



**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

|                       |  |  |              |
|-----------------------|--|--|--------------|
| <b>SIZE</b><br>[mm]   | Length                                     |  | <b>P28</b>   |
|                       | Width                                      |  | 4798         |
|                       | Height                                     |  | 1890         |
| <b>Weight</b><br>[kg] | <b>Body shell incl frt bumper</b>          |  | <b>1740</b>  |
|                       | <b>Total hang on</b>                       |  | <b>407</b>   |
|                       | <b>Paint and sealings</b>                  |  | <b>113,0</b> |
|                       | <b>Body complete incl closures</b>         |  | <b>16,4</b>  |
|                       | 2nd row seat subframe (structural part)    |  | <b>536,4</b> |
|                       | <b>Body complete incl 2nd row subframe</b> |  | <b>17,6</b>  |
| <b>Attributes</b>     | Static Torsional Stiffness BIG [kNm/deg]   |  | <b>554,0</b> |
|                       | 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

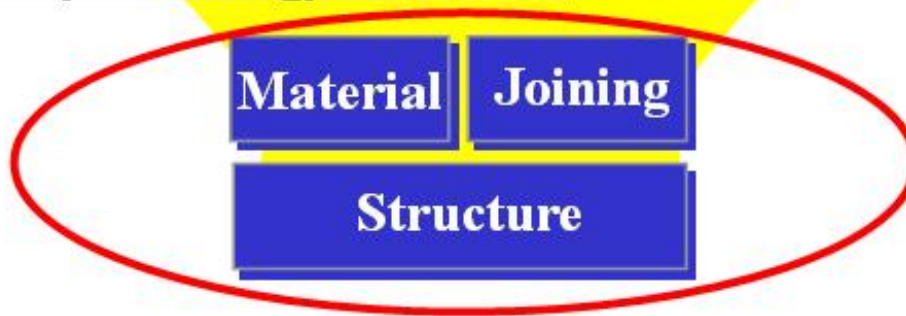
## Complete vehicle Properties



## Car Body Properties



## Basic Body Technology Parameters



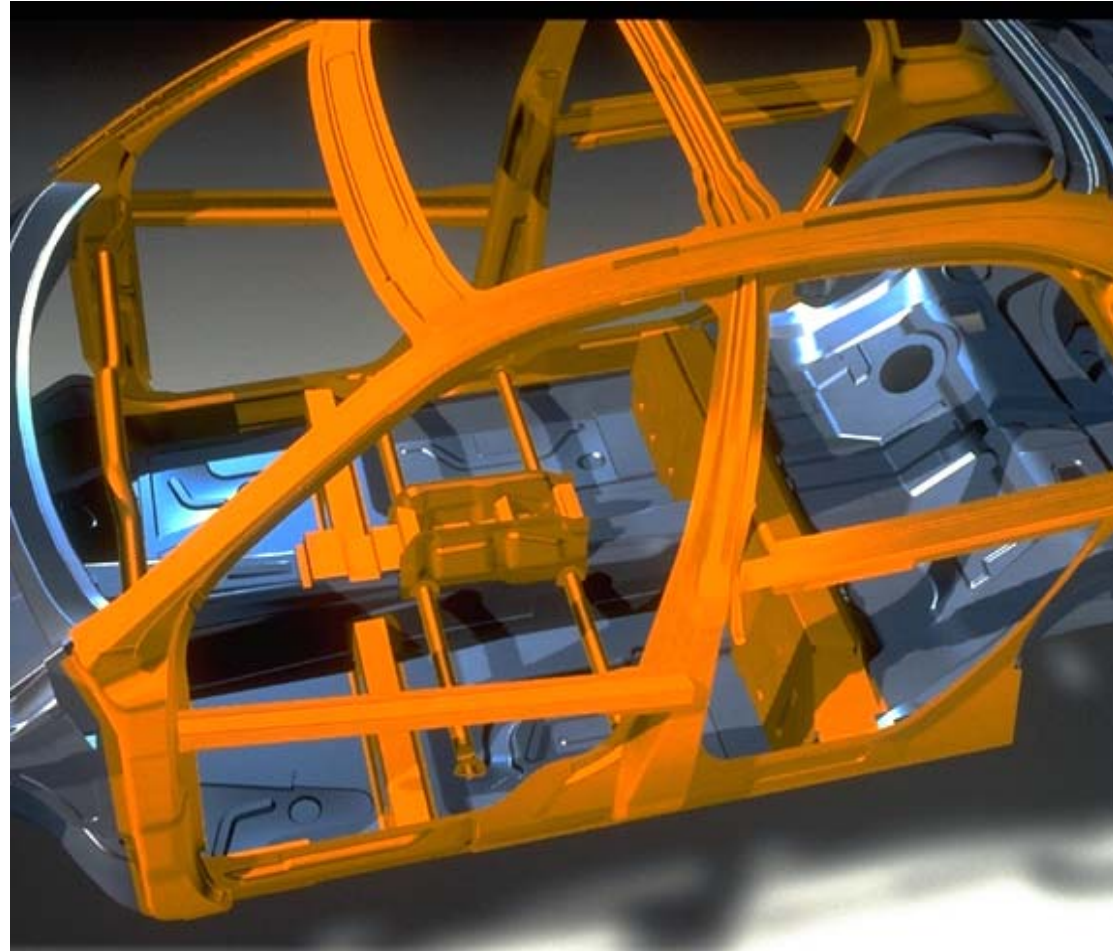




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## Body structure Safety cage 1

*“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”*

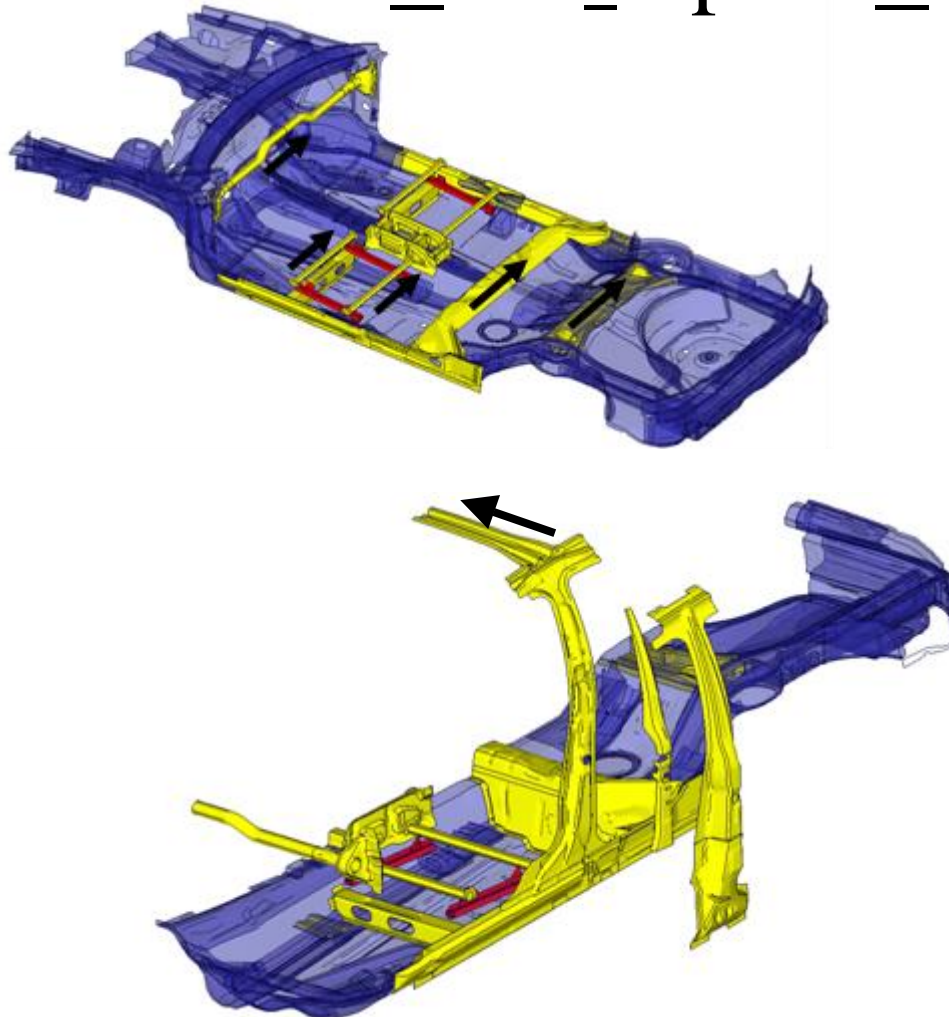




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## Body structure Safety cage 2: SIPS

