

On Site Child Safety Seat Investigation / Vehicle to Vehicle  
Dynamic Science, Inc. / Case Number: DS02008  
2002 Volvo V70 AWD Cross Country station wagon  
Washington  
May, 2002

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*The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.*

*Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.*

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16. Abstract <p>This two-vehicle collision occurred in the state of Washington in May, 2002 at 1500 hours. The crash occurred within the confines of a four-leg intersection. The case vehicle is a 2002 Volvo V70 station wagon driven by a 33-year-old male. The right rear seat was occupied by a 10-month-old male seated in a Britax Roundabout convertible child safety seat used rear-facing. The other vehicle was a 1985 Buick Skylark four-door sedan driven by a 55-year-old male.</p> <p>The case vehicle was traveling eastbound approaching a four-leg intersection. The other vehicle was traveling northbound approaching the same intersection. The traffic light was green for eastbound traffic. The other vehicle entered the intersection against a red light. The front of the other vehicle struck the right side of the case vehicle (01RZEW2). The case vehicle began a clockwise rotation. The front left tire engaged a yellow colored raised curb in the eastern leg of the intersection. This tripped the vehicle and it began a roll onto its left side. The vehicle continued rolling over and went onto its roof (00TDDO2). While overturning, the vehicle was also rotating in a clockwise direction. The vehicle continued northeast until the left side (while upside down) contacted a wooden power pole (00LFEE3). This impact redirected the vehicle into a counterclockwise rotation and came to rest on its roof facing south. The other vehicle rotated clockwise after impact and came to rest in the intersection.</p> <p>The driver of the case vehicle sustained bilateral knee abrasions and an abrasion to his left shoulder. The rear right occupant did not sustain any injuries. Both occupants were transported from the scene and held overnight for observation.</p>					
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**Dynamic Science, Inc.**  
**Accident Investigation**  
**Case Number: DS02008**

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**BACKGROUND:**

Description: This Child Safety Seat case was generated through a police report provided by NASS PSU 82. The crash occurred in May, 2002. The PSU was contacted and it was determined that this was not a sampled case. DSI was assigned the case on May 28, 2002. The scene was inspected on June 9, 2002. The case vehicle was inspected on June 10, 2002.

Investigation Type: On-scene  
 Crash Location: Washington  
 Crash Date: May, 2002  
 Notification Date: May 28, 2002  
 Field Work Completed: June 11, 2002

**SUMMARY:**

This two-vehicle collision occurred in the state of Washington in May, 2002 at 1500 hours. The crash occurred within the confines of a four-leg intersection. The northbound leg of the intersection is comprised of two northbound travel lanes and a single southbound travel lane. The concrete surface was dry and there was a 2% positive grade. The eastbound leg of the intersection is comprised of one eastbound through lane and one right turn only lane. There is a raised island that re-directs travel to the north, east, and south. The concrete surface was dry and there was a 3% positive grade. The intersection is controlled by tri-color traffic signals. The speed limit is 48 km (30 mph) in all directions.



**Figure 1.** Approach to area of impact – east (case vehicle)

The case vehicle is a 2002 Volvo V70 station wagon driven by a lap and shoulder restrained 33-year-old male. The right rear seat was occupied by a 10-month-old male (69 cm/27 in, 9 kg/20 lbs) restrained in a Britax Roundabout convertible child safety seat used rear-facing.

The other vehicle was a 1985 Buick Skylark four-door sedan driven by a 55-year-old male.

The case vehicle was traveling eastbound approaching a four-leg intersection. The other vehicle was traveling northbound approaching the same intersection. The traffic light was green for eastbound traffic. The other vehicle entered the intersection against a red light.

