



VOLVO

Safety Cage Design in the Volvo XC90

Jonas Bernquist
Volvo Car Corporation





VOLVO

Presentation overview

- General
- Body structure
 - Safety cage
 - XC90: New structural solutions
- Materials
 - General
 - XC90: Materials
- Sum-up





VOLVO

General

The first Volvo SUV?



1943



2002





VOLVO

General Key attributes

SIZE [mm]	Length		P28
	Width		4798
Weight [kg]	Height		1890
	Body shell incl frt bumper		1740
	Total hang on		407
	Paint and sealings		113,0
	Body complete incl closures		16,4
	2nd row seat subframe (structural part)		536,4
Attributes	Body complete incl 2nd row subframe		17,6
	Static Torsional Stiffness BIG [kNm/deg]		554,0
	1st Dynamic Torsion mode BIG [Hz]		21,4
	1st Dynamic Lateral Bending mode BIG [Hz]		33,6
	1st Dynamic Vertical Bending mode BIG [Hz]		44,1
			47,4





VOLVO

General Advanced Body Engineering

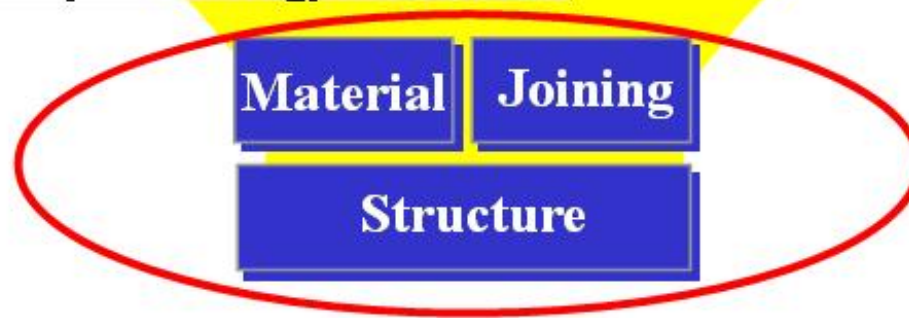
Complete vehicle Properties



Car Body Properties



