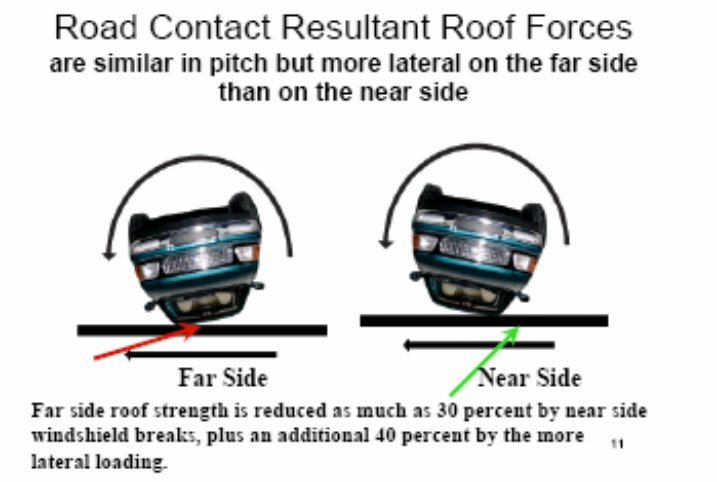
Appendix A

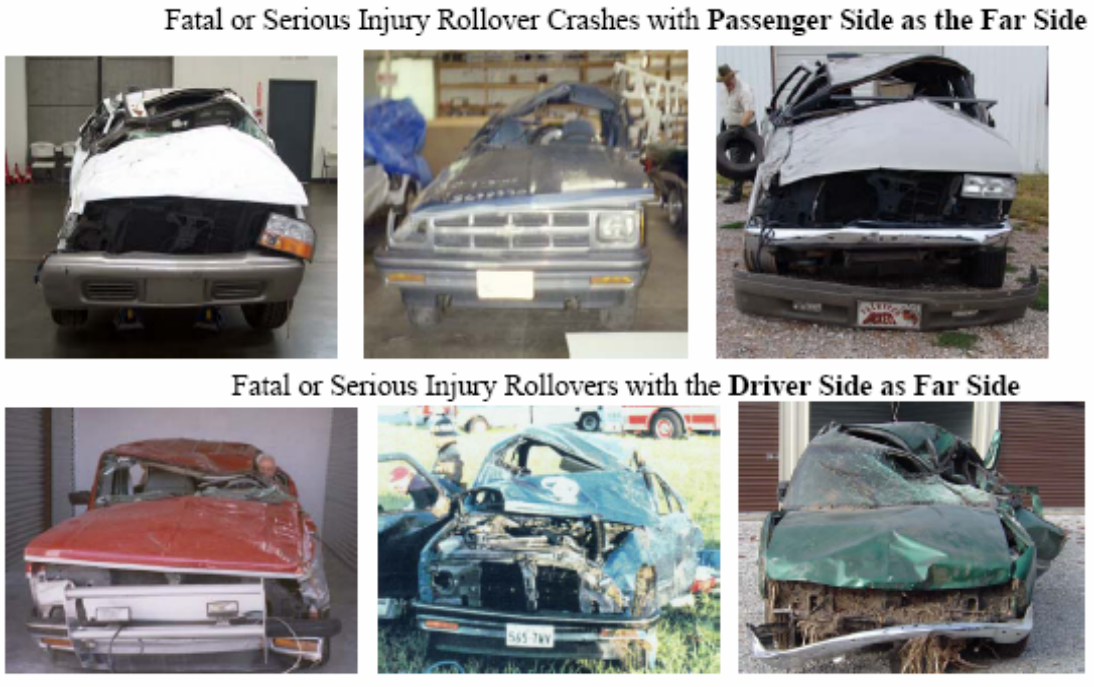
Roof crush can result in distortion that shifts a roof to the side of its original position over occupants' heads. In cases in which this occurs, properly restrained occupants in an upright seating position can be partially ejected through side windows, which are likely to shatter. The picture below demonstrates this danger.

Appendix B

In a rollover, the far side of a vehicle experiences loading at greater roll angle, moving crash forces away from the B-pillar and towards the center of the roof, which is less structurally sound.

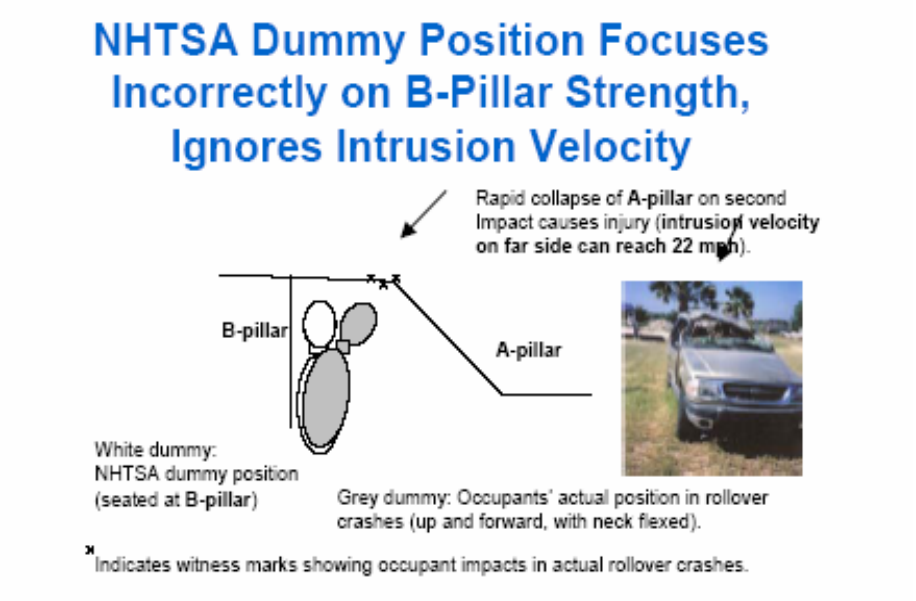


Below are vehicles involved in real-world rollover crashes showing severe roof crush to the far side of the vehicle.



Appendix C

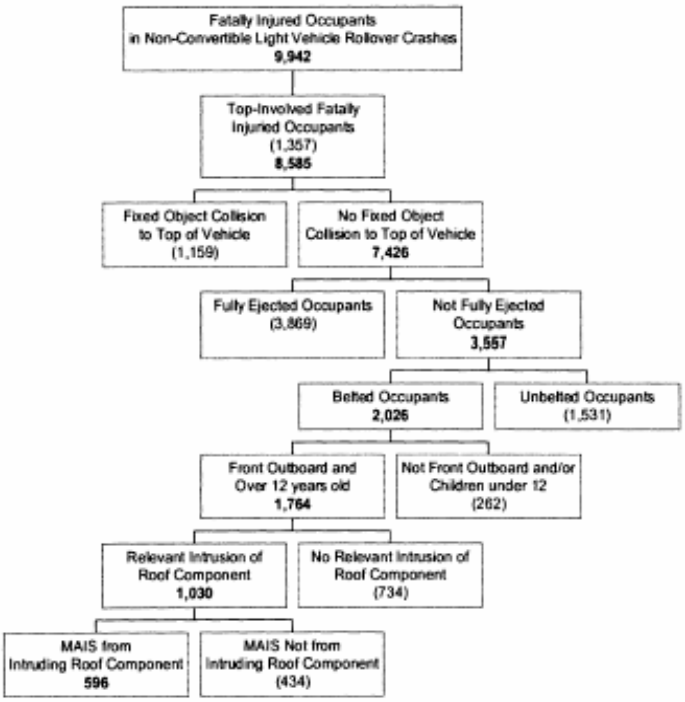
Due to the weight of the engine, vehicles pitch forward in rollovers at an angle of 10 degrees or more, which throws occupants forwards toward the A-pillar. NHTSA's proposed test applies force to vehicles' roofs at an angle of 5 degrees, exerting force mostly to the B-pillar and not the A-pillar. Without being stringently tested by NHTSA's roof crush test, A-pillars in the vehicle fleet are weak, exposing occupants to significant danger of head or neck injury in rollovers.



Appendix D

NHTSA's analysis whittles away the population affected by the rule to arrive at the estimate that the rule offers potential benefits for only 596 of 9,942 non-convertible rollover fatalities. The agency neglects key portions of the population that would benefit from increased roof strength such as fully ejected and unbelted occupants.

Population Affected by this Proposal.



Source: NHTSA – 70 FR 49230.

Appendix E

Figure 1

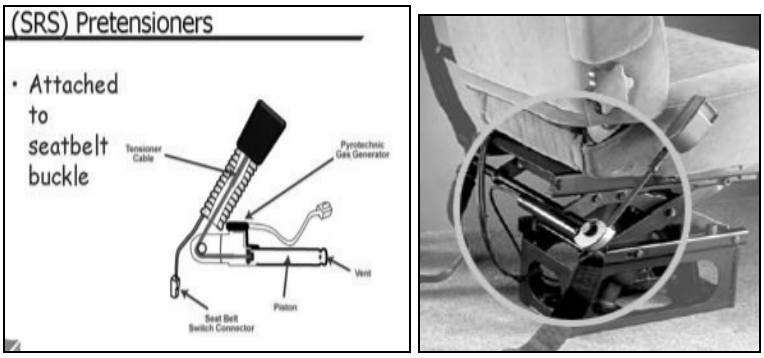


Figure 2

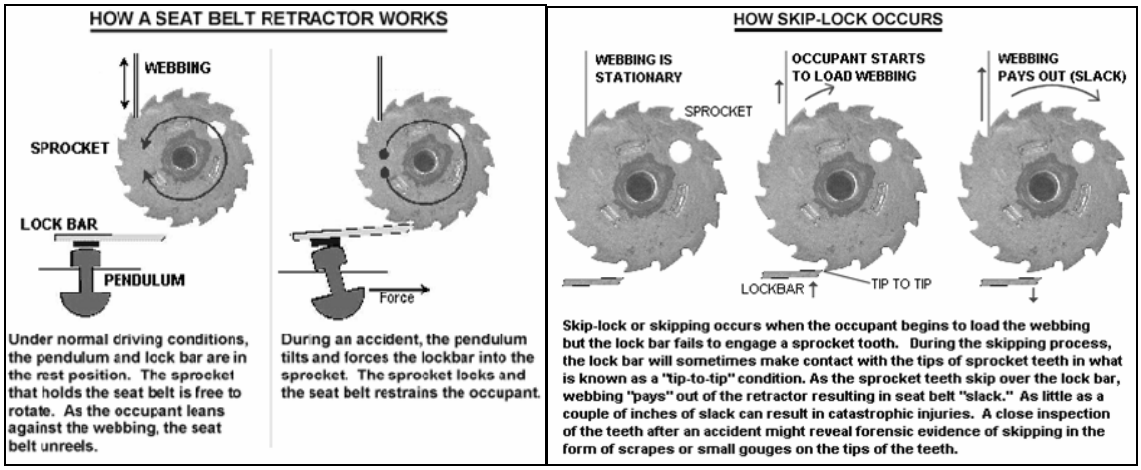


Figure 3

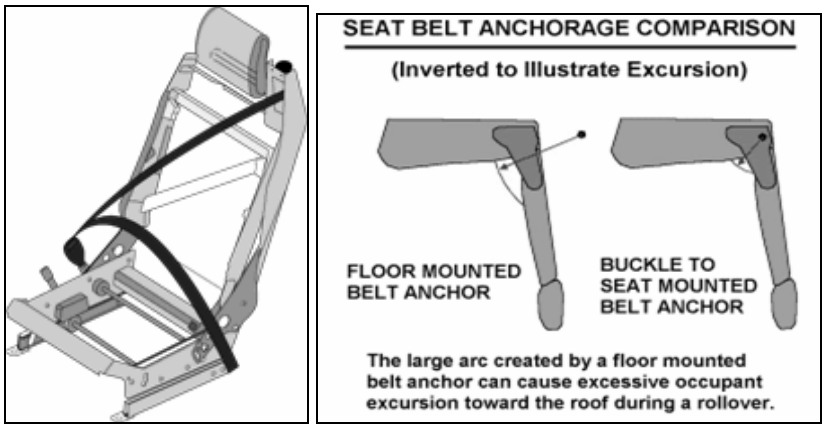


Figure 4

Source: "General ITTR Information Forward-facing Seat Application," Inflatable Safety Systems, Simula Safety Systems, Inc. Available at: http://www.tslaerospace.com/product/simula/PDF/ITTR%20Forward%20Facing%20Flyer.pdf.

