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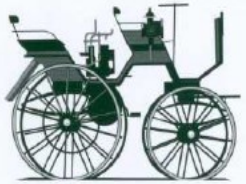
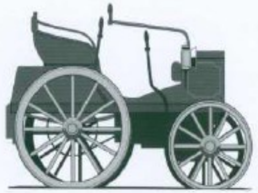
Body architecture



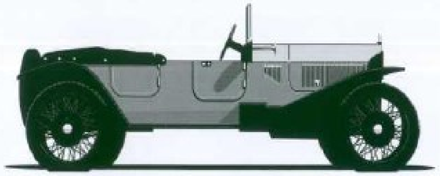
1886
DAIMLER MOTOR CARRIAGE
(GERMANY)



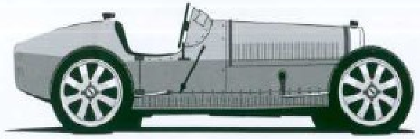
1891
PANHARD-LEVASSOR
(FRANCE)

1908
BAKER ELECTRIC
(USA)

1912
MODEL T
(USA)



1922
LANCIA LAMBDA
(ITALY)



1922
BUGATTI TYPE 35
(FRANCE)

1934
CHRYSLER AIRFLOW
(USA)

1938 (45)
VW BEETLE
(GERMANY)

1945
JEEP WILLIES (CJ)
(USA)

1948
FORD F1 TRUCK
(USA)

1956
CHEVROLET BEL AIR
(USA)

1959
BMC MINI
(ENGLAND)

1959
COOPER CLIMAX T51
(ENGLAND)

1962
LOTUS ELAN
(ENGLAND)

1963
JEEP WAGONEER
(USA)

1965
CHAPPAREL

1975
VW GOLF

1985
CHRYSLER MINIVAN
(USA)

1990
SMART FORTWO
(GERMANY)

1992
HUMMER H1
(USA)

1998
GEM E4
(USA)

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body shop at the beginning of the 20th Century;

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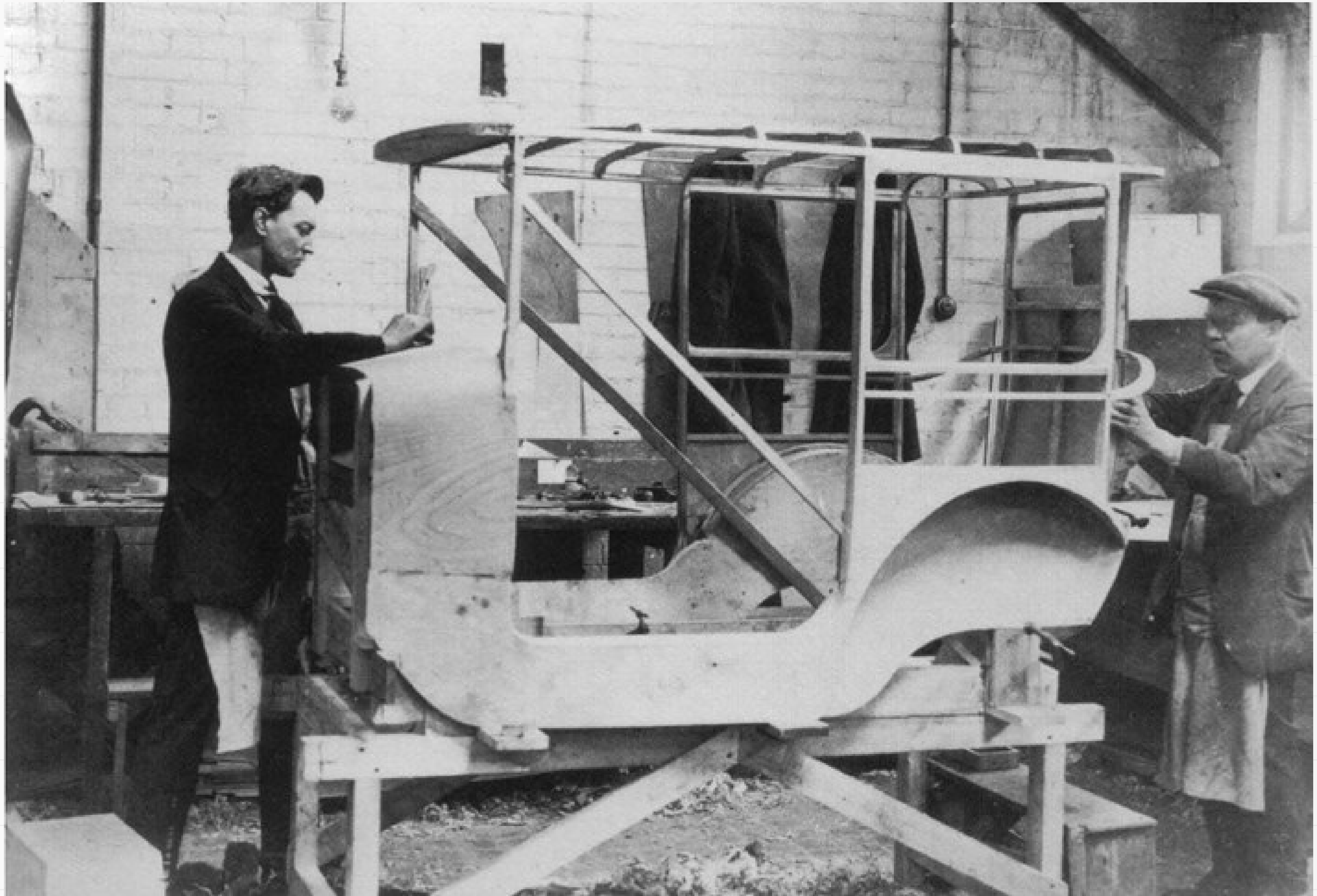

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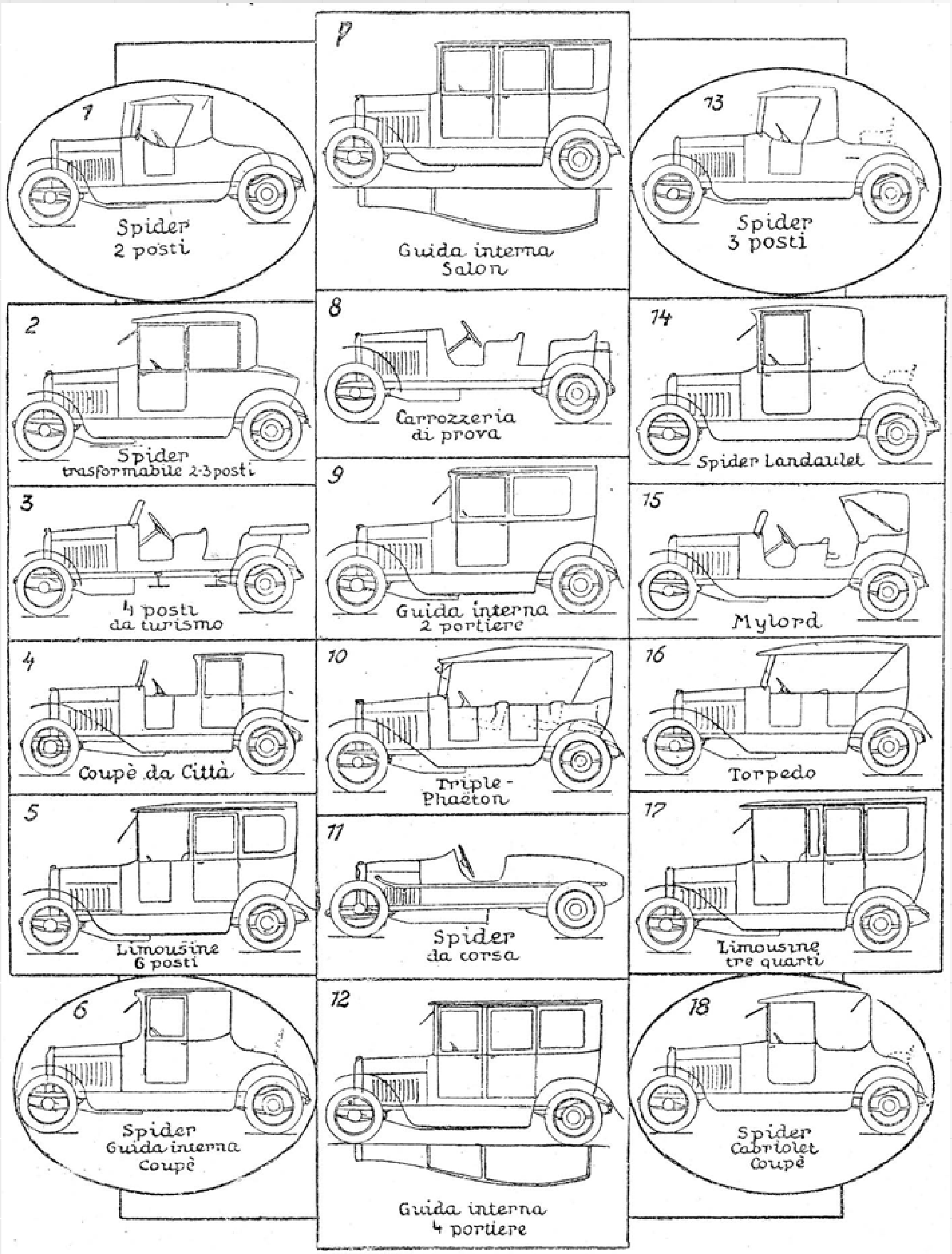
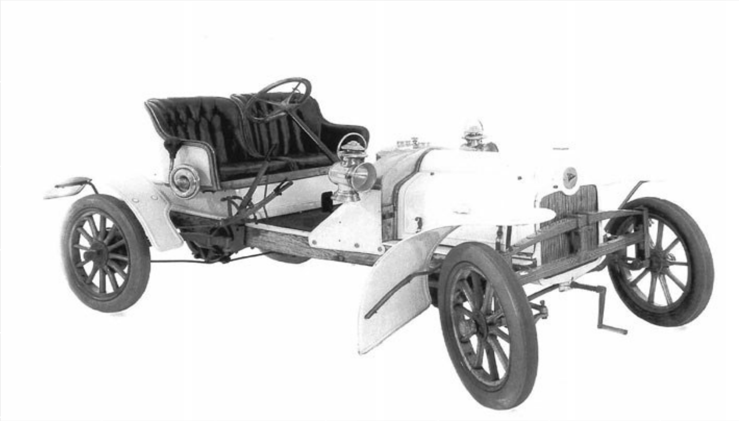
Body styles classified at the beginning of the 20th Century in an Italian engineering manual



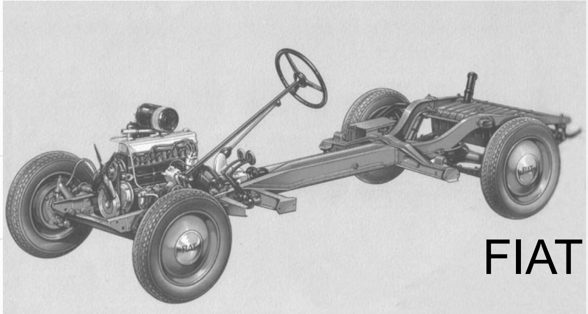
Historical evolution of chassis frame and body shell will be presented according to three historical periods

1. Non-unitized chassis frames;



1907 Sizaire Naudin;
a wooden chassis frame with steel sheet body.

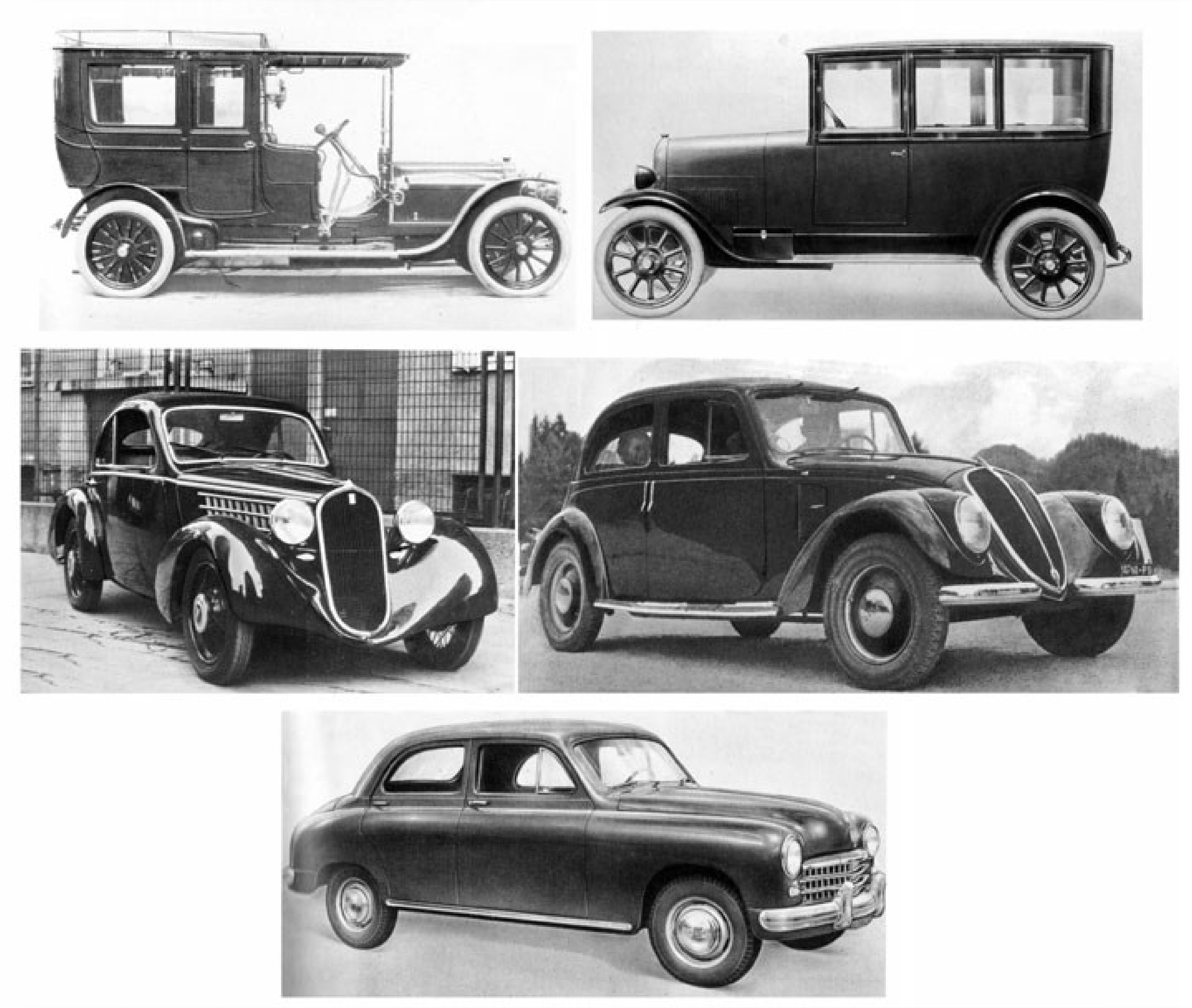
2. Partially unitized chassis frames;