Basic Body Technology Parameters



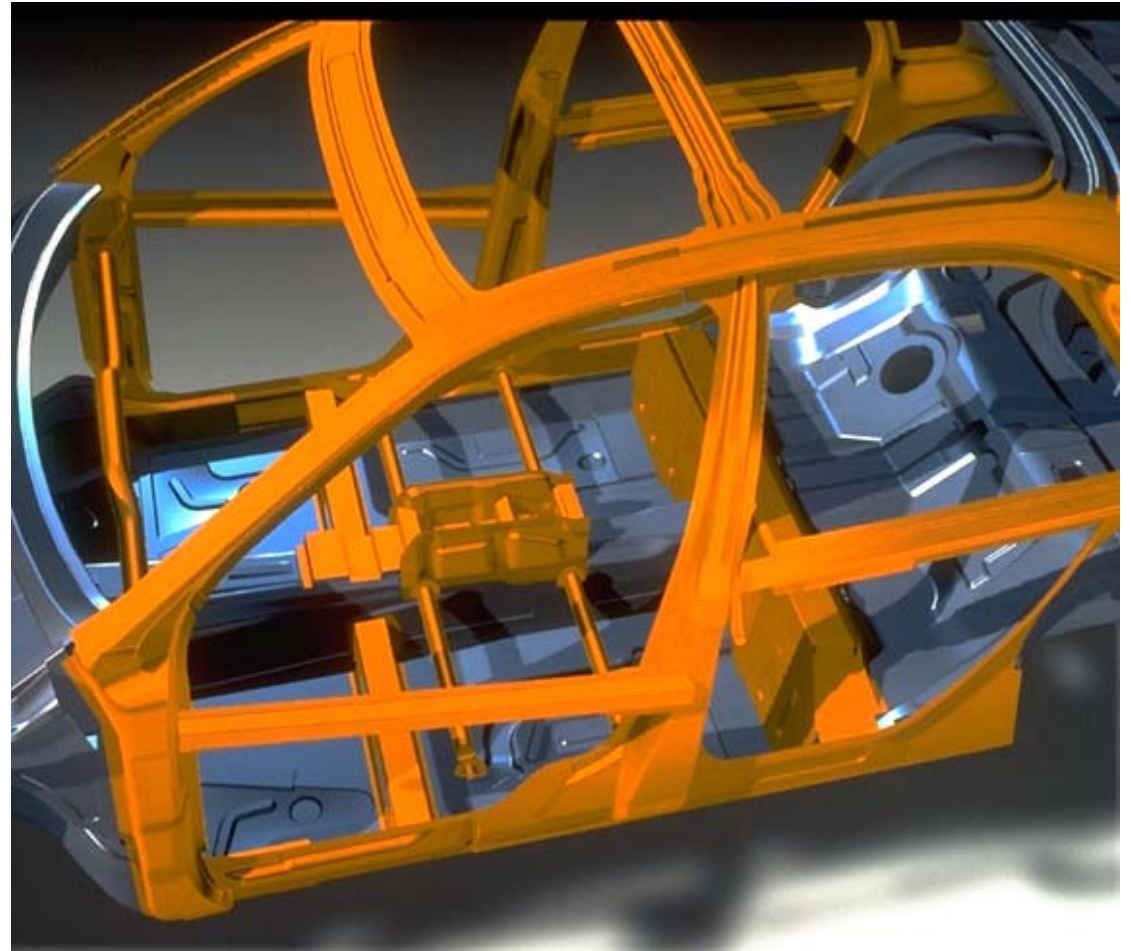


VOLVO

Body structure

Safety cage 1

“A rigid framework surrounding the occupants which creates a support for the interior safety equipment and provides a survival space for the vehicle occupants in case of a crash”



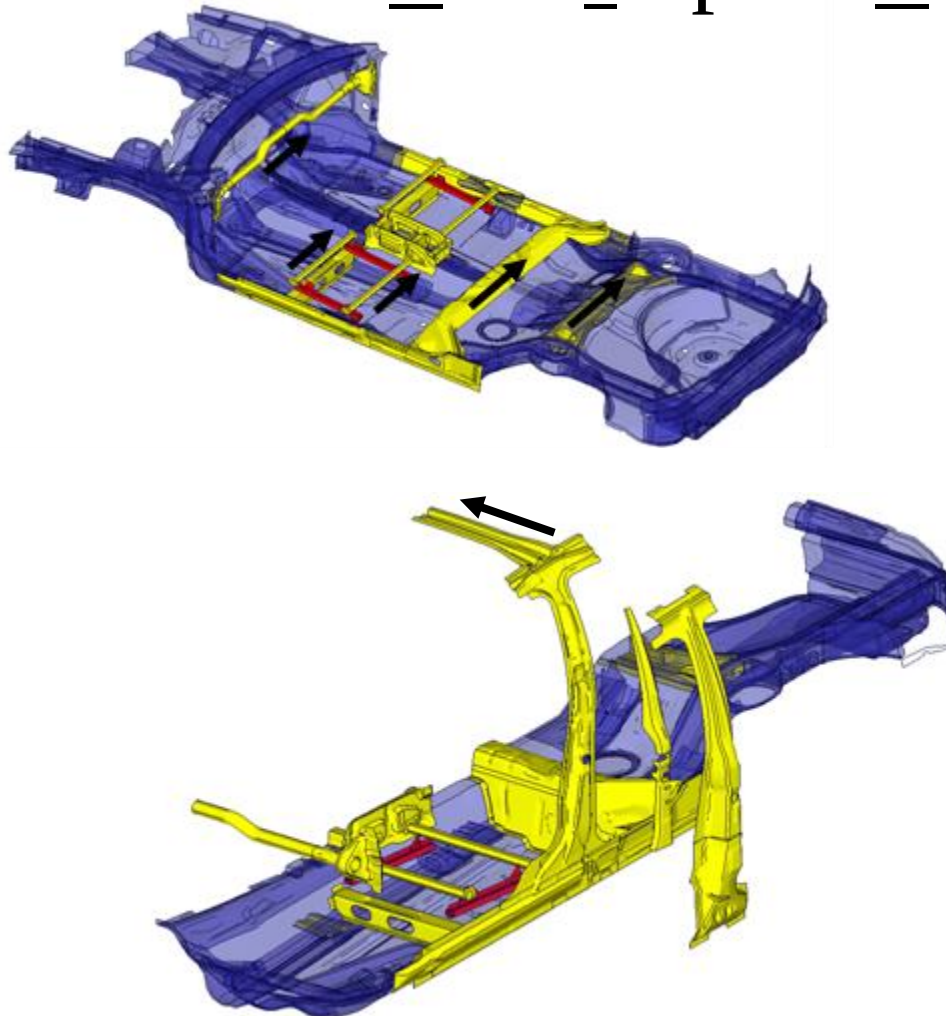


VOLVO

Body structure

Safety cage 2: SIPS

Side Impact Protection System



- Introduced in 1991
- The structure minimises the intrusion by the:
 - very strong B-pillars
 - rigid rockers
 - transverse floor/roof members
 - SIPS-box
 - framework of the front seats





VOLVO

Body structure *New structural solutions*

The XC90 BIW challenge

S80



V70

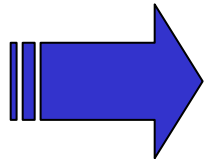


S60



- Increased front crash demands
- Compatibility small cars
- Rollover protection
- Protection 3rd row
- Increased side-impact protection

P2x-platform



Body implications:

New structural and material solutions!