Appendix F

NCAP-Tested 2003 Model Year Vehicles with Integrated Safety Belts

Key: S = Standard
A = Available

Make	Model	Integrated Seat Belt
Acura	MDX	S
BMW	3 Series	S
BMW	3 Series/M3 2-DR	S
BMW	3 Series/M3 Convertible	S
BMW	3 Series Sports Wagon	S
BMW	5 Series	S
BMW	7 Series	S
BMW	Alpina Roadster	S
BMW	X5	S
Buick	LeSabre	S
Buick	Park Avenue	S
Cadillac	CTS	S
Cadillac	De Ville	S
Cadillac	Escalade	S
Cadillac	Escalade EXT	S
Cadillac	ESV	S
Cadillac	Seville	S
Chevrolet	Avalanche	S
Chevrolet	Silverado	S
Chevrolet	Silverado Crew Cab	S
Chevrolet	Silverado ExCab	S
Chevrolet	SSR	S
Chevrolet	Suburban	S
Chevrolet	Tahoe	S
Chevrolet	Trailblazer	S
Chevrolet	Trailblazer EXT	S
Chrysler	Sebring Convertible	S
Ferrari	456 M	S
Ford	Expedition	S
Ford	Explorer	S
Ford	Explorer Sport Trac	S
Ford	F-150 ExCab	A
Ford	F-150 King Ranch Crew	S
GMC	Envoy	S
GMC	Envoy XL	S
GMC	Sierra	S
GMC	Sierra Crew Cab	S
GMC	Sierra ExCab	S
GMC	Yukon	S
GMC	Yukon XL	S
GMC	Yukon Denali	S
GMC	Yukon Denali XL	S
Honda	Insight	S
Honda	Odyssey	S
Honda	Pilot	S
Hyundai	Elantra	S
Isuzu	Ascender	S
Lexus	GX470	S
Lexus	LX470	S
Lexus	RX300	S
Lincoln	Aviator	S
Lincoln	Navigator	S
Mercedes Benz	CL-Class	S
Mercedes Benz	SL-Class Convertible	S
MINI	Cooper/ Cooper S	S
Oldsmobile	Aurora	S
Oldsmobile	Bravada	S
Pontiac	Bonneville	S
Saturn	VUE	S
Toyota	4-Runner	S
Toyota	Highlander	S
Toyota	Land Cruiser	S
Toyota	Sequoia	S
Volvo	V40	S
Volvo	V70	S
Volvo	XC70	S

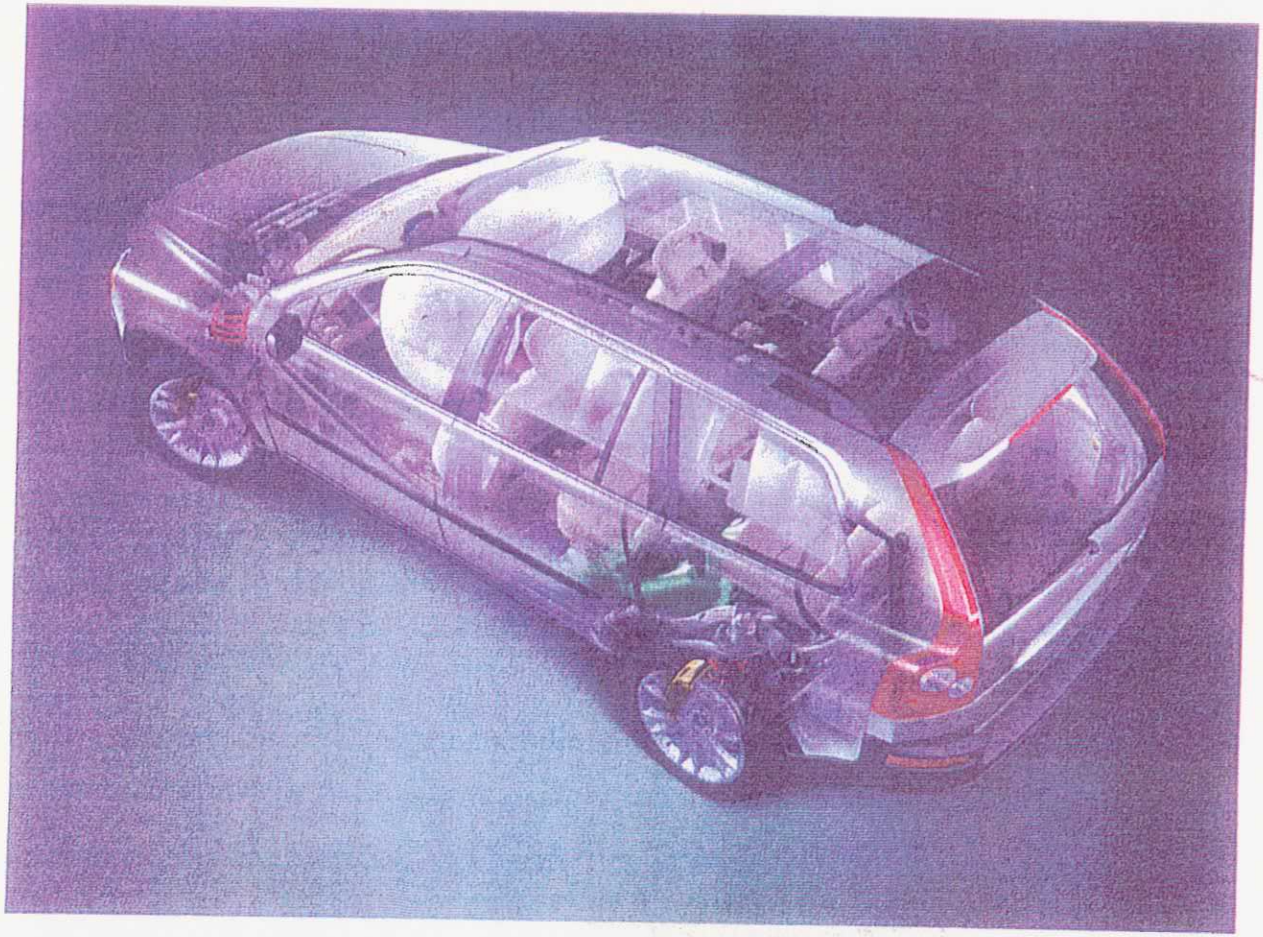
Source: National Highway Traffic Safety Administration

Appendix G

Following is an internal document used in the development of the Volvo XC90.

5-4-04 pm
EXHIBIT
WILKMAN 9

Safety Product Development - XC90



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XC90 Safety Target

Make a safe car for the occupants and the traffic environment

- Real life safety!

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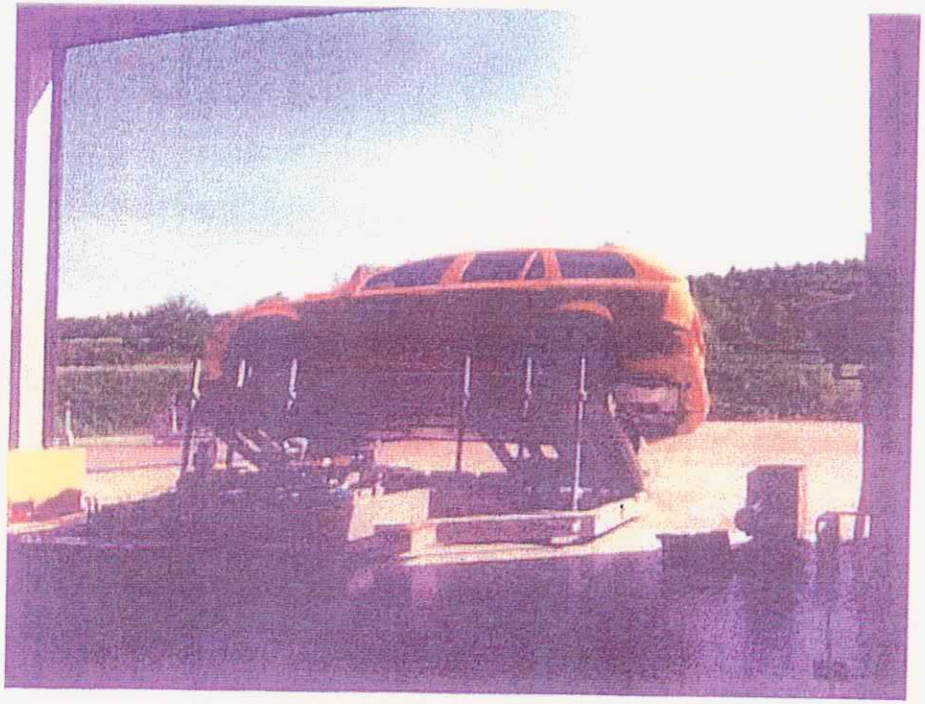
XC90 Safety Challenge

Focused areas when creating a Volvo SUV, based on field accident research:

- **Rollover**
  - Prevention
  - Protection
- **Compatibility**
  - Must cover all crash situations including.
  - SUV vs. other Cars
- **Third row seat safety**
  - Rear, Side and Rollover

