



VOLVO

Safety Cage Design in the Volvo XC90

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Presentation overview

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





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General

The first Volvo SUV?



1943



2002



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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





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General Advanced Body Engineering

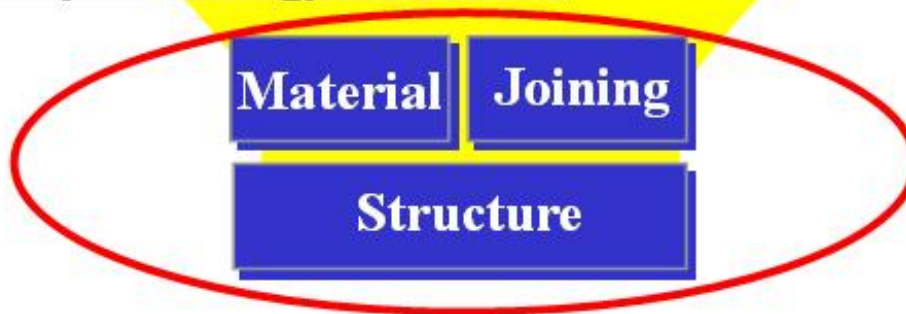
Complete vehicle Properties



Car Body Properties



Basic Body Technology Parameters



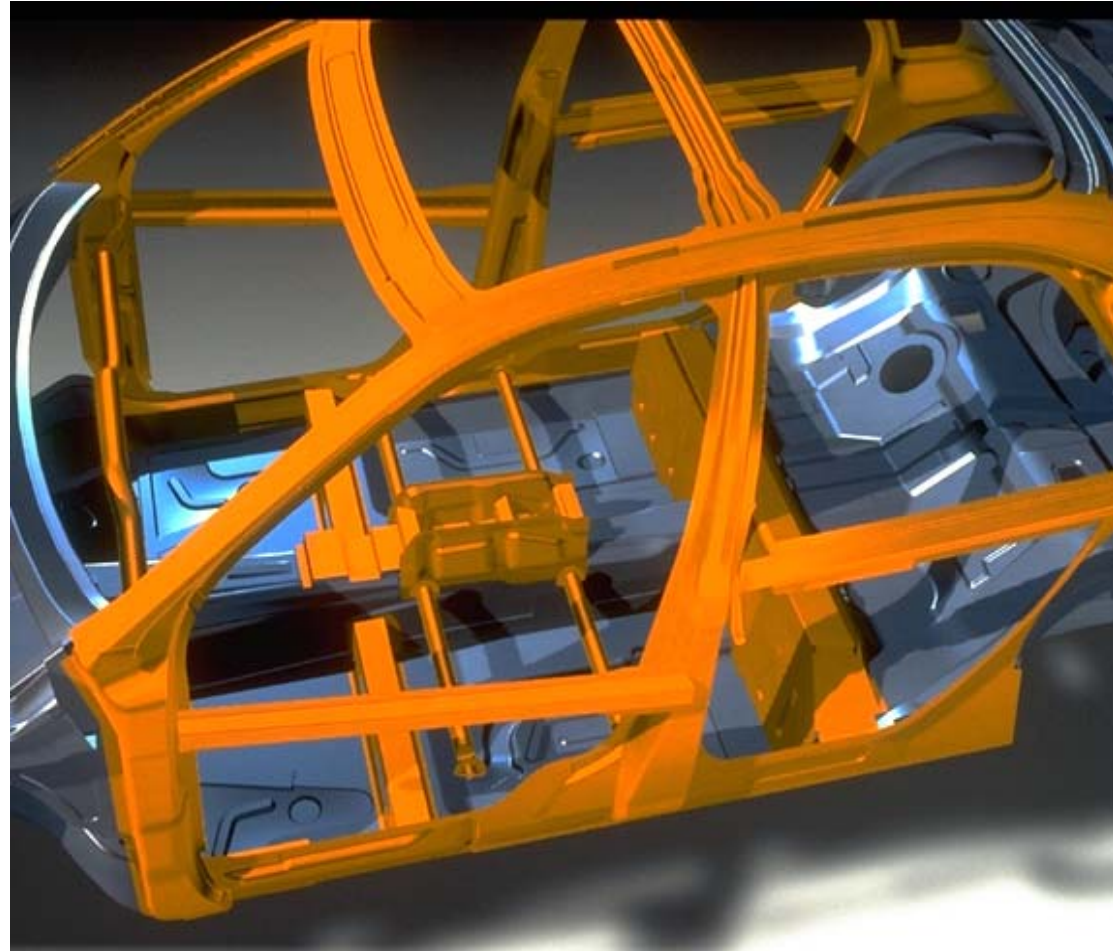


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Body structure

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”

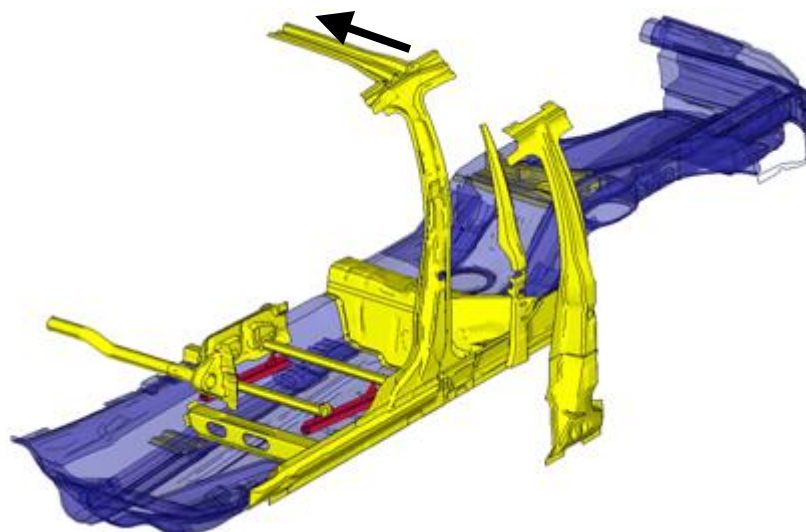
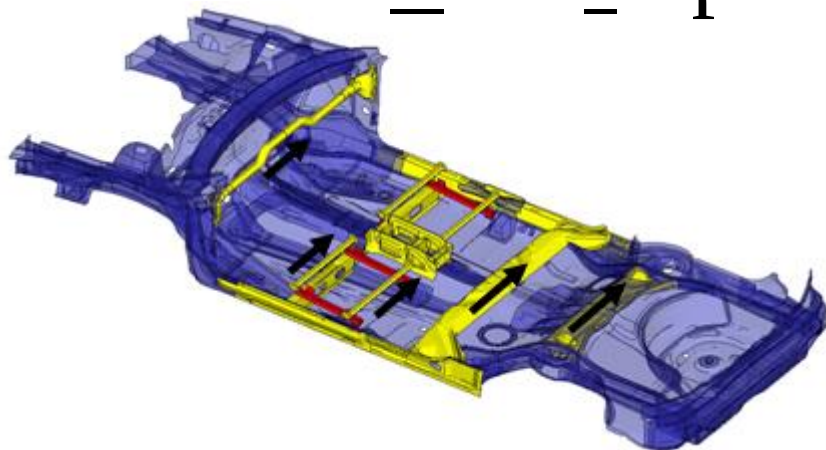




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Body structure Safety cage 2: SIPS

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



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Body structure New structural solutions