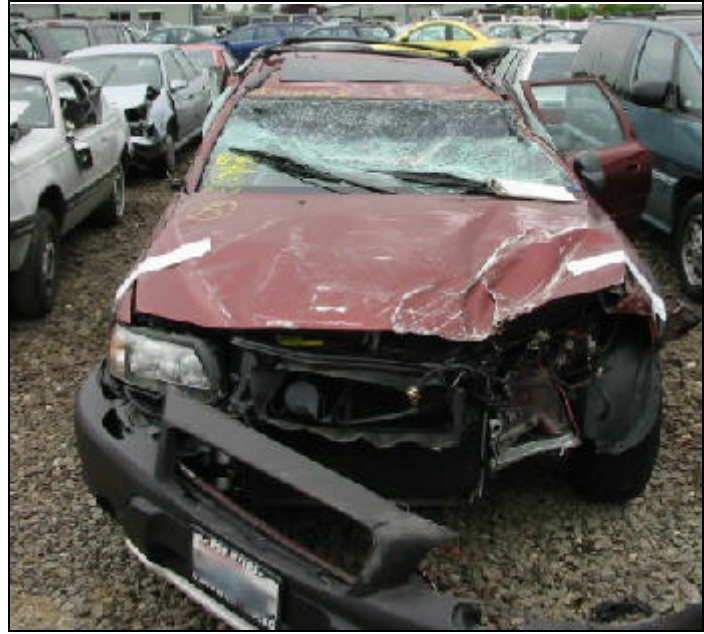


**Figure 2.** Case vehicle approach to overturn and impact with power pole—east



**Figure 3.** Right side, case vehicle

The front of the other vehicle struck the right side of the case vehicle (01RZEW2). The total velocity change calculated by the missing vehicle algorithm of WinSmash was 14.0 km/h (8.7 mph). The longitudinal and lateral components were -10.7 km/h (-6.7 mph) and -9.0 km/h (-5.6 mph)<sup>1</sup>, respectively. The case vehicle began a clockwise rotation. The front left tire engaged a yellow colored raised curb in the eastern leg of the intersection. This tripped the vehicle and it began a roll onto its left side. The vehicle continued rolling over and went onto its roof (00TDDO2). While overturning, the vehicle was also rotating in a clockwise direction. The vehicle continued northeast until the left side (while upside down) contacted a wooden power pole (00LFEE3). This impact redirected the vehicle into a counterclockwise rotation and came to rest on its roof facing south. The other vehicle rotated clockwise after impact and came to rest in the intersection.



**Figure 4.** Front of case vehicle

The second occupant in the case vehicle was seated in the right rear seat in a Britax Roundabout convertible child safety seat. The seat had been placed in the rear-facing position. The seat is designed to be rear-facing for infants up to 13.6 kg (30 lbs). The seat had been attached to the vehicle using the available lap and shoulder belt.

The driver of the case vehicle sustained bilateral knee abrasions and an abrasion to his left shoulder. He was transported by the local fire department to a local trauma center where he admitted for observation. The driver arrived with a GCS of 15. He underwent CT scans for his chest, head, and neck. All the scans proved to be negative for injury. Abdominal and closed head injuries were ruled out. He was held overnight and released the following morning. A timetable of medical activities is shown below:

<u>Event</u>	<u>Time</u>
Crash	1500
Time into ER	1540
Time out of ER	1730
Admitted	1945
Discharged	0810 (following day)

<sup>1</sup>Calculated using the Missing Vehicle algorithm for WinSmash version 2.12—results appear low

The rear right occupant of the case vehicle did not sustain any injuries. There was no loss of consciousness. He was transported by the local fire department to a local trauma center where he was admitted for observation. This occupant arrived at the hospital with a GCS of 12 (E4 V3 M5). He underwent CT scans for his chest, head, and neck. All the scans proved to be negative for injury. Abdominal and closed head injuries were ruled out. He was held overnight and released the following morning. A timetable of medical activities is shown below:

<u>Event</u>	<u>Time</u>
Crash	1500
Arrived	1542
Time into ER	1600
Trauma series	1630
Time out of ER	1900
Admitted	1945
Discharged	0800 (following day)