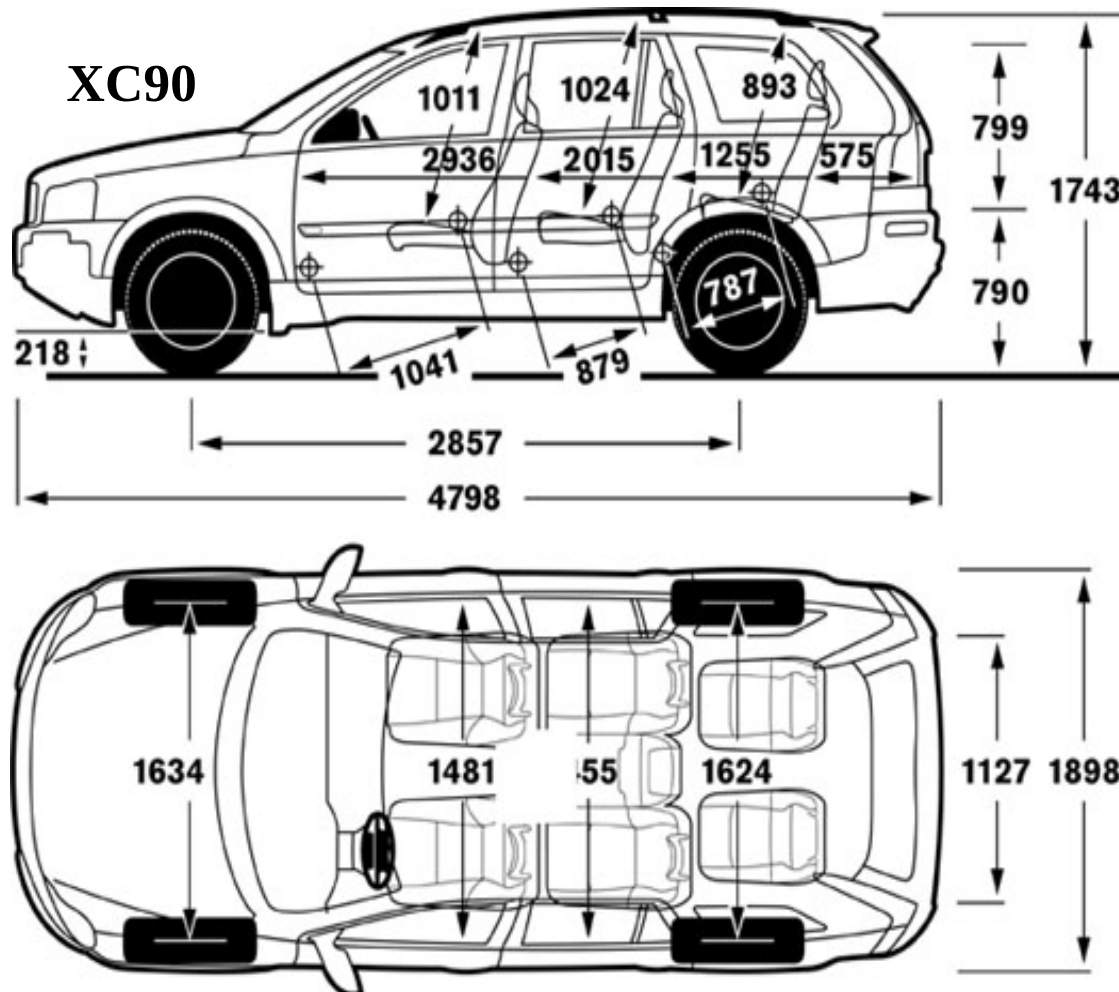




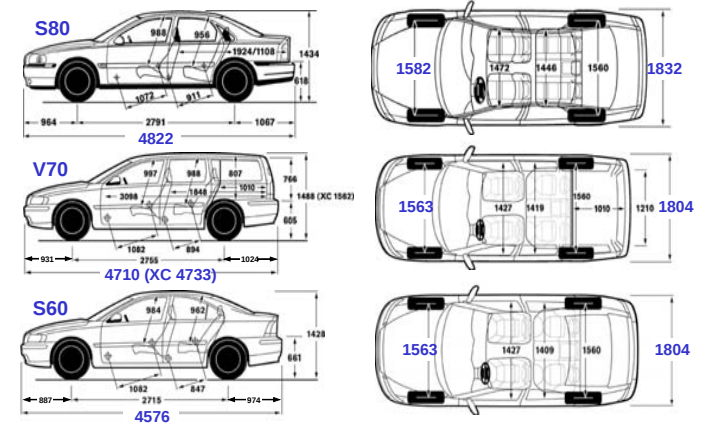
VOLVO

Body structure XC90 dimensions

Comparison with other cars on the P2x-platform



Kerb weight: 2070kg



Width (mm)