The XC90 BIW challenge

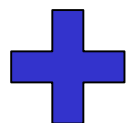
S80



V70

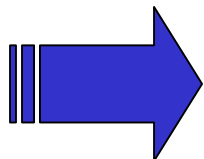


S60



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

P2x-platform

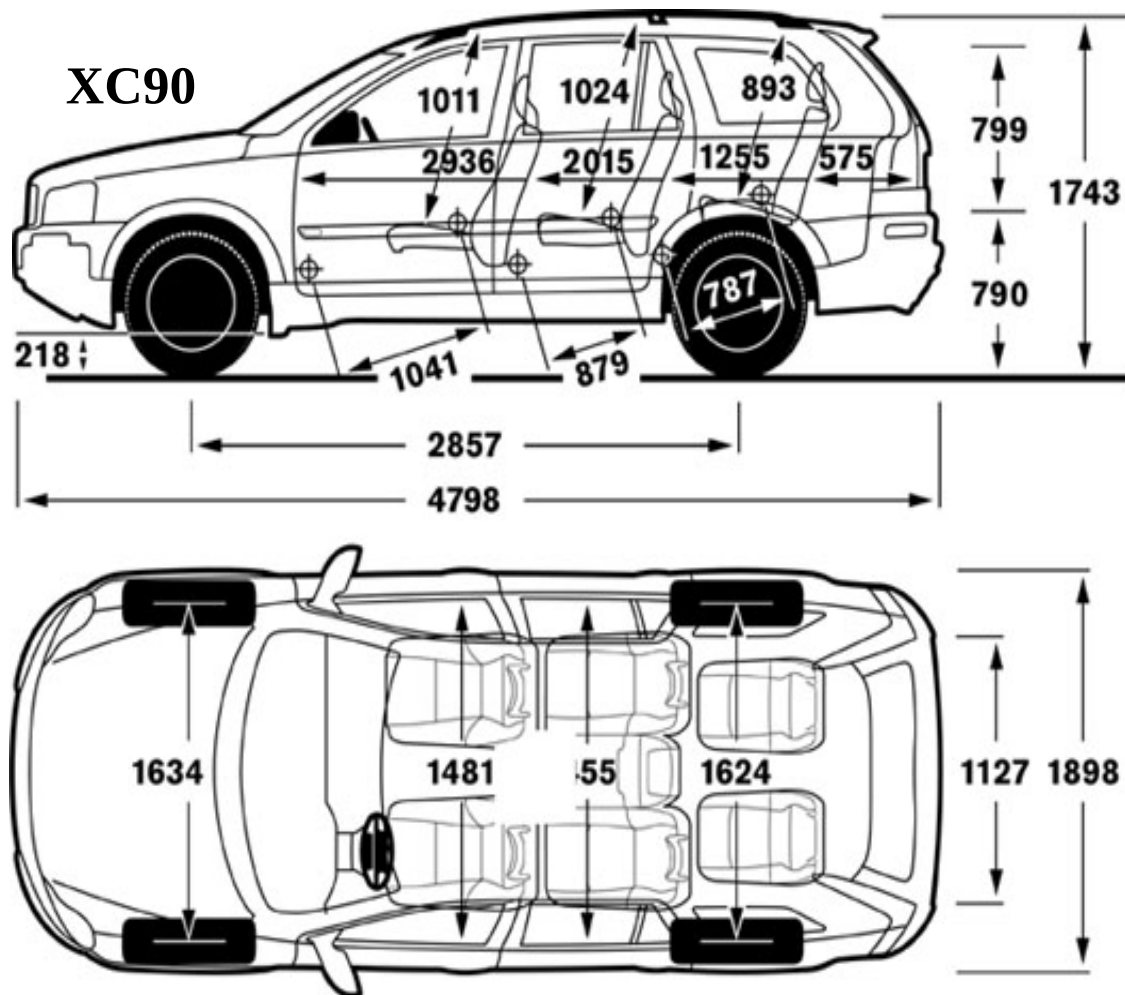


Body implications:

New structural and material solutions!