Scene Diagram

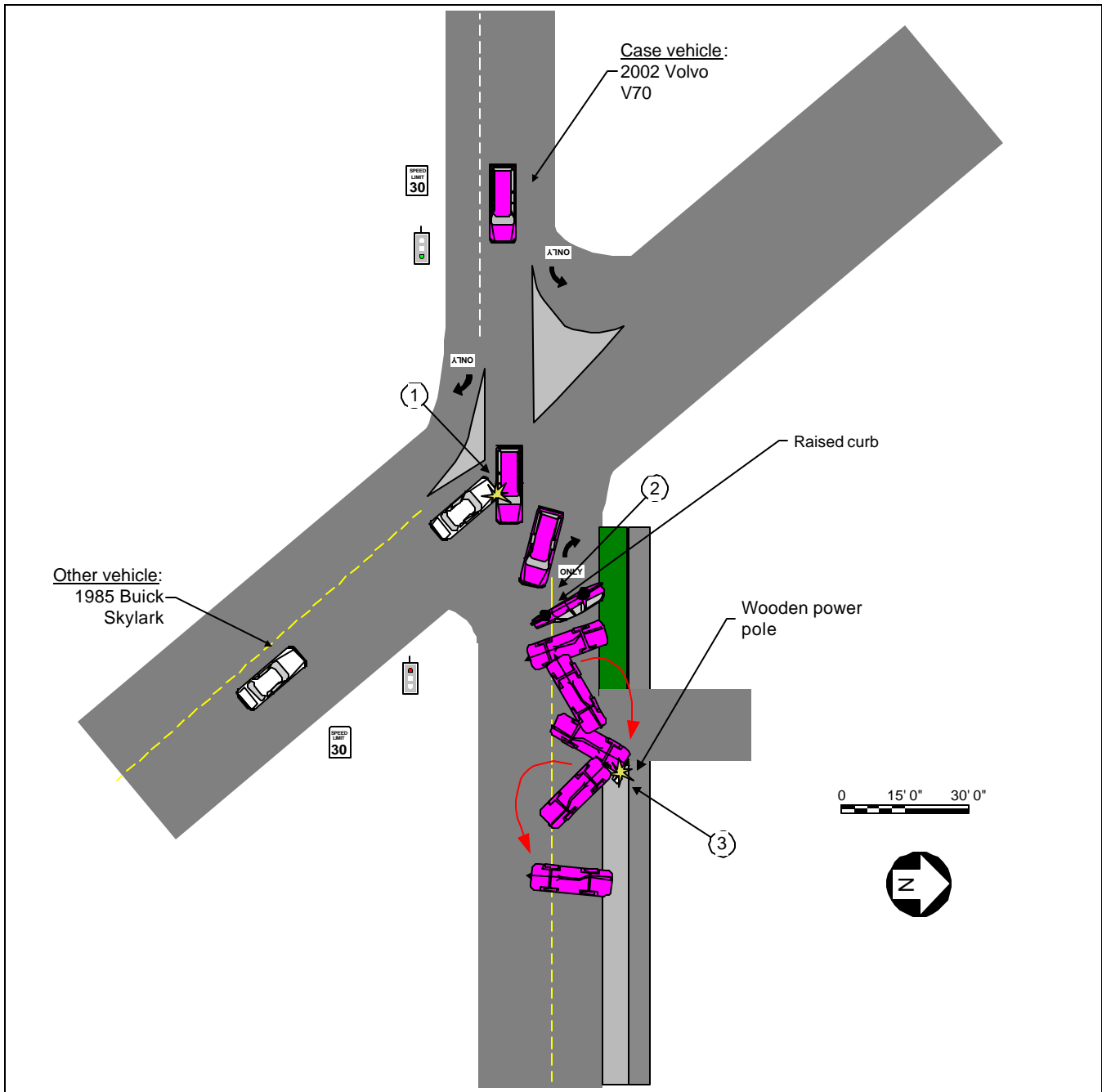


Figure 5. Scene diagram

**DETAILED INFORMATION****Vehicles**Case vehicle

Description:	2002 Volvo V70 XC AWD Cross Country station wagon	
VIN:	YV1SZ58D621XXXXXX	
Odometer:	6,437 km (4,000 miles) per interviewee	
Engine:	2.5L L5	
Reported Defects:	None	
Cargo:	11 kg (30 lbs) / planter boxes in rear hatch area	
Damage Description:	Direct contact damage to entire right side, both right doors jammed shut, scratches and intrusion to roof and A-pillars, direct contact damage through left side front plane–bumper dislodged. Vehicle towed from the scene due to damage. Later declared a total loss by insurance company.	
CDC:	Impact 1: 01RZEW2 Impact 2: 00TDDO2 Impact 3: 00LFEE3	
Delta V (Impact 1):	Total	14.0 km/h (8.7 mph)
	Longitudinal	-10.7 km/h (-6.7 mph)
	Latitudinal	-9.0 km/h (-5.6 mph)
	Energy	21,929 joules (16,174 ft-lbs)

During the first impact, the case vehicle sustained 288 cm (113.4 in) of direct to the right side. The maximum crush was located at C3 and measured 16 cm (6.3 in). The principle direction of force was within the 1 o'clock sector and was an estimated 40 degrees. The impact caused both right side doors to be jammed. The right rear side glass was fractured but remained in place<sup>2</sup>. The window frame was bent outward, but this was at least partially as a result of extrication efforts. There was a 2 cm (0.8 in) shortening of the wheelbase on the right side.



**Figure 6.** Right side, case vehicle

During the subsequent rollover, the case vehicle sustained direct contact damage to the roof, windshield, and hood. The fixed left rear side glass and the backlight disintegrated during the rollover.

After the rollover, the case vehicle began rotating clockwise. The roof and hood remained in contact with the ground. The rotation brought the front left fender into contact with a wooden power pole.



**Figure 7.** Top, case vehicle



**Figure 8.** Left side, case vehicle

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<sup>2</sup>Volvo Securit AS2 laminated