XC90
Rollover Protection



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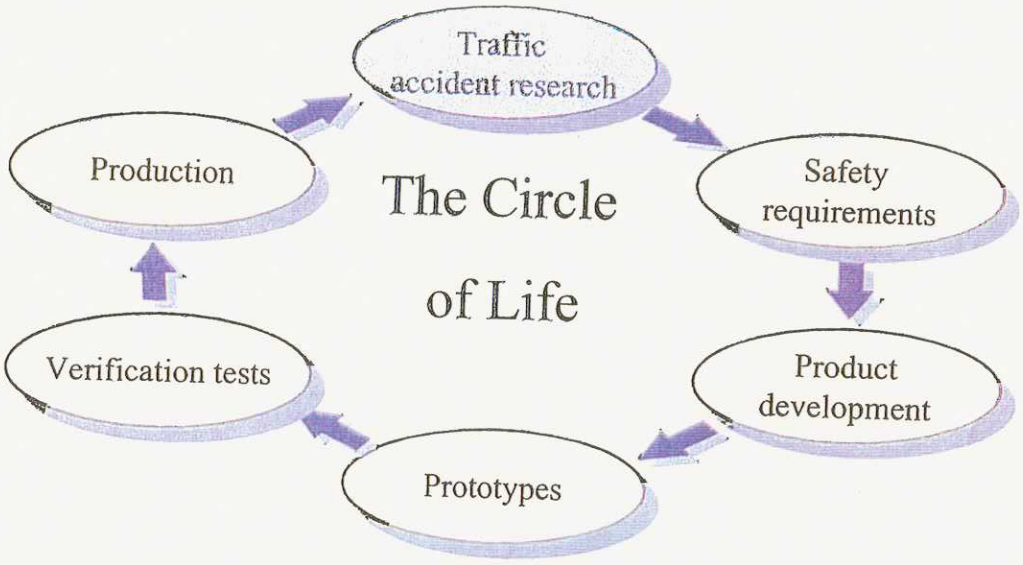
Volvo Safety Work

Continuously improving real life safety



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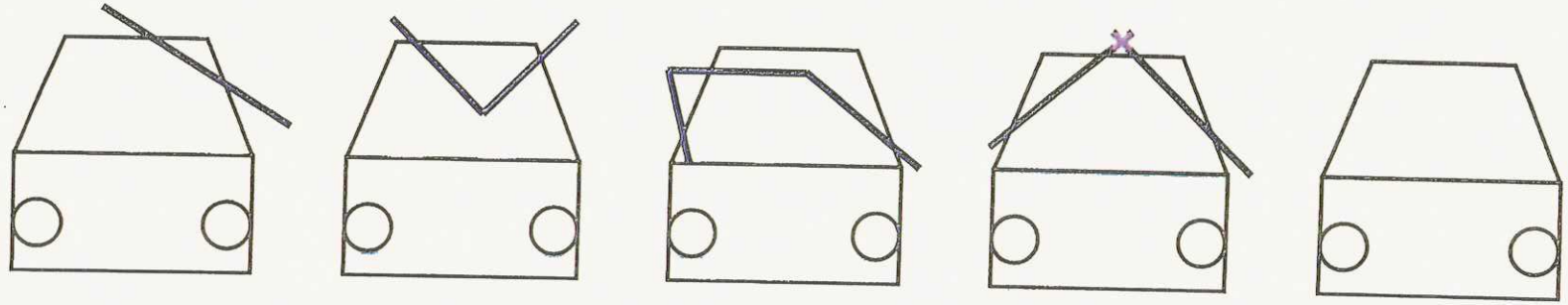
Findings from the statistical databases (STO, NASS):

- Head and neck/spine are most frequently injured
- Higher amount of chest injuries in NASS compared to STO
- In-depth sample slightly more extensive car deformation
- Number of turns and ground contacts show similarities between samples

Traffic accident research

Upper Structure Deformation Modes



T M S R O

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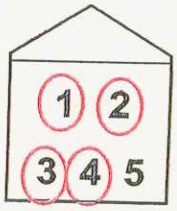
Traffic accident research



Field case D

Max roof def. 25 cm at passenger side

Driver: (F 27 yr)
AIS 0

Pass (2): (M 31 yr, 77 kg)
AIS 6 head, face: crush inj

- inj head in contact with roof, ground

Pass (3): (F 1yr - ejected, unbelted)
AIS 5 head: concussion
AIS 3 head: fracture
AIS 3 chest: lung rupture

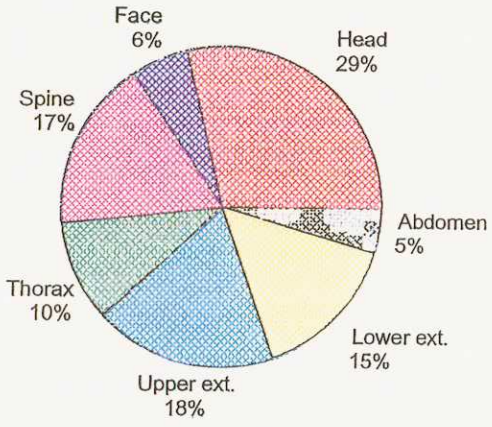
ejected

Pass (4): (F 2yr - unbelted)
AIS 1 spine: cut

unbelted

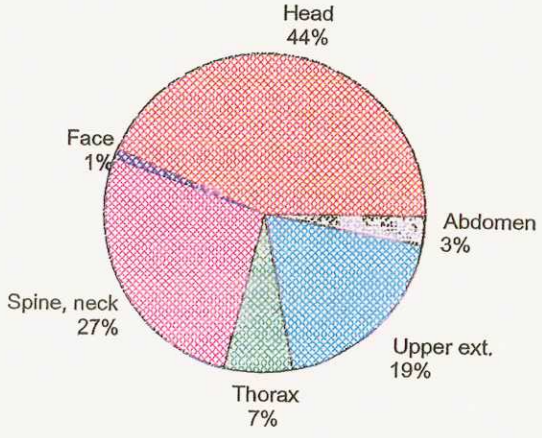
Traffic accident research

Distribution of AIS 2+ injuries by body area
Belted occupants NASS 93-95



Rollovers and multiple events including rollover
87 injuries AIS 2+

Distribution of AIS 2+ injuries by body area
Belted occupants Volvo database



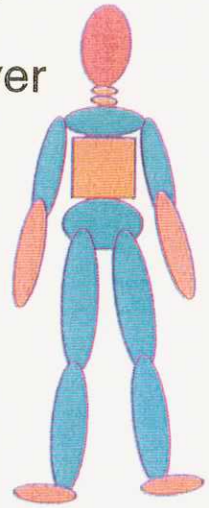
"Pure" rollovers (no multiple events)
101 injuries AIS 2+

Traffic accident research

Conclusions

Belted occupants:

- The head and neck/spine were found to be the most frequently injured body parts
- Partial ejection of the head caused the most severe injuries
- New rollover requirements and test methods needed to cover real life situations



Unbelted occupants:
Will have no benefit from improved seatbelt
also less benefit from improved roof structure

Fact

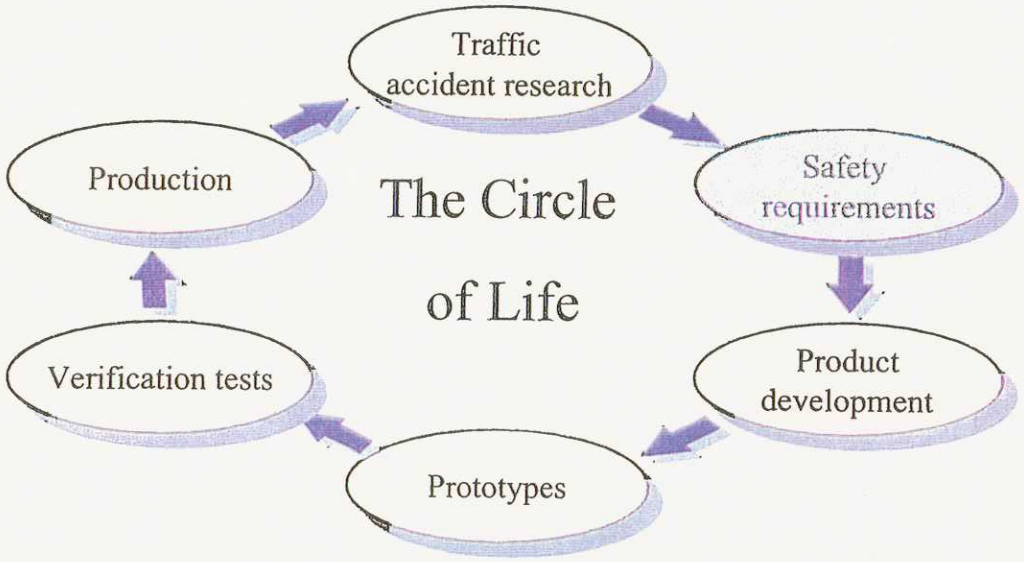
- Field data with belted occupants shows that the majority of injuries in rollover accidents are related to the head and spine caused by impacts and partial ejection

Main design objective

- Eliminate head impacts and partial ejection in rollover accidents

Volvo Safety Work

Continuously improving real life safety

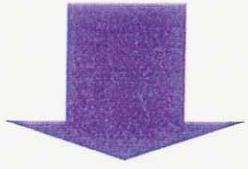


Requirements on a new Volvo SUV

- Same injury mechanisms in cars and SUV's.
- SUV's in general more exposed to rollover accidents