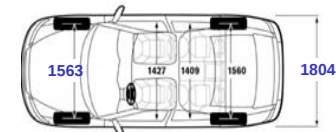
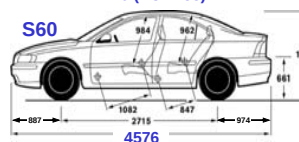
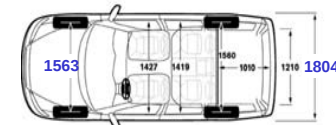
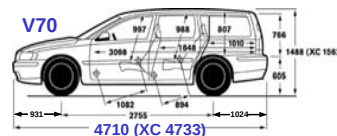
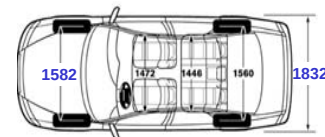
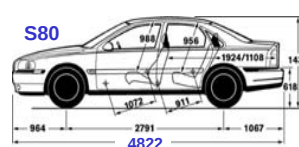


XC90



Kerb weight: 2070kg

Comparison with other cars on the P2x-platform

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



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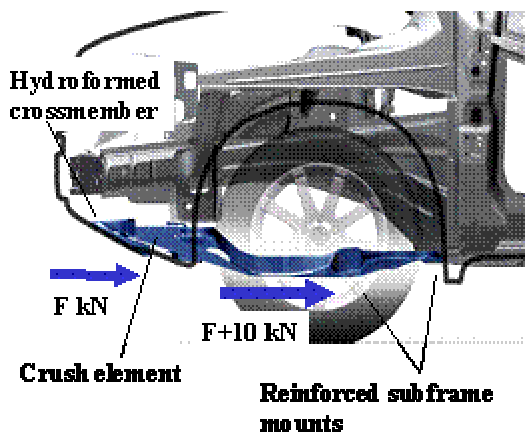
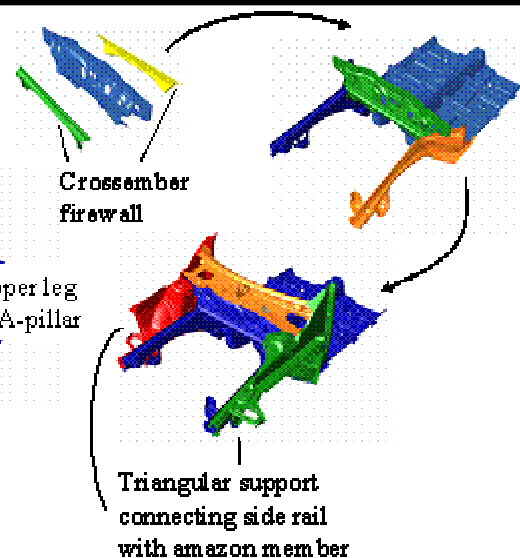
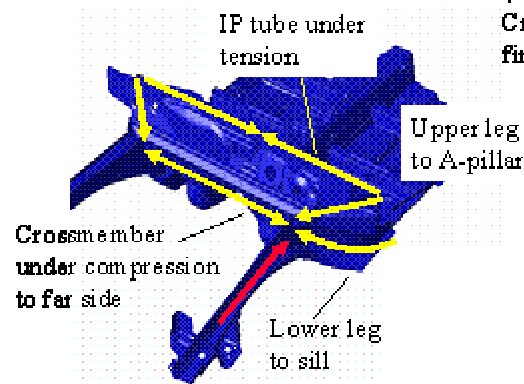
Body Structure

New structural solutions: Front

New front structure

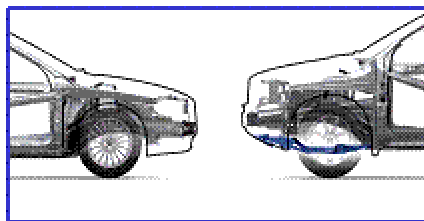
- To handle higher forces and weight
- Centre floor is carry over P2 platform
- “Three leg support”
- Cross member firewall

Three leg support



S60

XC90



Compatibility

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



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Body Structure

New structural solutions: Safety cage - Side

1st attempt



Low hit

Side impact common accident type

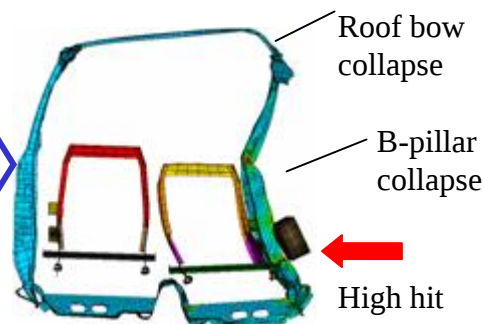
SUV hit by SUV

Side impact + higher rollover requirement

Controlled deformation



New demands...



