On-scene Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS01015
1994 Ford Probe
California
August, 2001

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16. Abstract

The crash occurred in California in August, 2001. The crash occurred in the southbound approach to a three-leg intersection. The intersection is controlled by tri-color overhead traffic signals. There is a slight right hand curve as the roadway approaches the intersection with a -2.6% down grade. The bituminous roadway was dry and free of defects. The speed limit is 80 km/h (50 mph). The case vehicle, a 1994 Ford Probe three-door hatchback driven by a restrained 39-year-old female (170 cm/67 in., 70 kg (155 lbs), was traveling southbound on the divided roadway at a police calculated speed of 82-85 km/h (51-53 mph). The front right seat was occupied by a 2 month/19 day old male child (63 cm/25 in., 7.7 kg/17 lbs). The child had been placed in a rear-facing Evenflo Discovery Adjust Right infant seat. The infant seat had been incorrectly attached to the vehicle. The other vehicle, 1997 Toyota 4Runner, was traveling in front of the case vehicle at a driver estimated speed of 5-8 km/h (3-5 mph). The driver of the case vehicle, the grandmother to the child, was momentarily distracted as she was trying to feed the child some milk. The case vehicle failed to negotiate the curve and drifted from the third travel lane into the left turn lane. As the driver's attention returned to the road, she saw that all traffic ahead of her was slowing or stopped for a red light at the intersection. The driver of the case vehicle braked and steered to the right, but was unable to stop her vehicle in time and rear-ended the other vehicle.

The driver of the other vehicle had seen the crash coming and had taken his foot off the brake. After impact, his vehicle was pushed into the intersection where it came to rest. The case vehicle came to rest in the third lane facing its initial path of travel.

The case vehicle sustained a longitudinal delta v of -13.4 km/h (-8.3 mph). Both the driver's air bag and the front right passenger's air bag deployed. The deploying passenger air bag struck the rear of the infant seat. The impact fractured the back of the seat horizontally. The crack extends completely from left to right. The seat back struck the back of the child's head. According to the autopsy report, he sustained jagged bilateral linear fractures to the parietal skull with torn dura (AIS=4) and brain contusions–especially to the lateral aspect of the right cerebral hemisphere (AIS=3). The child was transported from the scene by ambulance. He was hospitalized and died four days later without regaining consciousness (AIS=5). The cause of death was listed as bilateral confluent pneumonia due to a fractured skull and edema, contusions and hemorrhages of the brain. The driver of the case vehicle complained of pain to her left shoulder and rib cage. Her left ankle and left side of her face were swollen. The driver of the other vehicle did not report any injuries.

17. Key Words Air bag, deployment, infant seat, rear-facing, fatality, passenger,	18. Distribution Statement

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Dynamic Science, Inc.
Accident Investigation
Case Number:DS01015

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BACKGROUND:

Description: This air bag related infant fatality was initiated based on a news report regarding the crash. DSI notified NHTSA on August 15, 2001. DSI was assigned the case on August 16, 2001. The case vehicle was inspected on August 23, 2001.

Investigation Type: On-scene

Crash Location: California
Crash Date: August, 2001
Notification Date: August 16, 2001
Field Work Completed: August 23, 2001

SUMMARY:

The crash occurred in California in August, 2001. The crash occurred in the southbound approach to a three-leg intersection. The intersection is controlled by tri-color overhead traffic signals. The northern leg of the intersection is comprised of three southbound through lanes, one left turn lane, a raised median, and three northbound through lanes. There are bike lanes on both the west and east side of the trafficway. There is a slight right hand curve as the roadway approaches the intersection with a -2.6% down grade. The bituminous roadway was dry and free of

Figure 1. Final rest, case vehicle, south

defects. The police report that it had a coefficient of friction of 0.73. The speed limit is 80 km/h (50 mph).