## Restraint systems and occupant protection discussion

The case vehicle was equipped with driver's and front right passenger's dual stage front air bags, three-point seat belts with pyrotechnical pretensioners at the front seating positions, two inflatable protective curtains fitted under the roof lining along each side of the car, driver and front right passenger side impact air bags integrated in the outer edges of the front-seat backrests, rear impact protection for front seat occupants, anti-submarining front and rear seats, rear seat LATCH connections.



**Figure 9.** Outside view of side curtain

The side air bags are integrated in the outer edges of the front seat back rests. The inflatable “protective curtains” are fitted under the roof lining along each side of the vehicle. In a crash, the curtain is released and inflates to full volume in approximately 25 thousandths of a second<sup>3</sup>. After three seconds, the deflation process begins. Both the side air bag and the side air curtain are activated by electronic sensors fitted in the B-pillar and behind the rear door opening.



**Figure 10.** Inside view of side curtain

Both the front right passenger side air bag and right side curtain deployed during the initial impact with the other vehicle in this case. The curtain likely remained inflated throughout the rollover event. There were no visible occupant contacts to the curtain. The pretensioner for the front right side fired and locked the unlatched lap and shoulder into place. The pretensioner on the driver's side did not fire.

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<sup>3</sup>According to information found on the Volvo web site



### Child seat discussion

The second occupant in the case vehicle was seated in the right rear seat in a Britax Roundabout convertible child safety seat. The seat had been placed in the rear-facing position. The seat is designed to be rear-facing for infants up to 13.6 kg (30 lbs). The seat had been anchored to the vehicle using the available lap and shoulder belt<sup>4</sup>. The seat had been secured to the seat belt using the CSS built-in lock-off clamps. The seat had also been secured to the vehicle using the Britax Versa-Tether as recommended by the manufacturer for rear facing seats. The tether extended from the top of the child seat back forward to the tether attachment anchorage present beneath the right front seat. The tether attachment is original equipment for this vehicle.

The vehicle was equipped with the LATCH system in the rear seats, but this production model of the Britax seat does not use it.