### 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

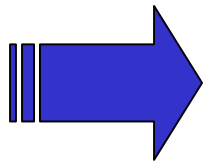


S60



- 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!**

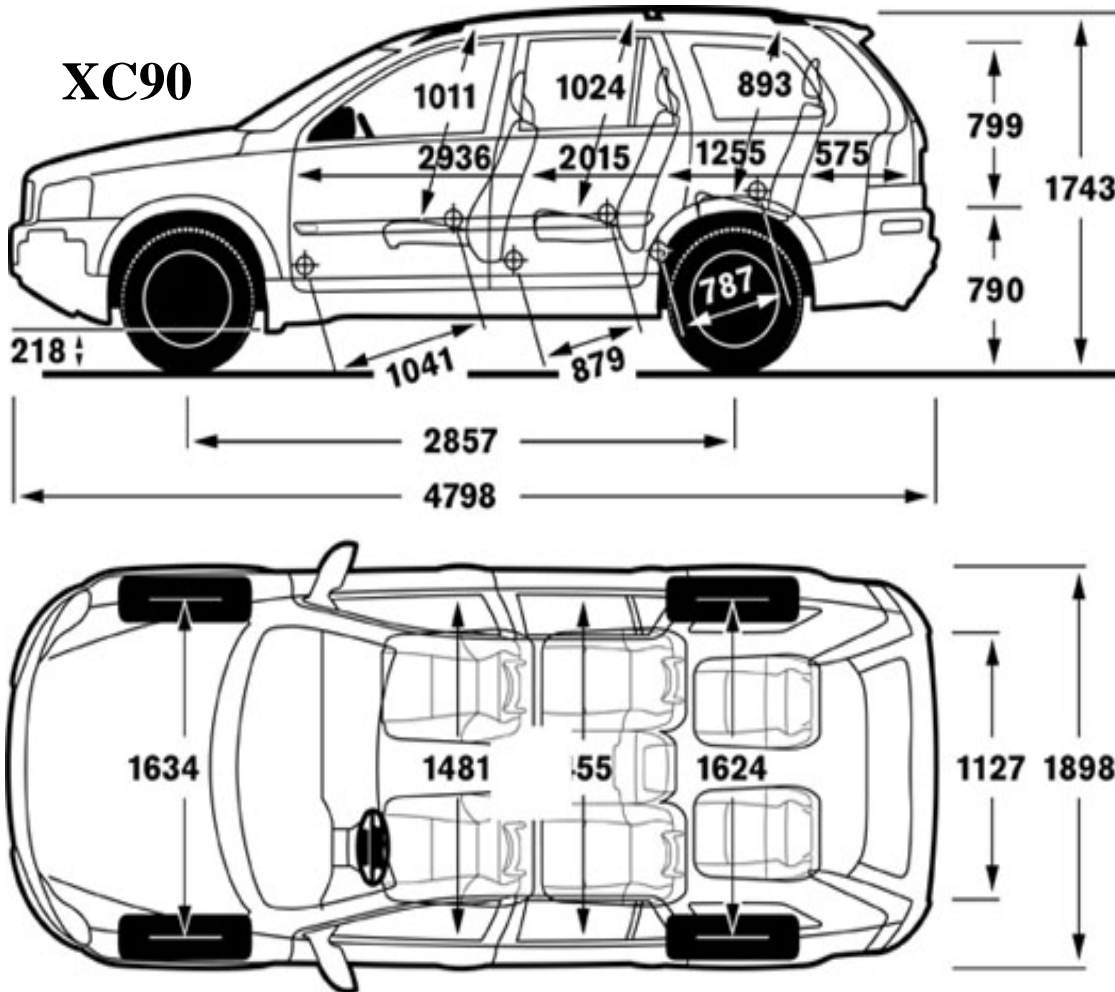




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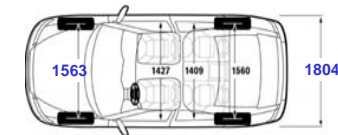
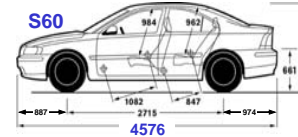
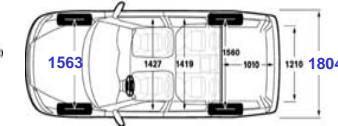
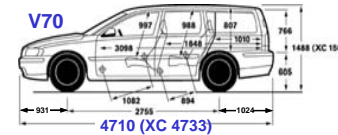
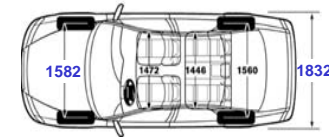
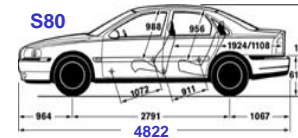
## Body structure XC90 dimensions

XC90