The case vehicle, a 1994 Ford Probe three-door hatchback driven by a restrained 39-year-old female (170 cm/67 in., 70 kg/155 lbs), was traveling southbound on the divided roadway at a police calculated speed of 82-85 km/h (51-53 mph)[1]. The front right seat was occupied by a 2 month/19 day old male child (63 cm/25 in., 7.7 kg/17 lbs). The child had been placed in a rear-facing Evenflo Discovery Adjust Right infant seat. The infant seat had been incorrectly attached to the vehicle (see Child Safety Seat discussion). The front right seat has four possible track positions; the seat had been adjusted to the

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[1]The data used by the police to calculate the initial velocity was based on their inaccurate assumption the air bags will deploy at a minimum speed range of between 24-28 mph (delta v).

third position from the front. The seat back was 68 cm (26.7 in.) from the air bag opening. The
maximum deflated excursion of the air bag was 70 cm (27.5 in.). The driver, who was the grandmother of the male child, had told the investigating officers that she had purchased the case vehicle used (two years earlier) and didn't know it had air bags.

The other vehicle, 1997 Toyota 4Runner, was traveling in front of the case vehicle at a driver estimated speed of 5-8 km/h (3-5 mph).

The driver of the case vehicle, the grandmother to the child, was momentarily distracted as she was trying to feed the child some milk. The case vehicle failed to negotiate the curve and drifted from the third travel lane into the left turn lane. As the driver's attention returned to the road, she saw that all traffic ahead of her was slowing or stopped for a red light at the intersection. The driver of the case vehicle braked and steered to the right, depositing 28.9 m (95 ft) of locked

Figure 2. Front right, case vehicle

Figure 3. Left side, case vehicle

wheel skids, but was unable to stop her vehicle in time and rear-ended the other vehicle. The case vehicle was assigned a CDC of 12FZEW1 and had a maximum crush of 4 cm (1.5 in) at C_6.

The driver of the other vehicle had seen the crash coming and had taken his foot off the brake. After impact, his vehicle was pushed into the intersection where is came to rest. The case vehicle came to rest in the third lane facing its initial path of travel.

The case vehicle sustained a longitudinal delta v of -13.4 km/h (-8.3 mph)[2]. Both the driver's air bag and the front right passenger's air bag deployed. The deploying passenger air bag struck the rear of the infant seat. The impact fractured the back of the seat horizontally. The crack extends completely from left to right. The seat back struck the back of the child's head. According to the autopsy report, he

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[2]Calculated using stiffness values from NCAP test 2043 for the case vehicle and averaged weights for the other vehicle. The results appear slightly low.

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sustained jagged bilateral linear fractures to the parietal skull with torn dura (AIS=4) and brain contusions–especially to the lateral aspect of the right cerebral hemisphere (AIS=3). The child was transported from the scene by ambulance. He was hospitalized and died four days later without regaining consciousness (AIS=5). The cause of death was listed as bilateral confluent pneumonia due to a fractured skull and edema, contusions and hemorrhages of the brain.

The driver of the case vehicle complained of pain to her left shoulder and rib cage. Her left ankle and left side of her face were swollen. The driver of the other vehicle did not report any injuries.

Child safety seat discussion

Seat type:	Rear facing infant seat, equipped with a separate auto base
Manufacturer:	Evenflo
Model:	Discovery Adjust Right
Model No.:	2121E7
Specifications:	Designed for infant from 2.2-9 kg (5-20 lbs) and from 48-66 cm (19-26 in.)
Recalls:	None. There were two safety notices, however. Both apply to all Discovery seats.

Safety notice #1: Original instructions state that, when seat is used with base, vehicle shoulder belt should be kept in slot with lap portion of belt. If vehicle belt retractor is locked and shoulder belt is pulled tight, it can lift up one side of base. Current recommendation by manufacturer is to remove the shoulder belt from slot and allow it to rest against vehicle seat.

Safety notice #2: Due to thick fold in webbing where it is stitched, metal slide sewn to shoulder strap may not lie flat against back of plastic shell. Make sure strap is pushed completely through the slot so there is no excess strap behind seat.