S80: 1832

V70: 1804

S60: 1804

Length (mm)

S80: 4822

V70: 4710

S60: 4576

Kerb weight (kg)

1631

1670

1574

Height (mm)

1434

1488 (XC1562)

1428



VOLVO

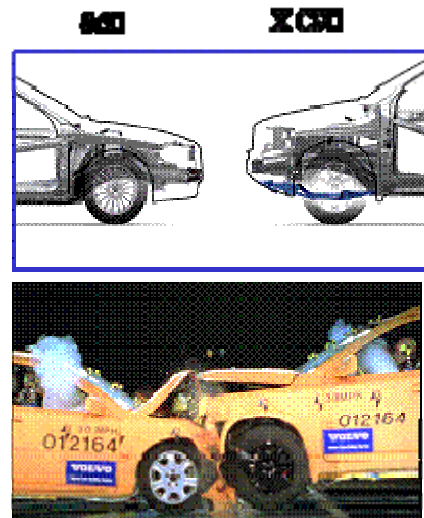
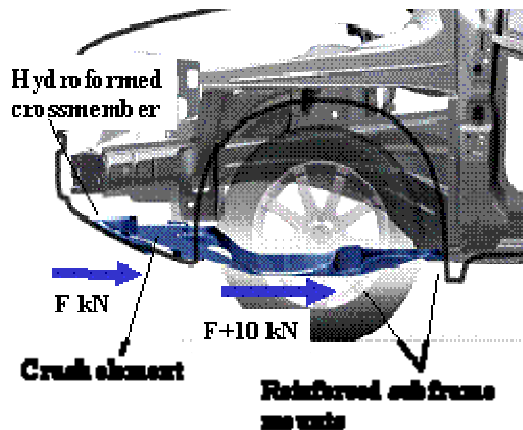
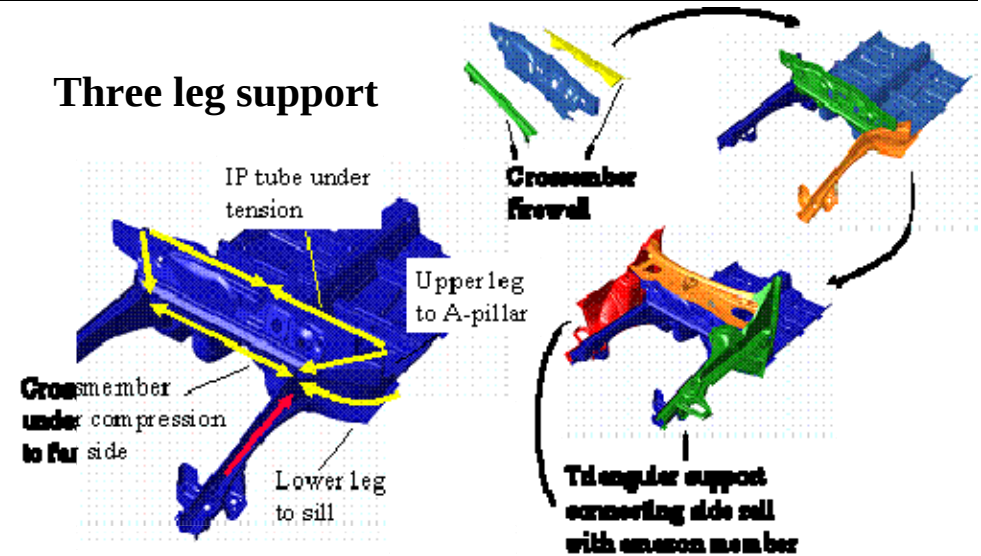
Body Structure

New structural solutions: Front

New front structure

- To handle higher forces and weight
- Centre floor is carry over P2 platform
- “Three leg support”
- Cross member firewall

Three leg support



Compatibility

- SUV hitting car
- Different side rail heights
- Engine sub frame (cradle) reinforced and extended forward
- Height aligned with car rail height