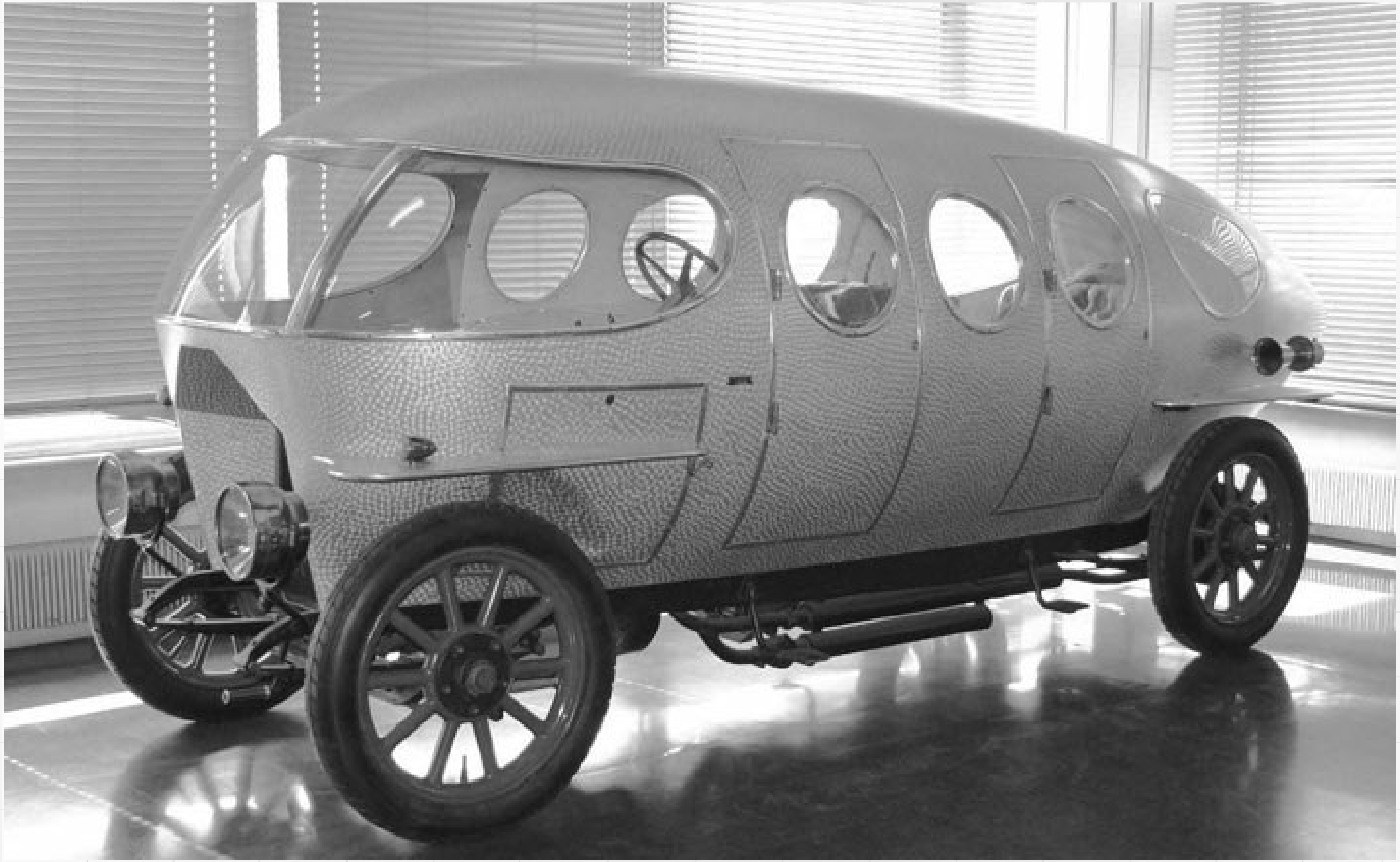
FIAT 1500 of 1935;

3. Unitized chassis frames or unitized bodies.

Body Shape Evolution



Body Shape Evolution



Body Shape Evolution

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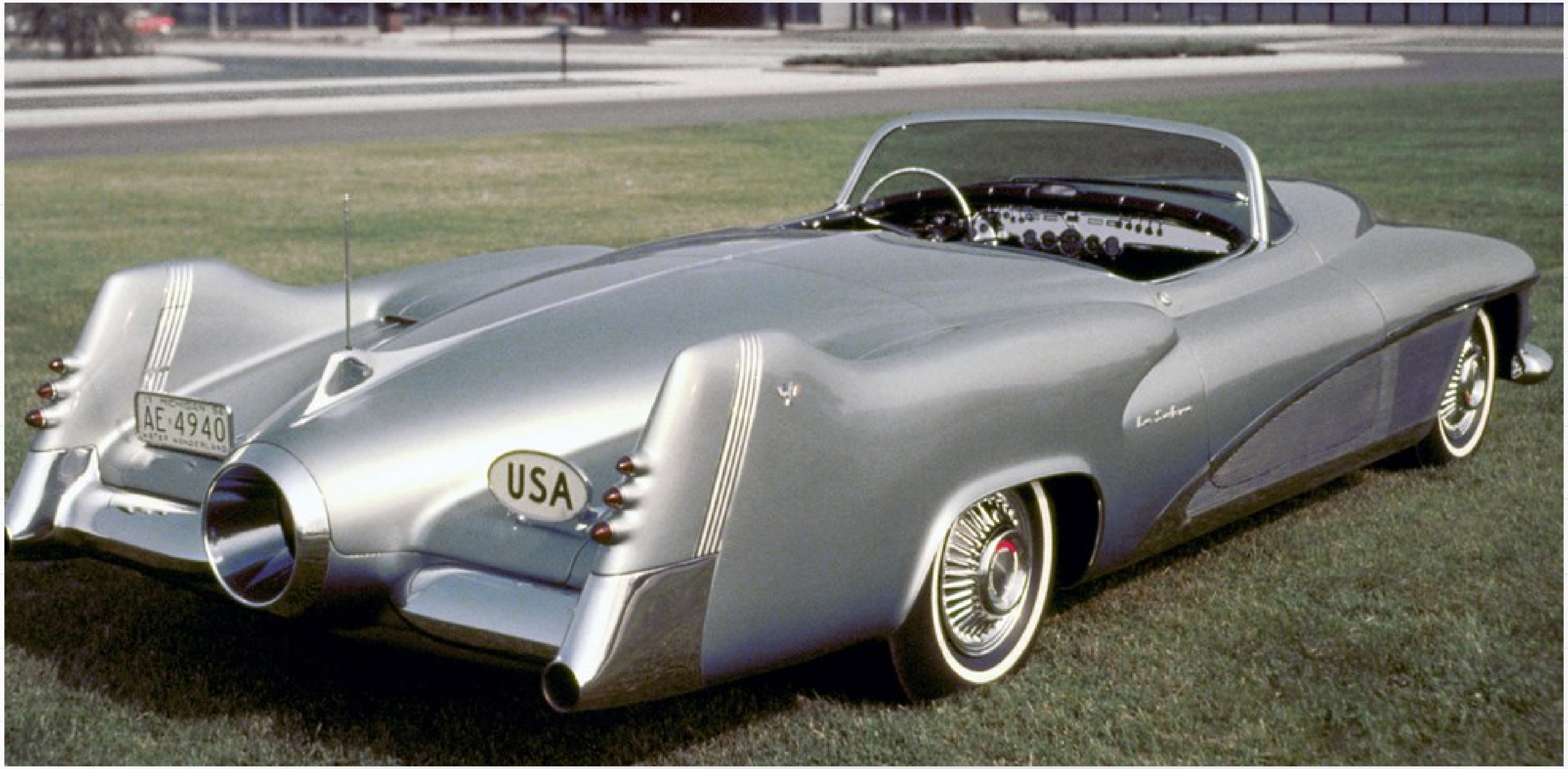
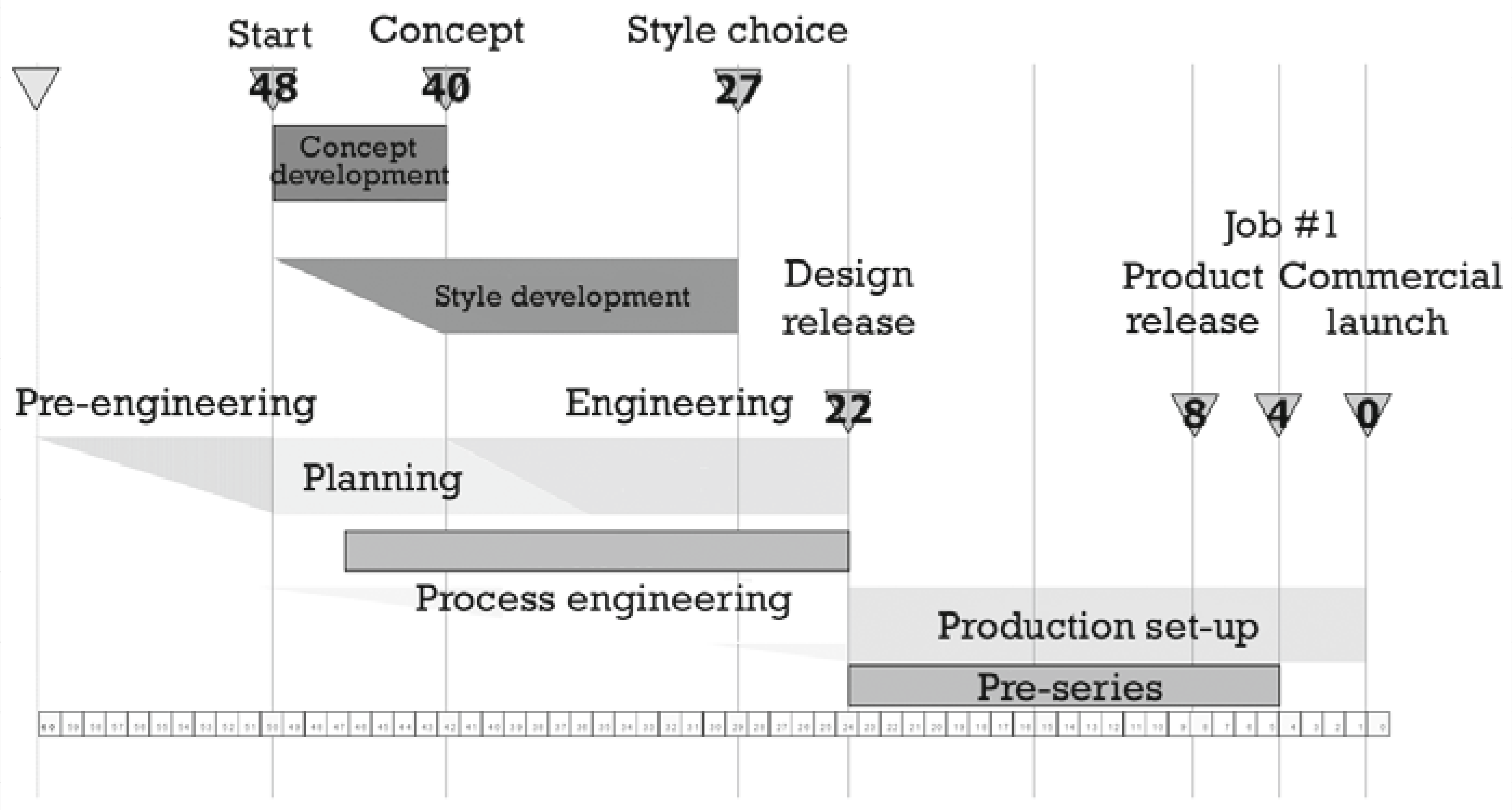
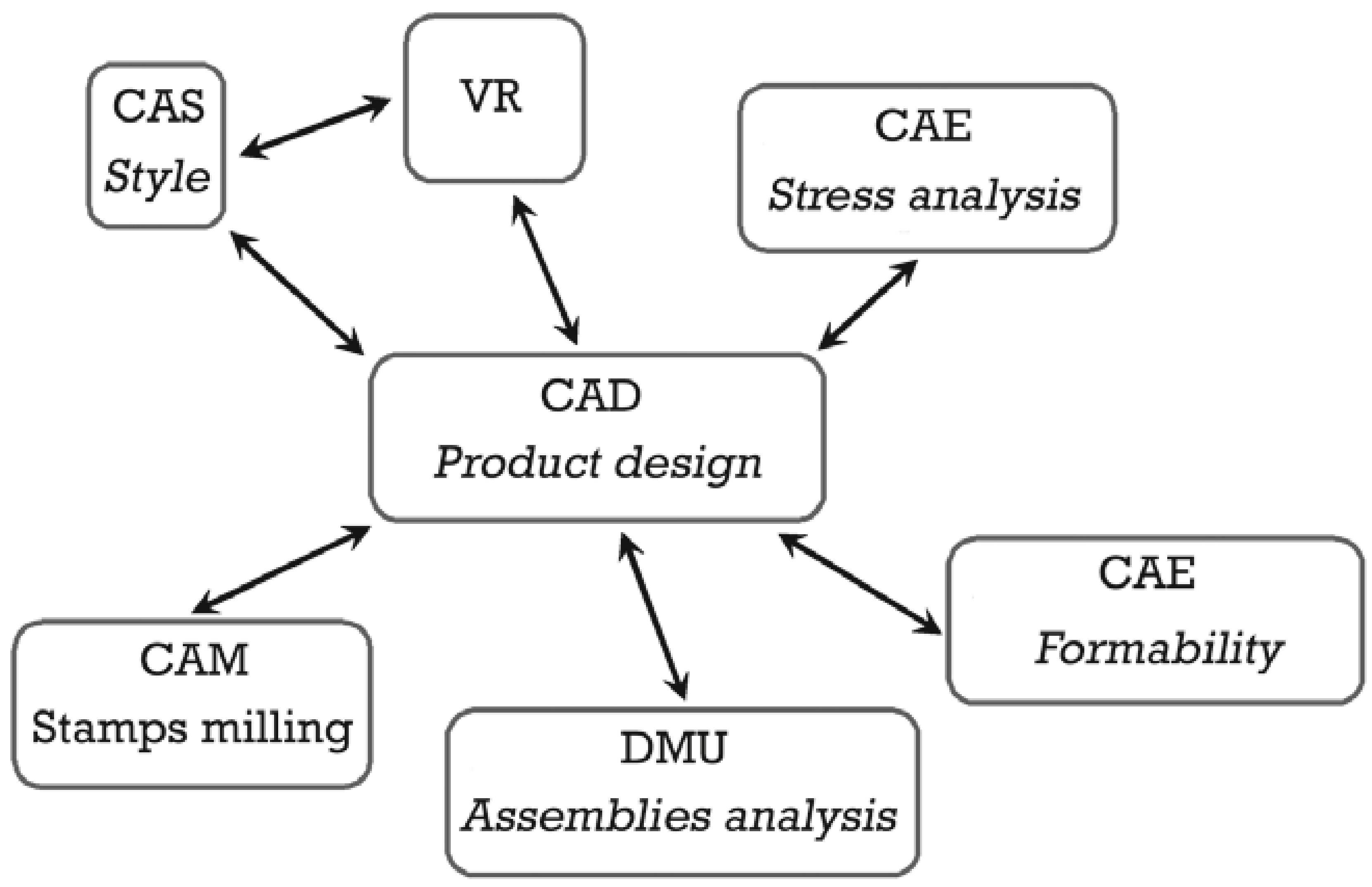
Body Shape Evolution