The vehicle and Evenflo infant seat were examined by a deputy who has undergone the child passenger safety training provided by the NHTSA shortly after the crash. The child was within the height and weight parameters for the seat design. The angle indicator on the seat was "green", indicating that the seat was at the proper inclination. Regardless of the placement of the CSS in front of the air bag, the seat base was found improperly attached with the vehicle's lap and shoulder belts. This vehicle was equipped with emergency locking retractor seatbelts with sliding latchplates. To properly install the infant seat base in this vehicle requires the use of a locking clip. The locking clip was still attached to the back of the infant seat and was not used.

Figure 4. Front view, infant seat in vehicle

Investigating officers determined that there was 7.6 cm (3 in) of lateral movement in the seat when buckled in place. The carry handle was found in the upright locked position. The retainer clip was attached to the left side only. This position is normal when placing an infant in or taking an infant out of the seat. The infant seat was found to be properly attached to the removable base. The left side harness adjustment clip was found removed from the locking position on the back of the seat. The red release handle on the left side on the back of the seat was damaged and out of adjustment. The locking clip was still attached to the back of the seat. The instruction manual was available. There were air bag placement warnings on the seat belt and the visor.

Figure 5. Side view, infant seat in vehicle
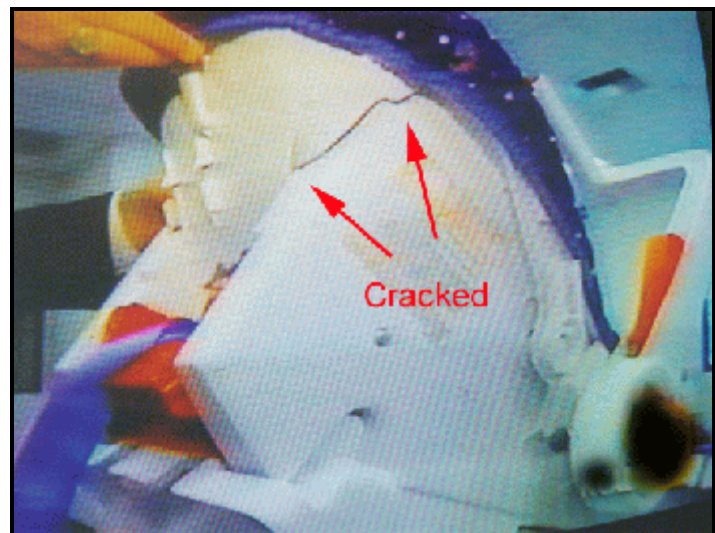