High hit



Preferred B-pillar intrusion and deformation mode



Reinforced side- and roof structure



Dual piece sunroof frame clinched together

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



New seat crossmbr



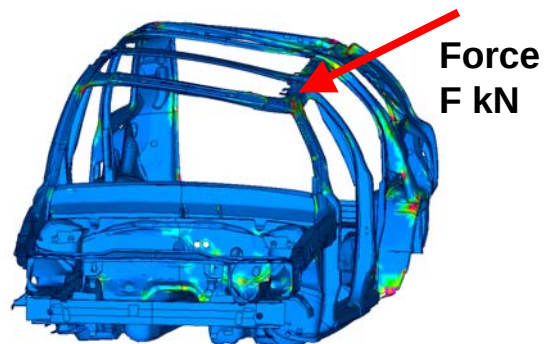
★★★★★ !
EuroNCAP



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Body Structure

New structural solutions: Safety cage - Roof



Rollover accidents

Increased req's rollover impact

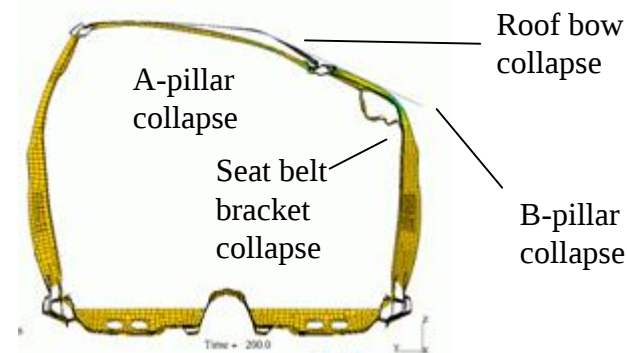
Heavy vehicle

Strong structure

Packaging

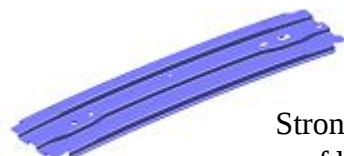


New demands...



Reinforced side- and roof structure

No structural collapse allowed.