Main design objective

- Eliminate head impacts and partial ejection in rollover accidents

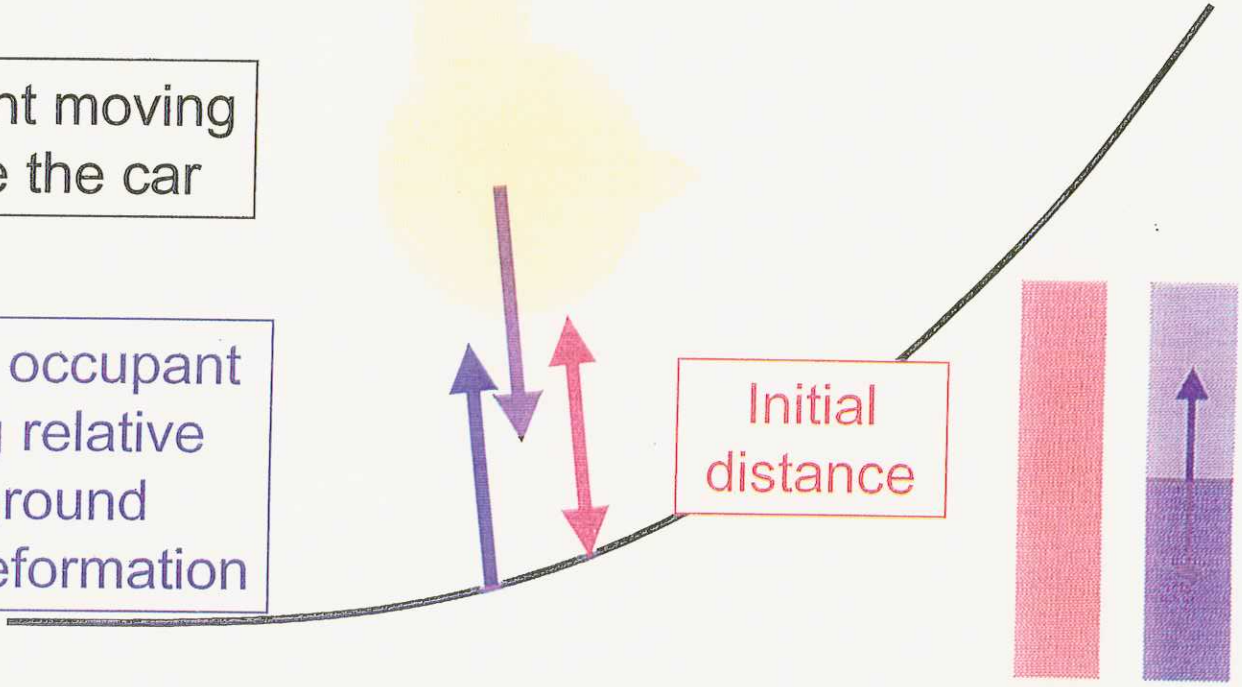


Basic Requirement:
No contact between head and roof

Occupant movement relative the ground

Occupant moving relative the car

Car and occupant moving relative the ground due to deformation



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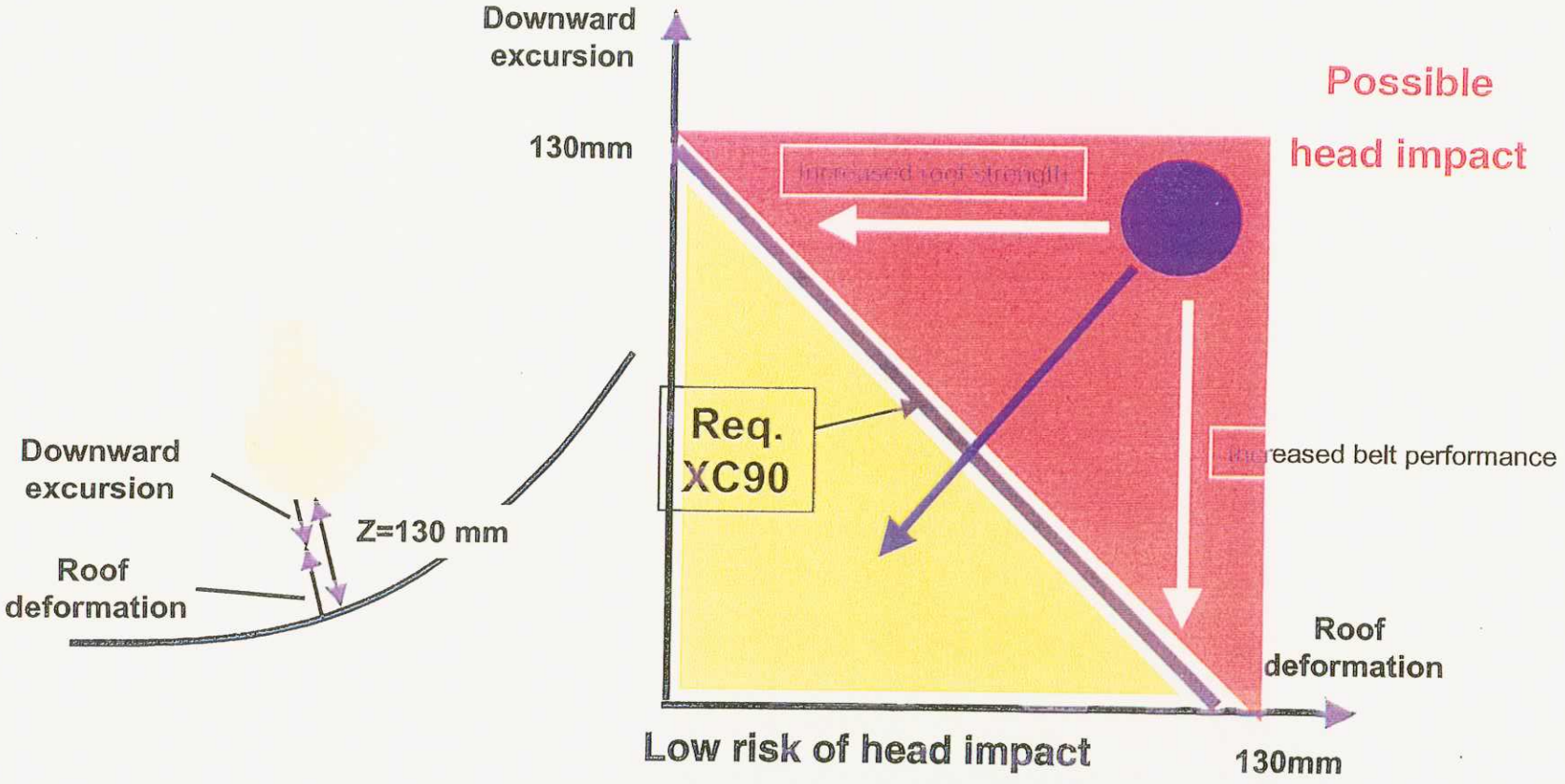
Rollover deformation schematic



Considered parameters in Requirements

Field accident research

- **Injury Mechanisms:**
  - Impact with body load (diving mechanism).
  - Friction impact (sliding contact with ground/roof).
  - Minor impact (minor body load).
  - Non-impact.
- **Roof deformation modes:**
  - T: Similar to FMVSS216/208 deformation
  - S: Shearing of roof and pillar sideways.
  - M: M-shaped roof in front view.
  - R: as T but on the whole vehicle width.
- **Rollover initiation types:**
  - Ramping down
  - Ramping up
  - Lateral deceleration
  - Collision
  - Pitch over

Further requirements on the rollover systems

Pretensioners:

- Maximum peak and remaining forces on lap belt.
- Retention performance belt system, drop test.

IC:

- Out Of Position test
- Ejection mitigation component test
- Bottoming out component test
- Several side impact complete vehicle tests including pole front and rear.

Interior panels:

- Component head impact testing beyond legal (FMVSS201) locations.
- Frontal (including moose), side and rear end complete vehicle tests.

Rescue:

- Test to cut pillars to lift off roof to rescue occupants from inside the vehicle.

Summary of test methods

- Development tests for retention system and roof characteristics:
  Drop tests with same energy level as FMVSS208.
- Occupant performance and vehicle performance:
  FMVSS208, SAE J857 (modified).
- Vehicle performance including activation of protection systems:
  FMVSS208 incl soil/curb tripped, SAE J857 (modified),
  TÜV screw rollover, ditch test.
- Vehicle performance, legal requirement:
  FMVSS216, static roof crush test.

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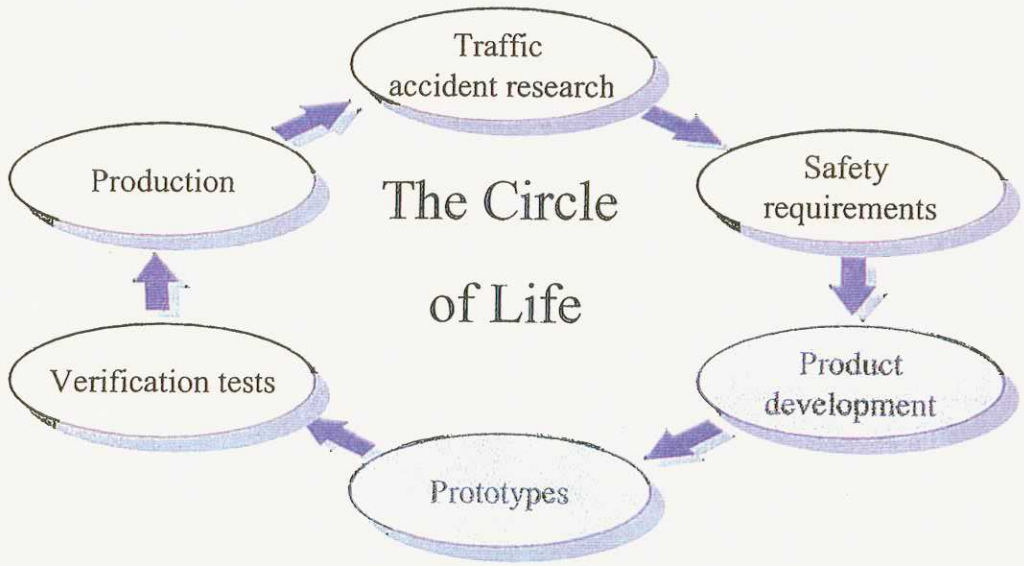

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XC90: 3 legs to improve rollover performance in passive safety

Objective: To avoid head impact and partial ejection for belted occupants in rollover

- 1: Belt pretensioner

Objective: restrain the occupant and minimise diving

and

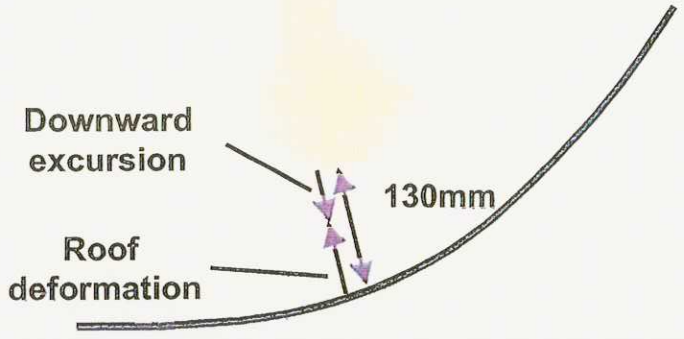
- 2: Strengthened upper body structure

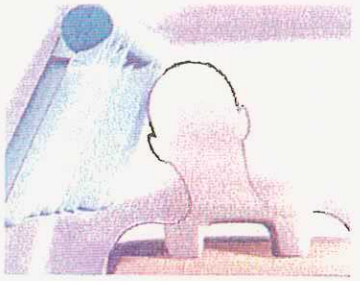
Objective: prevent the body structure to impact the occupant and partial ejection

and

- 3: Inflatable curtain and padding

Objective: prevent the occupant head to impact sideways and partial ejection





Component Tests Series, Retention Performance Belt System

Dynamic dummy movement = 30-40 mm

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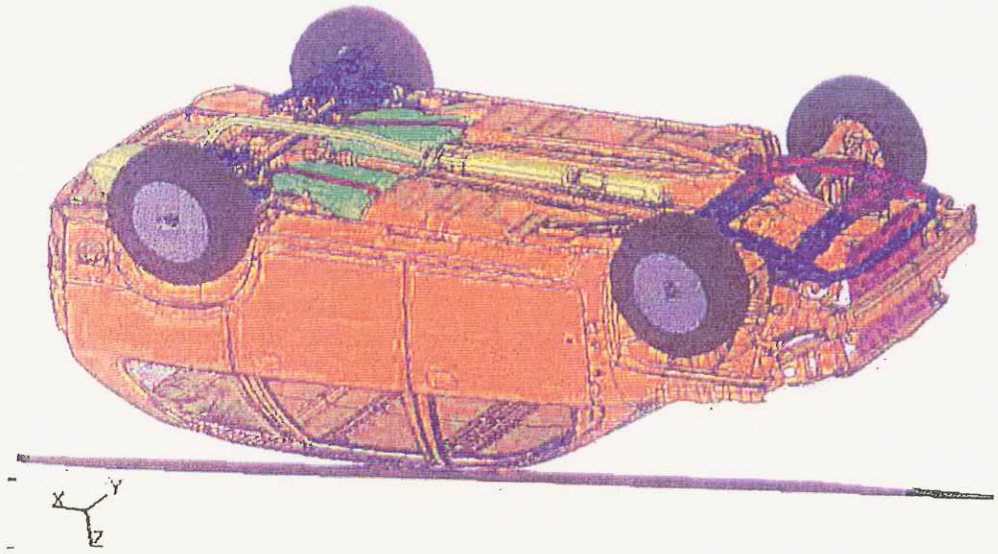
Basic Rollover Sensor Function

- Sensor activation is based on calculation from angle / angular velocity / vertical and lateral acc.
- Activation angle is 10-50 deg.
- Bosch MM2

Occupant position at activation of seat belt pretension.