At the time of the vehicle inspection, the child seat was found to be securely fastened to the vehicle. There was less than one inch of movement to either the front/rear or, side-to-side.

The child seat was purchased new and was being used on a regular basis. The spouse of the driver had read the instruction manual. Both parents normally buckle the child into the seat.



**Figure 11.** Britax Roundabout convertible child safety seat



**Figure 12.** Tether attachment anchorage

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<sup>4</sup>See Attachment 1-excerpted Britax installation instructions

Other vehicle

Description:	1985 Buick Skylark four-door sedan	
VIN:	1G4XC69X8FWXXXXXX	
Odometer:	Unknown	
Engine:	2.8 L, V6	
Reported Defects:	None	
Cargo:	Unknown	
Damage Description:	Frontal damage. Vehicle towed from the scene.	
CDC:	Unknown	
Delta V:	Total	18.0 km/h (11.2 mph)
	Longitudinal	-17.7 km/h (-11.0 mph)
	Latitudinal	3.1 km/h (1.9 mph)
	Energy	16,608 joules (12,250 ft-lbs)

**Occupants**

<u>Case vehicle</u>	Occupant 1	Occupant 2
Age/Sex:	33/Male	10 month/Male
Seated Position:	Front left	Rear right
Seat Type <sup>5</sup> :	Bucket, leather, seat at rear most track position	40/20/40 split fold bench seat, leather, no seat track adjustment
Height:	193 cm (76 in)	69 cm (27 in)
Weight:	122 kg (270 lbs)	9 kg (20 lbs)
Occupation:	Unknown	NA
Pre-existing Medical Condition:	Hypercholesterolemia <sup>6</sup> , hypertension	None
Alcohol/Drug Involvement:	None	NA
Driving Experience:	> 10 years	NA
Body Posture:	Leaning to right	Normal
Hand Position:	Left hand on steering wheel, right comforting right rear child	Unknown
Foot Position:	Right foot on brake, left on floor board	NA
Restraint Usage:	Continuous loop 3-point lap and shoulder belt available, used	Continous loop 3-point lap and shoulder belt available, used with child safety seat
Air bag:	Multiple air bags, no deployments	Side air curtain available, deployed

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<sup>5</sup>Both front and rear seats have anti-submarining guards

<sup>6</sup>An inherited condition that results in elevated low-density lipoprotien cholesterol levels that greatly increase the chance of having a heart attack early in life.

Other vehicle

Age/Sex:	55/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	Unknown
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Presumed to be > 20 years
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report



**Injuries and Injury Mechanisms**

Case vehicle

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Bilateral knee abrasions	890202.1,1 890202.1,2	916.0 916.0	Left instrument panel
	Left shoulder abrasion	790202.1,2	912.0	Door side panel

RR Occupant: Not injured

Other vehicle

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Non-disabling (evident) injury – not codeable			

## Occupant Kinematics

The 33-year-old driver (193 cm/76 in, 122 kg/270 lbs) of the case vehicle was initially seated in a normal, upright fashion. He was wearing prescription glasses. He was using the available lap and shoulder belt. He was seated in a leather covered bucket seat that had been adjusted to the rear-most track position. His left hand was on the steering wheel, his right hand was reaching to the right rear seat position trying to calm the child in that seat position. His left foot was on the floor, his right on the accelerator. At impact, he pitched to the right and forward. As the vehicle rotated clockwise he continued that right side movement until being constrained by the seat belts. As the vehicle tripped and went over onto its left side, the driver engaged the door/B pillar with his left shoulder—causing an abrasion. As the vehicle continued to roll, both of the driver’s knees engaged the lower instrument—causing bilateral abrasions. As the vehicle struck the wooden pole with its left side, the driver would have moved to his left. This occurred while the vehicle was upside down.

