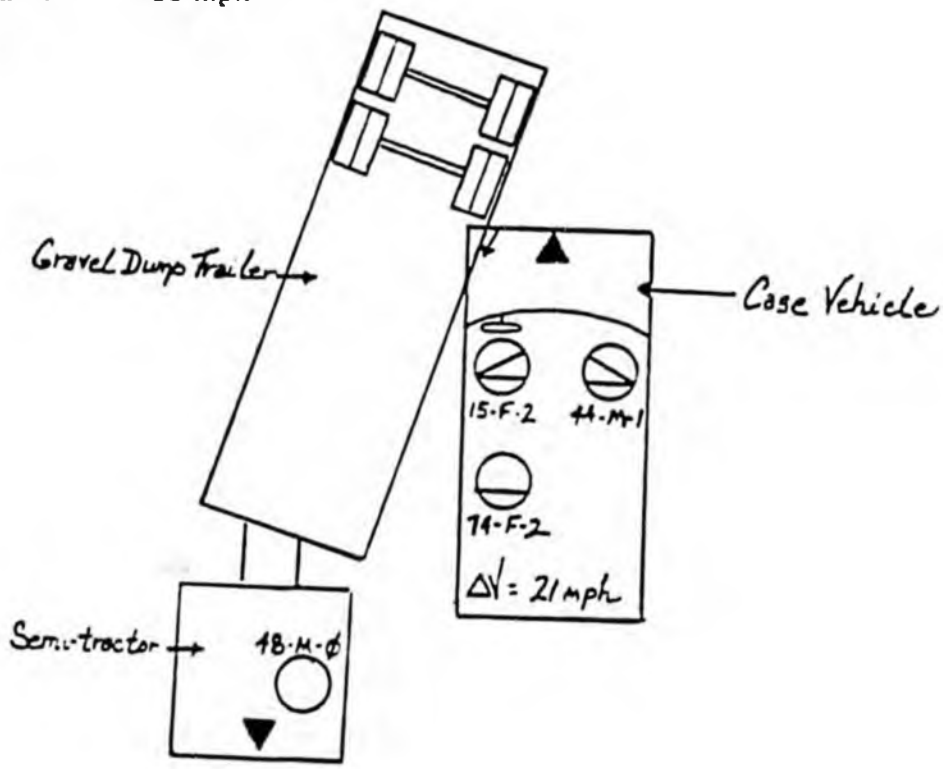
Injuries	AIS	Probable Source
Large contused area, left side mid-abdominal area	1	Lap belt
Contusion, front right hip	1	Lap belt and retractor
Contusion, upper right thigh, front	1	Lap belt and retractor
Extended period of soreness in abdomen	1	Lap belt

The right rear occupant's belt position was probably low across her hips prior to the crash. The abdominal contusion was lower on the right side, well below the iliac crest. The left side contusions appear to begin in the iliac crest area but extend upward into the side abdominal area. This riding up of the belt probably occurred due to the lateral acceleration following the initial impact. The left side of the lap belt would have been loaded as the upper body rotated forward and toward the left, thus allowing the belt to rise over the long iliac crest into an area of less resistance.

The jackknifing motion over the lap belt is also well illustrated by this occupant's contusion pattern. Again, the matching contusions due to folding over the retractor assembly are present, this time on the victim's right side. The resultant occupant travel, due to force line and vehicle rotation, was forward and to the left. This motion allowed her lower extremities to cushion the upper body contact and prevent the neck hyperflexion that occurred to other children in this study when their heads went far down between their legs.

CASE 12 (FTW-85-H-OR17)

Case vehicle: 1984 Chevrolet Cavalier, 2-door
Case vehicle weight: 2,920 pounds
Case vehicle Delta V: 21 mph



Circumstances

A 1984 Chevrolet Cavalier struck, left front corner first, the left leading dual tire assembly of a 42-foot dump trailer being pulled by a 1979 Ford semi-truck. The Chevrolet's left frontal structure was substantially damaged, with rearward displacement depths reaching 20 inches. The trailer unit received only minor damage and was not disabled.

This accident resulted in moderate injuries to the Chevrolet driver, a 15-year-old girl wearing a lap/shoulder belt; minor injuries to the right front passenger, a 54-year-old man wearing a lap/shoulder belt; and moderate to serious injuries to the left rear passenger, a 74-year-old woman wearing a lap belt. Both the driver and the left rear passenger required emergency aid and transportation to a hospital. The driver of the truck combination unit was not injured.

Restraint and Injury

Seating location: Driver
Age: 15
Height: 5 feet 1 inch
Weight: 125
Restraint used: Lap/shoulder belt (ELR)
Proper use? No

This girl was wearing the available 3-point, continuous loop, lap/shoulder belt with a vehicle motion sensitive ELR, a cinching type of latchplate, and a pushbutton release type of buckle attached to a flexible stalk. A windowshade type of tension relief device was also incorporated into the system. There was a webbing scar, from force loading of the cinching latchplate, 35 inches above the lower outboard anchor. Also found was an 8-inch-long area of vinyl transfer onto the shoulder strap webbing from the upper outboard seatback. A matching area of vinyl abrasion was noted on the seatback cushion. There were no webbing scars attributed to the B pillar-mounted D-ring.

The extreme left outboard instrument panel was displaced rearward by approximately 2 inches. The steering wheel rim was displaced forward about 2 1/2 inches at 9, 10, and 11 o'clock. The lowermost edge of the instrument panel was mildly deformed, and fabric scuffs were found at the left and right of the instrument panel. A plastic air duct, located under the instrument panel just to the left of the steering column, was shattered and displaced forward. This air duct was located directly forward of the left side fabric scuff. The seatback was deformed forward approximately 10 to 12 inches at the top.

Injuries	AIS	Probable Source
Deep abrasion with two areas of avulsions, left knee	2	Lower instrument panel
Right ankle sprain	1	Foot controls
Right ankle contusion	1	Foot controls
Contusion, abdominal muscle wall, lower left quadrant	1	Lap belt
Contusion, lower sternum	1	Steering assembly/shoulder restraint
Contusion, lower right chest	1	Steering wheel/shoulder restraint
Contusion, below left clavicle	1	Shoulder strap
Dislocated front teeth	1	Steering assembly
Abrasion, right knee	1	Lower instrument panel
Contusion, posterior upper left arm	1	Seatback cushion
Contusion, posterior upper right arm	1	Seatback cushion

The girl was treated and released at a hospital but required the use of crutches for 10 days.

A review of this girl's injuries, the apparent contact points within the vehicle, and the restraint webbing scars seem to indicate that the shoulder strap provided little or no restriction to upper body movement. A D-ring load mark should have been present in this type of impact if the upper body's forward movement loaded the webbing at impact. The shoulder strap was probably excessively slack; possibly this slackness was present because she set the "windowshade" tension relief incorrectly. This occupant should not have made the severe, rim-deforming, impact with the steering assembly with a properly adjusted restraint system. The vinyl transfer from the seatback onto the shoulder strap probably occurred as the seatback traveled forward, due to loading from the left rear passenger and due to distortion of the vehicle's floorpan. This loading probably took place just as the driver was striking the steering assembly.

This driver said that the lap belt was worn across her abdomen and that it was adjusted somewhere between loose and snug. This type of adjustment would also introduce slack into the shoulder strap as the lower belt system traveled through the cinching latchplate under load.

Seating location: Right front
Sex: M
Age: 44
Height: 6 feet 2 inches
Weight: 225
Restraint used: Lap/shoulder belt
Proper use? Yes

This man was wearing a lap/shoulder belt similar to the driver's. There was a webbing scar from force loading of the latchplate 33 inches above the lower outboard anchor. A second abrasion of the webbing fabric, 75 to 78 inches above the lower outboard anchor, was attributed to webbing travel through the B pillar-mounted D-ring. The seat was adjusted on its track at 5 1/2 inches from the forwardmost position and

1 1/2 inches from its extreme rear. There was no deformation of the seat assembly. Inspection of the forward compartment area at this position revealed a distorted area of the glove compartment: the compartment door was bent forward at the center of its lower edge, and the latching mechanism was broken.

Injuries	AIS	Probable Source
Contusion, chest wall	1	Shoulder belt
Contusion, left knee	1	Instrument panel
Abrasion, left wrist	1	Instrument panel
Contusion, right knee	1	Instrument panel
Contusion, lower right abdomen	1	Lap belt
Cervical strain	1	Transmitted forces

This man refused emergency treatment at the accident scene and transport by ambulance. He later sought treatment at a hospital, where he was released after being checked.

He apparently moved forward sufficiently within his lap/shoulder belt for knee contact with the instrument panel. He said the lap belt was across his abdomen but did not say whether the system was snug. Force loading marks on the webbi[illegible]ndicate that restraint was provided to both his upper and lower body. Considering the impact severity, the occupant's large body size, and the interior compartment dimensions of the case vehicle, it seems that the restraint system performed very well and was probably adjusted well.

Seating location: Left rear
Sex: F
Age: 74
Height: 5 feet 6 inches
Weight: 184
Restraint used: Lap belt (ALR)
Proper use? Yes

This woman was wearing a lap belt with an automatic locking retractor, sewn-in latchplate, and a pushbutton release type of buckle attached to a short length of webbing material. The uppermost surface of the driver's seatback, directly in front of this woman, was permanently deformed forward by several inches, and the lower surface of the seatback was pushed inward.

Injuries	AIS	Probable Source
Closed head injury, concussion	2	Transmitted forces
Deep (3 inch) laceration, right forehead	2	Contact with lower extremity
Major contusion/abrasion, left hip	2	Left interior sidewall
Major contusion, right side of face	2	Contact with lower extremity
Laceration, left forearm	1	Surface of driver seatback
Laceration, right forearm	1	Surface of driver seatback
Contusion, right lower chest	1	Contact with lower extremity
Foot laceration	1	Unknown
Lower left abdominal contusion	1	Lap belt
Contusion, right medial knee and below	1	Head contact
Contusion, right mid-abdomen	1	Lap belt

This woman was hospitalized for 1 day. There was no mention on the emergency treatment forms nor the hospital records indicating the use of a seat belt.

Although this woman described her lap belt as being positioned "across her abdomen," photographs of the belt induced contusion show that the belt was positioned below the iliac crest. The belt tension, as stated by the occupant, was somewhere between loose and snug.