The logical scheme of the main phases of the development process




CAS
Style
VR
CAE
Stress analysis
CAD
Product design
CAM
Stamps milling
DMU
Assemblies analysis
CAE
Formability

The purpose of body design is to achieve the following

- **Aesthetics**: to provide a pleasing overall appearance, surface quality and consistent details.
- **Structural function**: to support the weight of the transported passengers and load as well as the mechanical parts required for vehicle propulsion, control and other system functions, so withstanding mechanical stresses frommultiple sources.
- **Ergonomy and roominess**: to supply easy access and adequate room for the driver, passengers and transported goods.
- **Safety**: to ensure integrity of passenger compartment in the event of a crash, while absorbing the impact energy as well as to reduce injuries to vulnerable road users (pedestrians, wheelers), in case of collision.
- **Aerodynamics**: to minimize drag due to air impact; to control air flow effects on tyre-road contact and vehicle stability.
- **Insulation**: to minimize noise, vibration and thermal transmission, generated by body walls, by lack of sealing between compartment and movable parts and by thermal radiation from the surfaces of passengers compartment.
- **Visibility**: to provide the highest possible day and night visibility on the environment and to host the lighting devices in the most effective way

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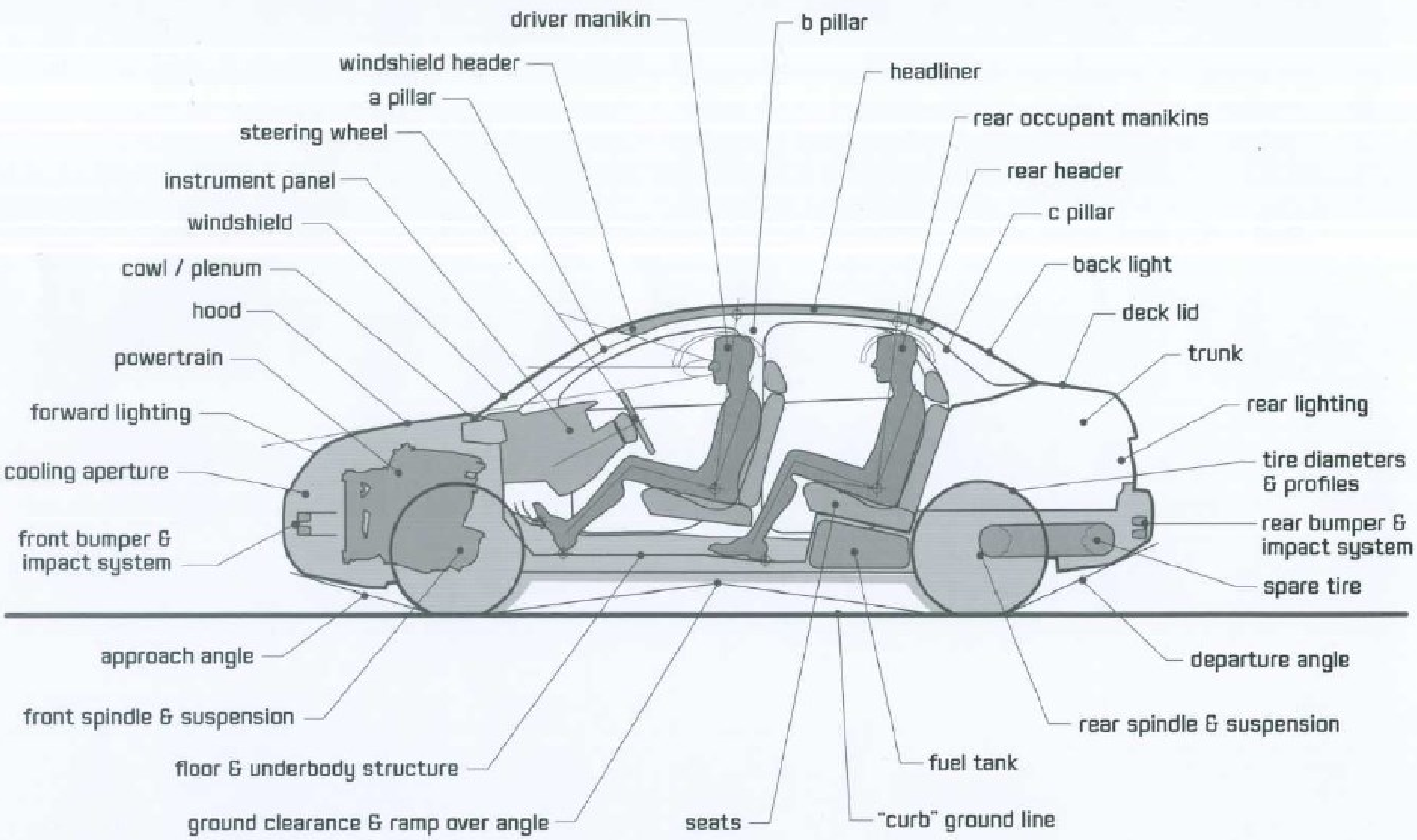
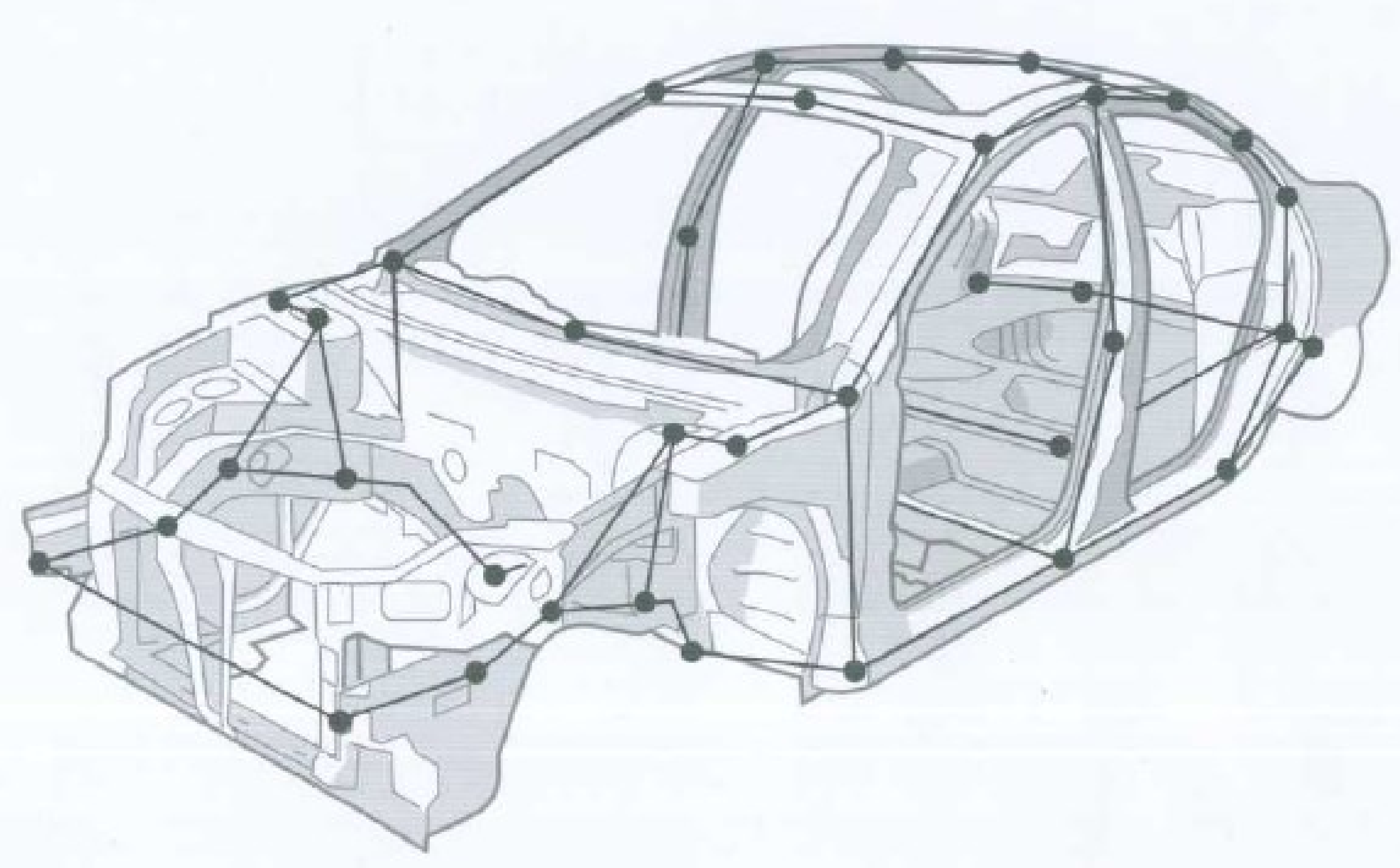
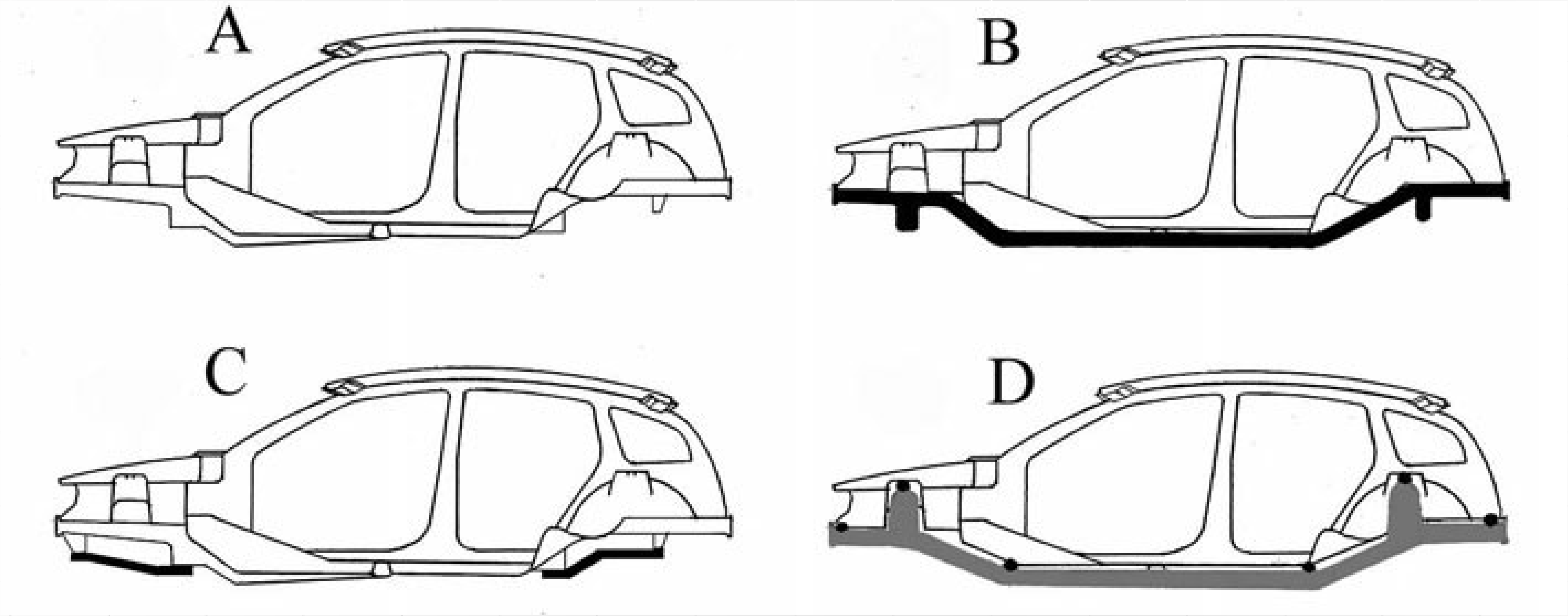