Figure 6. Infant seat, proximity to air bag

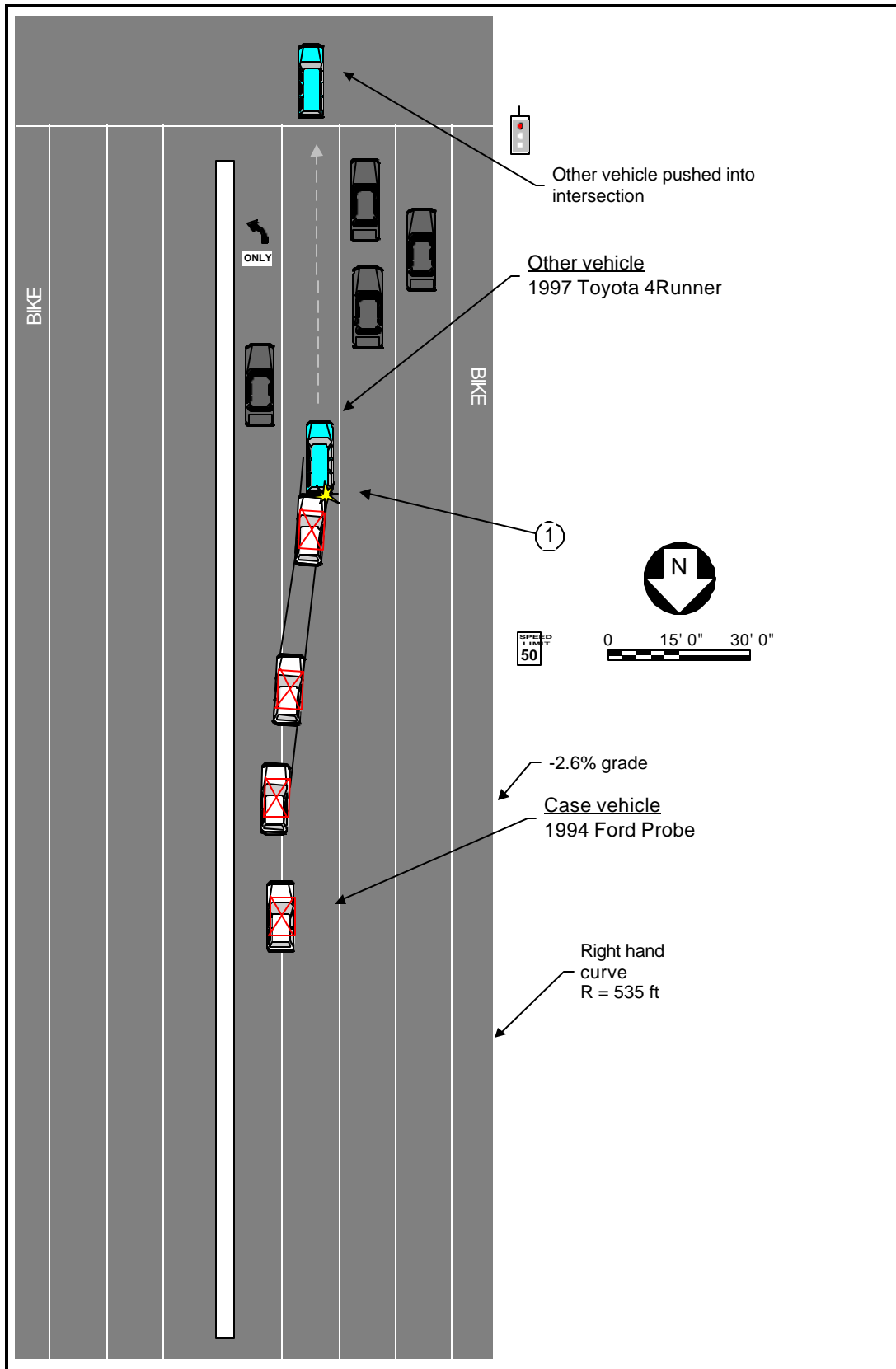**Figure 7**. Infant seat (image from news video)

Scene Diagram

Figure 8. Scene diagram

COLLISION MEASUREMENTS						
Reference point:	North curb line					
Reference line:	West curb line					
Data Point	**Distance and Direction from RP**			**Distance and Direction from RL**		
	ft	m	d	ft	m	d
BLF - V1	116.6	35.5	N	48.1	14.7	E
Intermediate LF - V1	92.3	28.1	N	41	12.5	E
ELF - V1	70.9	21.6	N	40.5	12.3	E
BRF - V1	140.9	42.9	N	42.75	13	E
Intermediate RF - V1	92.3	28.1	N	37.7	11.5	E
ERF - V1	71.5	21.8	N	35.7	10.9	E
Gouge on roadway from V1 undercarriage	86.2	26.3	N	38.7	11.8	E
Final rest - RF - V1	71.5	21.8	N	35.7	10.9	E
Final rest - RR - V1	79.9	24.4	N	36.2	11	E
Grade = -2.9%						
Bituminous-recently repaved						
Right hand curve						
Chord	30	9.1				
Middle ordinate	.20	0.1				