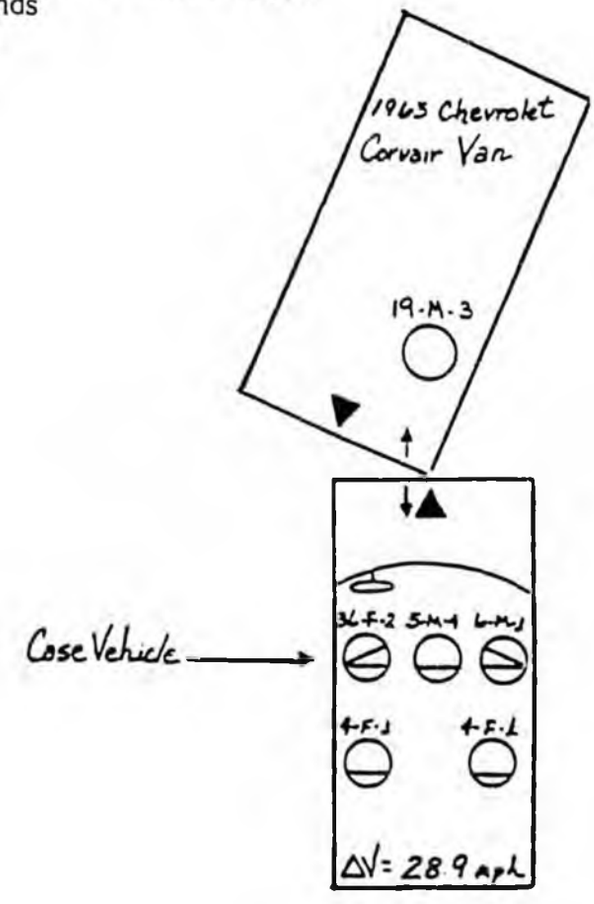
In riding down the impact forces, this occupant jackknifed violently. Her head injury was probably brought about by violent contact with her own right leg. This contact probably was intensified by the continuing travel into the semi-rigid rear surface of the driver's seat. The interior dimensions of the left rear passenger compartment were not great enough, even with the driver's seat adjusted fully forward, to avoid a contact by a person of her size. The forward displacement of the driver's seatback is evidence of that contact.

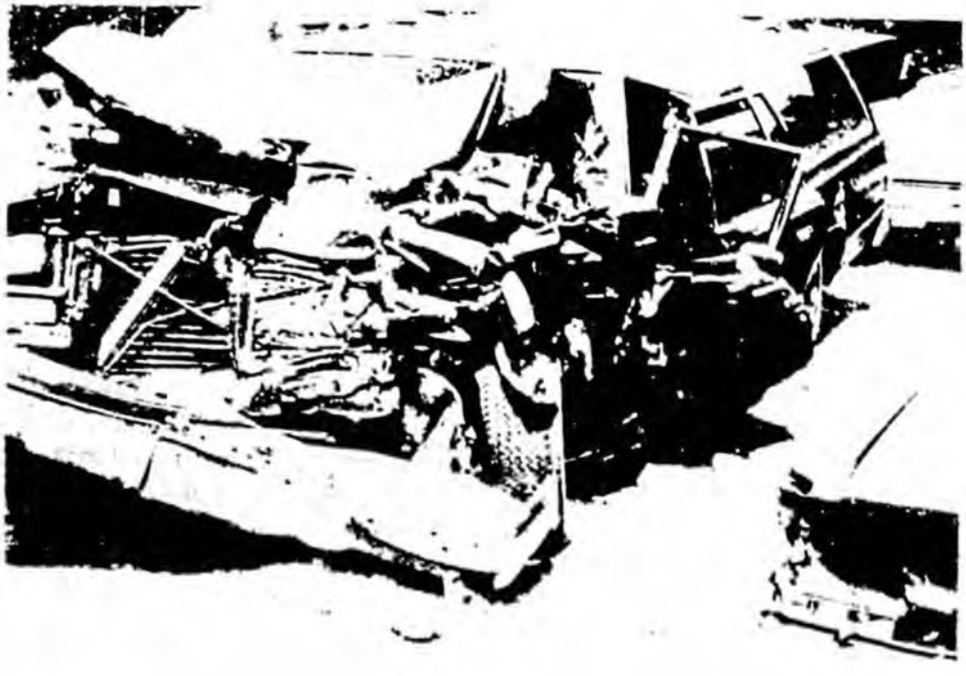
It is difficult to assess the probabilities of injury if this woman had not been restrained. There were no apparent internal injuries resulting from the lap belt. However, her head injury due to the jackknifing motion would probably not have occurred without the lap belt. If the lap belt had not restrained the lower body, a force dissipation would have occurred over her face, torso, and knees. There would also have been additional forward forces placed on the seatback, probably increasing the severity of injuries sustained by the driver. In short, the rear occupant, if unbelted, might have sustained less severe injuries at the expense of the driver.

Of course, the risk of loading the driver would be eliminated if the rear occupant were lap/shoulders belted, as would the occurrence of her several head and facial injuries due to jackknifing over the lap belt.

CASE 13 (SEA-85-H-OR20)

Case vehicle: 1978 Buick Estate station wagon
Case vehicle weight: 4,570 pounds
Case vehicle Delta V: 28.9 mph





CORRECTION

THIS DOCUMENT
HAS BEEN REPHOTOGRAPHED
TO ASSURE LEGIBILITY

CASE 13 (SEA-85-H-OR20)

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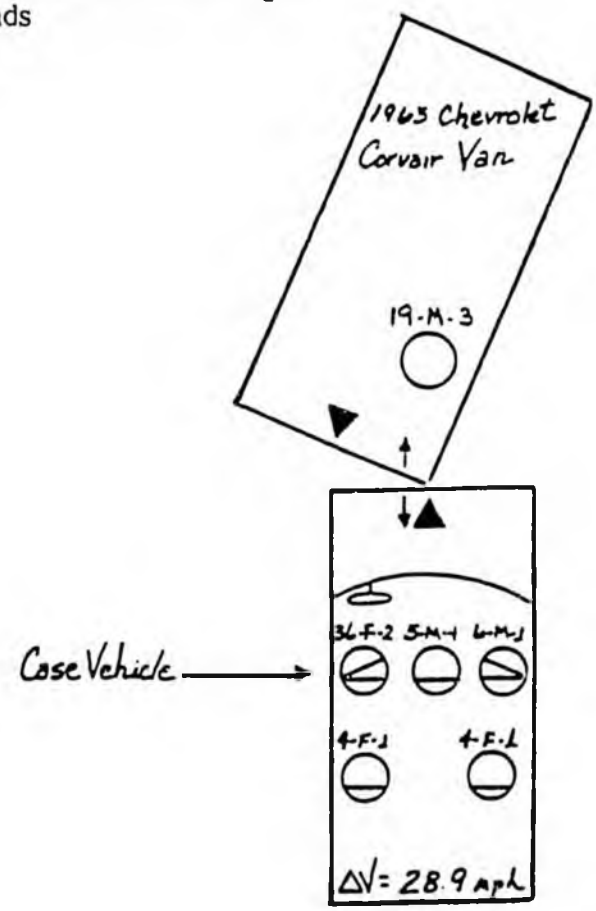
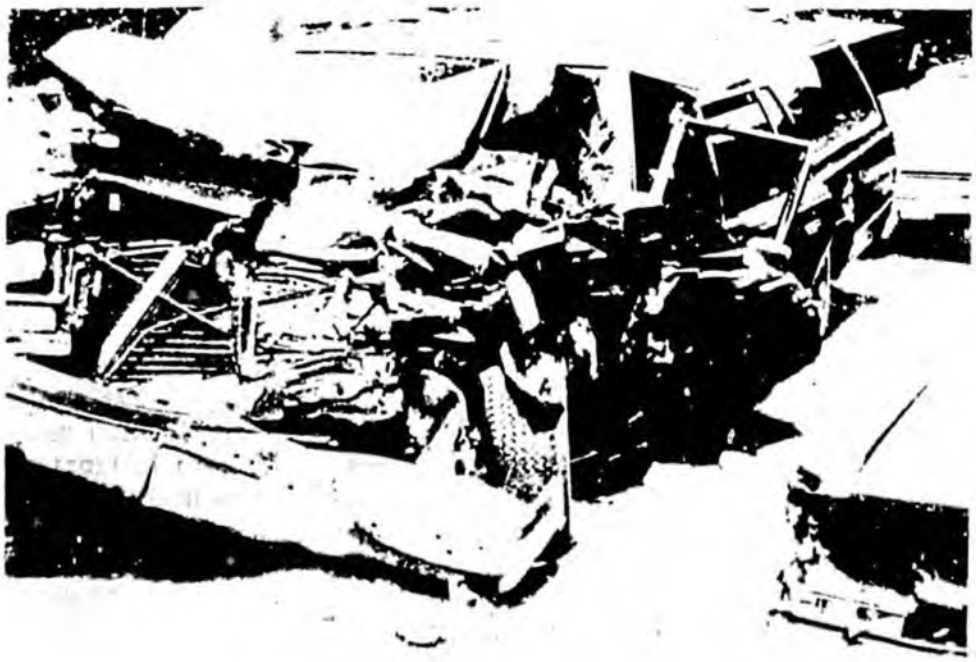




Circumstances

A 1978 Buick Estate station wagon was struck in the front, slightly left of center, by the left front corner of a 1963 Chevrolet van. The Buick was occupied by a lap/shoulder belted 36-year-old female driver, a lap belted 5-year-old boy at center front, a 6-year-old boy wearing a lap/shoulder belt at right front, and two 4-year-old girls seated in the left and right rear seats, restrained by lap belts. The force of this head-on collision destroyed the front structures of both vehicles.

This accident resulted in moderate injuries to the Buick driver, serious injury to the lap belted boy in the center front, and minor to moderate injuries to the children seated right front, left rear, and right rear. The unrestrained 19-year-old man driving the van, who had fallen to the floor before the impact, received multiple fractures of his left leg and required extensive medical care.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 36
Height: 5 feet 2 inches
Weight: 155
Seated height: 33 inches
Restraint used: Lap/shoulder belt
Proper use? Possible slack in shoulder belt

This driver was wearing a 3-point, continuous loop, lap/shoulder belt that incorporated an emergency locking retractor, cinching type of latchplate, and a pushbutton release type of buckle mounted to a flexible plastic stalk. A windowshade type of tension relief device also was incorporated into this restraint system.

The Safety Board investigation did not note loading marks on the system webbing at this position. The A pillar, instrument panel, and steering assembly were displaced several inches rearward. The steering column was broken, and the hub and wheel were displaced several inches outboard. The A pillar, deformed rearward approximately 6 inches at its base, had hair embedded around a trim mounting screw located on its interior side. The driver's portion of the split bench seat was found at its extreme forward adjustment on a 7-inch track.

The driver related that her lap belt was positioned low across her hips with "snug" tension, but could not give information concerning the adjustment or positioning of her shoulder strap.

Injuries	AIS	Probable Source
Closed head injury with unspecified loss of consciousness	2	A pillar
Major contusions, right and left eyes	2	Steering rim and A pillar
Lacerations with embedded glass, scalp	1	Windshield
Laceration, forehead	1	Steering rim or A pillar
Contusion (10-cm diameter), chest	2	Steering assembly
Contusion, right forearm	1	Steering assembly
Contusion, left forearm	1	Steering assembly
Contusion, left shoulder	1	Interior sidewall
Laceration, lower right leg	1	Below instrument panel

This woman was treated at a local hospital and released after several hours of observation required for the head injury. She required followup care by her personal doctor, but fully recovered from all injuries.

The driver's lap/shoulder belt did not prevent upper body contact with the vehicle interior, due to the driver's frontal compartment rearward displacement. When the distance of her head travel into the A pillar is considered, it appears that there was excess slack in the shoulder belt, possibly due to the "windowshade" device. The absence of pelvic, femur, and knee injuries (from the collapsed instrument panel) indicates that some amount of restraint was provided by the lap belt portion of the system. The use of the restraint system probably prevented a more severe level of injuries.