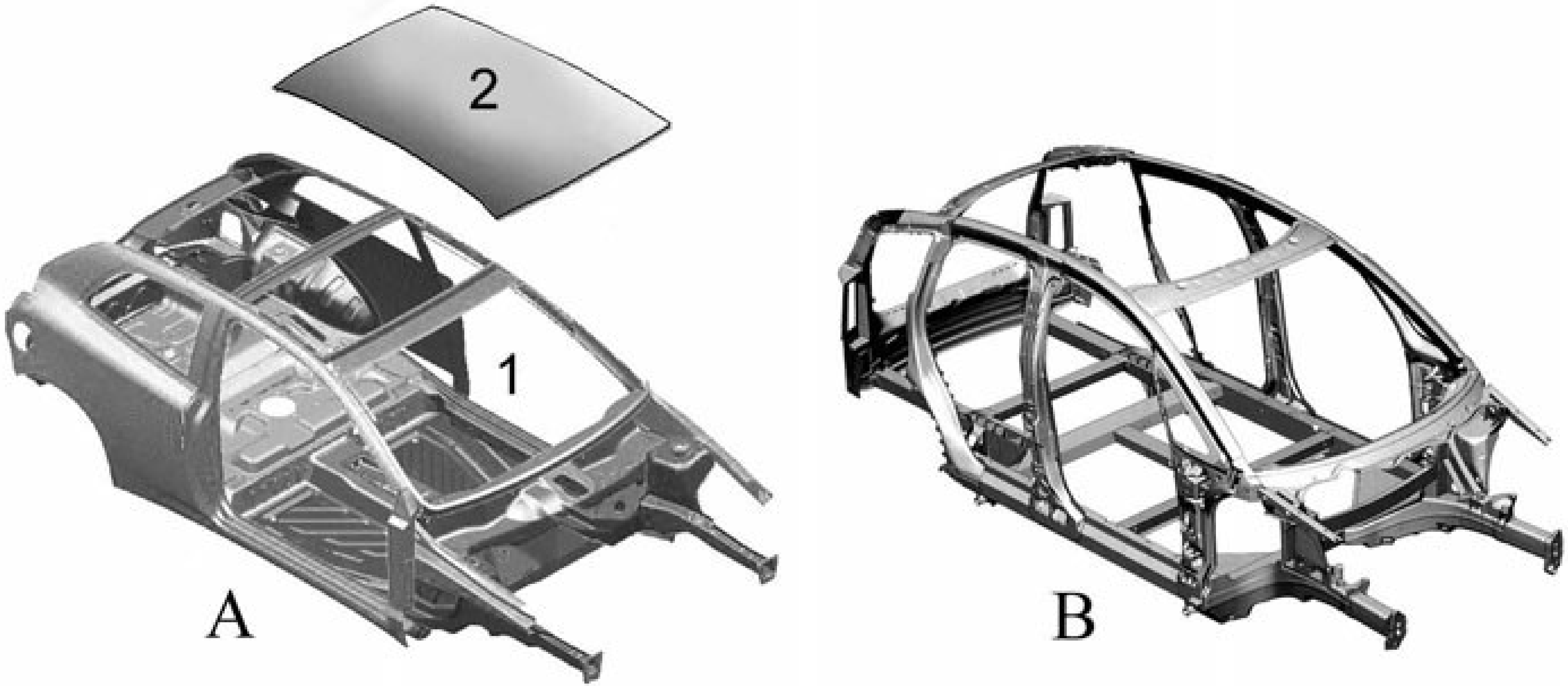
configurations of the underbody

A. ***Unitized body* or *unibody***, in which the chassis parts cannot be physically removed from the upper body parts.
B. ***Body on frame***, where the chassis frame is connected to upper body frame by bolts with or without the inter-position of rubber bushes
C. ***Body with ancillary subframes***, for powertrain and suspension systems; connections between the subframe and the body can be either rigid or through elastic bushes
D. ***Dual frame body***, in which body and chassis are separate and connected through elastic and damping bushes



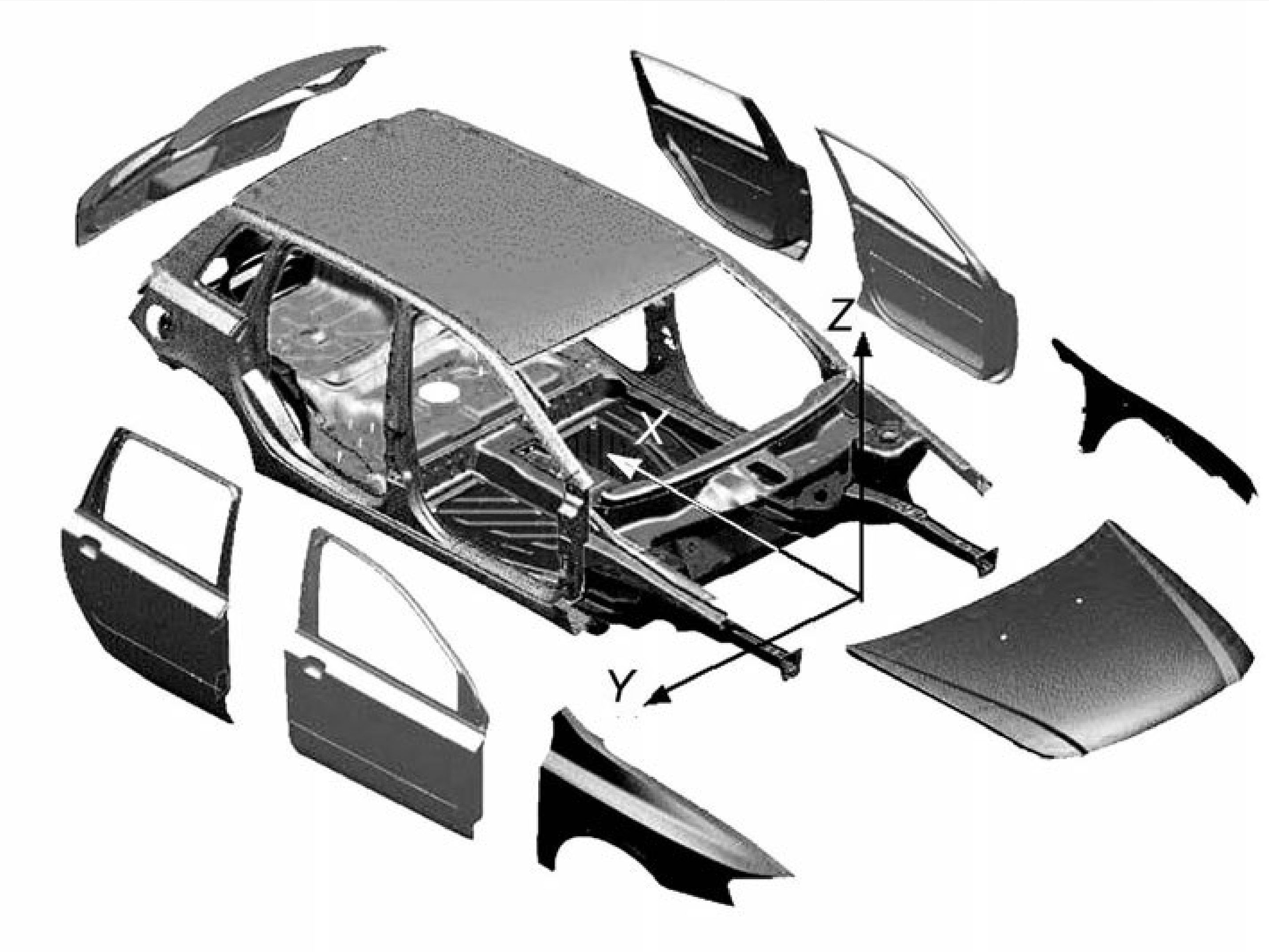
Body in White (B.I.W.)

In the usual configuration, a *body in white* is an assembly of a frame and panels, made up of homogeneous materials (for instance, steel or aluminum sheets or composites).



Body Setting

For a better understanding, it is appropriate to consider the split view of a five door *body in white (B.I.W.)* with movable parts



Body Functions

safety

Referring to the safety function, body parts can be divided into three families:

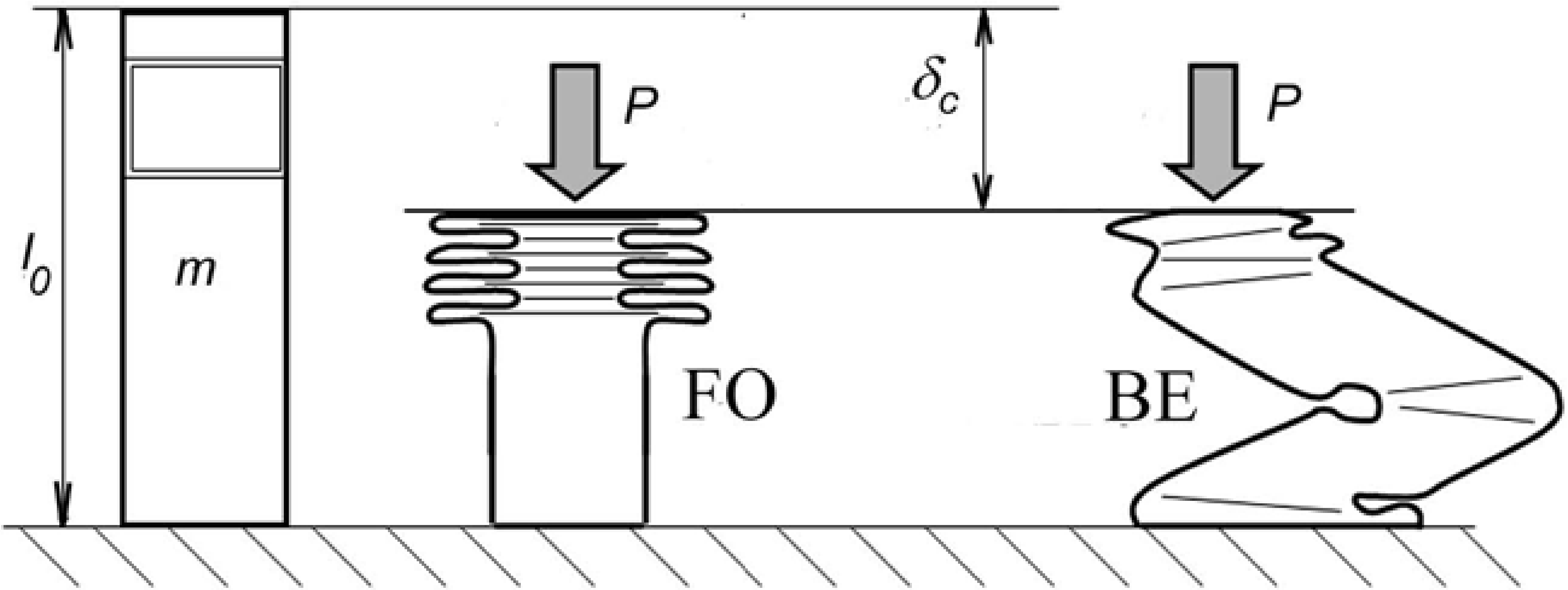
1. ***Outer panels***, usually deep drawn, whose resistance to deformation and therefore absorption capacity are very low.
2. ***Underbody frame***, with prevailing horizontal layout, designed to face strong axial loads and absorb a relevant amount of energy while crushing.
3. ***Passenger cabin frame***, designed to face relevant bending loads.

In practice, thin body outer panels have no influence at all on passengers safety, but are very important with respect to external vulnerable road users (mainly pedestrians and cyclists).