- Based on test experience the occupant pelvic will be around the normal seating position at activation

Drop-Test XC90



Dynamic deformation = 90 mm

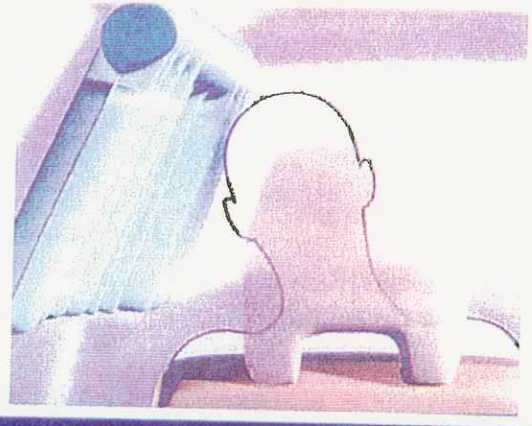
Drop height 300 mm. Drop angle 5/25 deg.
CAE and tests used for development

Main design objective

- Eliminate head impacts and partial ejection in rollover accidents

- Impact in one direction covered!

- **Impacts sideways**
- **Partial ejection**



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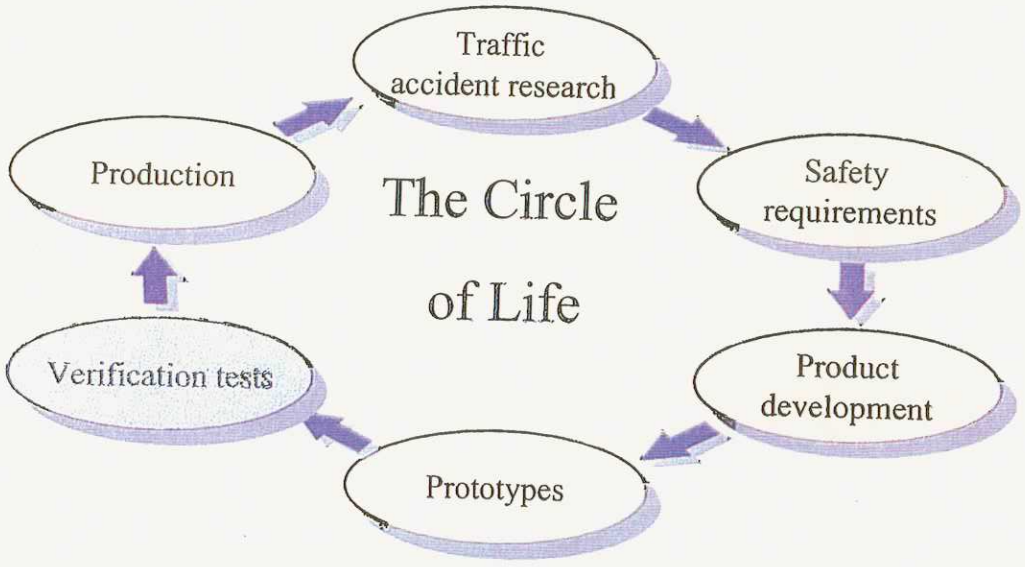
Continuously improving real life safety



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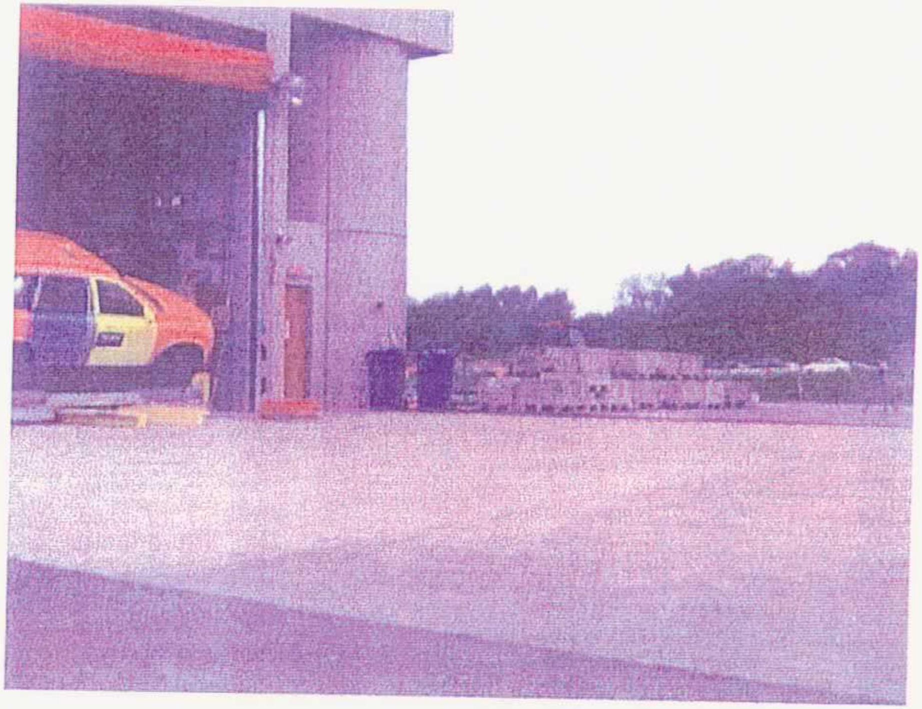

XC90 Safety Product Development
Slide 27

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Summary XC90 Passive Safety
Rollover

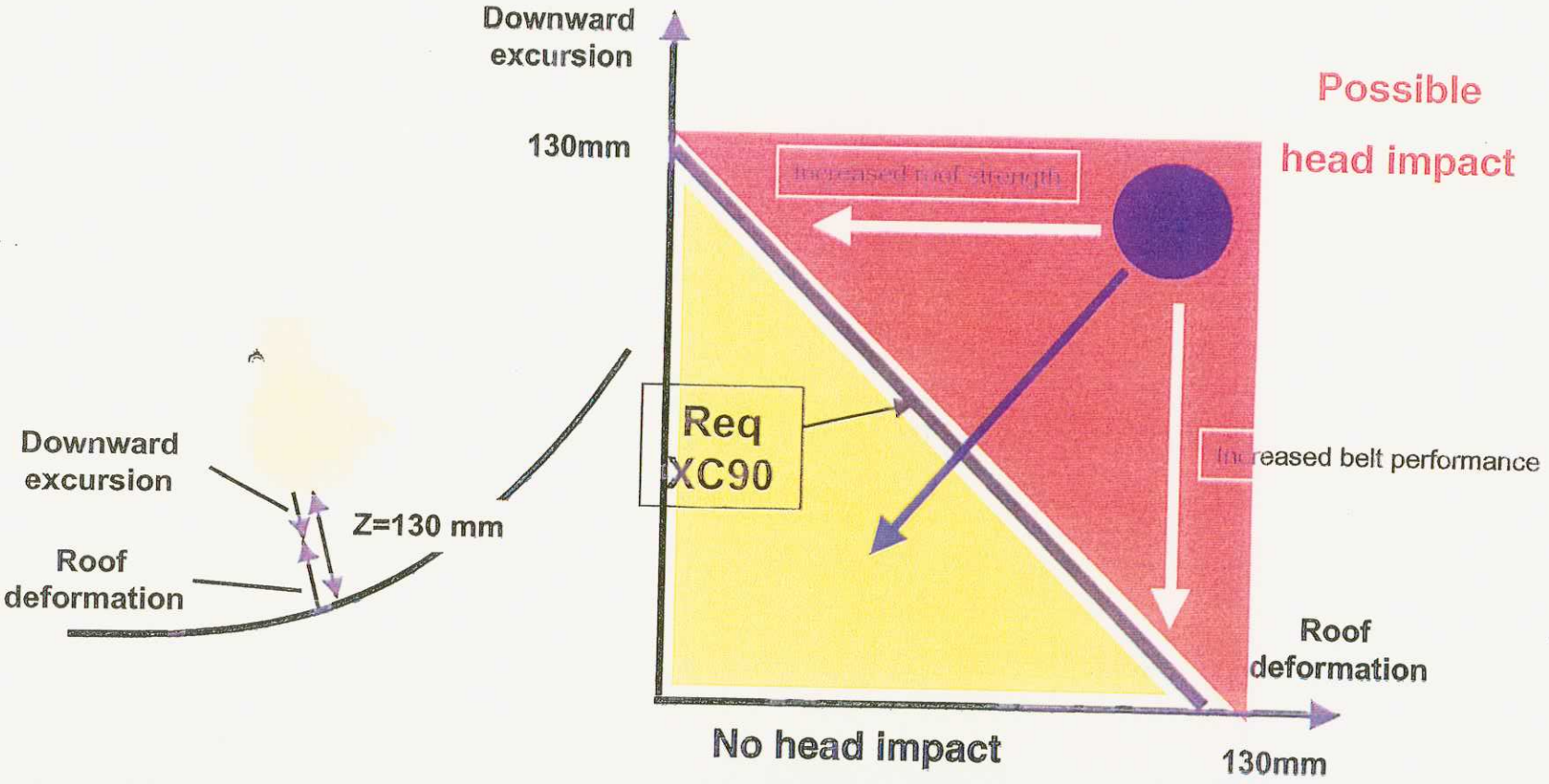
Fact

- Field data with belted occupants shows that the majority of injuries in rollover accidents are related to the head and spine caused by impacts and partial ejection

Main design objective

- Eliminate head impacts and partial ejection in rollover accidents

Rollover deformation schematic



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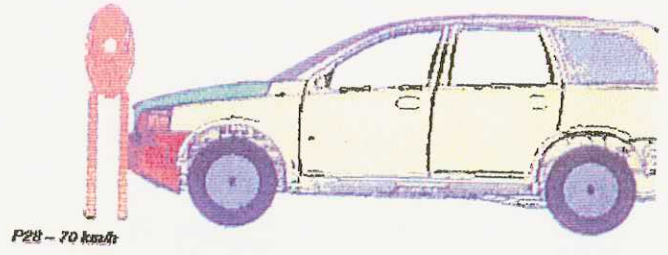
Solutions for XC90

Combination of all 3

- Belt pretensioner
- and Improved structural performance
  - This also applies to side impact, offset crash and moose collisions
- and the Inflatable Curtain



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Additional conclusions

- The pretensioner does give effect if used in combination with improved structural performance.
- An improved structural performance gives effect only in combination with a pretensioner.