VOLVO

Body Structure

New structural solutions: Safety cage - Side

1st attempt



Low hit

Side impact common accident type

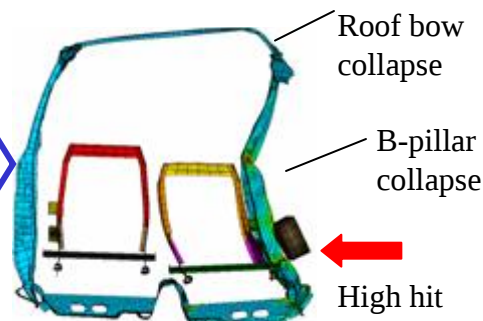
SUV hit by SUV

Side impact + higher rollover requirement

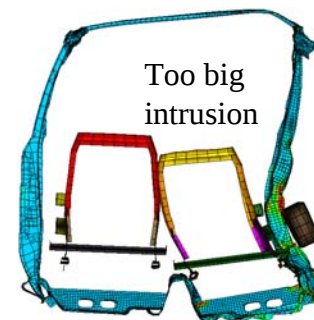
Controlled deformation



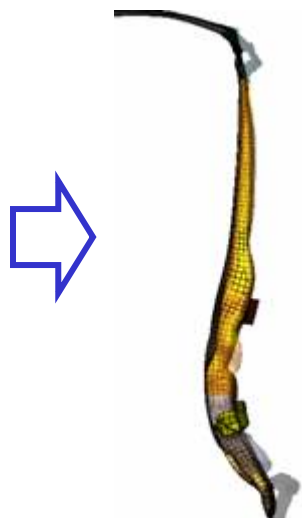
New demands...



High hit



Preferred B-pillar intrusion and deformation mode



Reinforced side- and roof structure



Strong B-pillar, B roof bow and seat belt bracket



Dual piece sunroof frame clinched together



New seat crossmbr



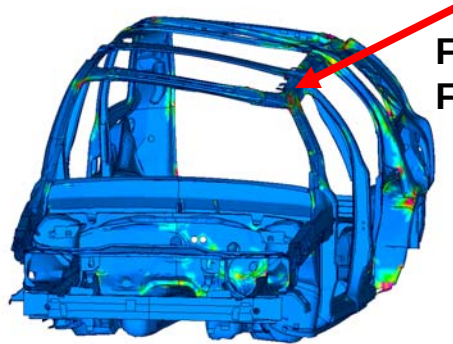
★★★★★★ !
EuroNCAP



VOLVO

Body Structure

New structural solutions: Safety cage - Roof



Force
F kN

Rollover accidents

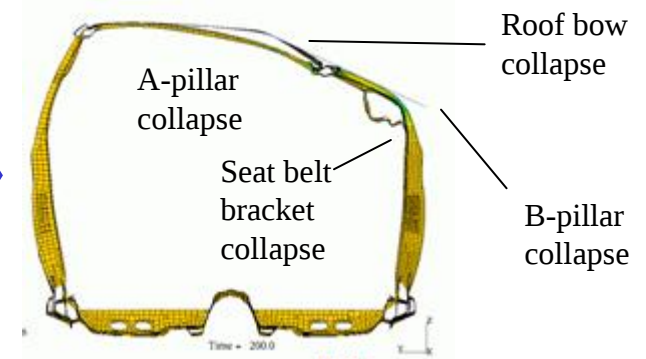
Increased req's rollover impact

Heavy vehicle

Strong structure

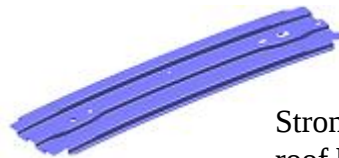
Packaging

New demands...



No structural collapse allowed.