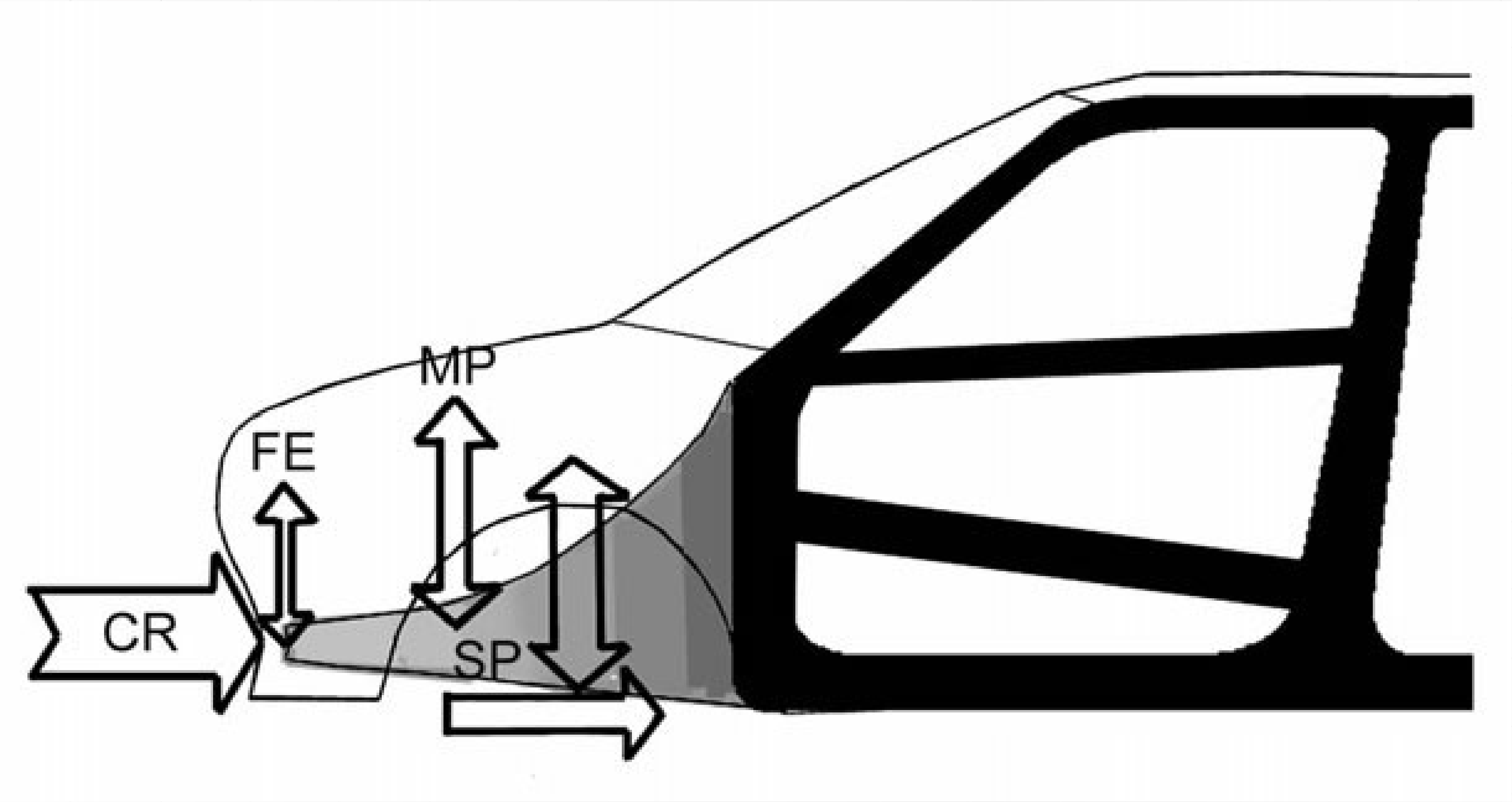
Body Functions

frontal crash

Front rails must support suspensions and, in the same time, absorb the frontal crash energy, caused by loads with the main component in *X* direction



Main load position on front frame and their cause.



MP: power train;
SP: suspension and steering;
FE: front end;
CR: crash

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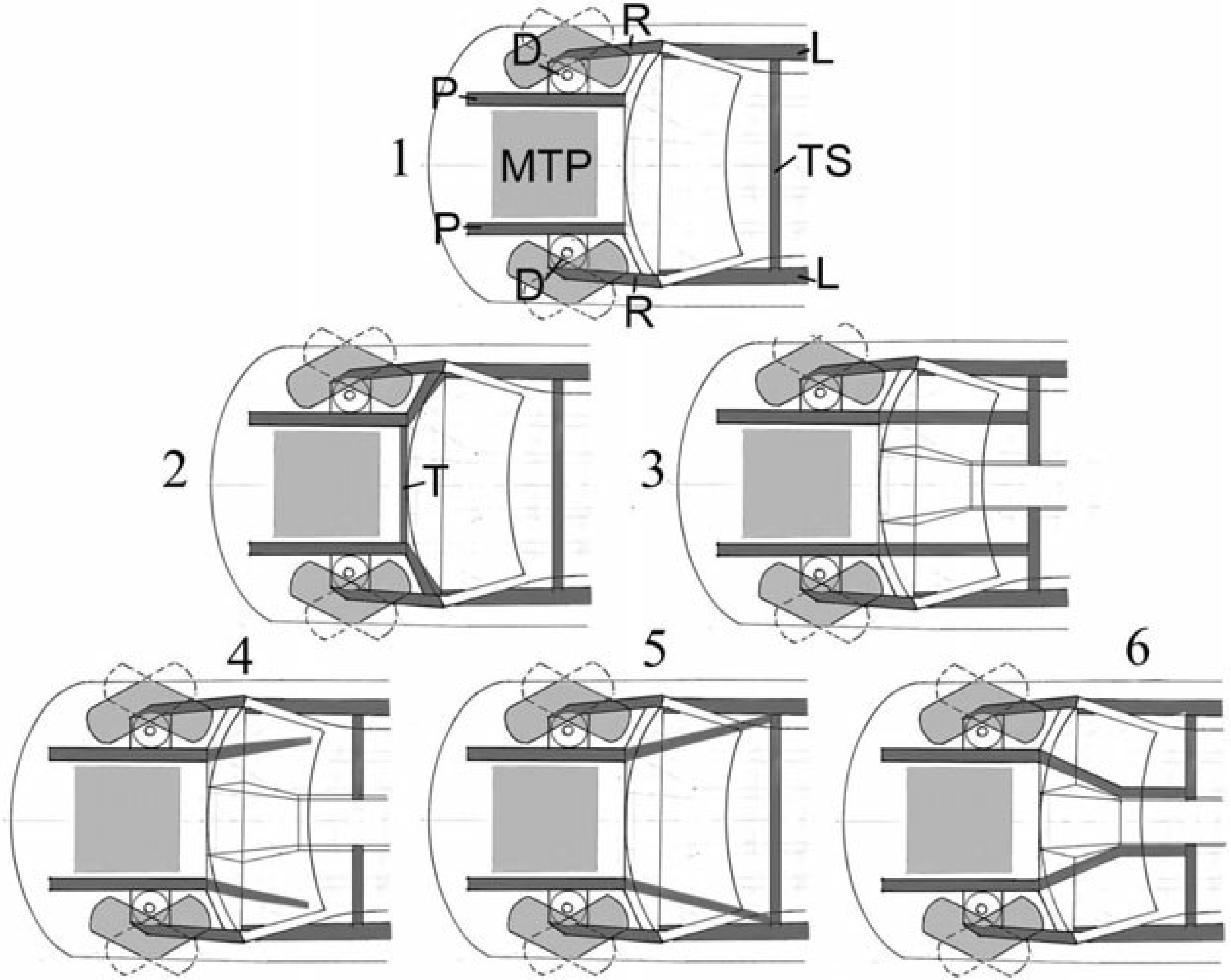


Contributions of front frame single members in terms of front crash Energy absorption *EA*.

A) impact at 56 km/h against offset rigid barrier

B) full front impact at 56 km/h against rigid barrier.

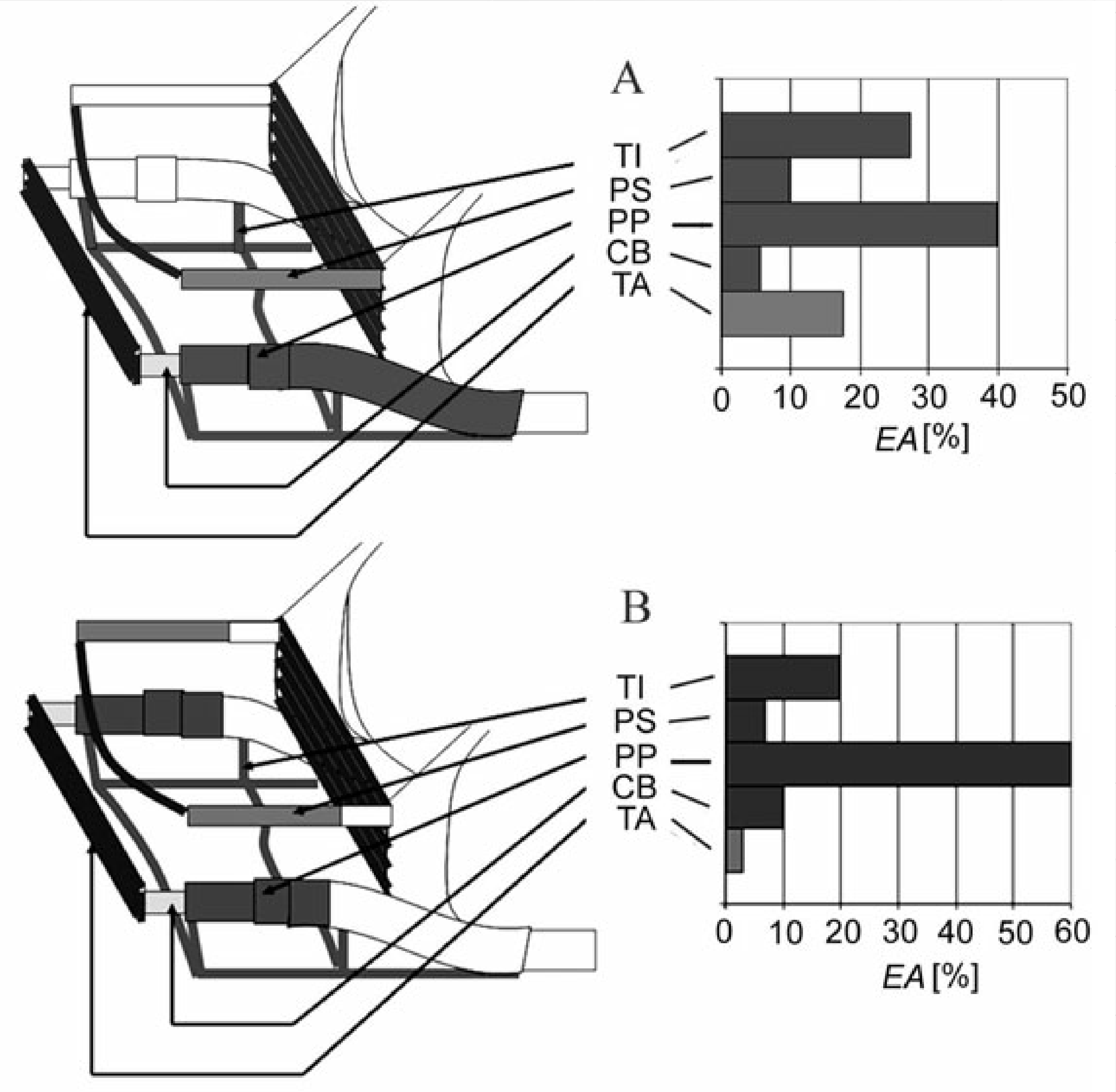
TI) lower frame;

PS) upper rail;

PP) main front rail;

CB) crash box;

TA) front cross member

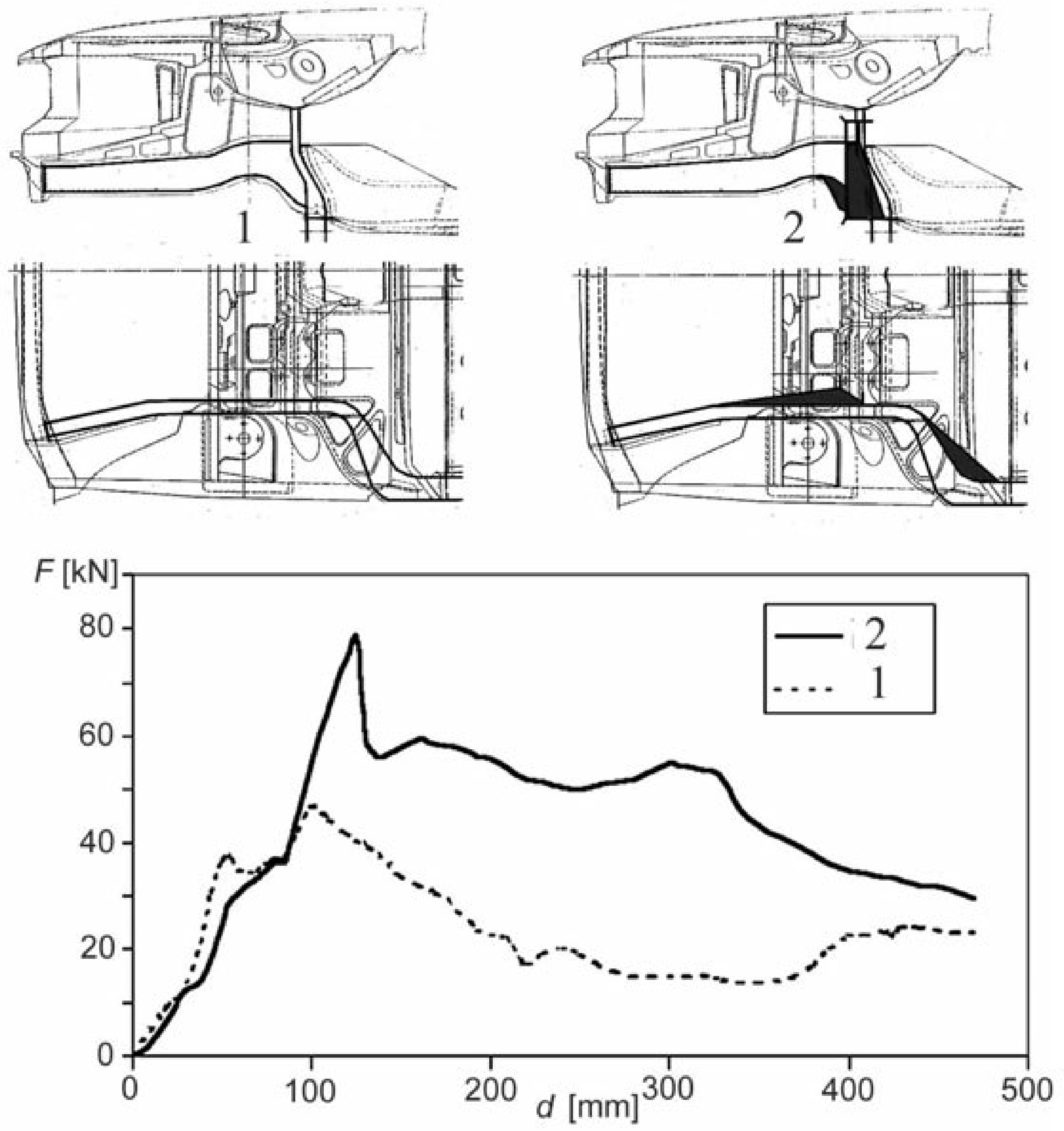


The following criteria can be adopted to increase front frame energy absorption capacity:

- **avoid section throats**, that could become plastic hinges;
- **increase sections and thickness towards the compartment** in order to have a progressive reaction of members;
- **avoid curves and joints with respect to the longitudinal axis**, because these areas would collapse suddenly, effectively wasting the potential contribution of straight members;
- **connect single members assigned to the task of energy absorption** in order to provide a consistent reaction against different impact counterpart frames and impact directions

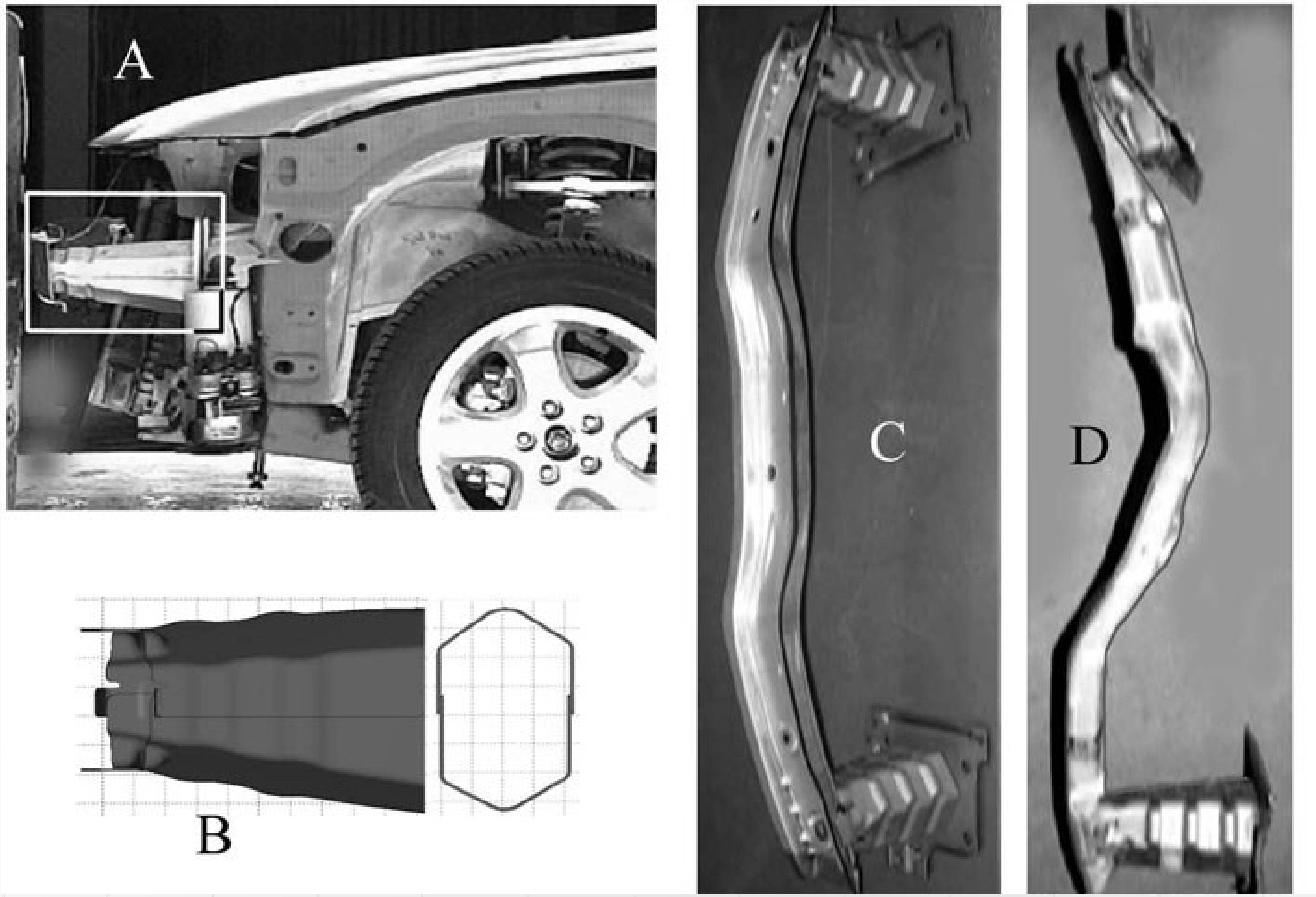
Frame 2 has been obtained from frame 1, by implementing the following changes:

- increase of front rail connecting section to firewall and sills,
- increase of stiffness of double firewall for a better fitting to sills



Crash boxes

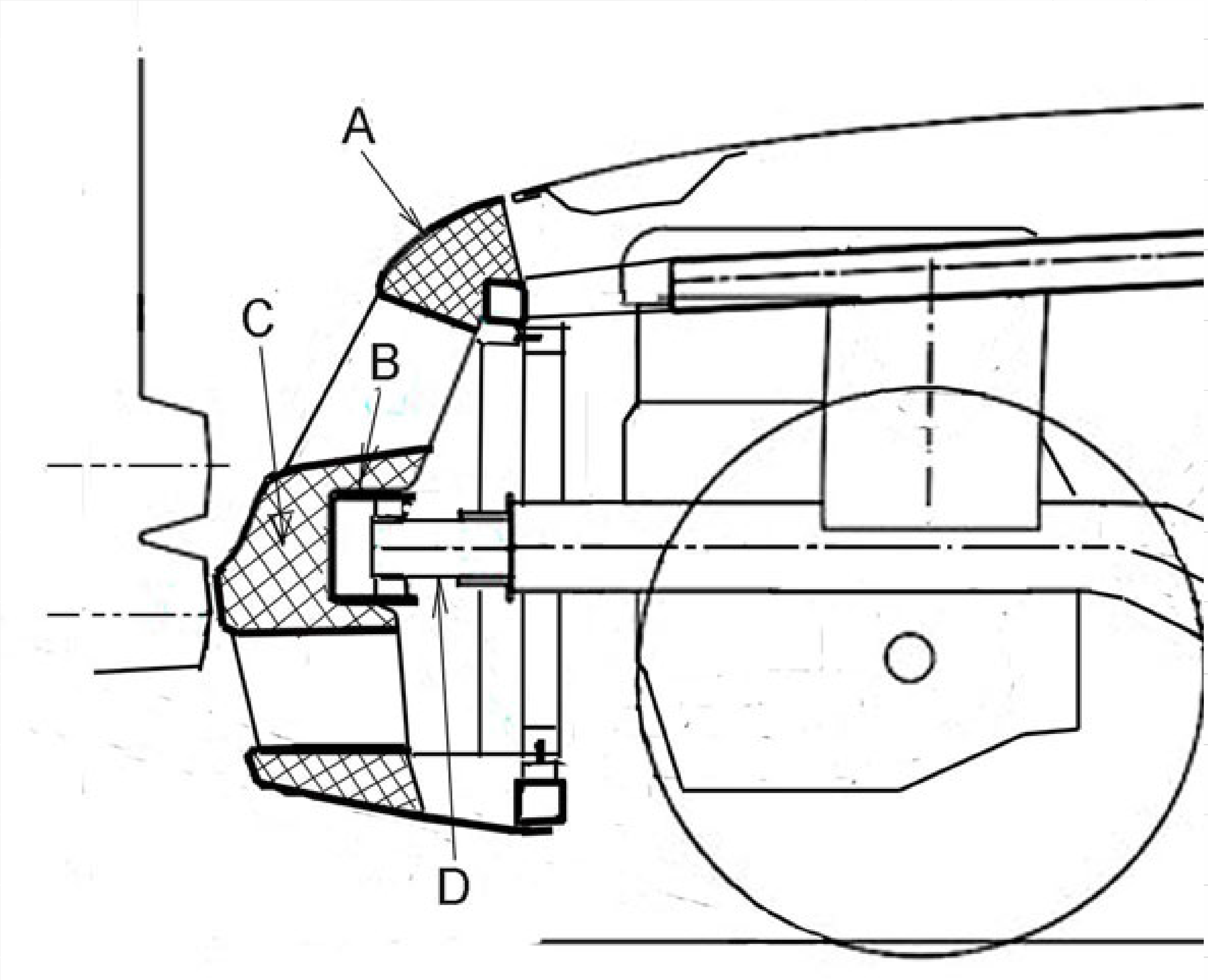
crash boxes are made up of a small boxed member screwed to the front rail and to bumper cross member. This device has the task of crushing during a front crash between 10 and 15 km/h, absorbing the impact energy without plastic deformation of the front rail

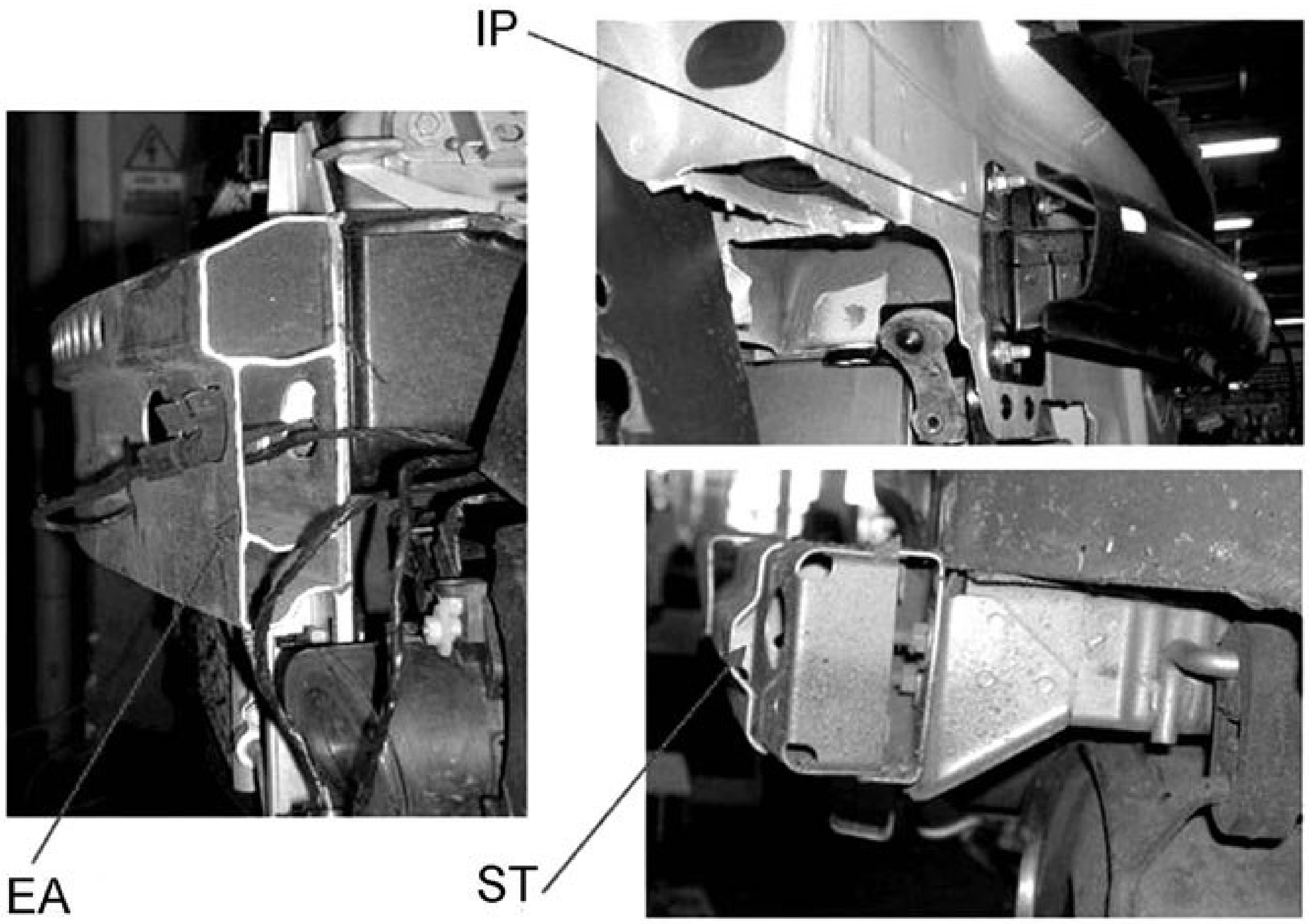


Bumpers

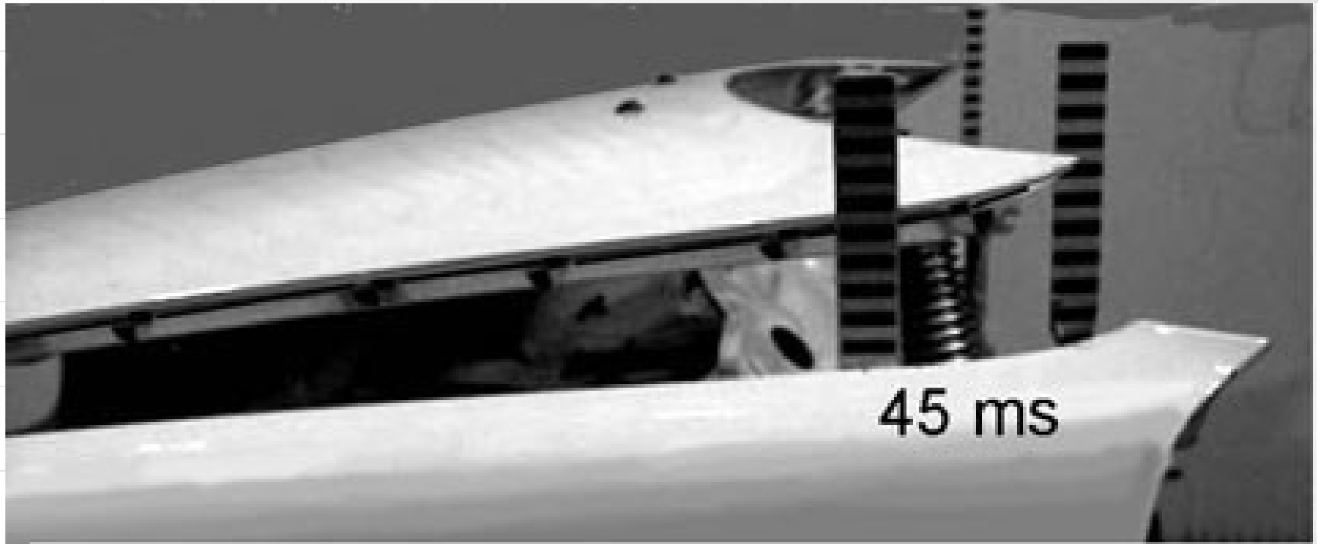
Bumpers

A) flexible skin;
B) Supporting bar;
C) foam insert;
D) absorbing/damping device.