**Kerb weight: 2070kg**

## Comparison with other cars on the P2x-platform



### Width (mm)

S80: 1832

V70: 1804

S60: 1804

### Kerb weight (kg)

1631

1670

1574

### Length (mm)

S80: 4822

V70: 4710

S60: 4576

### Height (mm)

1434

1488 (XC1562)

1428



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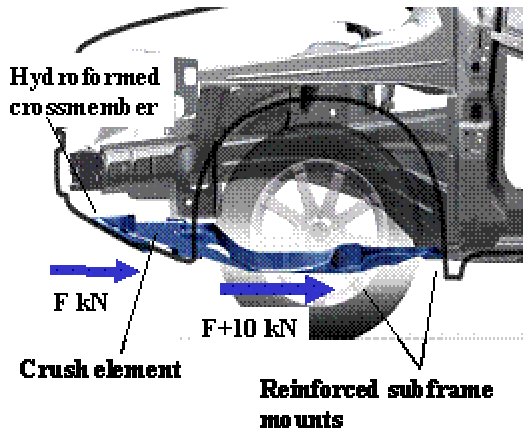
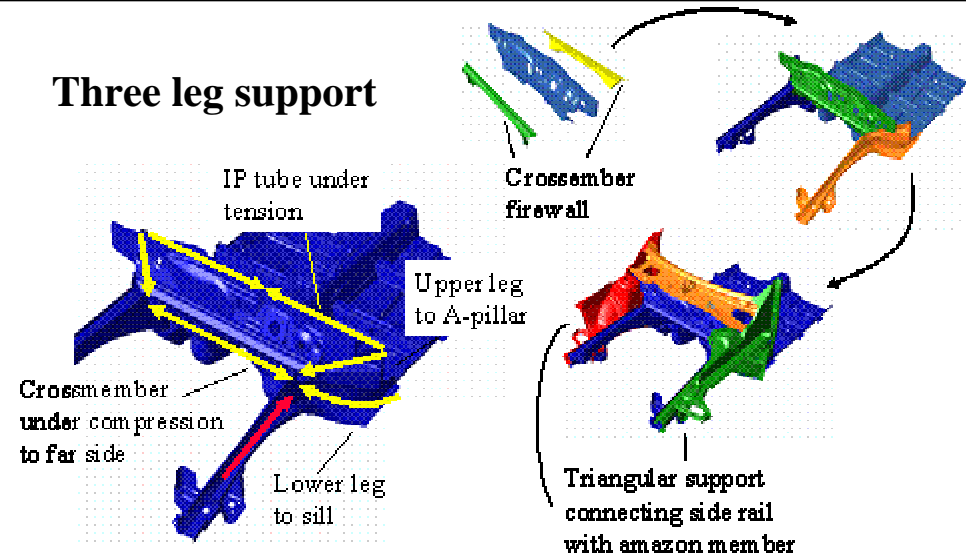
# Body Structure

## New structural solutions: Front

### New front structure

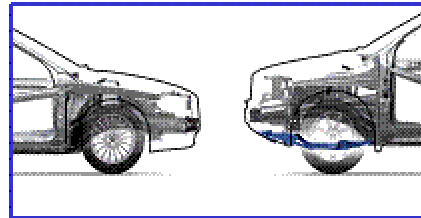
- To handle higher forces and weight
- Centre floor is carry over P2 platform
- “Three leg support”
- Cross member firewall