Seating location: Center front
Sex: M
Age: 5 1/2
Height: 40 inches
Weight: 52
Seated height: 23 inches
Restraint used: Lap belt (static)
Proper use? Probably

This child was wearing a static lap belt at the time of the collision. It had a pushbutton release type of buckle mounted to a 6 1/2-inch length of webbing which entered the seating area through the lower seat cushion, and a cinching type of latchplate adjustable on a 4?-inch length of webbing.

The top front surface of the cushioned instrument panel, just to the left of this position's approximate longitudinal center, was indented. The entire instrument panel forward of this position was pushed rearward due to compression of the frontal structure.

Injuries	AIS	Probable Source
Le Fort III maxilla fracture	4	Instrument panel
Le Fort II fracture	3	Instrument panel
Fractured nose	1	Instrument panel
Basilar skull fracture with cerebrospinal fluid leak	4	Instrument panel
Laceration to forehead	1	Instrument panel
Minor contusion, face	2	Instrument panel

This child spent 9 days in the hospital.

The evidence presented by this child's injuries and the vehicle interior damage in his vicinity suggests that the major deceleration took place as his head hit the instrument panel, with little deceleration occurring at the lap belt level. If he had not been wearing the lap belt, he would have sustained at least moderate injuries, since his body would have been thrown into the instrument panel. However, the severe head and face injuries that he in fact sustained were due to the jackknifing action induced by the lap belt, that accelerated his face into instrument panel and concentrated much of the forces on this small part of his body.

It is useful to compare the experience of this small child seated center front, lap belted, in a Delta V 28.9 mph crash inside a 4,500-pound large car, with the experience of the small child seated center front, unrestrained, in a Delta V 28.6 mph crash inside a 4,000-pound large car (Case 34). The unrestrained child rode down the crash forces by decelerating against the instrument panel with much of her body; she sustained only moderate injuries to her vulnerable head, although she sustained AIS 2 and 3 level injuries to her left leg. The small boy, on the other hand, lap belted, sustained one AIS 2 level injury, one AIS 3 level injury, and two AIS 4 level injuries, all to his face and head.

All things considered, the Safety Board concludes that this boy would likely have been better off unrestrained in this crash than wearing a lap belt with no upper torso restraint. If he could have been restrained in a lap/shoulder belt (not available at the center front position), he probably would have received only minor abrasions and/or contusions. Compare, for example, the injuries sustained by the boy of similar size seated next to him with a lap/shoulder belt: minor belt abrasions and an AIS 1 (minor) bump on his head.

Seating location: Right front
Sex: M
Age: 6
Height: 44 inches
Weight: 40
Seated height: 24 1/2 inches
Restraint used: Lap/shoulder belt
Proper use? Yes

This child was wearing a lap/shoulder belt similar to the driver's. There was no evidence of force loading scars recovered during the Safety Board investigation and no interior compartment distortion was noted. The seat was found adjusted to 3 inches from extreme forward on a 7-inch track.

Injuries	AIS	Probable Source
Minor lacerations at hairline	1	Broken glass
Abrasion, right shoulder	1	Shoulder strap
Abrasion, across abdomen	1	Lap belt
Small bump on head	1	Interior sidewall

This passenger was treated and released at a local clinic with a note at dismissal to contact the doctor if any abdominal complications developed. No complications were found during a followup interview 3 months after the crash.

Seating location: Left rear
Sex: F
Age: 4
Height: 41 inches
Weight: 40
Seated height: 23 inches
Restraint used: Lap belt (ALR)
Proper use? Yes

This girl was restrained by a lap belt with an automatic locking retractor, a latchplate sewn in to the end of a 35-inch length of retractable webbing, and a pushbutton release type of buckle attached to an 8-inch length of webbing. Both the latchplate webbing and the buckle webbing entered the seating area through the junction of the upper and lower seat cushions. There was no evidence of restraint use noted from the webbing system or hardware.

The seatback cushion was displaced forward approximately 6 inches by cargo within the rear area of the station wagon. No other compartment deformation was noted. No estimate of belt adjustment was available.

Injuries	AIS	Probable Source
Lower abdominal contusion	1	Lap belt
Lower back strain	1	Lap belt
Small laceration, left cheek	1	Broken glass

The child was treated and released at an area children's hospital. No complications developed.

This child and the little girl on the right of the rear seat probably benefited tremendously from the extra wide and firm lower seat cushion installed in the full size station wagon. Although they probably jackknifed severely about the lapbelt, the firm seat would not allow the submarining likely with an unsupported lower seat cushion. Also, the wide surface of the cushion allowed the downward acceleration, around the lap belt, to be dissipated into the cushion rather than hurling the girls' heads and necks downward between their knees into the area in front of their seat. The system anchor points being well below and behind the seat cushion junction kept the belt low on the girls' hips; the automatic locking retractor maintained "snug" tension.

Seating location: Right rear
Sex: F
Age: 4
Height: 40 inches
Weight: 60
Seated height: 23 inches
Restraint used: Lap belt (ALR)
Proper use? Yes

This child was restrained by a lap belt similar to the one at the left rear. No evidence of restraint use was recovered from the belt system. The girl was reportedly wearing the lap belt low across her hips. No interior compartment deformation was noted at this position.

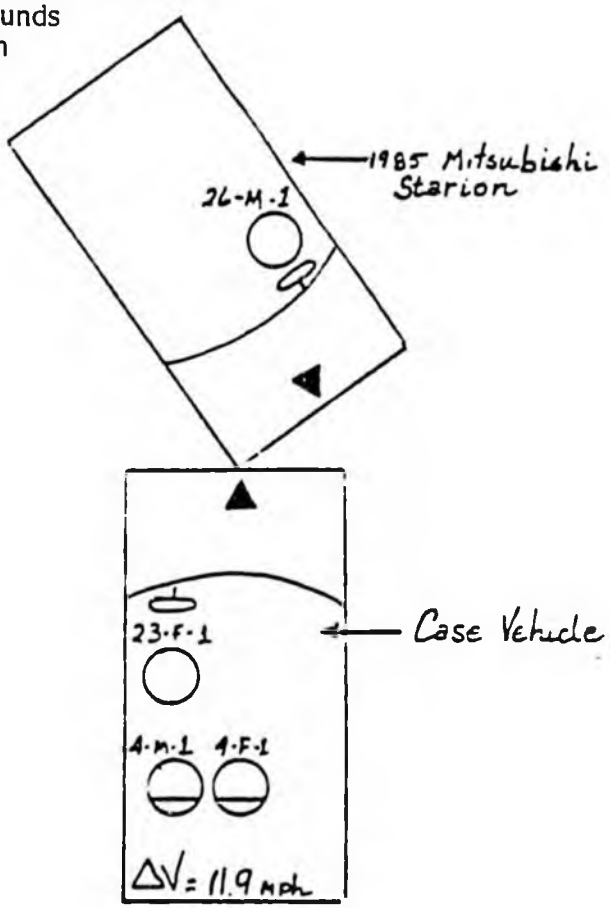
Injuries	AIS	Probable Source
Abdominal abrasions	1	Lap belt

This child was treated and released at a local clinic. The doctor specifically noted that there was no evidence of abdominal injury but cautioned to watch for later evidence of internal injury. A followup interview 3 months after the accident revealed no complications of the injury.

(See comments on the left rear position, above.)

CASE 14 (ATL-85-H-OR19)

Case vehicle: 1975 Oldsmobile Cutlass
Case vehicle weight: 3,964 pounds
Case vehicle Delta V: 11.9 mph



Circumstances

A 1975 Oldsmobile Cutlass struck, center front, the right front corner of a 1985 Mitsubishi Starion turning in front of the Cutlass. The Cutlass was driven by an unrestrained 23-year-old woman; 4-year-old twins occupied the left rear and center rear seating positions, both restrained by lap belts. Both vehicles received front structural damage which necessitated towaway removal.

This collision resulted in minor injuries to the Cutlass driver and minor injuries to the lap belted 4-year-old rear seat occupants. The unrestrained driver of the Mitsubishi sustained minor to moderate injuries.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 23
Height: 5 feet 4 inches
Weight: 115
Restraint used: None
Proper use? NA

This driver was not wearing the lap/shoulder belt at her seating position. There was no interior compartment compression. The entire steering assembly was displaced approximately 1 inch toward the left.

Injuries	AIS	Probable Source
Contusion, upper forehead	1	A pillar
Contusion, right jaw	1	Steering wheel rim
Abrasion, minor avulsion, right hip	1	Steering wheel rim
Contusion, left knee	1	Instrument panel

The woman did not seek medical attention on the day of the accident, but visited a local clinic approximately 2 weeks later. No followup care was required and no loss of work resulted.

Had she been wearing the available lap/shoulder belt, properly routed and tensioned, she probably would not have made the contacts with the vehicle interior. Considering the low Delta V, she probably could have decelerated into the restraint webbing without injury.

Seating location: Left rear
Sex: M
Age: 4
Height: 41 inches
Weight: 39
Seated height: 20 inches
Restraint used: Lap belt (ALR)
Proper use? Yes

This boy was wearing a lap belt with an ALR, a latchplate sewn in to the retractor webbing, and a pushbutton release type of buckle attached to a short length of webbing. Both the latchplate webbing and the buckle webbing entered the seating area by passing between the junction of the upper and lower seat cushions.

Injuries	AIS	Probable Source
Contusion, center forehead	1	Lower extremities

The investigating police officer's report indicates that this passenger received a visible injury but did not require emergency transport from the accident scene. The child's mother said no medical attention was sought until approximately 2 weeks after the crash. That visit was due to concern about the forehead contusion. Followup investigation revealed no complications of the injury.

The lap belt worn by this little boy restrained his forward movement without complications. However, the boy's lack of injury--belt induced or otherwise--is not suprising, given the low Delta V in this case. If the boy had been unrestrained, he would likely have moved forward into the rear surface of the seatback and it would not be expected to see a great difference in the level of his injuries in that case from those he in fact experienced. The vertical direction of the force line should not be expected to launch him up and over the back of the front seats, even if the Delta V had been much greater.

Seating location: Center rear
Sex: F
Age: 4
Height: 40 inches
Weight: 37
Seated height: 20 inches
Restraint used: Lap belt (static)
Proper use? Yes

This child was wearing a static lap belt with a pushbutton release type of buckle attached to short length of webbing and a cinching type of latchplate that was adjustable on a length of webbing. Both the buckle webbing and the latchplate webbing entered the seating area by passing between the junction of the upper and lower seat cushions. There was no interior deformation at this seating position.

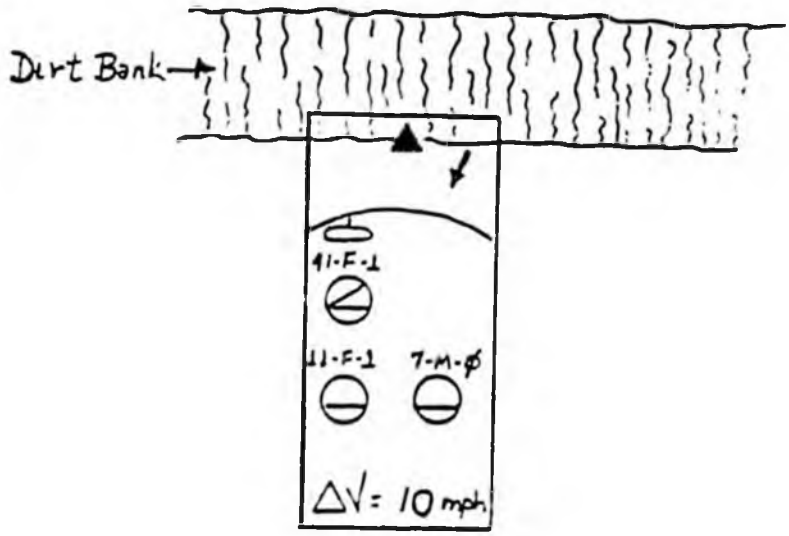
Injuries	AIS	Probable Source
Contusion, lower right abdomen	1	Lap belt hardware

This girl did not require medical attention at any time following the accident. Followup investigation revealed that no complications resulted from the abdominal contusion.