The 10-month-old male right rear seat occupant was seated in a Britax Roundabout convertible child safety seat. The seat had been placed in the rear-facing position. The seat is designed to be rear-facing for infants up to 13.6 kg (30 lbs). The seat had been anchored to the vehicle using the available lap and shoulder belt. The seat had been secured to the seat belt using the child seat’s built-in lock-off clamps. The seat had also been secured to the vehicle using the Britax Versa-Tether as recommended by the manufacturer for rear facing seats. The tether extended from the top of the child seat back forward to the original equipment tether attachment anchorage present beneath the right front seat. At impact, he pitched to the right and forward as the side cushion deployed. There are no indications of contact between the child seat and the cushion, but given the close proximity it would seem that some contact would have been likely. As the vehicle rotated clockwise he continued that right side movement until being constrained by the child seat shell. As the vehicle tripped and went over onto its left side, this



**Figure 13.** Driver's seated position



**Figure 14.** Rear right passenger seated position

occupant moved to his left then back again as the roll continued. As the vehicle struck the wooden pole with its left side, this occupant would have moved to his left. It appears that the child was securely fastened and these movements would have had minimal effect on this occupant's torso, but would have resulted in violent movements of his head. He did not, however, impact any objects with sufficient force to cause any injuries.

## Attachment 1. Britax Roundabout installation instructions (excerpted from Britax USA web site)

### Installation, rear facing

**2.** Rear Facing Installation with Lap and Shoulder Belts - This type of installation is for infants under one year of age and weighing between 5 and 30 pounds. After the child reaches one year and 20 pounds they can be put in a forward-facing position.

**2a.** Place restraint rear-facing on the vehicle seat and [pull the harness snug](#).

**2b.** To recline the seat, loosen the vehicle seat belt slightly. Squeeze the recline handle. Then slide the base into the required position. Let go of the [recline handle](#) and make sure that your restraint has locked into place. Then retighten the seat belt.

**2c.** Pass the seat belt through both [rear-facing slots](#) (located slightly under seat of restraint). Make sure the lock-off closest to you is open.

**2d1.** Fasten belt.

**2d.** Before going any further, make sure the vehicle belt is passed under the [buckle strap](#). (This can be done either under entire restraint cover or over the restraint cover, but under the belly pad and buckle).

**2e.** Pull seat belt tight while pushing down on the your restraint to ensure a firm fit.

**2f.** Close the [lock off](#)

**2g.** Next, See Tethering - Rear Facing

### Tethering Rear-Facing

**1.** Find the [Versa-Tether™](#) located on the back of the seat near the head area.

**2.** You can adjust the length by lifting the black and silver metal [tab](#) and pulling the web strap.

**3.** There are two ways to attach the tether to your vehicle, in front of the restraint, or behind the restraint.

**4.** A proper anchorage point in front of the restraint is one that is any structural metal part of the vehicle (one that does not move). These may include:

**4a.** [Seat frame bar](#) that the tether [connector strap\\*](#) can be wrapped around

**4b.** [Seat mounting rail](#) that is bolted to the floor of the vehicle

**4c.** A fixed vehicle seat belt [anchor](#) to the floor

**4d.** Vehicle [seat leg](#) that is bolted to the floor

**5.** Once you find an anchorage point, simply close the [clip](#) around the metal part and pull tightly on the extra web strap to secure the restraint.

**6.** When tightening the tether, be sure to recline the seat no more than 45°. It is ok to have the tether at an angle.

**7.** To [tether behind the seat](#), again look for an appropriate anchorage point. When connecting the tether, be sure that the "v" portion of the tether is separated by the restraint. One of each of the "v" straps should be on each side of the restraint.

**Placing child in restraint**

1. While pressing the harness adjuster button, pull straps forward.
2. Unfasten the chest clip by squeezing the middle tabs.
3. Unfasten the buckle.
4. Move the harness straps to the side and place your child in the restraint.
5. Position the harness straps around your child and bring the two pieces of the buckle together and insert.
6. Gently pull up on the harness straps to tighten the lap section of the harness.
7. Slowly pull the adjuster strap. This will tighten the harness around your child.
8. Fasten the chest clip and make sure that it is at armpit level.