### 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

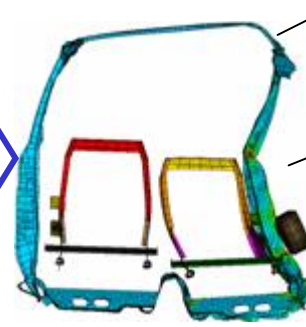
SUV hit by SUV

Side impact + higher rollover requirement

Controlled deformation



### New demands...



Roof bow collapse

B-pillar collapse

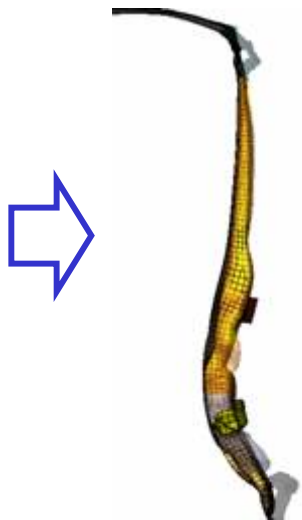
High hit



Too big intrusion

### 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

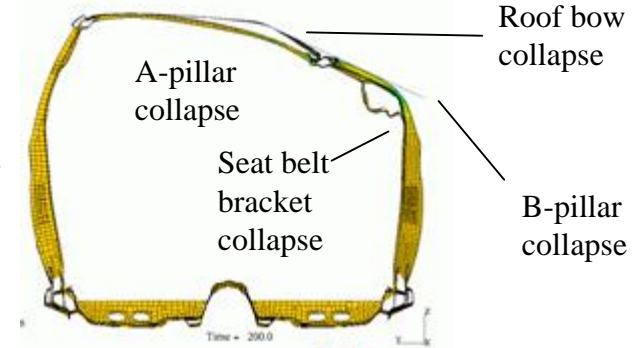
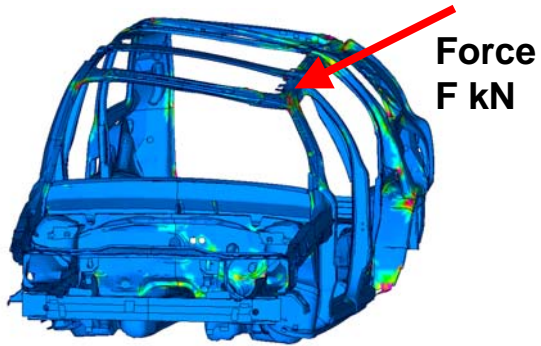
Increased req's rollover impact

Heavy vehicle

Strong structure

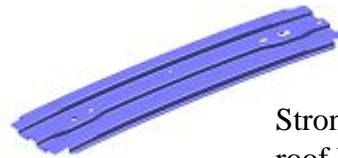
Packaging

New demands...



Reinforced side- and roof structure

No structural collapse allowed.



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



Dual piece sunroof frame clinched together



EHSS-reinforced A-pillar



Result:  
No structural collapse!