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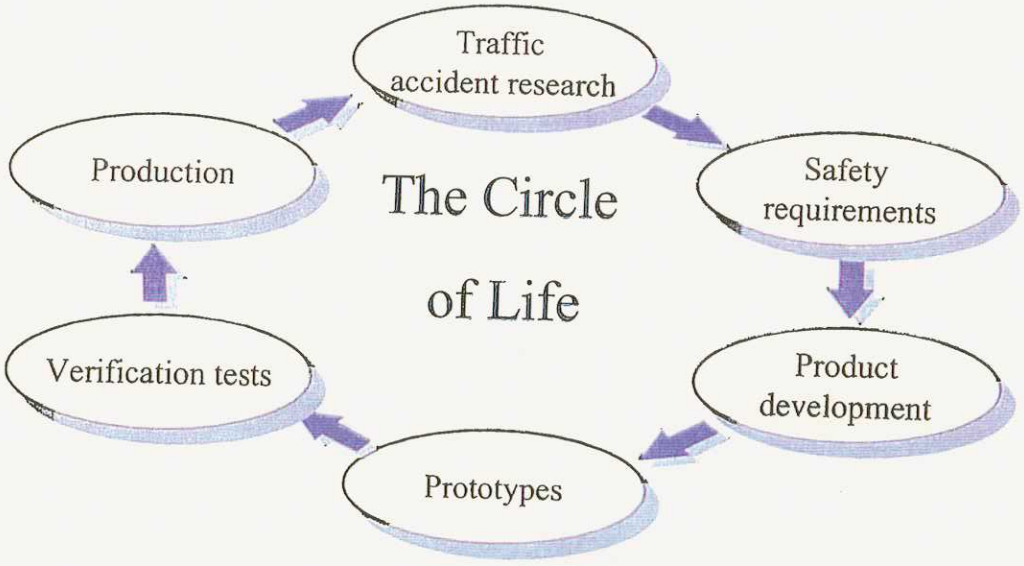

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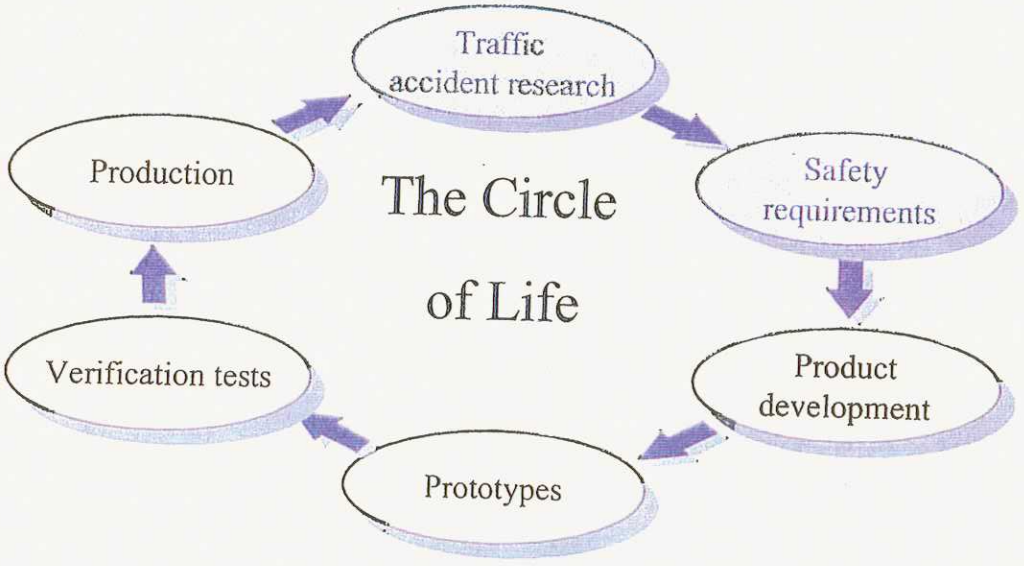
XC90 Safety Challenge

Focused areas when creating a Volvo SUV, based on field accident research:

- **Rollover**
  - Prevention
  - *Protection*
- **Compatibility**
  - Must cover all crash situations including.
  - SUV vs. other Cars
- **Third row seat safety**
  - Rear, Side and Rollover

Volvo Safety Work

Continuously improving real life safety



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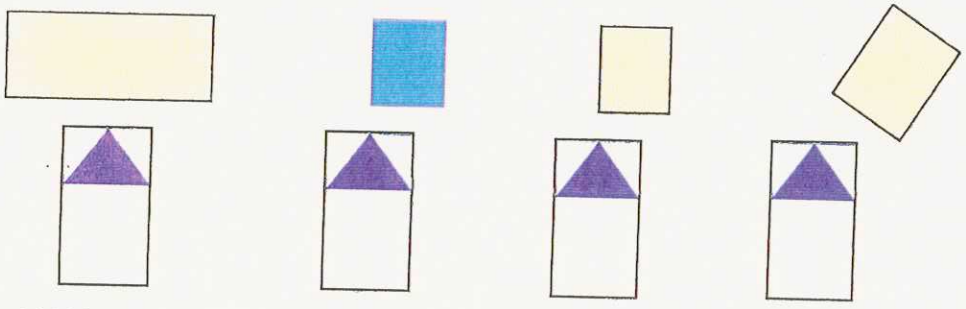
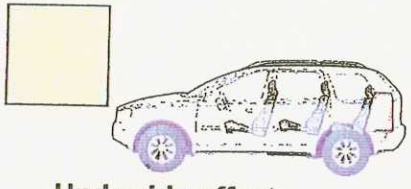
XC90 Safety Targets for front
Requirements for robust design

Self protection



100% o-lap | ODB 40% | SPOC 25-40% | 50-100% o-lap +/-45

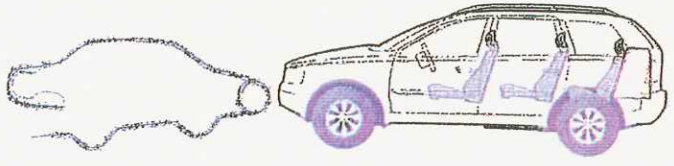
pole



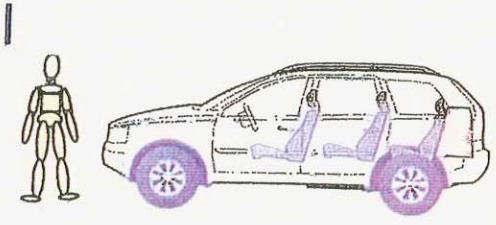
Underride offset

Large animals

Protection of collision partners



Car / Car



Pedestrian

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SUV XC90 Compatibility

Challenge: Less aggressive SUV!

Key parameters:

- Geometry
- Stiffness
- Weight

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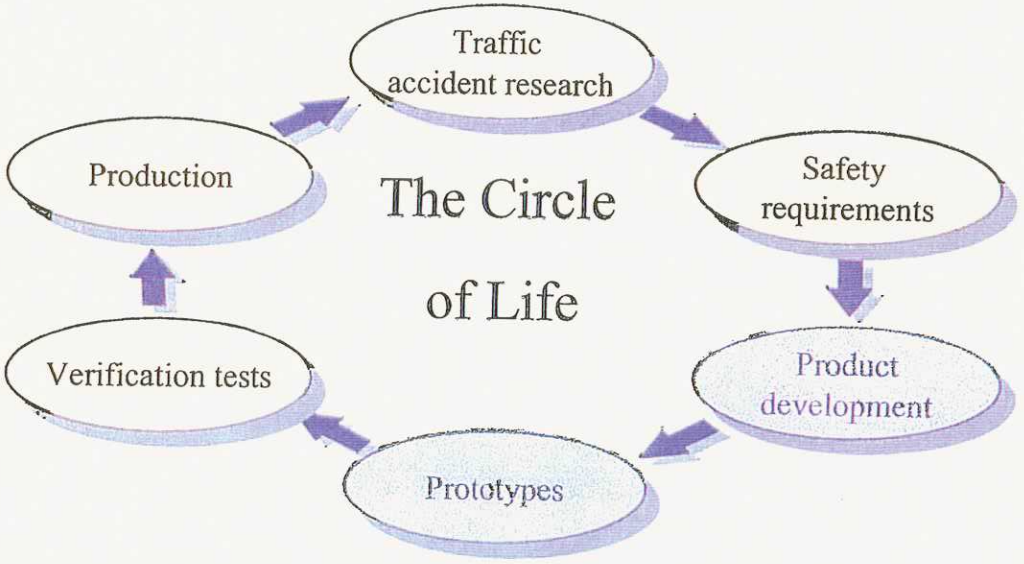
Continuously improving real life safety



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SUV Compatibility

XC90 compatibility strategy and design

- **Geometry**
  - Load path spread in height and width
  - Load path well connected
  - Unibody design, no frame.
- **Stiffness**
  - Additional load path instead of increased forcel level in single member.
- **Weight**
  - XC90 is heavier than a “normal” car but it is a light SUV