Reinforced side- and roof structure



Strong B-pillar, B roof bow and A-pillar upper



Dual piece sunroof frame clined together



EHSS-reinforced A-pillar

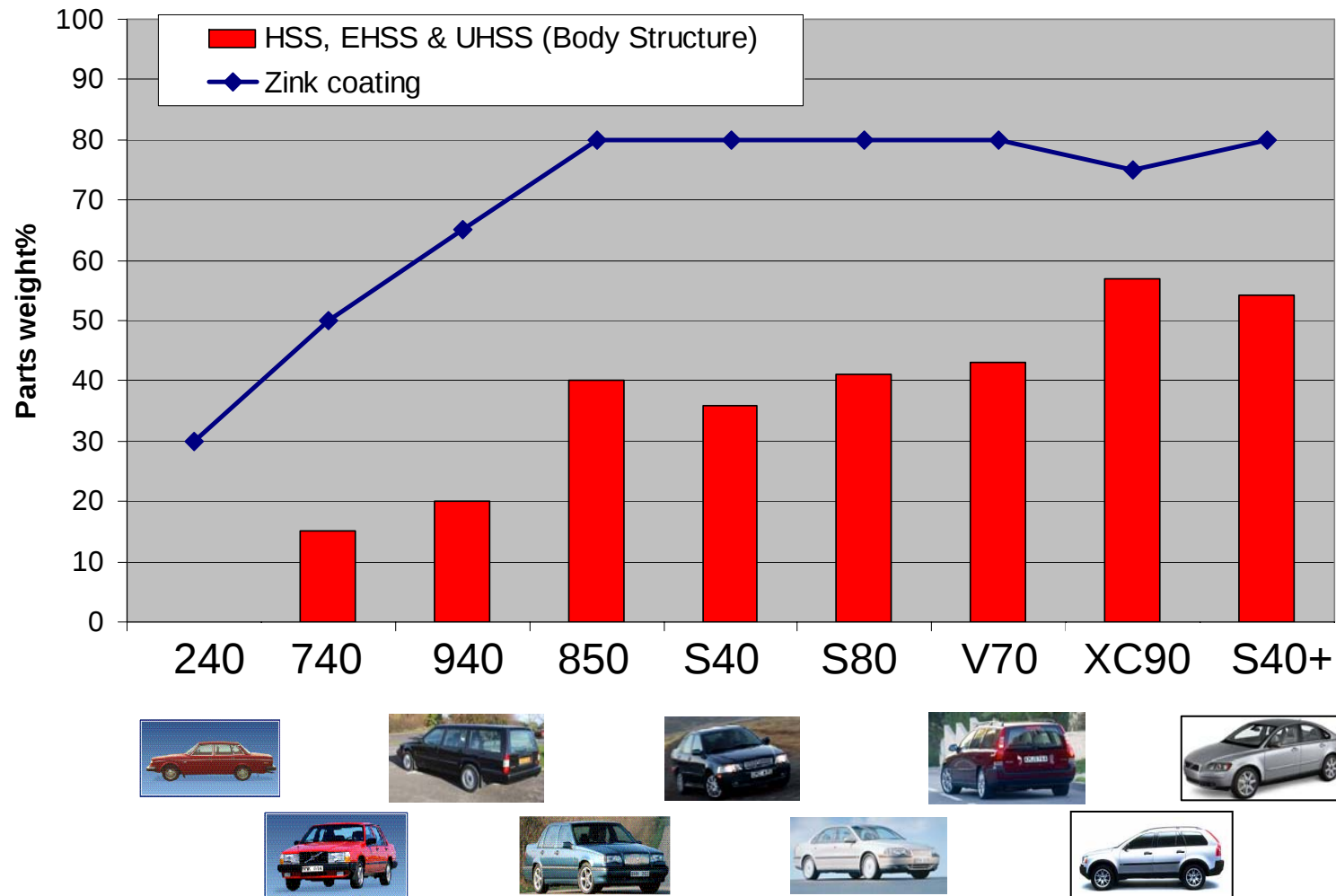


Result:
No structural collapse!



VOLVO

Materials General: Why HSS/EHSS/UHSS?



Annual total weight increase of 10 kg, platform to platform!