Dual piece sunroof frame clinched together

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



EHSS-reinforced A-pillar



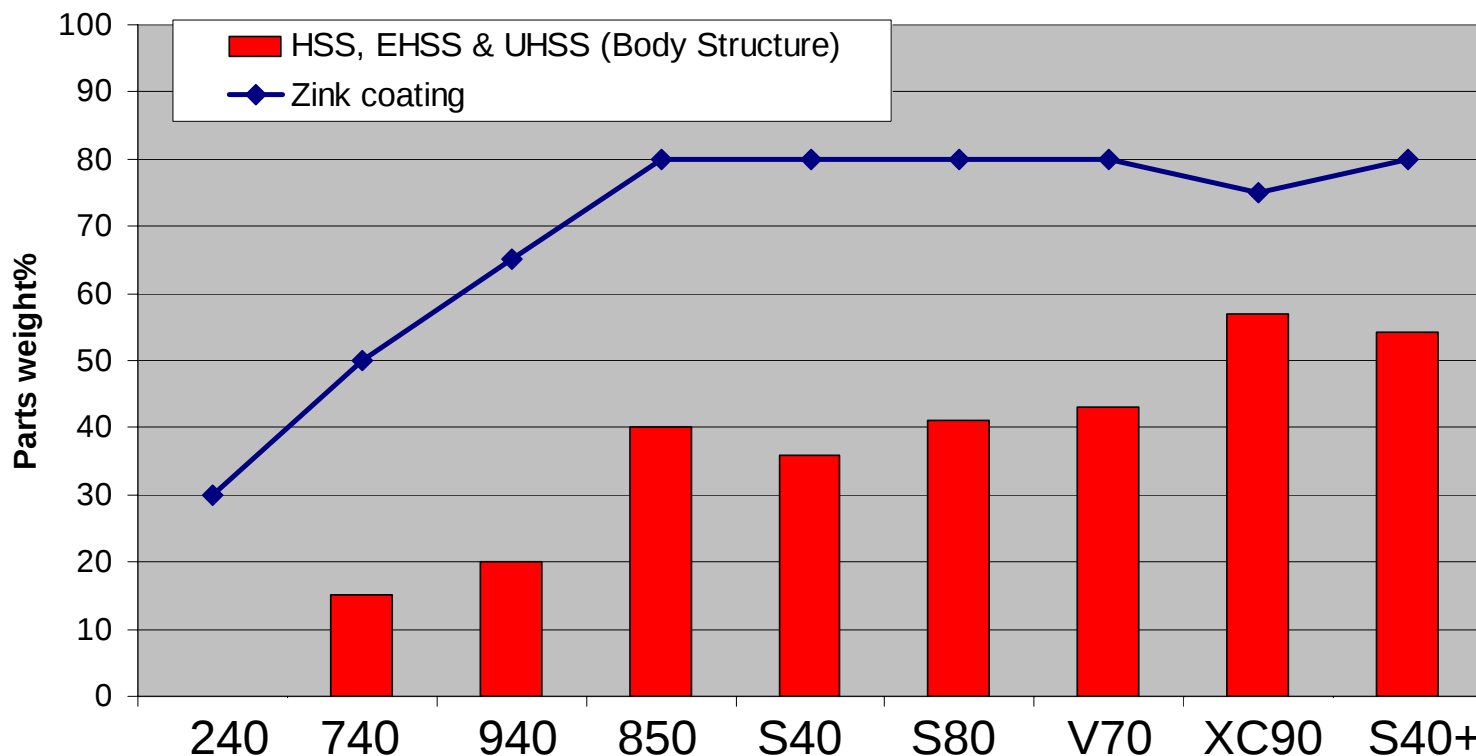
Result:
No structural collapse!



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Materials

General: Why HSS/EHSS/UHSS?