XC90 Front Structure

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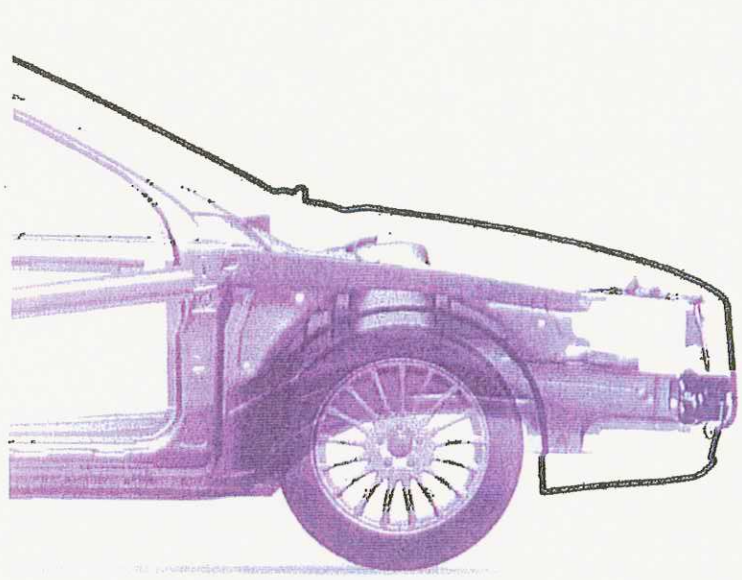
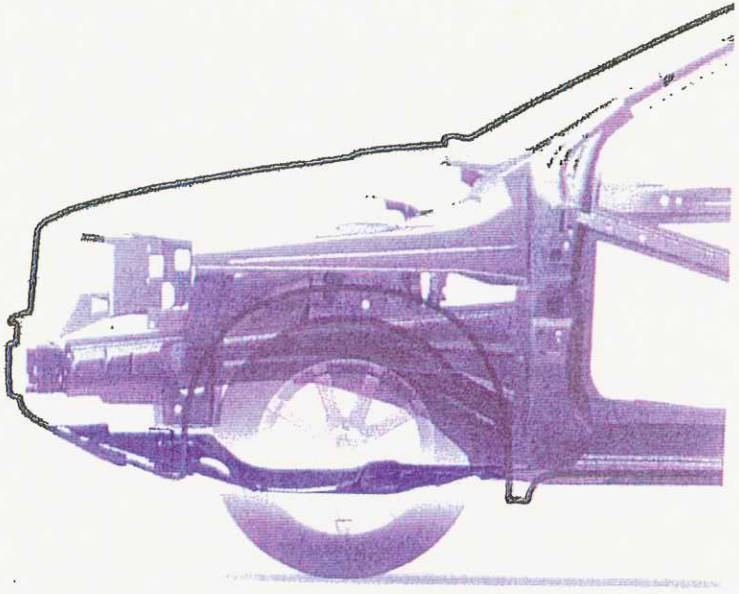
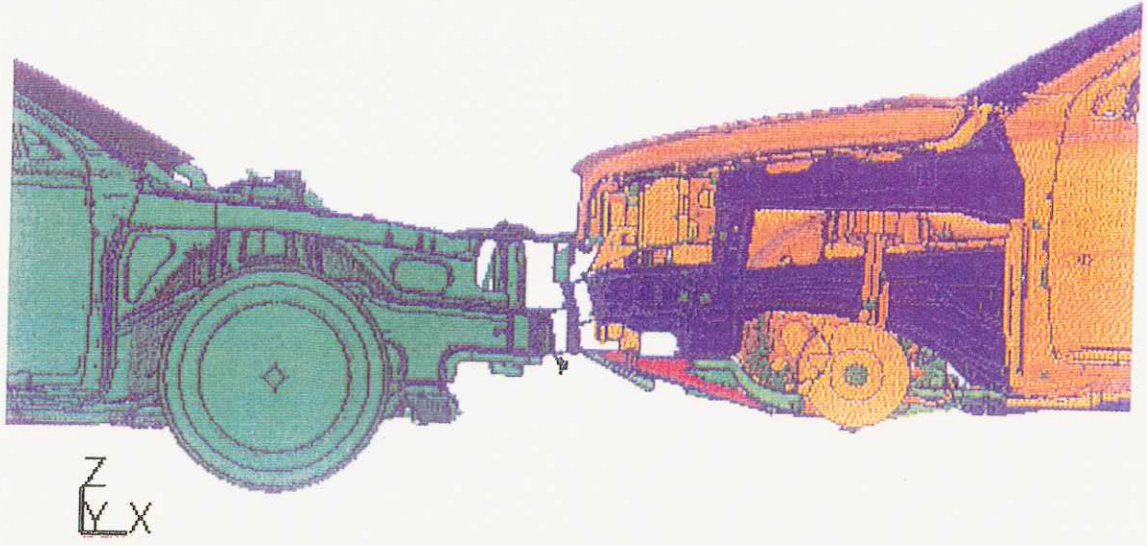
XC90 Compatibility





Car to car compatibility

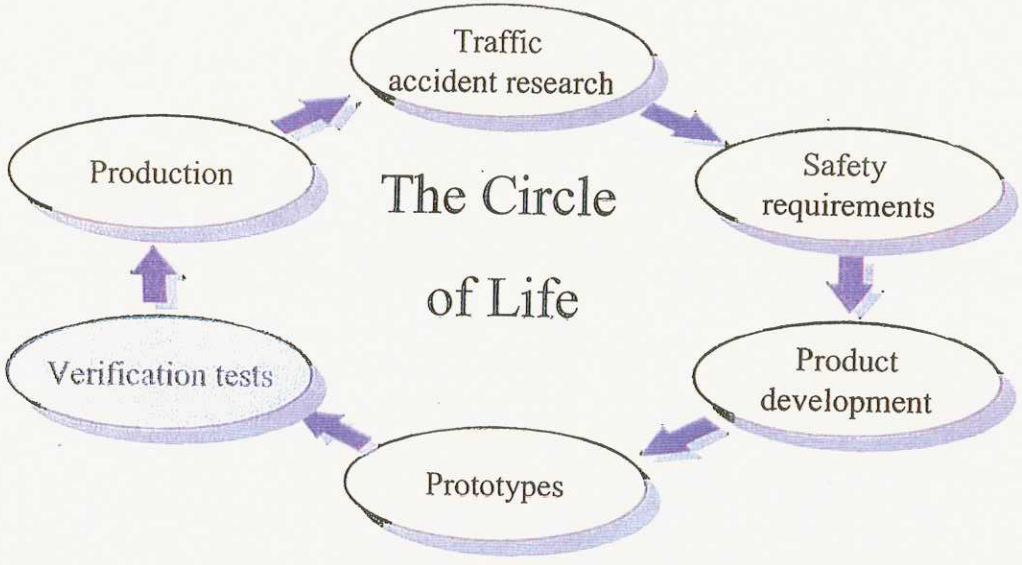
- S60-XC90 full frontal CAE



VOLVO
Volvo Car Corporation

Volvo Safety Work

Continuously improving real life safety



VOLVO
Volvo Car Corporation

XC90 Compatibility

VOLVO
Volvo Car Corporation

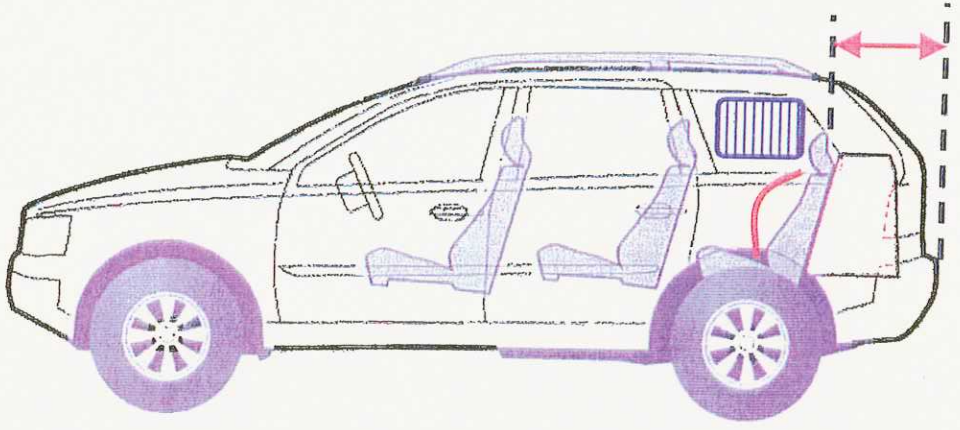
XC90 Safety Challenge

Focused areas when creating a Volvo SUV, based on field accident research:

- Rollover
  - Prevention
  - *Protection*
- Compatibility
  - Must cover all crash situations including.
  - SUV vs. other Cars
- Third row seat safety
  - Rear, Side and Rollover

XC90, Third Row Seat Safety

Challenge: Provide the same protection for third row seat occupants as other seating positions in the car!



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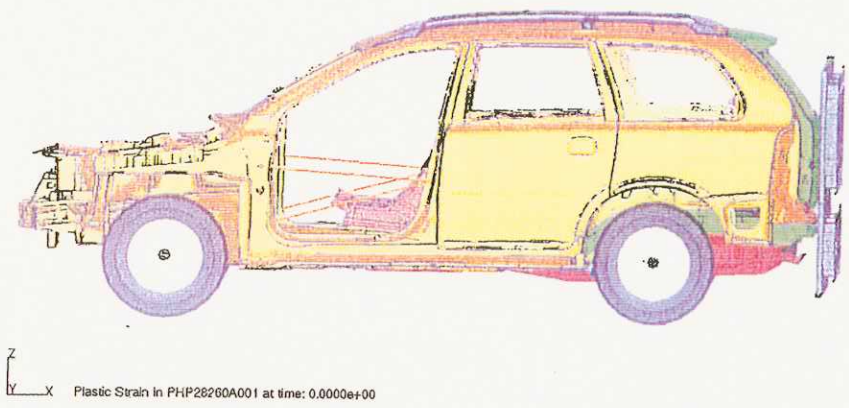
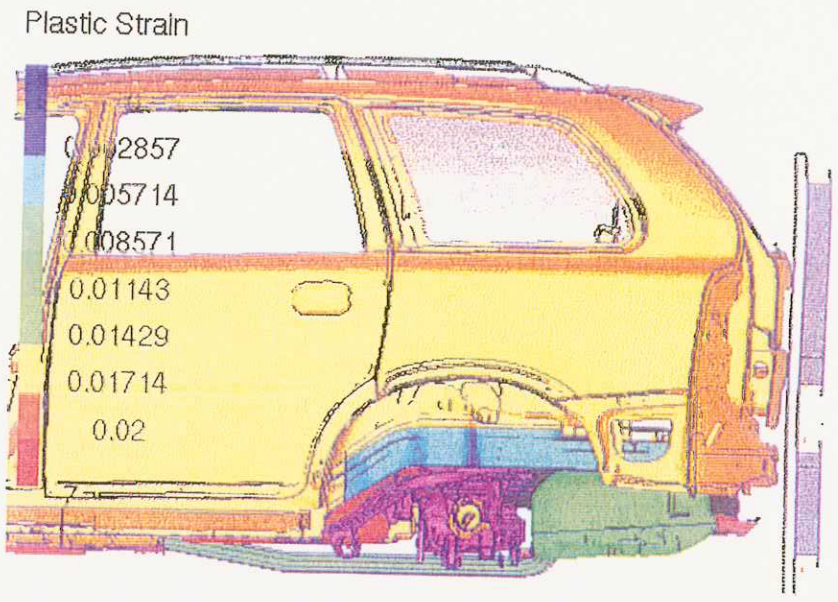
XC90, Third Row Seat Safety

- **Front**
  - Restraints with 3-p seatbelt with pretensioner
- **Rear**
  - Rigid seat with good head restraints
  - Deformation zone in rear impact
- **Side and Rollover**
  - 3-p seatbelt with pretensioner
  - Structure integrity
  - Inflatable curtain

XC90, Third Row Seat Safety

- Rear impact CAE





VOLVO
Volvo Car Corporation

Safety Product Development - XC90

- **Rollover**
  - Prevention
  - Protection
- **Compatibility**
  - Must cover all crash situations including.
  - SUV vs. other Cars
- **Third row seat safety**
  - Rear, Side and Rollover

Safety Product Development - XC90

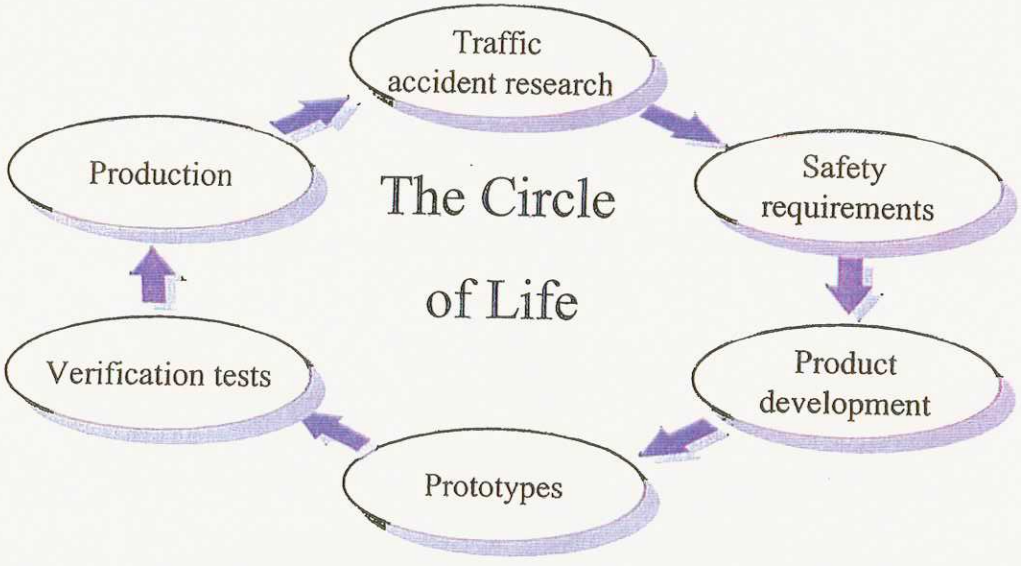
XC90 fulfil the Target:

Make a safe car for the occupants and the traffic environment

- Real life safety!