DETAILED INFORMATION

Vehicles

<u>Case vehicle</u>

Description:	1994 Ford Probe two-door sedan
VIN:	1ZVLT20A9Rxxxxxxx
Odometer:	Unknown
Engine:	2.0 l I4
Reported Defects:	None
Cargo:	Approximately 45 kg (100 lbs) (carriage, clock, chair)
Damage Description:	Moderate front contact to front bumper, hood buckled, right front fender buckled. Windshield damaged by air bag module cover.
CDC:	12FZEW1

Delta V:

	Total	13.4 km/h (8.3 mph)
	Longitudinal	-13.4 km/h (-8.3 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	2,646 joules (1,950 ft-lbs)

Figure 9. Close up, front of case vehicle

Other vehicle

Description:	1997 Toyota 4Runner sport utility vehicle
VIN:	Unknown
Odometer:	Unknown
Engine:	Unknown
Reported Defects:	None noted
Cargo:	Unknown
Damage Description:	Damage listed as "minor" by police. Vehicle driven from scene.
CDC:	Unknown

Delta V:

Total	9.9 km/h (6.2 mph)
Longitudinal	9.9 km/h (6.1 mph)
Latitudinal	0.7 km/h (0.4 mph)
Energy	13,596 joules (10,025 ft-lbs)

Occupants

Case vehicle	Occupant 1	Occupant 2
Age/Sex:	39/Female	2 months, 19 days / male
Seated Position:	Front left	Front right
Seat Type:	Bucket with folding back, fabric covered. This seat has four possible track positions; the seat had been adjusted to the third position from the front	Bucket with folding back, fabric covered. This seat has four possible track positions; the seat had been adjusted to the third position from the front. The seat back was 68 cm (26.7 in.) from the air bag opening.
Height:	170 cm (67 in.)	63 cm (25 in.)
Weight:	70 kg (155 lbs)	7.7 kg (17 lbs.)
Occupation:	Unknown	NA
Pre-existing Medical Condition:	None noted	None
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown, presumed to be over 10 years	NA
Body Posture:	Normal, upright	Supine in infant seat
Hand Position:	Unknown	NA
Foot Position:	Right foot on brake, left on floor board	NA
Restraint Usage:	Lap and shoulder belt used	Lap and shoulder belt used improperly with infant seat
Air bag:	Driver's air bag, deployed	Front right passenger's air bag, deployed

Other vehicle	Occupant 1
Age/Sex:	67/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	196 cm (77 in.)
Weight:	102 kg (225 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	Unknown
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown, presumed to be greater than 20 years
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Left on floor, right off of brake
Restraint Usage:	Lap and shoulder belt used, per police

Injuries and Injury Mechanisms

Case vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Not injured			
	Complaint of pain to left shoulder and rib cage. Left ankle and left side of face swollen.			
RF Occupant:	Bilateral jagged linear fractures with dura disruption	150406.4,1 150406.4,2	801.15 801.15	Child seat back-air bag engaged front of CSS
	Brain contusions, especially on lateral aspect of right cerebral hemisphere	140620.3,1	851.45	Child seat back-air bag engaged front of CSS
	Loss of consciousness (died four days after crash–unconscious the entire time)	160214.5,0	801.15[3]	Child seat back-air bag engaged front of CSS

Other vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Not injured			

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[3]Skull fracture given fifth-digit classification for loss of consciousness more than 24 hours.

Occupant Kinematics

The front left fabric-covered bucket seat was occupied by a 39-year-old female (170 cm/67 in., 70 kg/155 lbs). She was wearing the available lap and shoulder belt. The front left seat has four possible track positions; the seat had been adjusted to the third position from the front. Initially, this occupant was not looking forward. She had turned to the right to feed the front right seat child occupant. As the case vehicle neared the area of impact, she looked up and saw traffic slowing and stopped in front of her. She applied the brakes at this point and likely braced as she steered to the right.   After skidding 28.9 m (95 ft), the front of the case vehicle struck the rear of the other vehicle. She responded to the 0 degree direction of force and pitched straight foward. She loaded the seat belt at this time–likely causing the pain she report to her left shoulder and rib cage. As the steering wheel mounted air bag deployed, she engaged it with her face–causing some swelling. She was able to exit the vehicle on her own and later accompanied the front right occupant to the hospital.