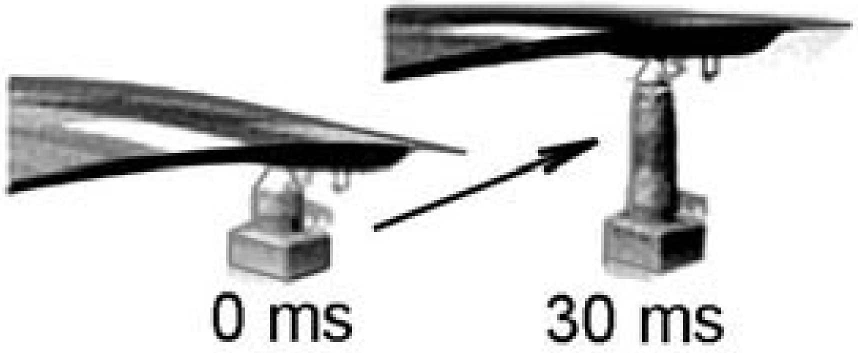




IP: injection molded thermoplastic;
EA: extruded aluminum;
ST: steel.


45 ms


30 ms


0 ms
30 ms

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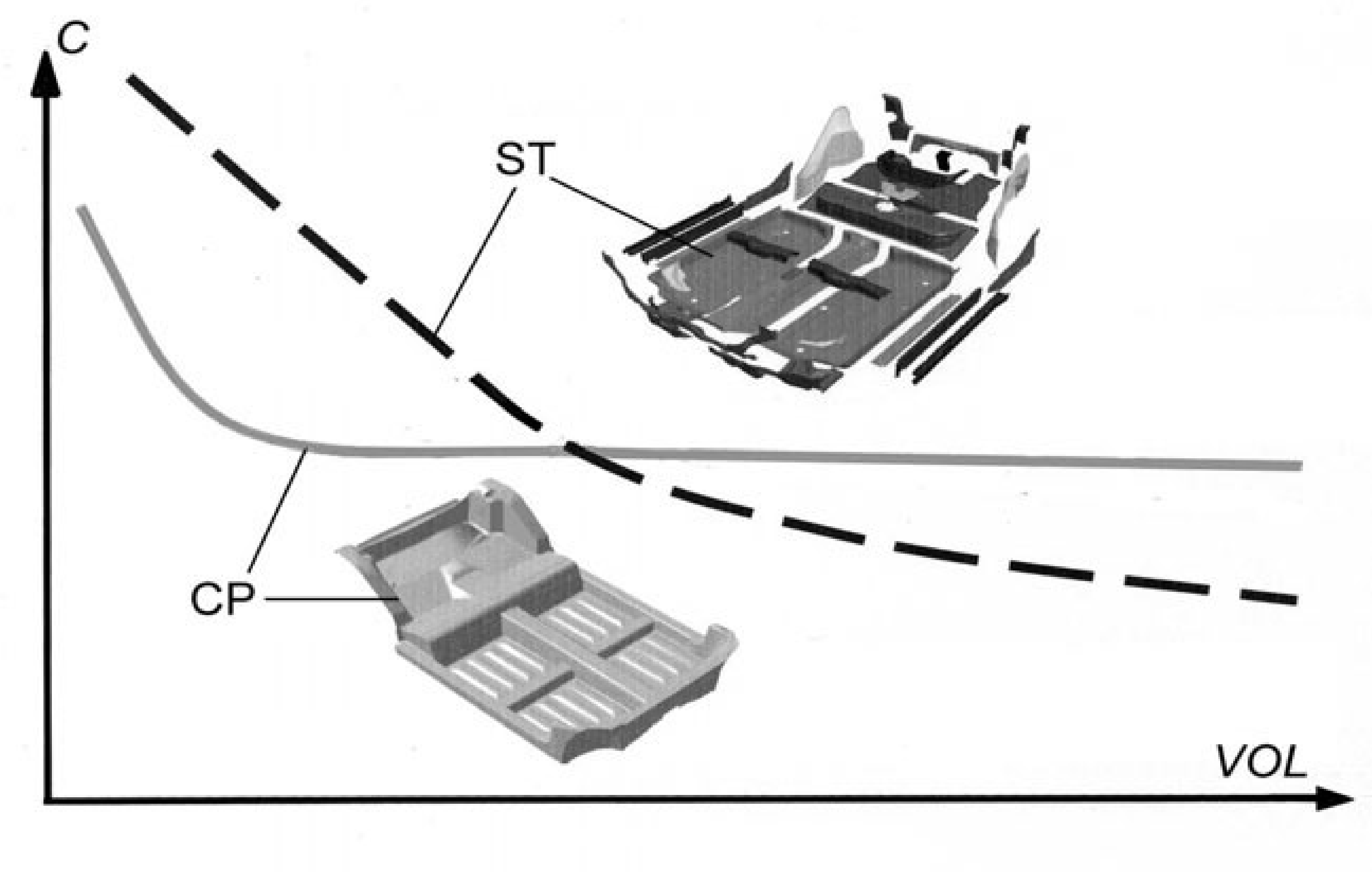
Compartment Floor



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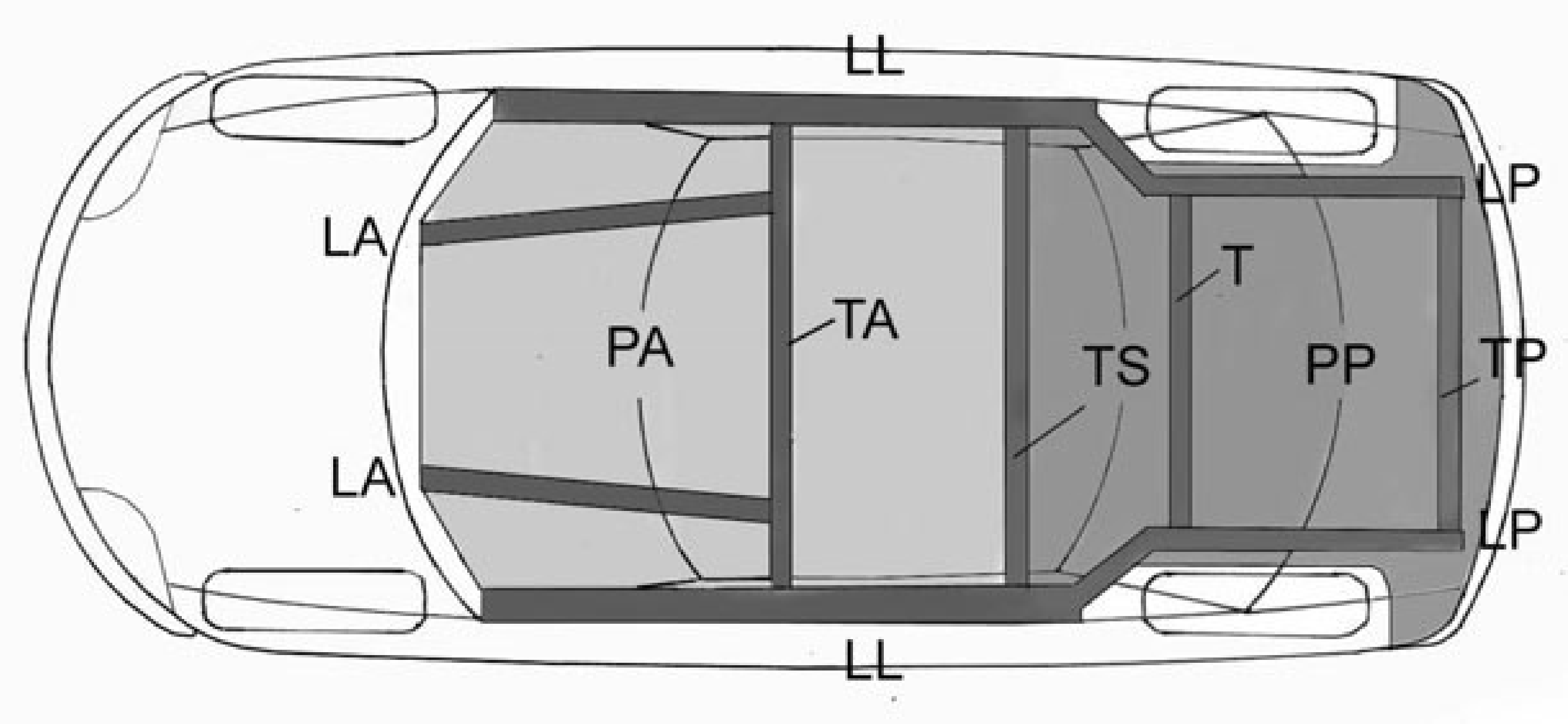
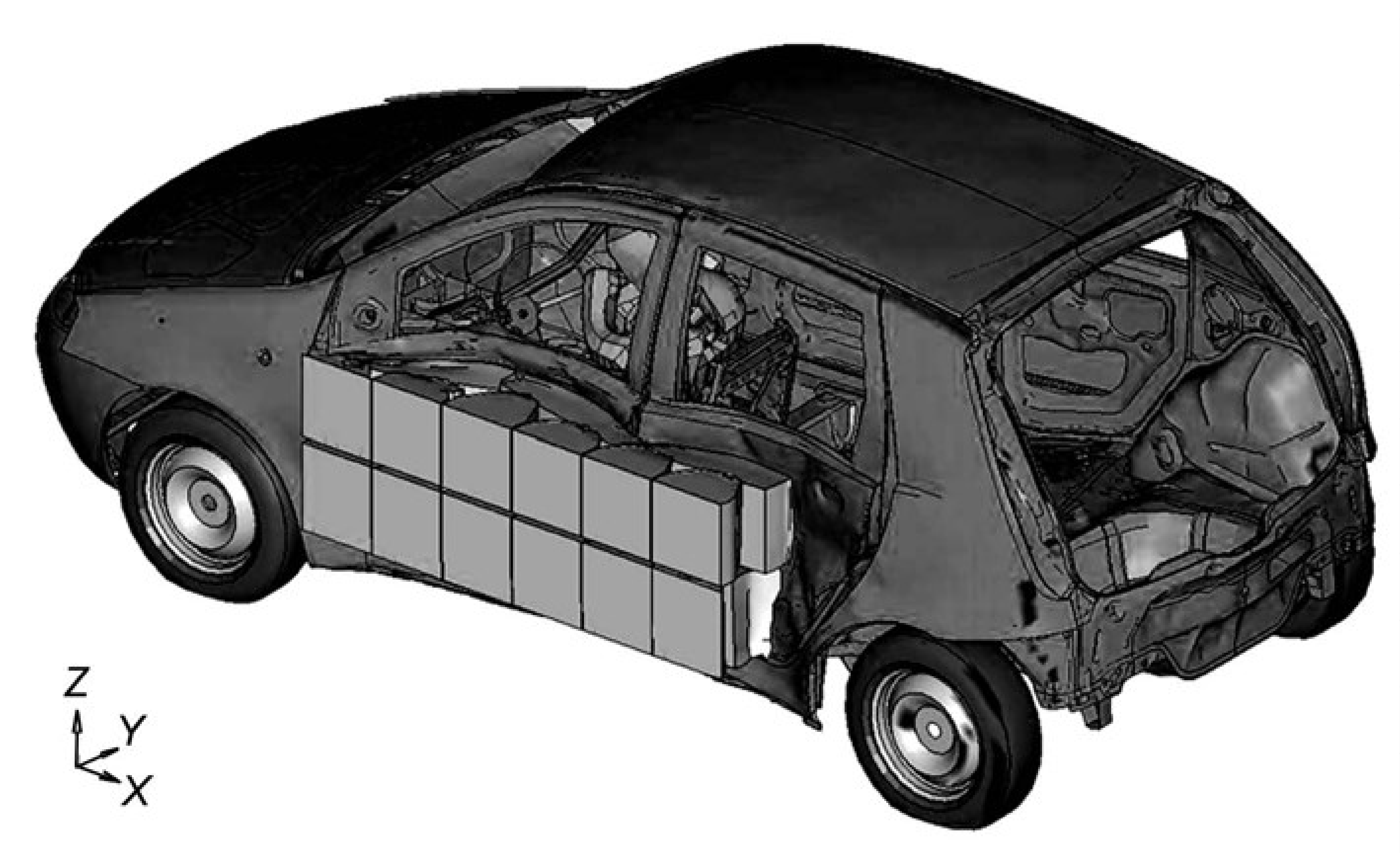
Compartment Floor

- two longitudinal rails (LA) below front floor and two (LP) below rear floor;
- two side sills (LL);
- a front seats cross member (TA) and a rear seats cross member (TS);
- a cross member between rear wheel houses (T) and a rear cross member (TP);
- a front floor (PA);
- a rear floor (PP), sometimes split in two pieces for stamping requirements



Side crash



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Body Side Specifications

The critical design properties of the body side are:

- dimensional precision of door housing,
- stiffness of nodes and beams,
- resistance to concentrated loads on hinges, latches and belt anchorages,
- fatigue strength,
- impact resistance,
- air and water tightness.