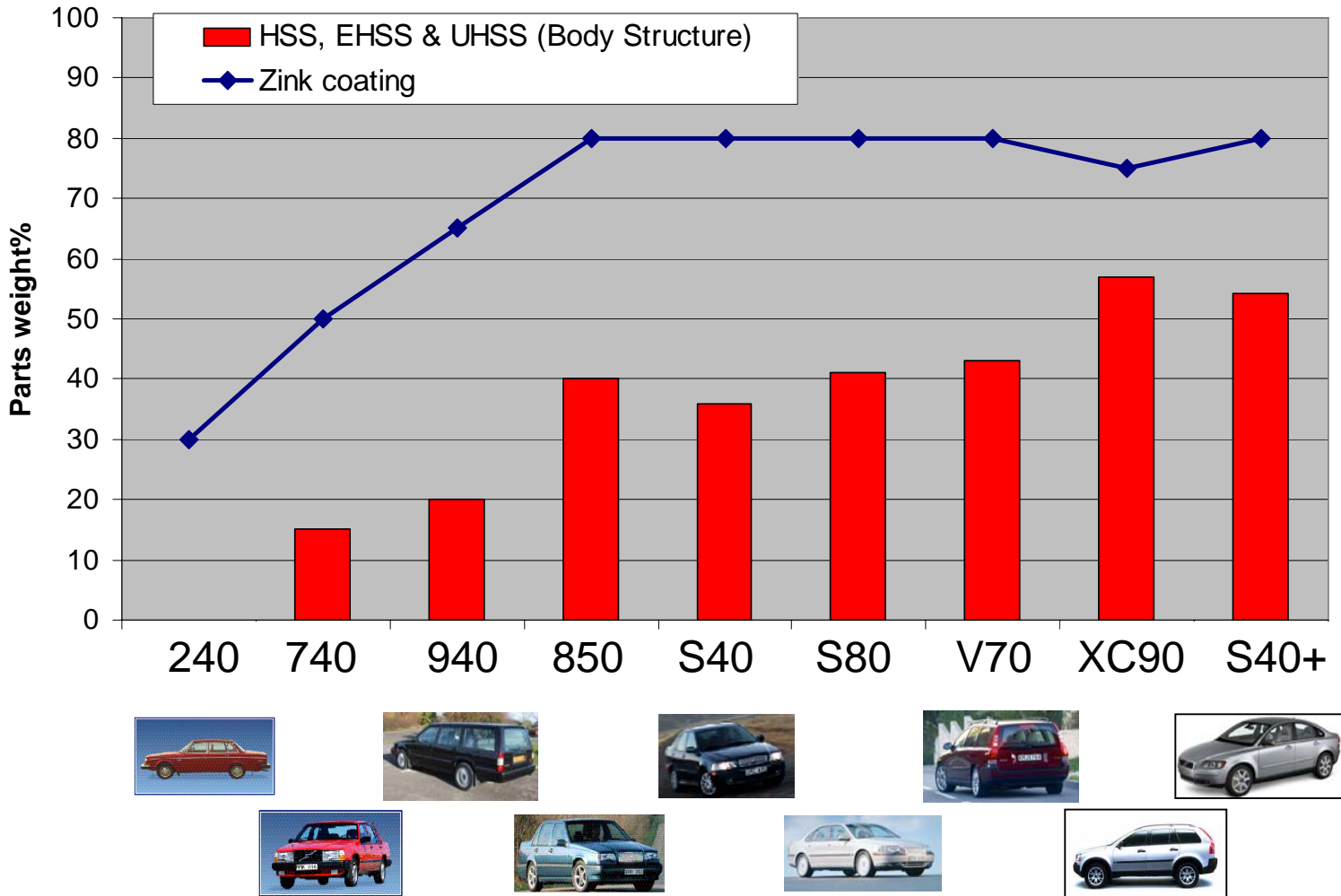




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# Materials

## General: Why HSS/EHSS/UHSS?