The analysis in this girl's situation is similar to that of her brother. If she had been unrestrained, however, she might have experienced slightly more serious injuries, since the back of the front seat was split in front of her, not solid as it was in front of her brother seated extreme left. Given the angular force line (-30°) in this impact, an unrestrained child probably would have decelerated into the unbroken rear surface of the driver's seatback, but if the force line had been from straight head-on, she might have experienced head and upper chest injuries due to the 8-inch wide split in the seatback immediately in front of her. However, with the low Delta V, those injuries would still have been only minor to possibly moderate.

CASE 15 (ATL-84-H-OR28)

Case vehicle: 1980 Ford Fairmont station wagon
Case vehicle weight: 3,338 pounds
Case vehicle Delta V: 10 mph



Circumstances

A 1980 Ford Fairmont station wagon struck a dirt embankment. Substantial damage resulted and towaway removal was required. The driver was a 41-year-old woman, restrained by a lap/shoulder belt; the left rear seat was occupied by an 11-year-old girl; a 7-year-old boy was seated right rear. Both rear seat occupants were restrained by lap belts.

This accident resulted in minor injuries to the driver of the Ford and to the left rear passenger. The right rear passenger was not injured.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 41
Height: 5 feet 4 inches
Weight: 125
Seated height: 26 inches
Restraint used: Lap/shoulder belt (ELR)
Proper use? No

The driver was restrained by a 3-point, continuous loop, lap/shoulder belt with an ELR sensitive to vehicle motion, a cinching type of latchplate, and a pushbutton release type of buckle. The buckle was attached to a flexible stalk that entered the seating area by passing through the lower seat cushion at the junction of the upper and lower cushions. No evidence of force loading was found on the system webbing. The windshield-mounted rear view mirror was broken from its pre-crash position. The lower area of the instrument panel, just inboard of the steering column, was damaged.

Injuries	AIS	Probable Source
Small laceration, right forehead	1	Rearview mirror
Abrasion, right forehead	1	Rearview mirror
Contusion, mid-sternum	1	Steering wheel rim
Contusion, lower right leg	1	Lower instrument panel

She was treated and released at a local hospital.

This woman told Safety Board investigators that the pre-crash adjustment of her lap/shoulder belt was "snug," with the lap belt portion low on her hips and the shoulder strap across her chest mid-sternum. However, the evidence indicates that either she was wearing her restraint with excessive slack or the retractor did not lock. Given her seated height, it was not possible for her to have struck the rearview mirror while remaining within a "snugged up" shoulder strap. Also, the "deep bruise" on her mid-sternum area is not the type of injury received from restraint webbing. The "deep" contusion would be expected from contact with the steering wheel rim. This accident's impact was simply not severe enough to result in much webbing stretch or more than just a few inches of travel within the webbing system. The Board concluded that the restraint was not being worn properly--that is, there was excessive slack in the system that was quite possibly the result of improper "windowshade" adjustment.

Seating location: Left rear
Sex: F
Age: 11
Height: 4 feet 8 inches
Weight: 85
Seated height: 23 inches
Restraint used: Lap belt (ALR)
Proper use? Yes

This child was restrained by a lap belt with an ALR, a latchplate sewn in to the 33-inch-long retractable webbing, and a pushbutton release type of buckle mounted to a short length of webbing. Both the latchplate and buckle webbing entered the seating area from between the junction of the upper and lower seat cushions. There was no interior compartment deformation at this seating position.

Injuries	AIS	Probable Source
Contusion, center forehead	1	Lower extremity
Contusion, lower right thigh	1	Right elbow

This child was treated and released at a local hospital. Her mother said that no school time was lost as a result of the accident.

(See discussion at end of this case summary.)

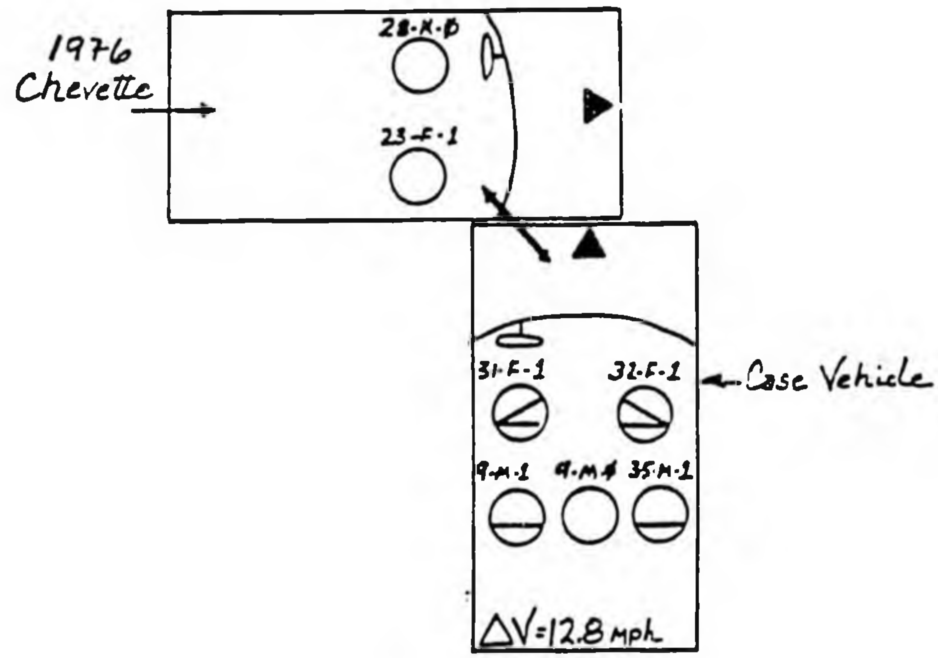
Seating location: Right rear
Sex: M
Age: 7
Height: 40 inches"
Weight: 40
Seated height: 18 inches
Restraint used: Lap belt (ALR)
Proper use? Yes

This child was wearing a lap belt similar to his sister's. There was no compartment deformation at this seating position. He was checked at a local hospital and released with no reported injuries.

Considering the relatively low Delta V of only 10 mph, the use of the lap belts by these children probably had little effect on injury. Had the children not been restrained, they would have been decelerated by the rear surface of the front bench seatbacks, a "containment" surface found to be an "occupant friendly" contact point in several cases with similar and higher crash forces.

CASE 16 (MKC-85-H-OR26)

Case vehicle:	1980 Ford Subaru GL station wagon
Case vehicle weight:	3,111 pounds
Case vehicle Delta V:	12.8 mph



Circumstances

A 1980 Subaru station wagon struck a 1976 Chevette in the front right side. The Delta V for the Subaru was 12.8 mph. It was driven by a 31-year-old woman restrained by a lap/shoulder belt. Other occupants of the Subaru included a 32-year-old woman seated right front wearing a lap/shoulder belt, a lap belt restrained 9-year-old boy seated left rear, a 35-year-old man seated right rear wearing a lap belt, and a 9-year-old boy seated center rear unrestrained. The impact substantially damaged both vehicles and both required towaway.

This accident resulted in minor injury to the Subaru driver, right front passenger, left rear passenger, and right rear passenger. The unrestrained center rear passenger was not injured. The Chevette right front passenger, an unrestrained 23-year-old woman, received minor injuries; the driver, an unrestrained 28-year-old man, was without reported injury.

In this case of low Delta V, little difference in injury lev seen between the restrained and unrestrained occupants.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 31
Height: 5 feet 7 inches
Weight: 130
Restraint used: Lap/shoulder belt (ELR)
Proper use? Yes

This driver was restrained by a 3-point, continuous loop, lap/shoulder belt with an ELR sensitive to webbing acceleration, a free-sliding latchplate, and a pushbutton release type of buckle mounted to a flexible stalk. A "comfort clip" was attached to the webbing as a tension relief device.

There was no interior deformation at he seating compartment and no indication of force loading scars on the belt webbing. The driver said she had adjusted her seat to the middle of its track. This adjustment position was confirmed at 3 1/2 inches from forwardmost on a 6 1/2-inch track.

Injuries	AIS	Probable Source
Small laceration, right hand	1	Broken sideglass from vehicle 2
Contusion, inside left knee	1	Steering column

This woman reportedly refused medical treatment for the minor injuries sustained in the collision.

Seating location: Right front
Sex: F
Age: 32
Height: 5 feet 6 inches
Weight: 200
Restraint used: Lap/shoulder belt
Proper use? Yes

This woman was restrained by a lap/shoulder belt similar to the driver's. Again, there was no interior compartment deformation at this seating position. This passenger seat was found adjusted to a position 3 1/2 inches from forwardmost on a 6 1/2-inch track.

Injuries	AIS	Probable Source
Contusion, right hip	1	Lap belt

This woman reportedly refused medical treatment of her minor injury.

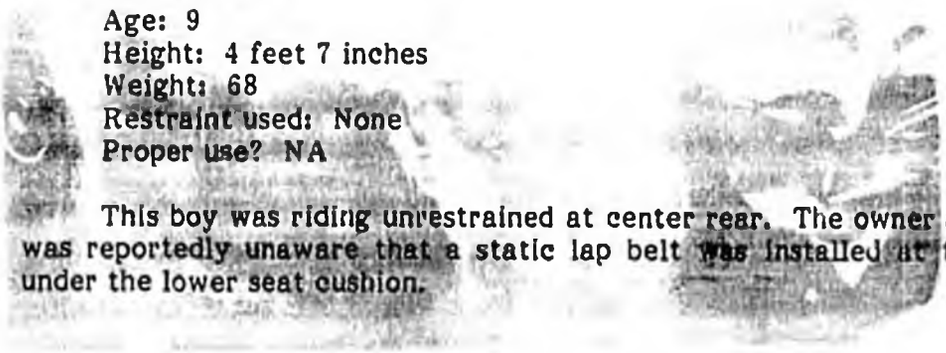
Seating location: Left rear
Sex: M
Age: 9
Height: 4 feet 6 inches
Weight: 73
Restraint used: Lap belt (ELR)
Proper use? Yes

This boy was restrained by a lap belt with an ELR sensitive to webbing acceleration, a latchplate sewn in to the retractor webbing, and a pushbutton release type of buckle attached to a short length of webbing. Both the latchplate webbing and the buckle webbing entered the seating area by passing between the junction of the upper and lower seat cushions. There was no compartment deformation at this seating position nor any evidence of force loading on the webbing system.

Injuries	AIS	Probable Source
Small laceration, right rear of head	1	Wristwatch worn by right rear passenger

This boy reportedly refused medical treatment.