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



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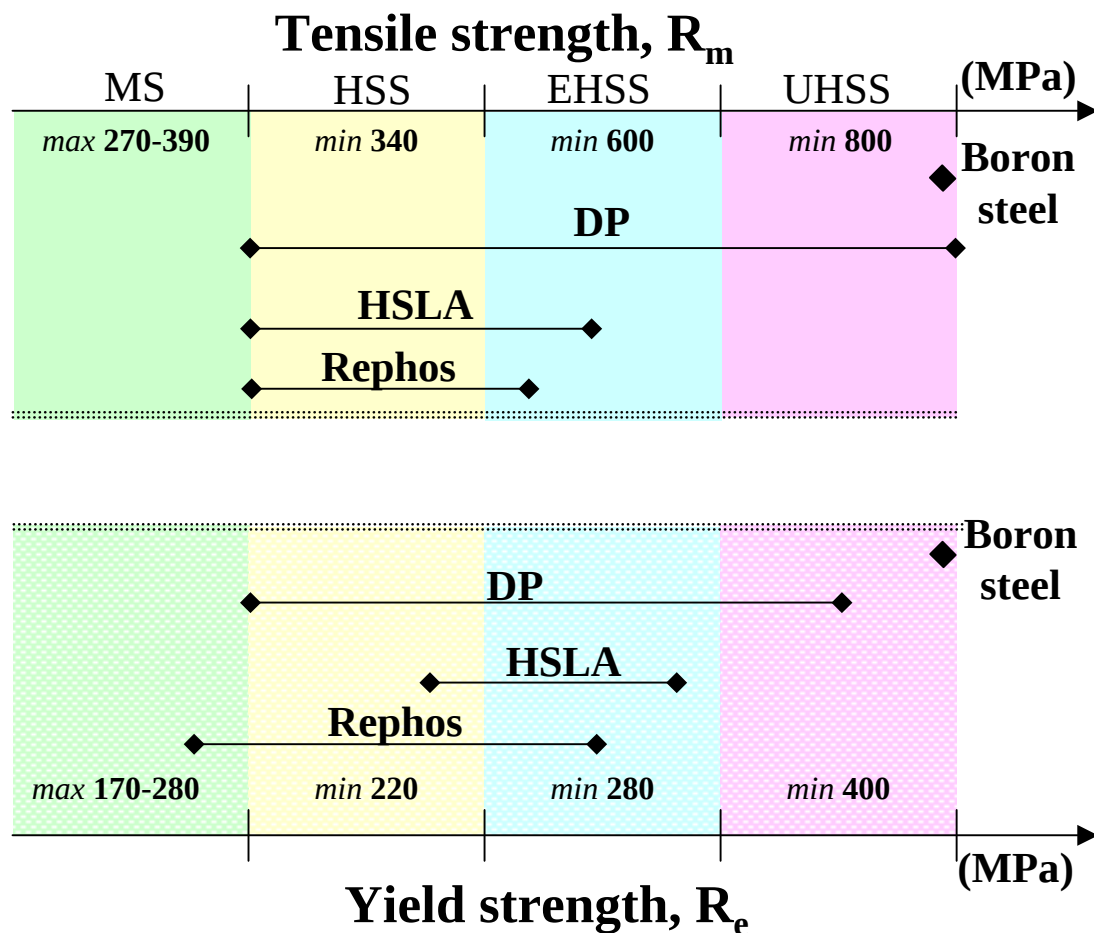
Materials

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 !