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







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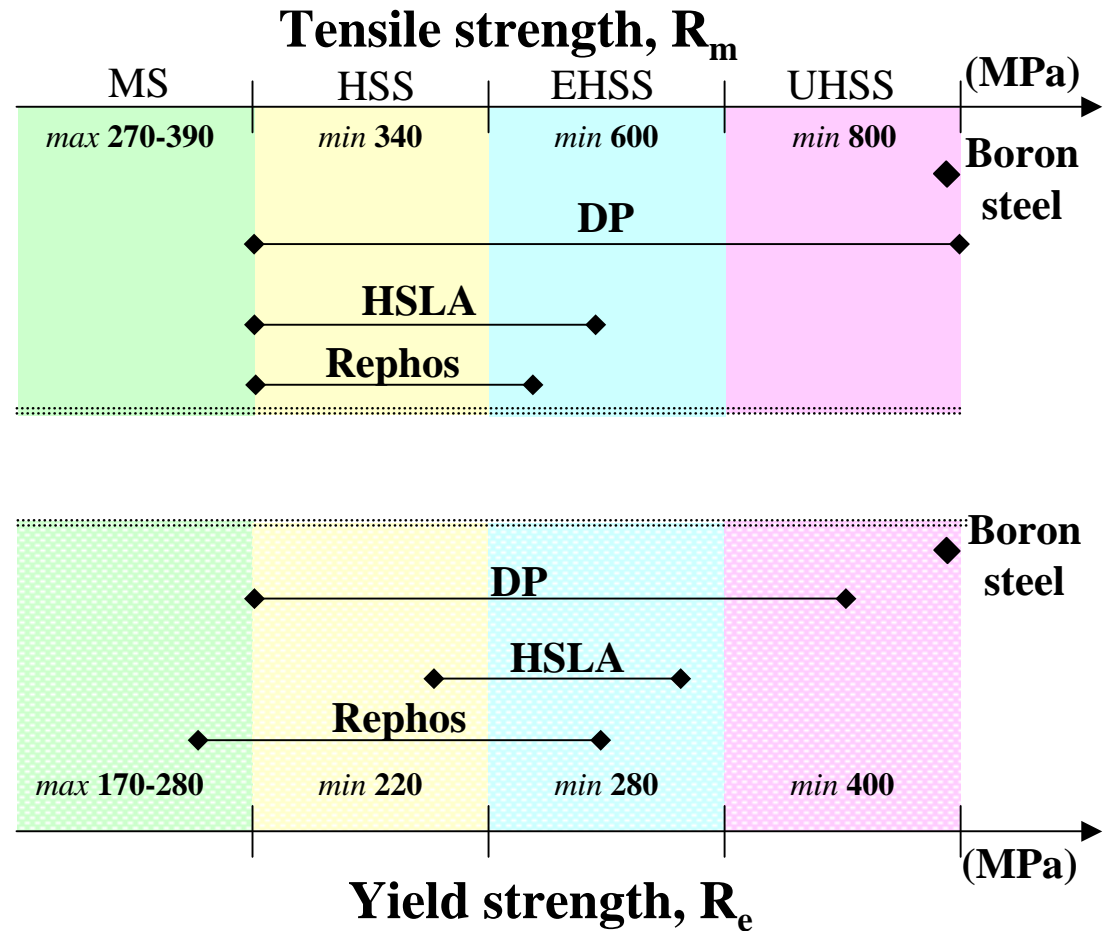
# Materials