Seating location: Center rear
Sex: M
Age: 9
Height: 4 feet 7 inches
Weight: 68
Restraint used: None
Proper use? NA



This boy was riding unrestrained at center rear. The owner and driver of the Subaru was reportedly unaware that a static lap belt was installed at the position but tucked under the lower seat cushion.

There was no compartment deformation noted at this position and no injuries were reported by the occupant.

Seating location: Right rear
Sex: M
Age: 35
Height: 5 feet 6 inches
Weight: 185
Restraint used: Lap belt (ELR)
Proper use? Yes

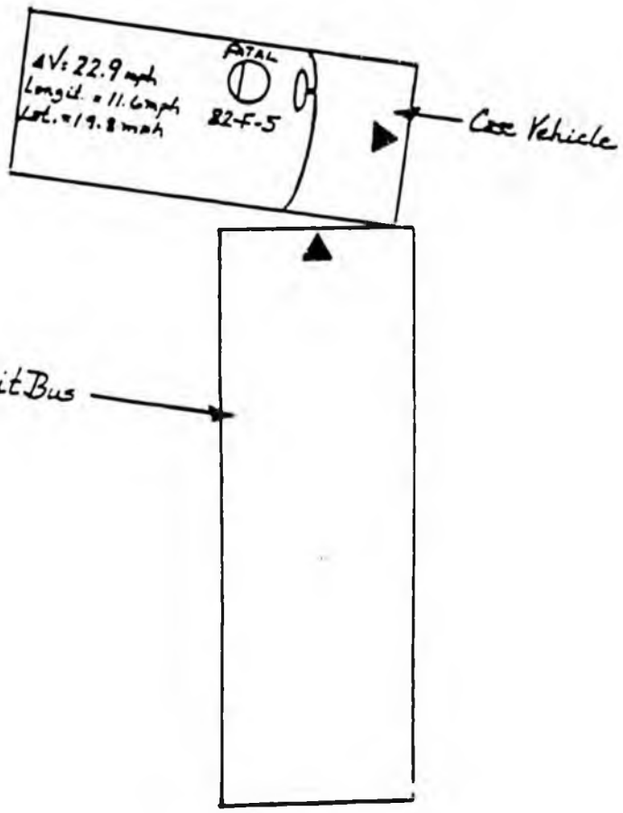
This man was wearing a lap belt similar to the one on the left. There was no evidence of interior compartment deformation nor force loading marks on the system webbing. This occupant was reportedly riding with his left arm extended and lying on the uppermost surface of the rear seatback. The wristwatch worn on his left arm was the source of minor laceration the left rear passenger's head.

Injuries	AIS	Probable Source
Sprained left thumb	1	Rear of front seat

This man reportedly refused treatment for his minor injury.

CASE 17 (LAX-85-H-OR18)

Case vehicle: 1967 Pontiac Catalina, 4-door
Case vehicle weight: 4,250 pounds
Case vehicle Delta V: 22.9 mph



Circumstances

A 1967 Pontiac was struck on the right front side by a city bus. The Pontiac was being driven by an 82-year-old woman who was restrained by a static lap belt. The Pontiac received substantial structural damage along its right side; there was no apparent compartment distortion at the driver's position.

This accident resulted in severe to critical intra-abdominal injuries to the driver of the Pontiac which proved fatal approximately 36 hours after the crash. The injuries were lap belt induced.

Restraint and Injury

Seating location: Driver
Sex: F
Age: 82
Height: 5 feet 1 inch
Weight: 150
Seated height: 33 inches
Restraint used: Lap belt (static)
Proper use? Yes

Injuries	AIS	Probable Source
Multiple through-and-through tears in mesentery	4	Lap belt
Perforation (15 mm) of bowel	5	Lap belt
Major contusion, abdomen	2	Lap belt
Contusions, both feet	1	Foot controls
Contusion, upper right arm	1	Cargo

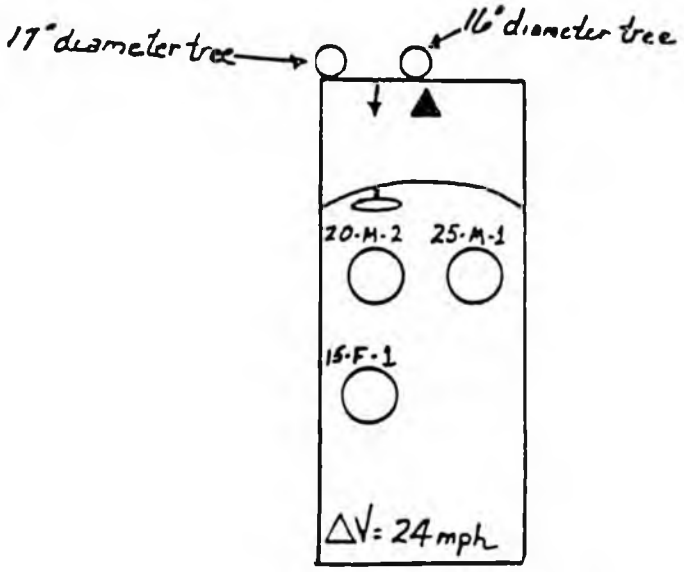
This case dramatically illustrates the fact that, contrary to widely-expressed views in the literature, a severe impact is not necessary to induce severe, even fatal, injuries in lap belt-restrained occupants (see, among others, Cases 6, 8, 9, 23, 25, and 27). In this case, the major area of belt loading was on the extreme right side of her abdomen--not surprising, given that the major crash forces came into play at approximately 70° to 80° into the right front side of the Pontiac. Given the crash configuration, it could also be expected that a shoulder strap might not have prevented either the type or severity of intra-abdominal injury, because she might well have traveled out from behind the shoulder strap in this crash (Federal safety standards for passive belt systems, the only systems covered by dynamic testing standards, require protection only in crashes within 30° of straight head-on).

This case is also important as an illustration of the sorts of postcrash medical handling deficiencies discussed in Baker and others. Hospital records here seem to reflect a lack of familiarity with the extent of intra-abdominal trauma possible with lap belts. Strong symptoms of the woman's massive internal injuries were apparently obvious for at least several hours after the crash. Medical personnel did keep a close watch on the woman's blood pressure; but when it dropped, the symptoms also accompanied by onset of rapid pulse, about 28 hours after the crash, no action was taken for several hours.

Internal X-rays were not taken for close to 3 hours, and then only after a second lapse in blood pressure at 8 p.m. An exploratory laparotomy was then planned, but within 25 minutes of the X-rays (while on the operating table), the woman died. Death was officially attributed to aspiration of gastric contents, due to generalized peritonitis from a ruptured bowel with mesenteric lacerations.

CASE 18 (SEA-85-H-OR25)

Case vehicle: 1980 Toyota Celica 2-door
Case vehicle weight: 2,885 pounds
Case vehicle Delta V: 24 mph



Circumstances

A 1980 Toyota Celica struck, head-on, two trees 16 to 17 inches in diameter. The impact resulted in substantial damage to the front structure of the vehicle, with rearward collapse reaching a depth of 26 inches at the front center point of impact. The vehicle was occupied by a 20-year-old male driver, a 25-year-old male right front passenger, and a 15-year-old female seated left rear. There were no restraints being used by these occupants.

This accident resulted in moderate injuries to the driver and minor to moderate injuries to the right front passenger. The left rear passenger sustained only minor abrasions attributed to contact with the rear surface and framework of the driver's seatback. All occupants were transported by ambulance to an area hospital, but only the front seat occupants required emergency room treatment before being released.

Restraint and Injury

Seating location: Driver
Sex: M
Age: 20
Height: 6 feet
Weight: 170
Restraint used: None
Proper use? NA

This driver was not wearing the available 3-point lap/shoulder belt furnished at his seating position. The steering column was deformed upward several inches. The wheel was displaced forward from its 6 o'clock to 1 o'clock position, and the lower instrument panel was broken, with substantial displacement of various components.

Injuries	AIS	Probable Source
Laceration (6 cm deep), left forehead	2	Windshield
Small lacerations (two), above right eye	1	Windshield
Unspecified left abdominal injury	7	Steering assembly
Contusion, left knee	1	Lower instrument panel
Laceration (2 inch), right lower leg	1	Lower instrument panel

This man required 2 days of hospitalization. Due to a continuing complaint of abdominal pain, treating physicians performed an exploratory abdominal paracentesis to determine if there were intra-abdominal ruptures or lacerations, and found none.

Seating location: Right front
Sex: M
Age: 25
Height: 5 feet 11 inches
Weight: 165
Restraint used: None
Proper use? NA

This man was not wearing the available 3-point lap/shoulder restraint provided at his position. There was substantial distortion of the instrument panel directly forward of this seating position. There was no apparent contact damage to the windshield directly forward of this seat position.

Injuries	AIS	Probable Source
Back strain	1	Impact forces
Laceration (8 cm), left knee	1	Instrument panel
Unspecified external superficial abrasions	7	Frontal interior

He was treated and released from an area hospital.

Seating location: Left rear
Sex: F
Age: 15
Height: 5 feet 5 inches
Weight: 120
Restraint used: None
Proper use? NA

Injuries	AIS	Probable Source
Abrasion, left side of face	1	Left front seatback
Abrasion, lower left leg	1	Left front seatback
Laceration, right hand	1	Instrument panel

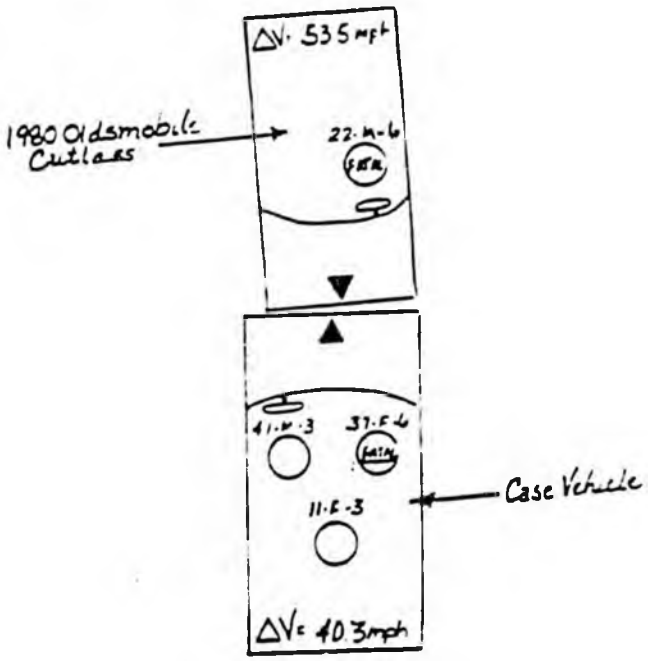
Although transported to an area hospital along with the other occupants, this girl did not require medical treatment.

This case again illustrates the potential for rear seat occupants to successfully "ride down" crash forces in situations that might well produce serious or fatal abdominal, head, and/or spinal injuries to lap belted occupants. Other cases of successful, unrestrained, rear seat "containment" can be seen in Case 4 (involving a much higher Delta V than this case), Case 7 (also involving a much higher Delta V), the unrestrained occupants of Case 23, and the occupants of the "comparison vehicle" in Case 24. The Safety Board believes that the rear seat occupant in this case might well have sustained serious head or internal/spinal injuries in this speed change of 24 mph because of the experience of similarly situated rear occupants in Cases 6, 8, 9, 10, 23, and 25.