The front right fabric-covered bucket seat was occupied by a 2 month/19 day old male child (63 cm/25 in., 7.7 kg/17 lbs).   The child had been placed in a rear-facing Evenflo Discovery Adjust Right infant seat. The infant seat had been incorrectly attached to the vehicle. This vehicle was equipped with emergency locking retractor seatbelts with sliding latchplates. To properly install this infant seat in this

Figure 10. Driver seated position

vehicle requires the use of a locking clip. The locking clip was still attached to the back of the infant seat and was not used. Investigating officers determined that there was 7.6 cm (3 in) of lateral movement in the seat when buckled in place. The front right seat has four possible track positions; the seat had been adjusted to the third position from the front. The seat back was 68 cm (26.7 in.) from the air bag opening. The maximum deflated excursion of the air bag was 70 cm (27.5 in.).

After skidding 28.9 m (95 ft), the front of the case vehicle struck the rear of the other vehicle. The front right occupant responded to the 0 degree direction of force by moving forward into the shell of the infant seat. The deploying air bag struck the back of the infant seat. There was no contact between the air bag module cover and the infant seat. The force of the air bag collapsed/fractured the plastic shell accelerating the shell rearward into the back of the child's head. The impact with the infant seat shell accelerated by air bag forces caused the multiple skull fractures.

The child was removed from the infant seat by medical personnel and transported by ground ambulance to a local community hospital where he died four days later.
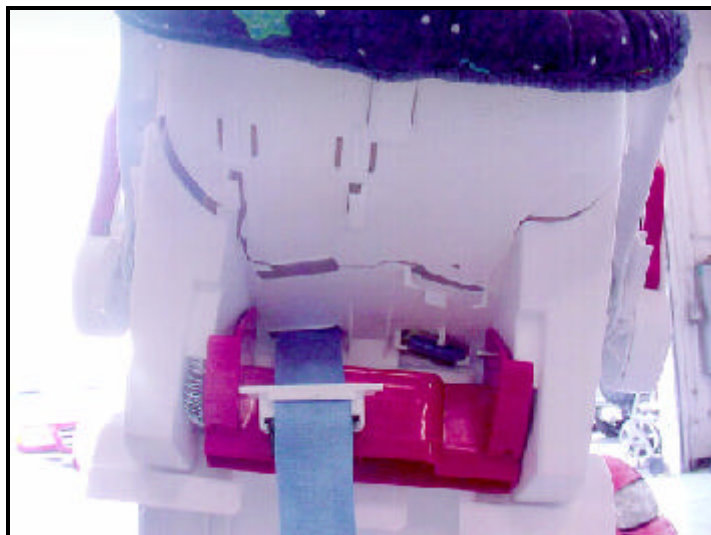

Figure 11. Back side of infant seat

Attachment 1. Calculations

CASE NUMBER: ds01015

* * RADIUS FORMULA * *

$$R = \frac{C^2}{8 \times M} + \frac{M}{2}$$

R = The Radius in Feet.
C = The Chord in Feet.
M = The Middle Ordinate in Feet.
8 = A Constant.
2 = A Constant.

$$R = \frac{30.00^2}{8 \times 0.21} + \frac{0.21}{2}$$

$$R = \frac{900.00}{1.68} + \frac{0.21}{2}$$

R = 535.71 + 0.10

R = 535.81

AR = (R ± Cntr of Mass Adjustment)
AR = 535.81 + 0.00
AR = 535.81

AR = The Adjusted Radius in Feet.
R = The Radius in Feet.