Volvo Safety Work

Continuously improving real life safety



Appendix H

International Herald Tribune
May 14, 2005

Ford and Volvo clash over automobile safety

Dispute centers on role crushed roofs play in nearly 40,000 rollover accidents

By Danny Hakim and Jeremy W. Peters

DETROIT: Three years after buying Volvo in 1999, Ford told Volvo executives that their view on one of the most contentious areas of automotive safety was out of step with Ford's and had to change, according to documents that have emerged in recent rollover cases.

The dispute between Volvo, the Swedish automaker with a longstanding reputation for promoting safety, and its new corporate parent centered on the role that crushed vehicle roofs play in nearly 40,000 deaths and serious injuries from rollover accidents each year in the United States.

U.S. regulators are considering the first changes to roof regulations since they were created in the 1970s. They have found that roofs crumple to varying degrees in more than a quarter of those accidents.

But there is a bitter debate over the extent to which crushed roofs cause injuries. For decades, American automakers have argued that injuries or deaths from rollovers almost always occur in the moments just before a roof crushes, when an occupant of a vehicle is thrown into the roof not when roofs collapse on people's heads.

"There is no data out there to suggest people are injured by a roof collapsing," said Susan Cischke, Ford's vice president for environmental and safety engineering.

But Volvo, cheered on by safety advocates who vigorously dispute Detroit's view, has a long history of making roof strength a priority, going back to 1967 when it began reinforcing the roof support pillars of its 140 Series sedan. The company aggressively promoted roof safety in a series of advertisements that began in the 1970s, with one asking, "Are you in the market for a hardtop?" in which seven 144-Series sedans were stacked on top of each other.

The previously hidden corporate battle inside Ford's sprawling global empire came to a head in an e-mail message dated Nov. 23, 2002, in which Priya Prasad, a top Ford safety engineer, told a top Volvo safety engineer, Ingrid Skogsmo, that it was "absolutely necessary to close the technical differences" between the two companies.

"U.S. does not currently believe in roof crush as the major contributor to head/neck injuries in rollovers," he wrote, adding, "does Volvo have any scientific study to show otherwise?"

"This issue has dragged on very long, is very litigation oriented in U.S. (close to 110 cases pending) and the topmost management in the company is impatient," Prasad wrote, explaining that Ford's second highest-ranking executive at the time, Nicholas Scheele, wanted to resolve the disagreement "immediately."

The e-mail message, and one written three weeks later, in which Prasad laid out new talking points for Volvo and its other subsidiaries, are under court seal. Three people on the plaintiff's side of separate cases read or copied portions of the e-mails and provided them to The New York Times. They spoke under condition of anonymity because of the court seal. Ford officials acknowledged the existence of the documents but did not describe their contents. '

'Ford and Volvo do share the same views regarding roof strength and we have not disagreed," Cischke said. "Where there have been some confusion is how we talk about things."

Ford executives, the e-mail messages suggest, were concerned that Volvo's view on roof strength would be used against Ford in rollover cases, a potentially expensive concern that turned out to be prescient. Plaintiff's lawyers are increasingly pitting the views of the parent company and its subsidiary against each other in court.

Warren Platt, a top outside counsel for Ford, said that "if you put all of the auto companies on a continuum, Volvo has had more belief that stronger roofs were going to make some difference than other companies have had." "I don't know that there was really any data to support that, and I don't know that Volvo has any safety data that it prevented any one injury."

Ford executives, according to Cischke, were concerned that Volvo was overemphasizing the role roof strength played in rollover safety. Ford officials also cited a 1999 Volvo study that said that the amount of roof crumpling could not be used in and of itself to predict what injuries might occur.

"We value the Volvo brand very much and would never compromise their ability to demonstrate safety leadership," Cischke said.

Prasad's e-mail messages were written as Volvo was introducing its first sport utility vehicle, the XC-90, selling it to consumers as "a different SUV" with crucial safety innovations to prevent and mitigate rollovers, including side airbags and improved seatbelts that cinch up during accidents.

One of the important features of the XC-90 is a roof reinforced with high-strength boron steel that "exceeds the legal requirements in the U.S.A. by more than 100 percent," according to a promotional video.

Internal Volvo documents describe the reinforced roof as a crucial component of the company's rollover protection strategy. But in an e-mail message dated Dec. 13, 2002, that Prasad sent to senior Ford executives, he laid out talking points for Ford and all of its subsidiaries

that said Ford studies showed "no direct causal correlation between roof strength" and neck injuries when people were wearing seatbelts.

Prasad also raised concerns about material on Volvo's Web site, suggesting it clashed with Ford's view. References to the XC-90's reinforced roof are no longer on Volvo's American Web site. Cischke said Prasad's memorandum was a normal "position paper" the company prepares on every significant safety issue.

Los Angeles Times
May 4, 2005

Ford, Volvo Clash on Roof Design

Auto regulators take internal files off the Web that depict a conflict over the safety feature.

By Myron Levin
Times Staff Writer

Federal auto safety regulators have taken the unusual step of removing documents on vehicle roof design from a government website at the request of Ford Motor Co. The material includes internal reports from Ford and its Volvo subsidiary that suggest the Swedish automaker views sturdy roofs as an important safety feature, a stance at odds with that of its parent company.

The National Highway Traffic Safety Administration on Friday removed the documents from a website of public comments on proposed changes in the federal standard for roof strength in passenger vehicles. Ford requested the material be removed, saying that a court order in a wrongful death case in Florida barred their release and that the disclosure would cause "irreparable" harm by revealing trade secrets.

An NHTSA spokesman said the agency would review Ford's confidentiality claim and decide what to do with the papers.

The action comes amid a highly charged debate over NHTSA's effort to craft a tougher vehicle roof strength standard, a move opposed by Ford and other major automakers who say roof strength has little effect on occupant injuries in rollover accidents.

The episode highlights a sensitive issue for Ford, a difference in design approach between Ford and the Swedish automaker that Ford acquired in 1999.

Ford spokeswoman Kathleen Vokes said Ford and Volvo "are both safety pioneers" that incorporated new safety features in their sport utility vehicles. She said research by both companies had shown "no direct causal correlation between roof strength and injury severity."

Roof collapse in vehicle rollovers may cause or contribute to as many as 6,900 serious to fatal injuries per year, NHTSA estimates. Safety advocates say the current roof crush standard, adopted in 1971, was too weak then and is grossly inadequate now given the popularity of top-heavy pickups and SUVs.

NHTSA recently sent a draft of a proposed new roof standard to the Office of Management and Budget, which reviews major federal regulations. The proposal has not been made public.

The Ford and Volvo documents had been posted for about 24 hours on the NHTSA site when Ford requested their removal.

The documents were submitted to NHTSA by Sean Kane, a Massachusetts-based safety consultant who often works with plaintiffs in automotive liability cases. Kane said in March that he and others obtained copies of the papers from public court files in Duval County, Fla., where they were exhibits in a wrongful death case involving a Ford Explorer.

A Jacksonville jury on March 18 ordered Ford to pay damages of $10.2 million to the husband of Claire Duncan, 26, who died after her 2000 Ford Explorer rolled and the roof collapsed. The Duncan family lawyers sought to prove with the documents that Ford skimped on safety and that its public position on roof strength was undercut by Volvo's.

Ford had produced the documents to the Duncan lawyers under a protective order that barred them from publicly releasing the documents. But the papers were stored in court files after the case ended. Realizing that people were copying the documents, Ford filed a motion April 22 to enforce the protective order.

By then, court clerks had made copies for Kane and others, including the Detroit News, which publicized some of the documents in an article in late March.

The documents include test data suggesting that roofs on Ford Explorers were made progressively weaker during the 1990s to the point where they were barely more robust than required by the federal standard. The Explorer roofs have a "less than desirable safety margin," said a Ford engineer in an e-mail in October 1999.

The Volvo documents reflect its concern about increasing roof strength for the new Volvo XC90 SUV, along with improving seat belts to hold passengers firmly in place in a rollover. The documents discussed the development of more advanced tests to see how roofs actually perform in rollovers.

"Improvements in this area will increase the passengers' rollover protection," one Volvo report said.

The roof of the Volvo SUV is more than twice as strong as required by the federal standard, the Swedish company has previously said.

Ford told NHTSA in its letter Friday that the documents could expose trade secrets, such as "the strategies by which new technological advancements are introduced."

NHTSA spokesman Rae Tyson said removal of the material might be only temporary.

"There were some documents that were placed in the public docket, which is a privilege or right that anyone has," Tyson said. In response to Ford's request, "we have removed

the documents from the public file while Ford makes its claim for confidentiality, which we'll review and then make a decision."

Randy Barnhart, a Denver lawyer who has battled Ford in roof crush cases, said the company had acted too late. "The problem is, the genie is out of the bottle," Barnhart said. "Volvo's philosophy, which is entirely contrary to its parent Ford, is now well-known to the public."

Automakers have long contended that roof strength is of little consequence, because vehicle occupants typically strike the roof when a vehicle flips over. According to this argument, an injury will result from the force of a body pressing down on the head and neck, whether or not the vehicle's roof holds up.

The cornerstone of the industry's argument is research sponsored by General Motors Corp. in which test dummies were just as likely to strike their heads and necks in rollovers of cars with reinforced roofs as in cars with standard roofs.

However, critics said the data actually showed that the force of the head and neck impacts was less severe in cars with reinforced roofs than in conventional roofs that collapsed.