The severity of injuries sustained by the driver in this case probably would have been reduced if he had been wearing the available lap/shoulder belt. The right front passenger probably would not have cut his knee on the instrument panel if he had worn his belt, but he probably would have sustained some level of injury due to the impact force.

CASE 19 (CHI-85-H-OR27)

Case vehicle: 1979 Dodge Ramcharger, 4-wheel drive
Case vehicle weight: 4,720 pounds
Case vehicle Delta V: 40.3 mph



Circumstances

A 1979 Dodge Ramcharger was struck head-on by a 1980 Oldsmobile Cutlass, with a resulting Delta V of 40.3 mph to the Dodge and 53.3 mph to the Cutlass. Rearward structural collapse was more than 35 inches at the right front of the Dodge; deformation at the Oldsmobile's right front exceeded 50 inches.

The unrestrained 41-year-old man driving the Dodge was seriously injured. His 37-year-old wife, seated right front restrained by a lap belt, sustained massive abdominal trauma and cervical injuries that resulted in her death. The couple's 11-year-old daughter, lying across the rear bench seat unrestrained, was seriously injured. The unrestrained 22-year-old male driver of the Oldsmobile sustained crushing chest injuries and was pronounced dead at the scene.

Restraint and Injury

Seating location: Driver
Sex: M
Age: 41
Height: 5 feet 6 inches
Weight: 150
Restraint used: None
Proper use? NA

This man was not wearing the lap belt at his position. There was extensive compartmental distortion forward of this seat position: the entire steering assembly was damaged, with forward deformation of the lower rim reaching 15 inches relative to the column hub. The entire column was collapsed forward approximately 11 inches and downward several inches. The lower instrument panel surface was distorted forward on the right and left side of the steering column.

Injuries	AIS	Probable Source
Laceration (4 inch), lower face	2	Instrument panel
Multiple contusions, face	2	Instrument panel
Unspecified head injury (amnesia)	2	Instrument panel
Multiple abrasions, face	2	Instrument panel
Fracture, left ribs 5 - 8	2	Steering assembly
Pneumothorax, left side	3	Steering assembly
Abrasion, right knee	1	Lower instrument panel
Multiple abrasions, contusions to extremities	7	Frontal interior
Contusions, left chest	2	Steering assembly

This man was in a hospital for 5 days and was unable to return to work for at least 1 month.

As in several cases investigated by the Safety Board, this man was inaccurately recorded in medical reports as having been ejected. It is virtually certain that he was not. There was no lifting force during the impact sequence that could have acted upon his body mass to bring about his ejection. The principal force was directed from the lower front of the vehicle upwards, and the driver's reactive travel would have been forward and down. This travel direction is evidenced by the forward displacement of the lower instrument

panel due to the driver's knee contact, and the forward and downward displacement of the steering assembly. With the driver's body mass concentrated lower than the steering column's principal structure, along with the forward and down reactive travel, the possibility of ejection can be ruled out. Furthermore, at maximum force exchange between the vehicles, the distorted hoods of the vehicles would have prevented his forward travel. This man probably was assisted from the car by a passerby, just as his daughter was.

Seating location: Right front
Sex: F
Age: 37
Height: 5 feet 6 inches
Weight: 185
Restraint used: Lap belt (ALR)
Proper use? Yes

This woman was wearing a lap belt with an ALR, a sewn-in latchplate attached to the retractor webbing, and a pushbutton release type of buckle mounted to a short flexible stalk. Both the retractor anchor and resultant buckle position were located well below and behind the woman's lower body mass.

There was little compartmental compression at this seating position. There was a circular depression just below the hinged glove compartment door, directly forward of the seat. Inspection of the restraint system webbing revealed a force loading scar on the retractable latchplate webbing.

Injuries	AIS	Probable Source
Multiple lacerations, left eye	2	Instrument panel and below
Contusion, left temporal lobe	2	Instrument panel and below
Translocation, 1st cervical vertebra	3	Hyperextension force
Complete transection of spinal cord at base of skull	6	Hyperextension force
Fractured sternum	2	Lower extremities contact
Major abrasion, lower abdomen	2	Lap belt
Major contusion, lower abdomen	2	Lap belt
Multiple transections, small intestine	5	Lap belt
Transection, descending aorta (small intestine)	6	Lap belt
Extensive avulsion, posterior peritoneum	5	Lap belt

This woman was found at the accident without signs of life.

This woman's internal injuries appear to have been concentrated in the area directly over the crest of the ilium and resulted from the belt's penetration into the abdominal cavity. The injury location does not indicate improper belt routing when the force line, Delta V, and resultant body travel are considered. An extremely violent jackknife

occurred as the woman's upper and lower body mass folded over the lap belt webbing. The front portion of the iliac crest is rounded; as a body jackknifes over a lap belt, the belt may also fold over, resulting in a much narrower restraining surface. As the pelvic bone, itself rounded, pushes forcefully against the folded belt webbing, there would be little resistance to the webbing riding up and over the iliac crest. This fact, combined with the force line acting on the victim's body seems to indicate that the lap belt webbing was probably routed in the area considered to be proper. Had the lap belt been routed over the mid-abdomen prior to the impact, the internal injury pattern would have been to organs located higher in the abdominal cavity.

If this passenger had been wearing a 3-point lap/shoulder belt system, the probability of survival would have been much greater. Some level of restraint-related injuries would be expected, but the violent jackknife and resultant neck hyperextension would not have occurred. The severity of her internal injuries also would have been reduced by use of a shoulder strap, due to prevention of the jackknife over the lap belt webbing.

Seating location: Rear seat
Sex: F
Age: 11
Height: 4 feet 6 inches
Weight: 70
Restraint used: None
Proper use? NA

This child was reportedly lying across the rear bench seat. There was no compartmental compression or deformation at this seating area.

Injuries	AIS	Probable Source
Fracture, upper right femur	3	Rear framework of front seat
Abrasion, chin	1	Rear framework of front seat
Major contusion, right ankle	2	Rear framework of front seat
Laceration, left upper forehead	1	Rear framework of front seat

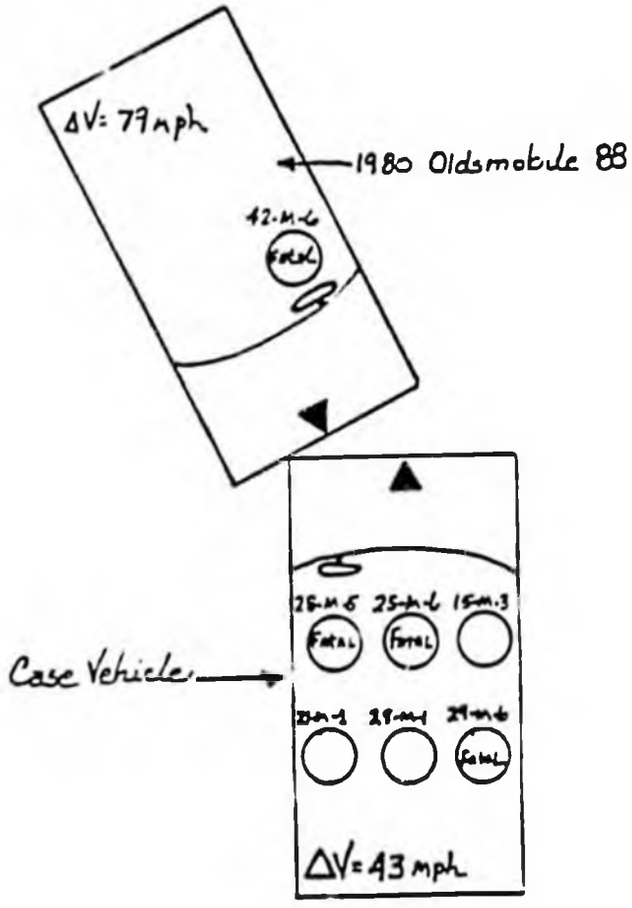
This girl spent 4 days in a local hospital.

She probably came out of this accident with as low a level of injuries as could be expected, when the high Delta V is considered. Even a fully-restrained passenger would probably have sustained moderate to serious injury in this speed change of more than 40 mph.

Certainly the types of injuries she sustained are different from those which would be expected if a restraint had been worn. If this child had been wearing a lap belt only, it would be reasonable to expect massive injuries similar to those sustained by the right front passenger. (See also the injuries sustained by 13-year-old boys, lapbelted, in Case 1, a Delta V 37 mph crash, or the lap-belted children in Cases 8, 10, and 23.)

CASE 20 (FTW-85-H-OR39)

Case vehicle: 1973 Chevrolet Impala, 4-door
Case vehicle weight: 5,200 pounds
Case vehicle Delta V: 43 mph



Circumstances

A 1973 Chevrolet Impala was struck head-on, right front to left front corner, by a 1980 Oldsmobile 88. From the area of impact, the Oldsmobile was deflected rearward approximately 14 feet from its original travel path. The Chevrolet rotated counterclockwise over 27 feet to its final resting position. Both vehicles were destroyed by the severe impact forces.

The Chevrolet was occupied by 6 males who ranged in age from 15 to 29 years. There were no restraints being used by these occupants. This collision resulted in fatal injuries to the unrestrained driver of the Oldsmobile (a 42-year-old man), the Chevrolet driver, the Chevrolet center front passenger, and the Chevrolet right rear passenger. The right front passenger of the Chevrolet sustained serious to severe injuries and required extensive medical treatment. Both the center rear and left rear passenger of the Chevrolet received only minor contusions and abrasions.

Restraint and Injury (Chevrolet)

Seating location: Driver
Sex: M
Age: 28
Restraint used: None
Proper use? NA

This driver was not wearing the available lap/shoulder belt. There was massive rearward distortion of the frontal interior at this seating position. The instrument panel, steering assembly, and A pillar with surrounding structure were displaced rearward into the driver, requiring extensive extrication efforts by rescue personnel.

Injuries	AIS	Probable Source
Frontal subarachnoid hemorrhage	3	Co"apsed structure
Multiple lacerations to liver	5	Steering assembly
Lacerations to abdominal wall	5	Steering assembly
Torn aorta	5	Steering assembly forces
Contused lungs	4	Steering assembly forces
Fractured pelvis	2	Collapsed structure
Fractured left radius	2	Collapsed structure
Fractured right fibula	2	Collapsed structure
Fractured right tibia	2	Collapsed structure

This man died after 12 days of intensive care provided at an area hospital.

This severe collision was not survivable for either driver. The fact that the Chevrolet driver lived 12 days was due only to the intensive efforts of medical personnel. Even if he had been wearing the available lap/shoulder belt, the frontal interior would still have collapsed rearward into his body. The fact that the left rear passenger was not restrained probably increased the severity of this driver's massive chest injuries, as the seatback was loaded and pushed forward in opposition to the impact forces. However, even without this additional seatback loading, this man would have received the critical internal injuries due to the crushing deformation of the frontal interior.

Seating location: Center front
Sex: M
Age: 25
Height: 5 feet 3 inches
Weight: 152
Restraint used: None
Proper use? NA

This occupant was not wearing the static lap belt available at his seating position. There was moderate rearward displacement of the forward compartment at this position.