INPUTS:		RESULTS:	
The Chord in Feet is:	30.00	The Radius in Feet is:	535.81
The Middle Ordinate in Feet is:	0.21	The Adjusted Radius in Feet is:	535.81

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DS01015

CASE NUMBER: ds01015

* * MINIMUM SPEED W/ KNOWN DRAG FACTOR * *

$S = \sqrt{30 \times D \times f}$

$S = \sqrt{30 \times 95.00 \times 0.73}$

$S = \sqrt{2080.50}$

$S = 45.61$

S = The Speed in MPH.
30 = A Constant.
D = The Distance in Feet.
f = The Adjusted Accel/Drag Factor.

INPUTS:		RESULTS:	
The Acceleration/Drag Factor is:	0.73	The Speed in MPH is:	45.61
The Distance in Feet is:	95.00	The Velocity in FPS is:	66.86

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CASE NUMBER: ds01015

Comments: pre-impact braking

* * MINIMUM SPEED W/ KNOWN DRAG FACTOR * *

$S = \sqrt{30 \times D \times f}$

$S = \sqrt{30 \times 89.00 \times 0.73}$

$S = \sqrt{1949.10}$

$S = 44.14$

S = The Speed in MPH.

30 = A Constant.

D = The Distance in Feet.

f = The Adjusted Accel/Drag Factor.

INPUTS:		RESULTS:	
The Acceleration/Drag Factor is:	0.73	The Speed in MPH is:	44.14
The Distance in Feet is:	89.00	The Velocity in FPS is:	64.70

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CASE NUMBER: ds01015

Comments: v1 - impact speed

* * LINEAR MOMENTUM * *

W1 × V1 + W2 × V2 = W1 × V3 + W2 × V4

2619.00 × V1 + 3691.00 × 3.00 = 2619.00 × 18.71 + 3691.00 × 13.74

2619.00 × V1 + 11073.00 = 49001.49 + 50714.34

2619.00 × V1 + 11073.00 = 99715.83   W1 = The Wt of Veh 1 in Pounds.

2619.00 × V1 = 99715.83 - 11073.00   W2 = The Wt of Veh 2 in Pounds.

2619.00 × V1 = 88642.83   V1 = The Speed of Veh 1 in MPH.

          V2 = The Speed of Veh 2 in MPH.

          88642.83   V3 = The Spd After Impact, Veh 1.

V1 = —-—―-—-   V4 = The Spd After Impact, Veh 2.

          2619.00

V1 = 33.84

INPUTS:		RESULTS:	
The Wt of Veh 1 in Pounds is:	2619.00	The Spd of Veh 1 in MPH is:	33.84
The Min. Spd After Impact, Veh 1 is:	18.71	The Vel of Veh 1 in FPS is:	49.60
The Wt of Veh 2 in Pounds is:	3691.00		
The Impact Spd of Veh 2 is:	3.00		
The Min. Spd After Impact, Veh 2 is:	13.74		

INCREMENTATION CALC's:

IS V2	Speed		IS V2	Speed
0.00	38.07			
1.00	36.66			
2.00	35.25			
3.00	33.84			
4.00	32.43			

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CASE NUMBER: ds01015

Comments: v1 - pre-braking travel speed

* * COMBINED MINIMUM SPEEDS W/ KNOWN SPEEDS * *

$$S = \sqrt{S^2(1) + S^2(2) + ... S^2(n)}$$

$$S = \sqrt{(33.84)^2 + (44.14)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2}$$

$$S = \sqrt{1145.14 + 1948.33 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00}$$

$$S = \sqrt{3093.47}$$

$$S = 55.61$$

S = The Speed in MPH.

S^2 = The Individual Min. Speed.

$(1), (2), (n)$ = The # of the individual speed.

INPUTS:		RESULTS:	
Speed #1 in MPH is:	33.84	The Speed in MPH is:	55.61
Speed #2 in MPH is:	44.14	The Velocity in FPS is:	81.52

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