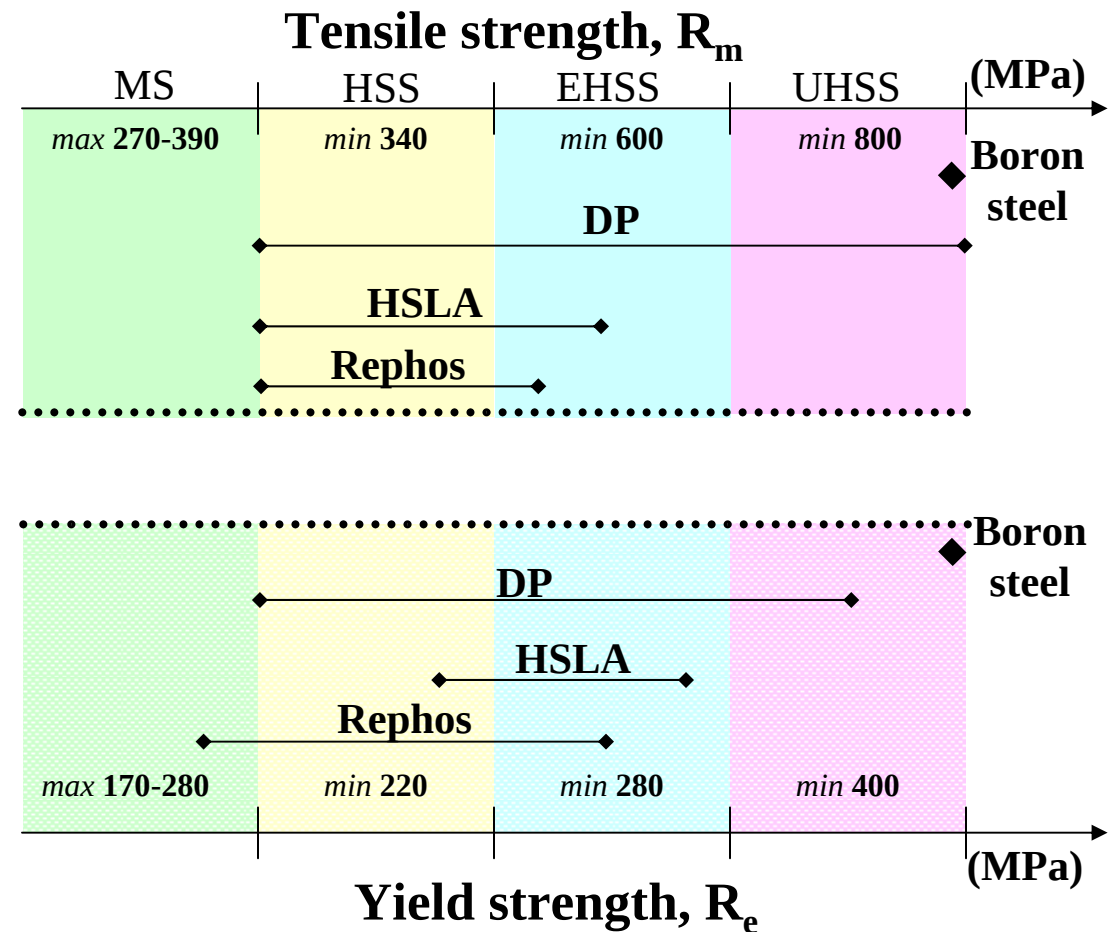


VOLVO

Materials

General: High strength steels at VCC

- **HSS:** Rephosphorized & HSLA steels. VCC “standard qualities for high strength material. Slightly better formability with Rephos.
- **HSS/EHSS:** Dual phase steels, used for reinforcements.
- **UHSS:** Boron steel. Used for reinforcements subjected to extreme load cases.



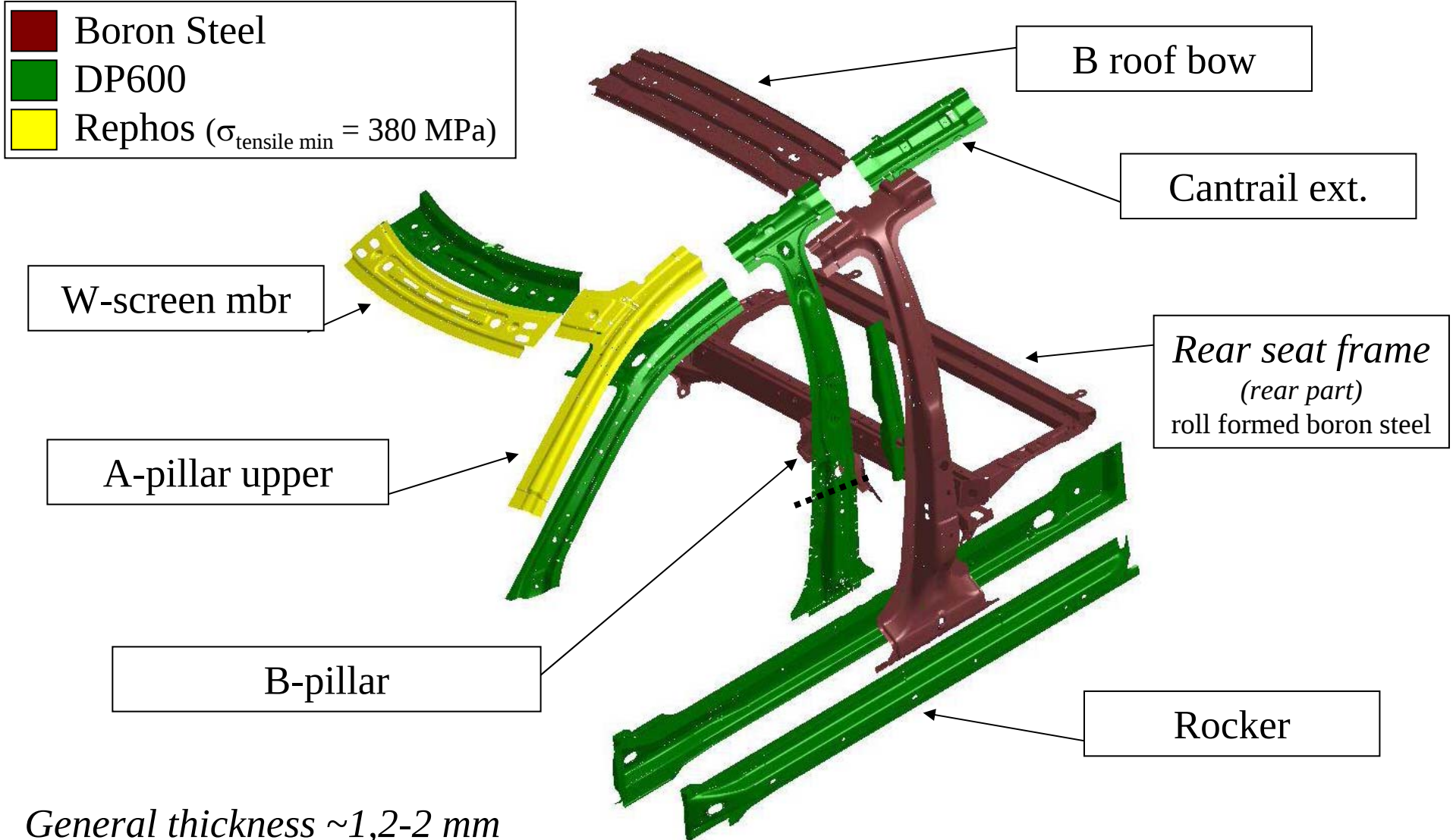
Using HSS/EHSS/UHSS for cost efficient weight reduction !