Injuries	AIS	Probable Source
Facial abrasions	1	Instrument panel and windshield
Massively crushed chest (upper)	6	Instrument panel
Laceration of aorta	5	Instrument panel
Laceration, liver	4	Instrument panel
Bilateral pulmonary contusion	4	Instrument panel
Multiple contusions and abrasions	7	Frontal interior

This occupant died as a result of his injuries.

Had some type of upper and lower body restraint been available to, and used by, this man, it is possible he would have survived. However, given the high Delta V, he would still have been susceptible to serious, restraint induced injuries and other injuries.

Seating location: Right front
Sex: M
Age: 15
Restraint used: None
Proper use? NA

This passenger was not wearing the lap/shoulder restraint available at his position.

Injuries	AIS	Probable Source
Fracture, left jaw	2	Instrument panel and A pillar
Fracture, right jaw	2	Instrument panel and A pillar
LeFort II fracture	3	Instrument panel and A pillar
Laceration, lower lip	1	Instrument panel and A pillar
Fracture, left side 1st rib	1	Instrument panel and A pillar
Abrasion, left flank	1	Instrument panel
Large contusion, front lower left leg	2	Instrument panel and below
Large contusion, front lower right leg	2	Instrument panel and below
Closed displaced fracture, left pelvis	3	Instrument panel and below
Displaced fracture, left 6th rib	2	Instrument panel and below
Multiple contusions and abrasions	7	Instrument panel and below

This boy received extensive medical treatment for 11 days before being discharged to outpatient care.

If this boy had used the lap/shoulder belt, he probably would have avoided his serious facial injuries, or at least they would have been less severe. However, like the other front seat occupants in this severe impact, he would have been susceptible to serious injuries, belt induced and otherwise.

Seating location: Left rear
Sex: M
Age: 22
Restraint used: None
Proper use? NA

This man was not wearing the available lap belt. There seems to have been little forward distortion of the rear surface of the front seatback directly forward of this passenger's position. It should be noted, however, that the driver's body was compressed rearward into the seatback, due to the collapse of the front interior and steering assembly.

Injuries	AIS	Probable Source
Multiple contusions and abrasions	1	Front seatback

This passenger was treated and released at a local hospital.

Seating location: Center rear
Sex: M
Age: 28
Restraint used: None
Proper use? NA

This passenger was not wearing the static lap belt available at his seat position. There was moderate to severe forward distortion of the front seatback cushion directly in front and toward the right of this seat position.

Emergency medical technicians said that this passenger was taken to an area hospital with minor contusions and abrasions. Hospital officials said that he must have refused treatment, since the hospital has no record of him.

Injuries	AIS	Probable Source
Multiple contusions and abrasions	1	Front seatback

The survival, with only minor injuries, of the left and center rear passengers was due to the containment provided by the rear surface of the front seatback. (See Cases 4, 18, 23, and 24.)

Seating location: Right rear
Sex: M
Age: 23
Height: 5 feet 6 inches
Weight: 138
Restraint used: None
Proper use? NA

This passenger was not wearing the available lap/shoulder belt. There was substantial forward displacement of the extreme right side of the front seatback in front of this man.

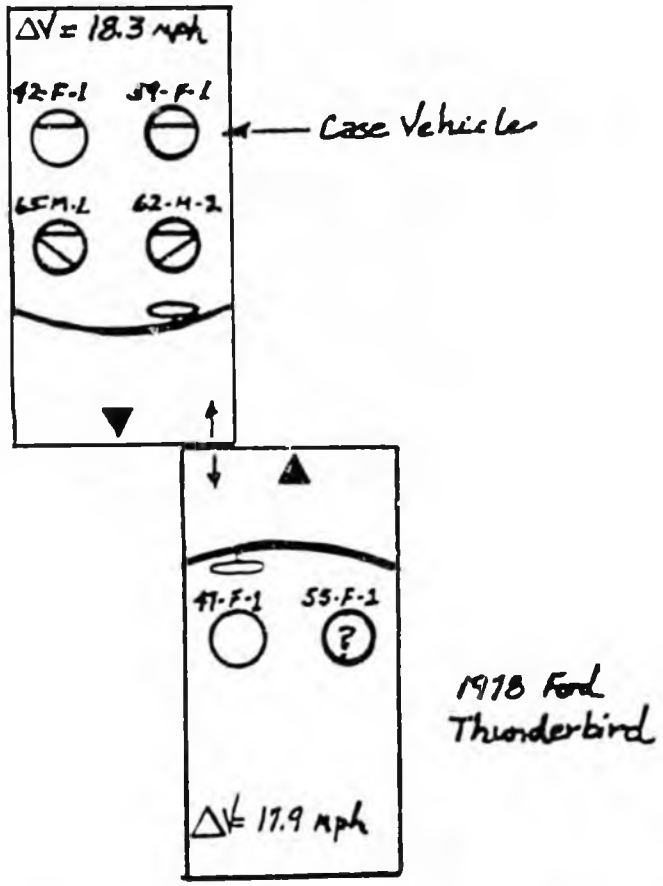
Injuries	AIS	Probable Source
Transection of aorta	6	Front seatframe and interior sidewall
Massively crushed chest	6	Front seatframe and interior sidewall
Multiple lacerations, liver	4	Front seatframe and interior sidewall
Multiple contusions, lower extremities	2	Front seatframe and interior sidewall
Multiple abrasions, lower extremities	2	Front seatframe and interior sidewall
Facial abrasions, contusions	1	Front seatframe and interior sidewall

This man was pronounced dead at the accident scene; he was found wedged between the outboard edge of the front seat and right interior sidewall.

Had any of the rear occupants been restrained by the available lap belts, some level of restraint-related injuries would have resulted, due to deceleration into the 2-inch-wide webbing. With the probability of severe jackknifing over the belt and injury-producing hyperflexion. Fatal internal, spine, or head and neck injuries would have been very possible if lap belts had been used in the rear seat. The right rear passenger probably would have survived if he had been restrained in a properly fitted lap/shoulder belt.

CASE 21 (SEA-85-H-OR26)

Case vehicle:	1983 Chevrolet Malibu station wagon
Case vehicle weight:	4,258 pounds
Case vehicle Delta V:	18.3 mph



Circumstances

A 1983 Chevrolet Malibu station wagon was struck straight head-on, left front to left front, by a 1978 Ford Thunderbird. The Malibu was occupied by a lap/shoulder belt restrained 62-year-old male driver, a lap/shoulder belt restrained 65-year-old man seated right front, a lap belted 59-year-old woman seated left rear, and a lap belted 42-year-old woman seated right rear. The Thunderbird was driven by an unrestrained 47-year-old woman, accompanied by a 55-year-old woman in the right front, probably unrestrained. The Delta V for both vehicles was virtually identical at approximately 18 mph (longitudinal).

This accident resulted in moderate injuries to the Malibu driver. The remaining passengers of the Malibu sustained minor injuries. The unrestrained occupants of the Thunderbird received minor injuries.

Restraint and Injury

Seating location: Driver
Sex: M
Age: 62
Height: 5 feet 7 inches
Weight: 160
Restraint used: Lap/shoulder belt (ELR)
Proper use? Probably

This driver was wearing a 3-point, continuous loop, lap/shoulder belt with ELR, a windowshade tension relief feature, a cinching type of latchplate, and a pushbutton release type of buckle attached to a flexible stalk. The occupant described the pre-crash lap belt adjustment as snug, positioned low on his hips, but he was unable to relate the shoulder strap adjustment. There were force loading marks on the system webbing, attributed to webbing load at the D-ring. The steering assembly was displaced inboard and the instrument panel was moderately deformed.

Injuries	AIS	Probable Source
Abrasion, left forehead	1	Steering wheel rim
Sprain, right shoulder	1	Impact forces
Contusion, left elbow	1	Interior sidewall
Major contusion, right thigh	2	Steering wheel rim
Abrasion, left forearm	1	Interior sidewall
Small laceration, left hand	1	Broken side glass

This man was treated and released at a local hospital. He might have sustained serious injuries if he had been unrestrained, making violent contact with the steering assembly, A pillar, and lower instrument panel.

Seating location: Right front
Sex: M
Age: 65
Height: 5 feet 11 inches
Weight: 195
Restraint used: Lap/shoulder belt
Proper use? Unknown

This passenger was wearing a lap/shoulder belt similar to the driver's. No information concerning precrash system adjustment was furnished by this occupant. There was a force loading scar, attributed to the D-ring, on the system webbing at approximately 33 inches above the retractor. There was no compartment deformation noted forward of this seating position.

Injuries	AIS	Probable Source
Transverse fracture, 10th and 11th left ribs	1	Shoulder strap
Abrasion, left elbow	1	Right side steering wheel rim
Abrasion, left forearm	1	Right side steering wheel rim
Contusion, diagonally across chest	1	Shoulder strap
Abrasion, diagonally across chest	1	Shoulder strap
Contusion, over left iliac crest	1	Lap belt
Small laceration, lower right leg	1	Lower instrument panel

This man was treated and released at an area hospital.

Given this man's height, he probably would have received some level of facial injuries (from contacting the windshield), along with a higher level of injuries to his lower extremities, due to contacts with the lower instrument panel and below, if he had been unrestrained.

Seating location: Left rear
Sex: F
Age: 59
Height: 5 feet 6 inches
Weight: 155
Restraint used: Lap belt (ALR)
Proper use? Yes

This passenger was wearing a lap belt with an ALR, a sewn-in latchplate attached to the retractable webbing, and a pushbutton release type of buckle. The buckle was attached to an 11-inch portion of webbing which entered the seating area at the junction of the upper and lower seat cushions. This woman said that the pre-crash lap belt adjustment was "snug," with the webbing positioned low on her hips. There was no compartment deformation at this seating position.

Injuries	AIS	Probable Source
Laceration (1 cm), over left eye	1	Eyeglasses
Abrasion, lower abdomen	1	Lap belt
Contusion, lower abdomen	1	Lap belt
Contusion, around left eye	1	Front seatback

She was treated and released at an area hospital. A Safety Board followup interview revealed that she was still experiencing abdominal tenderness 1 month after the accident.

It is highly probable that this woman's principal deceleration in this moderate (18 mph Delta V) crash took place into the rear surface of the front seat. Given the rear compartment dimensions, she moved forward into the lap belt only a small amount before she contacted the seatback. Thus, the penetration of the lap belt into her abdominal area was not forceful enough to cause serious internal injury.

Seating location: Right rear
Sex: F
Age: 42
Height: 5 feet 2 inches
Weight: 170
Restraint used: Lap belt (ALR)
Proper use? No

This passenger was wearing a lap belt similar to her seat mate's. There was no deformation of the compartment at this seating position.