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 !**






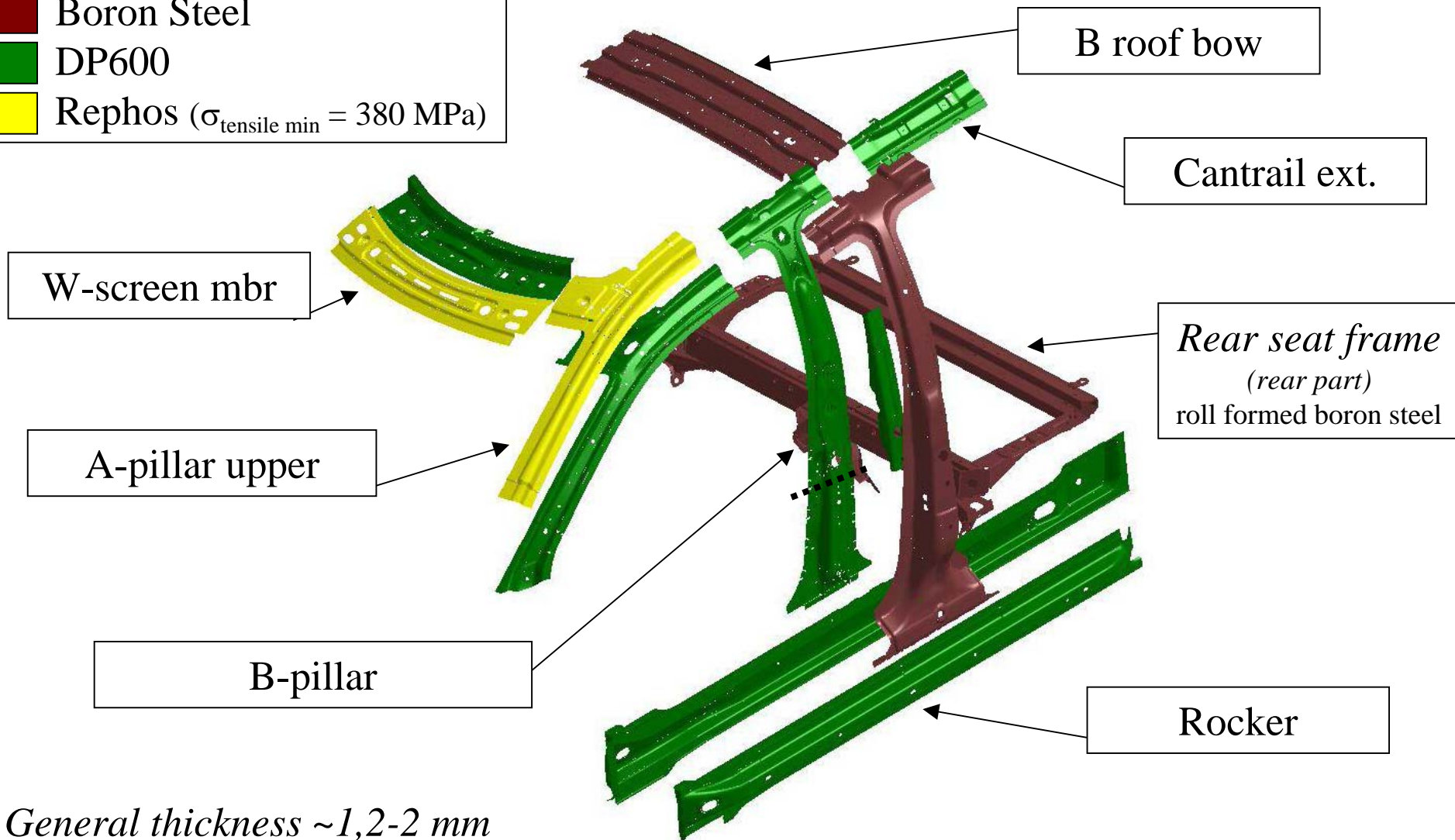


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# Materials

## XC90: Side-impact & roll-over

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



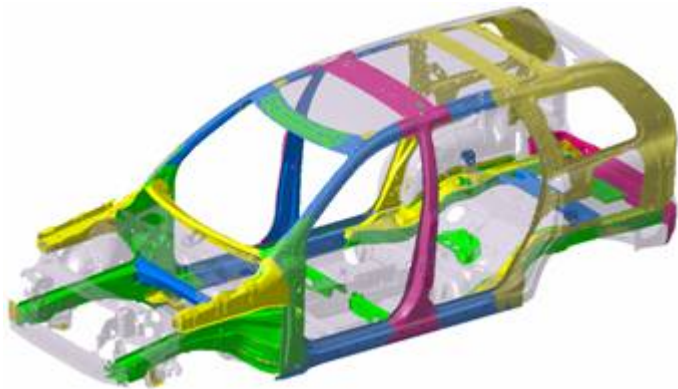
General thickness ~1,2-2 mm








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# Materials

## XC90 BIW Material distribution



|   |  |        |      |
|---|--|--------|------|
|  | $Rm_{max} \approx 300$ MPa                       | } MS   | 42%  |
|  | $Rm_{min} > 340$ MPa<br>(DP, HSLA el Rephos)     |        |      |
|  | $Rm_{min} > 380-420$ MPa<br>(DP, HSLA el Rephos) | } HSS  | 36%  |
|  | $Rm_{min} > 600$ MPa<br>(DP600)                  |        |      |
|  | $Rm_{min} > 1400$ MPa<br>(Boron steel)           | } UHSS | 6,5% |
|   |  |        |      |
|   |  | } AI   | 1%   |



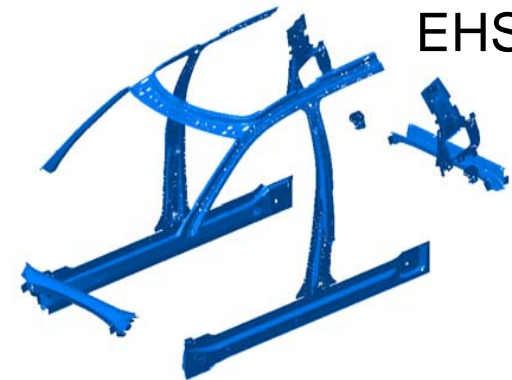
UHSS

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!