VOLVO

Materials XC90: Side-impact & roll-over

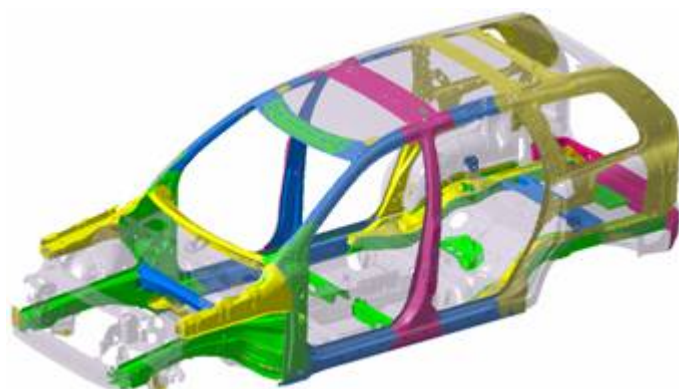




VOLVO

Materials

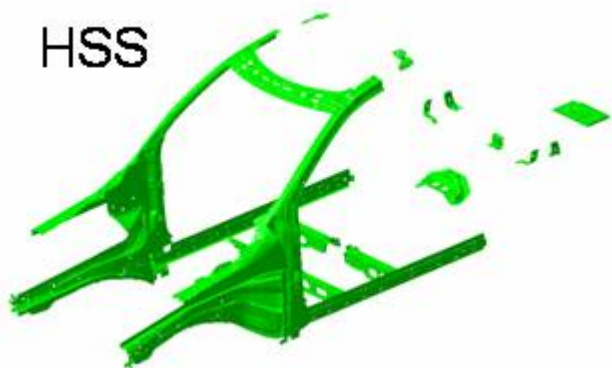
XC90 BIW Material distribution



	$R_{m_{max}} \approx 300 \text{ MPa}$	MS	42%
	$R_{m_{min}} > 340 \text{ MPa}$ (DP, HSLA el Rephos)		
	$R_{m_{min}} > 380 - 420 \text{ MPa}$ (DP, HSLA el Rephos)	HSS	36%
	$R_{m_{min}} > 600 \text{ MPa}$ (DP600)		
	$R_{m_{min}} > 1400 \text{ MPa}$ (Boron steel)	UHSS	6,5%
		Al	1%

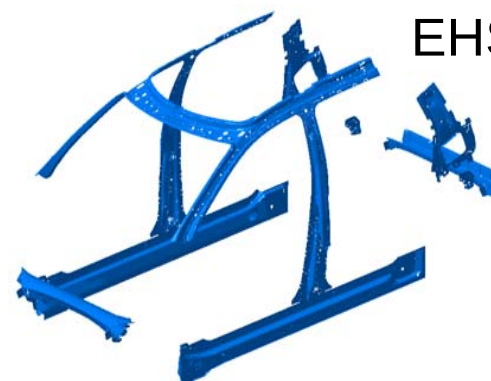


HSS



•Body structure	407 kg
•Hang on parts	113 kg
•Polymer tailgate	~11 kg

EHSS



HSS





VOLVO

Sum-up

Ratings



	<u>Europe</u>	<u>USA</u>
Front	★★★★★	★★★★★
Side	★★★★★	★★★★★





VOLVO

Sum-up

- XC90 incorporated several, for Volvo, new structural concepts and material applications
- High degree of HSS-material in the body structure (HSS→EHSS→UHSS)
- Extremely strong upper body structure for good rollover properties





VOLVO

Thank you for your attention!



www.autosteel.org

Great Designs in

STEEL

Sponsored by: American Iron and Steel Institute