Injuries	AIS	Probable Source
Abrasion, left forehead	1	Rear surface of front seat
Contusion, mid-abdominal area	1	Lap belt
Contusion, left knee	1	Rear surface of front seat
Contusion, right knee	1	Rear surface of front seat

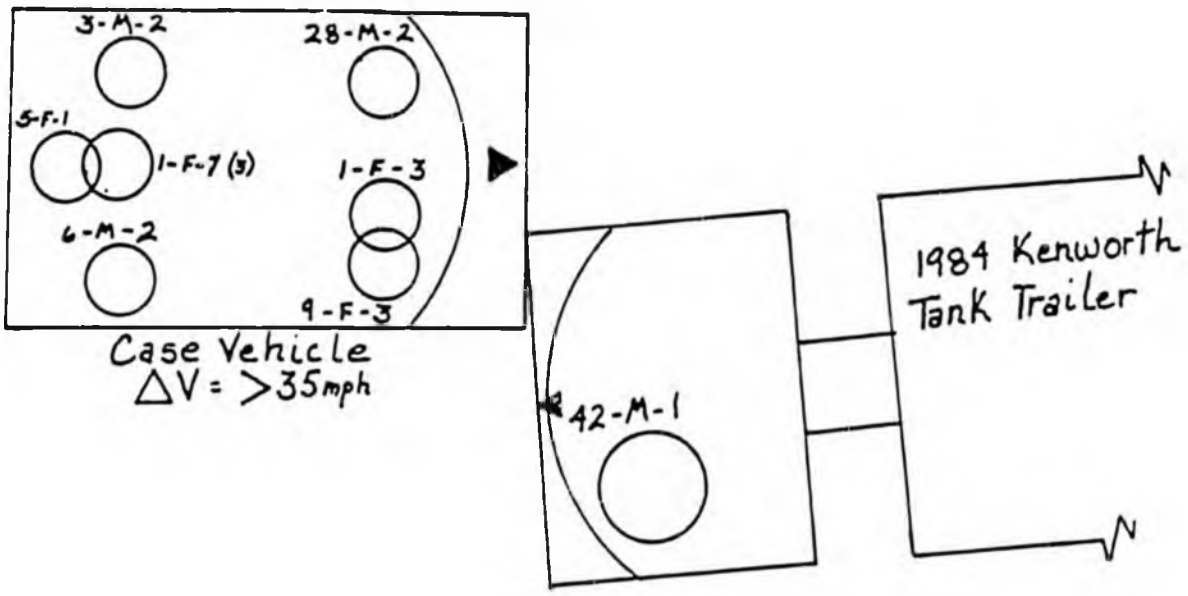
She was treated and released at an area hospital. A Safety Board followup interview one month after the accident revealed that she was experiencing abdominal soreness and bruising was still evident.

The precrash adjustment of this woman's lap belt was described as "snug," but with the webbing positioned above the navel. Despite the incorrect placement of this lap belt, and the overweight condition of this woman, the Delta V was sufficiently low in this case (combined with her principal deceleration into the right front seatback) to prevent serious internal injury.

The most serious injury sustained in this crash was the contused thigh of the Malibu driver. All others, restrained and unrestrained, suffered only minor injuries. If the rear seat passengers in the Malibu had been wearing lap/shoulder belts, they probably would not have sustained minor facial injuries.

CASE 22 (FTW-86-H-OR02)

Case vehicle:	1979 Chevrolet Impala station wagon
Case vehicle weight:	4,700 pounds
Case vehicle Delta V:	35 mph



Circumstances

A 1979 Chevrolet Impala station wagon struck a 1984 Kenworth tractor-trailer (gasoline tanker) head-on, right front to right front. The station wagon was driven by a 28-year-old man accompanied by six other passengers who ranged in age from 10 months to 9 years. None of the stationwagon occupants were restrained.

The truck was hauling 8,600 gallons of gasoline at a driver-estimated 55 mph when the impact occurred. The estimated right front to right front structural overlap in the collision was 24 inches; the crash destroyed the passenger car and resulted in a post-crash gasoline fire that substantially consumed the gasoline truck.

The station wagon driver received moderate injuries. The right front passengers, a 10-month-old infant girl and a 9-year-old girl, received moderate to serious injuries. Injuries sustained by the rear seat passengers varied, with a 10-month-old infant girl being held at center rear and a 6-year-old boy in the right rear receiving the most serious injuries. The 3-year-old boy at left rear received moderate injuries; the 5-year-old girl at center rear received only minor injuries.

Restraint and Injury

Seating location: Driver
Sex: M
Age: 28
Restraint used: None
Proper use? NA

This driver was not wearing the available 3-point lap/shoulder belt. There was forward displacement of the steering assembly and distortion of the upper instrument panel surface in front of the driver. Forward displacement of the lower instrument panel surface was also noted at both the left and right sides of the steering column.

Injuries	AIS	Probable Source
Closed head injury	2	Steering assembly and windshield
Unspecified neck injury	1	Steering assembly and windshield
Laceration, right knee and below	1	Lower instrument panel
Multiple contusions, abrasions	7	Frontal interior

The forces acting on the Chevrolet driver were not as great as those acting through the right side of the vehicle, due to the rapid counterclockwise rotation. It would be difficult to say that his injury level would have been reduced had he been restrained by the available system. With the speed involved, it is quite likely that some level of moderate injury would still have occurred.

Seating location: Right front, on lap of a 9-year-old girl
Sex: F
Age: 10 months
Restraint used: None
Proper use? NA

There was substantial rearward distortion of the front area at this position. The A pillar was displaced rearward several inches, and exterior components apparently intruded into the passenger compartment at windshield level. Accurate documentation of the compartment compression was not possible, due to extrication alterations. The seatback at this position was deformed forward several inches, due to loading by the rear seat occupants. The instrument panel forward of this seating position was found with substantial deformation, pushed inward and upward from its lower surface.

Injuries	AIS	Probable Source
Closed head injury w/neurologic defect	3	Instrument panel
Occipital hematoma	1	Instrument panel
Contusion, right check	1	Instrument panel
Laceration, left hand	1	Instrument panel

This child was most likely compressed between the instrument panel and the 9-year-old who was reportedly holding her at the time of the crash. If this infant had been properly restrained at center front in an adequate child safety seat, she probably would have escaped without serious injuries.

Seating location: Right front (holding infant)
Sex: F
Age: 9
Restraint used: None
Proper use? NA

This child was not wearing the available 3-point lap/shoulder belt. It was reported that she was holding a 10-month-old child on her lap at the time of the collision. See previous occupant discussion for description of compartment, postcrash.

Injuries	AIS	Probable Source
Pulmonary contusion	3	Instrument panel
Comminuted fracture, right ulna	3	instrument panel
Comminuted fracture, right radius	3	Instrument panel
Displaced fracture, left ulna	3	Instrument panel
Displaced fracture, left radius	3	Instrument panel

The 9-year-old probably would have received serious injuries even if she had been properly restrained by the 3-point lap/shoulder belt. This seating compartment had extensive intrusion from exterior components which penetrated at approximately the level where a restrained occupant's head and upper torso would have been positioned due to the shoulder strap. It could be speculated that this accident would not have been survivable for a fully restrained adult occupant because of that extensive intrusion.

Seating location: Left rear
Sex: M
Age: 3
Restraint used: None
Proper use? NA

This boy was not restrained by the available lap belt. There was no intrusion of the passenger compartment at this position. However, the back cushion of the front seat was deformed forward several inches directly in front of this occupant's precrash seating position.

Injuries	AIS	Probable Source
Fractured right metatarsals	2	Rear of front seat
Laceration, right forehead	1	Rear of front seat
Nonpenetrating laceration, left abdominal wall	1	Interior sidewall components
Unspecified closed head injury	2	B pillar and rear of front seat
Contusion, bridge of nose	1	B pillar and rear of front seat
Contusion, left cheek	1	B pillar
Abrasion, anterior right lower leg	1	Rear of front seat
Fracture, right hand metacarpal	2	Rear of front seat

This boy was admitted to a local hospital for 3 days due to the closed head injury and fractured right foot.

This little boy sustained less serious injuries than would normally be expected in an accident of this severity. He was allowed to decelerate into the rear surface of the front seatback without serious injury. He should have been in a child safety device appropriate for his size and weight. Given the severity of this collision, it is very likely that serious to critical injuries would have occurred if this boy had been lap belted.

Seating location: Center rear, on lap of 5-year-old girl
Sex: F
Age: 10 months
Restraint used: None
Proper use? NA

The back cushion of the front seat in front of this infant was deformed forward several inches. Multiple scuffs on the rear surface upholstery were noted across the entire width of the front seatback cushion.

Injuries	AIS	Probable Source
Intra-abdominal injury (required surgery)	7	Compression between 5-year-old holding her and front seatback
Fracture, right femur	3	Compression between 5-year-old and front seatback

This infant spent an unspecified period of time in an area hospital for surgery and other treatment.

If this infant had been properly restrained in a child safety seat, it is unlikely that any serious injuries would have occurred. However, there was insufficient space to install a safety seat for this child.

Seating location: Center rear (holding infant)
Sex: F
Age: 5
Restraint used: None
Proper use? NA

This child was not wearing the available static lap belt at her seating position. She was reportedly holding a 10-month-old child at the time of the accident. The back cushion of the front seat was deformed forward several inches in front of this seat position. Multiple scuffs on the rear surface upholstery were noted across the entire width of the front seatback cushion.

Injuries	AIS	Probable Source
Abrasion, right wrist	1	Rear of front seatback
Superficial abrasions, contusions	1	Rear of front seatback

She was checked at an area hospital and released without significant injury.

The 5-year-old's deceleration was cushioned by the infant she was holding at the time of the crash. Even without the cushioning, this child probably would not have sustained serious injury, due to the containment provided by the rear surface of the front seatback. If this passenger had been lap belted, her entire deceleration would have been into the 2-inch-wide restraint webbing, and serious internal injuries might well have resulted from such a deceleration.

Seating location: Right rear
Sex: M
Age: 6
Restraint used: None
Proper use? NA

This child was not wearing the available lap belt at his seating position. There was probably exterior metal intrusion into this compartment area. Also, the back cushion of the front seat was deformed forward several inches at the front of this seating position. Multiple areas of scuffs were noted across the rear surface of the front seatback forward of this seat position.

Injuries	AIS	Probable Source
Laceration (1 inch), over left eye	1	Intrusion of exterior metal
Laceration (2 inch), under lower lip	1	Intrusion of exterior metal
Avulsion, front tooth	1	Intrusion of exterior metal
Puncture, right shoulder crest	1	Intrusion of exterior metal
Laceration (3 inch), right side neck	2	Intrusion of exterior metal
Hematoma, right forehead	1	B pillar
Mild closed head injury	2	B pillar
Large laceration of tongue	2	Forces transmitted through teeth
Abrasion, right knee	1	Rear of front seat
Chemical keratitis, left eye	1	Battery acid or fuel spill

This boy required 3 days of hospitalization.

While use of a lap belt by this boy might have prevented the facial lacerations and contusions received from intruding exterior components, the lap belt itself would probably have resulted in a more serious level of injuries. A deceleration impulse of 35 mph into the 2-inch-wide lap belt could have caused serious intra-abdominal injuries, regardless of pre-crash adjustment. The probability of head or cervical injury would have been increased by jackknifing over the lap belt webbing.

If a lap/shoulder belt had been available to, and worn by, this boy, he could probably have ridden down the deceleration with only moderate contusions resulting from the restraint webbing. With upper torso restraint, his head would not have been allowed to contact the B pillar and intruding exterior metal.

CASE 23 (CHI-85-H-OR18)

Case vehicle: 1984 Ford Econoline Van
Case vehicle weight: 4,935 pounds
Case vehicle Delta V: 25-28 mph