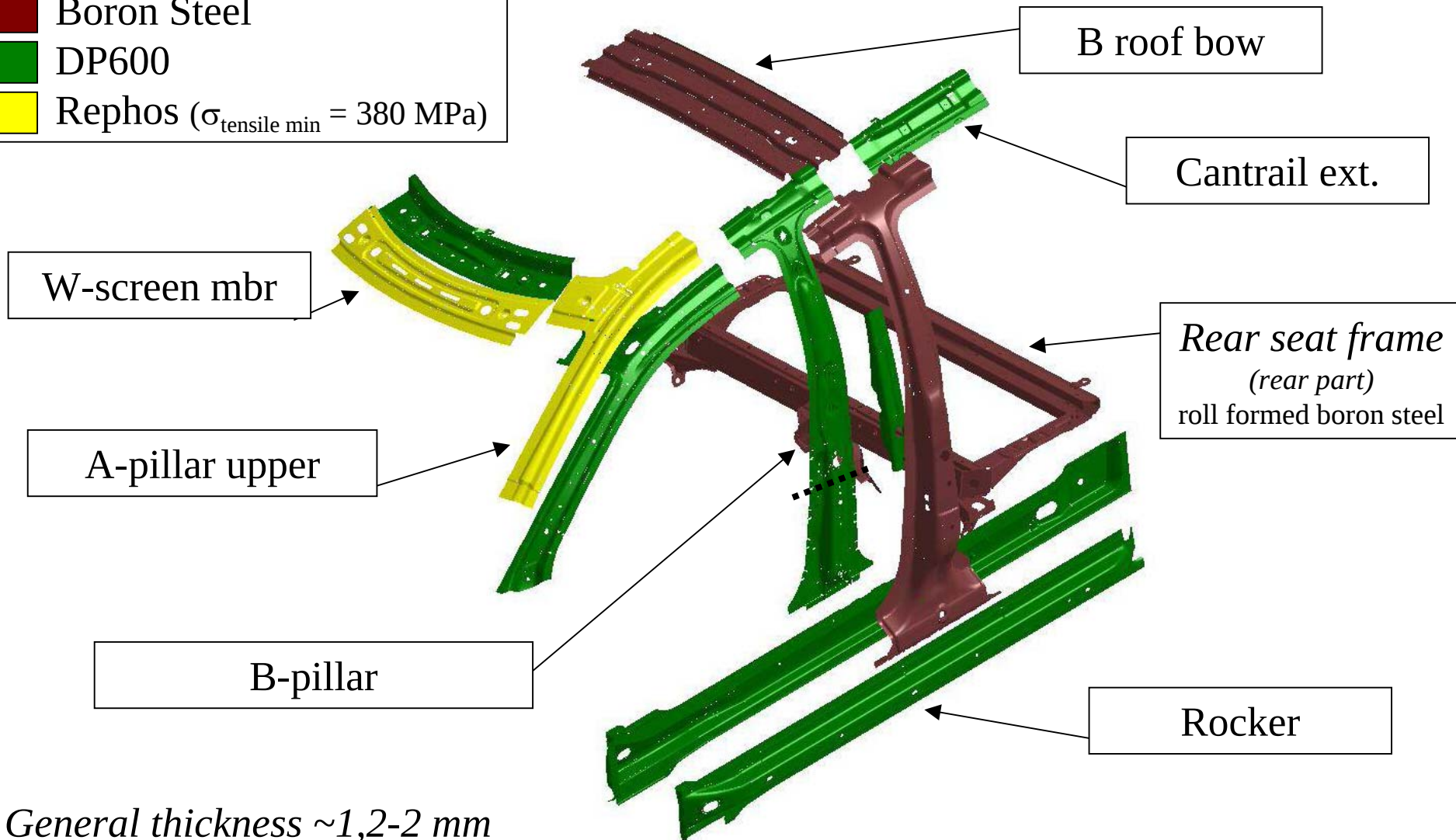


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Materials

XC90: Side-impact & roll-over

- Boron Steel
- DP600
- Rephos ($\sigma_{\text{tensile min}} = 380 \text{ MPa}$)

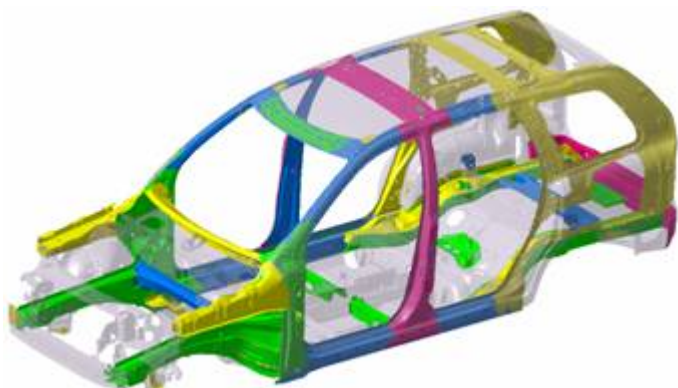




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Materials

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)	} EHSS	14,5%
		} UHSS	6,5%
		Al	1%



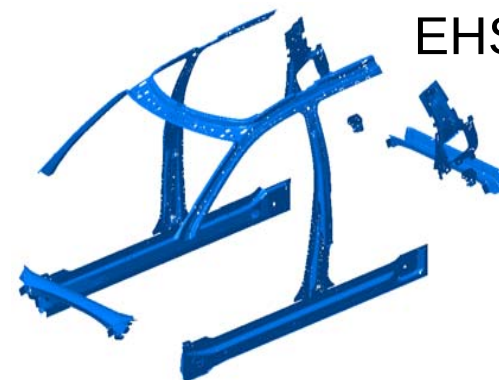
UHSS

HSS



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

EHSS



HSS





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Sum-up

Ratings



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



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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



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Thank you for your attention!