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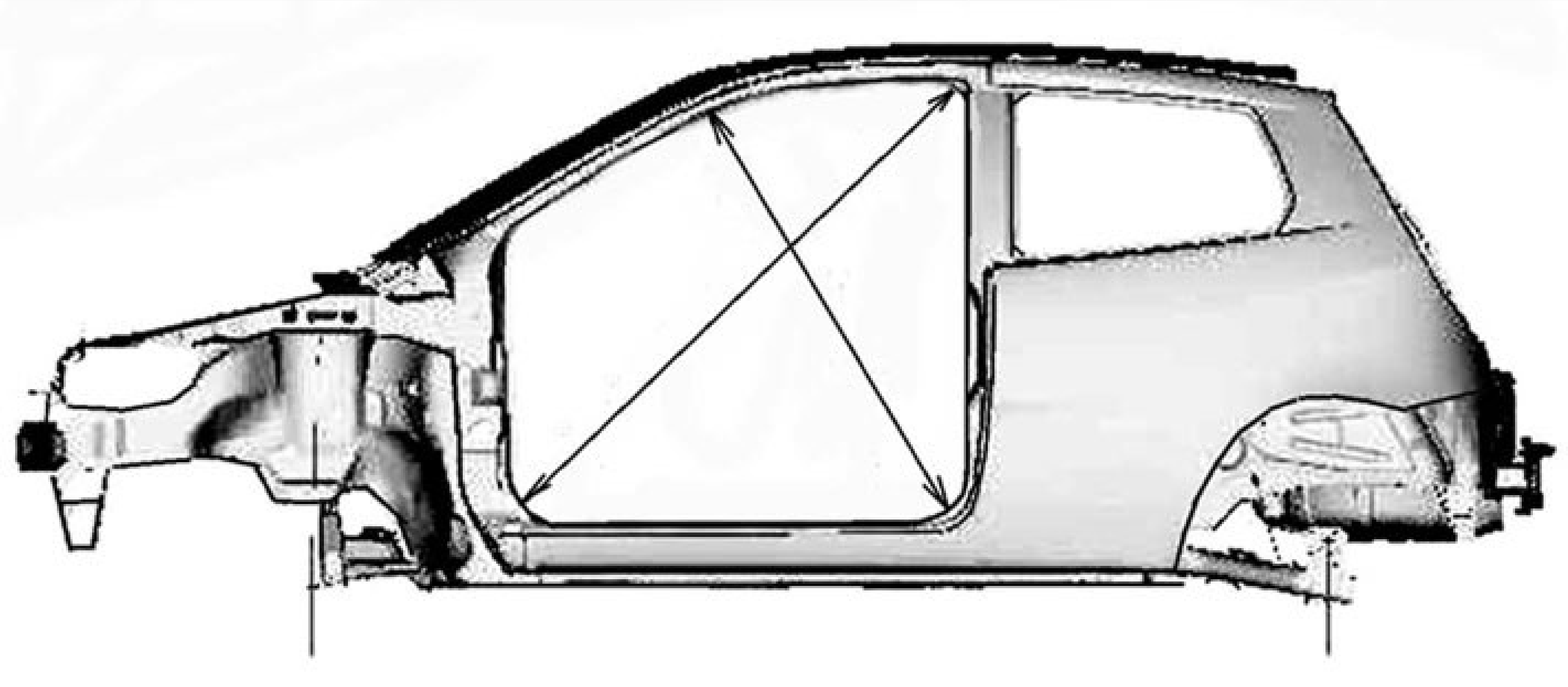
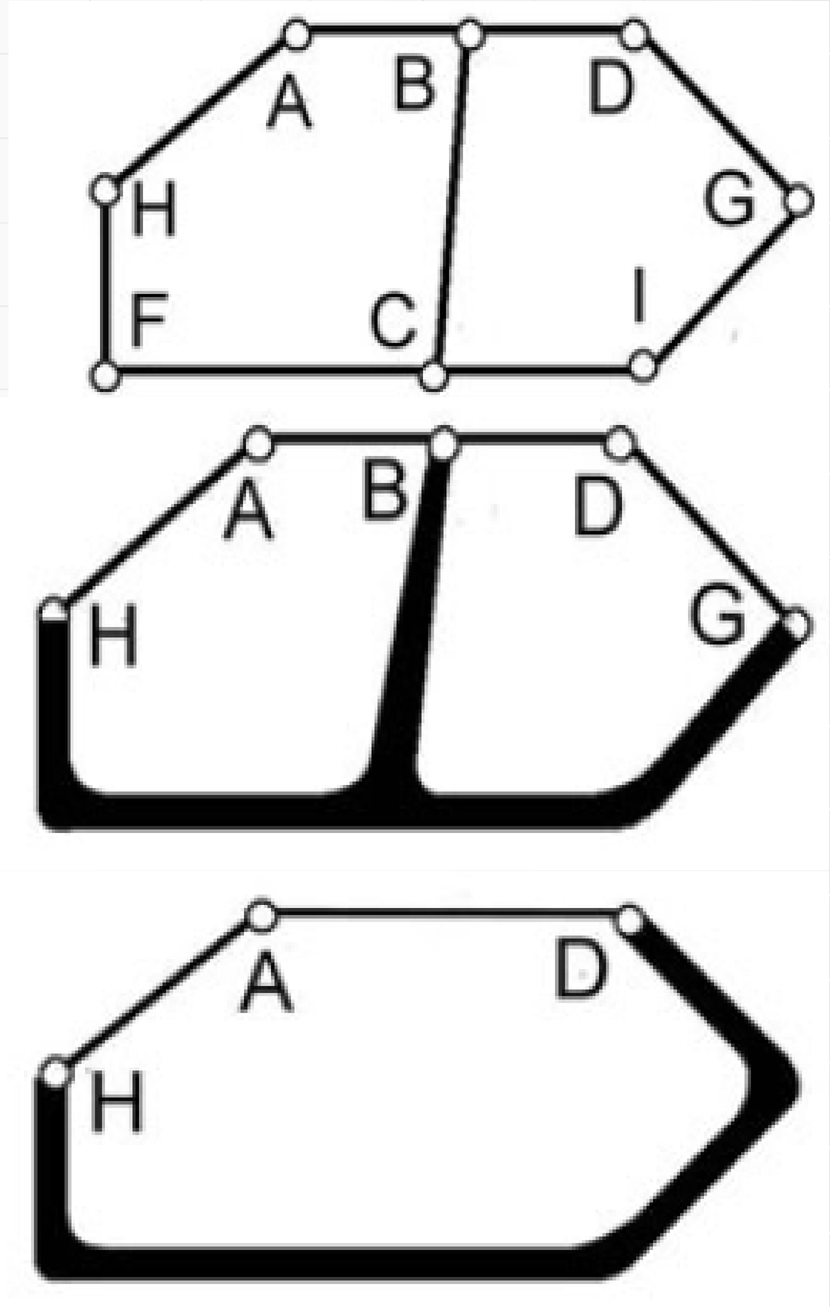
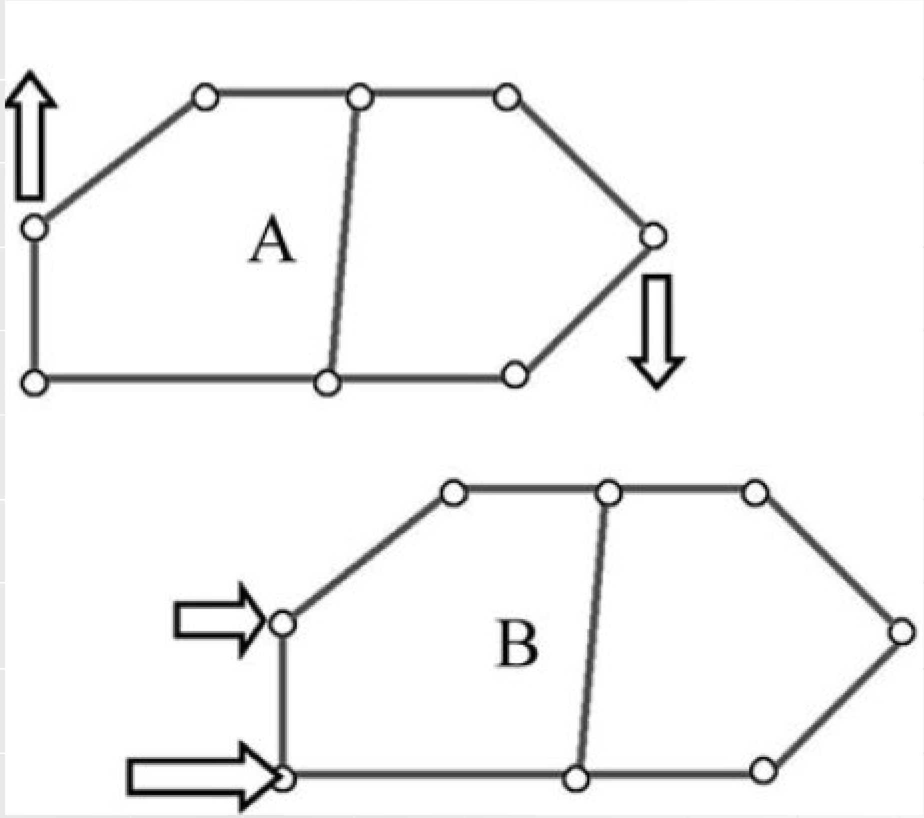
dimensional precision of door housing



Main nodes can be identified





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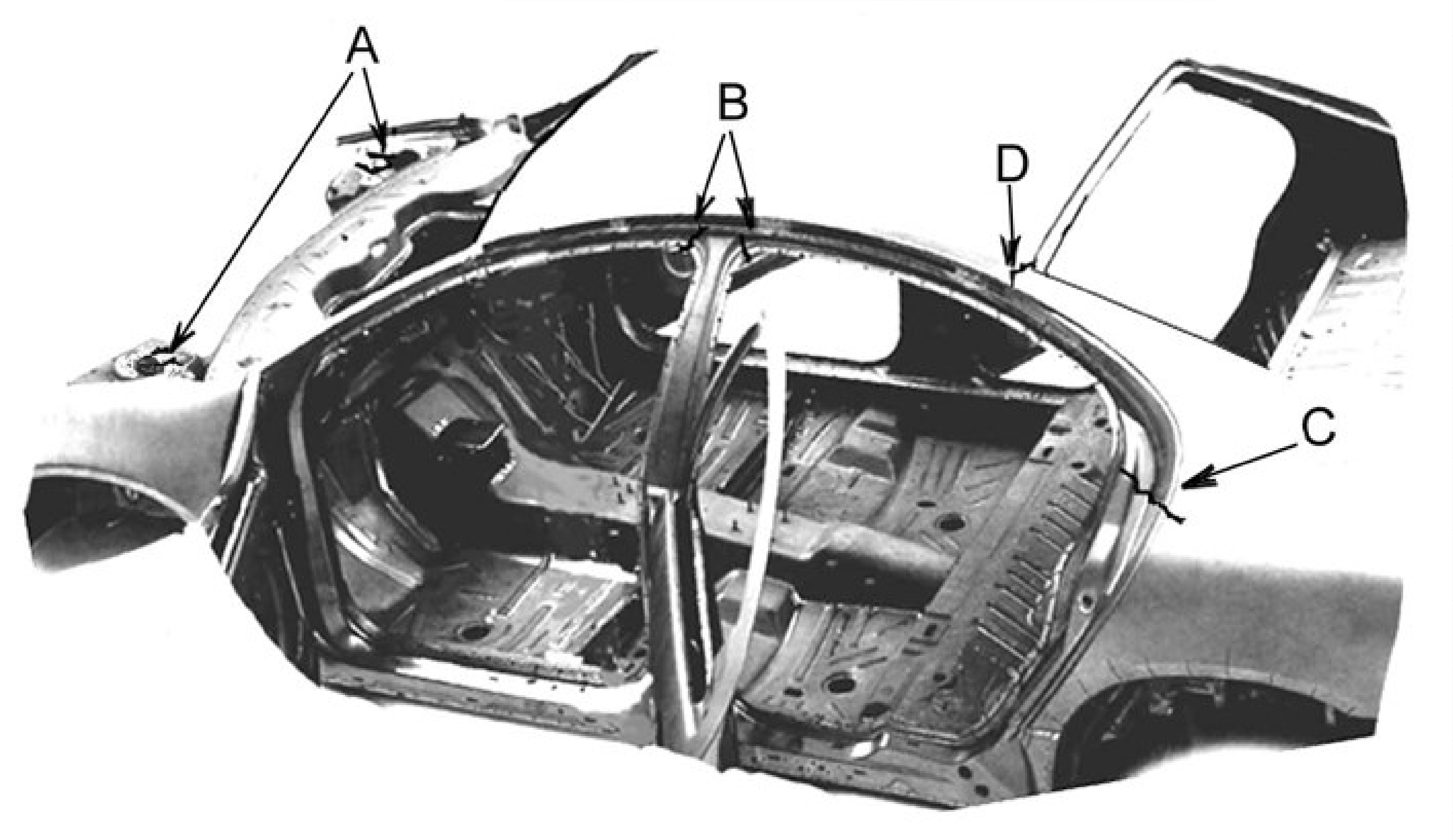
common fatigue crack initiation locations



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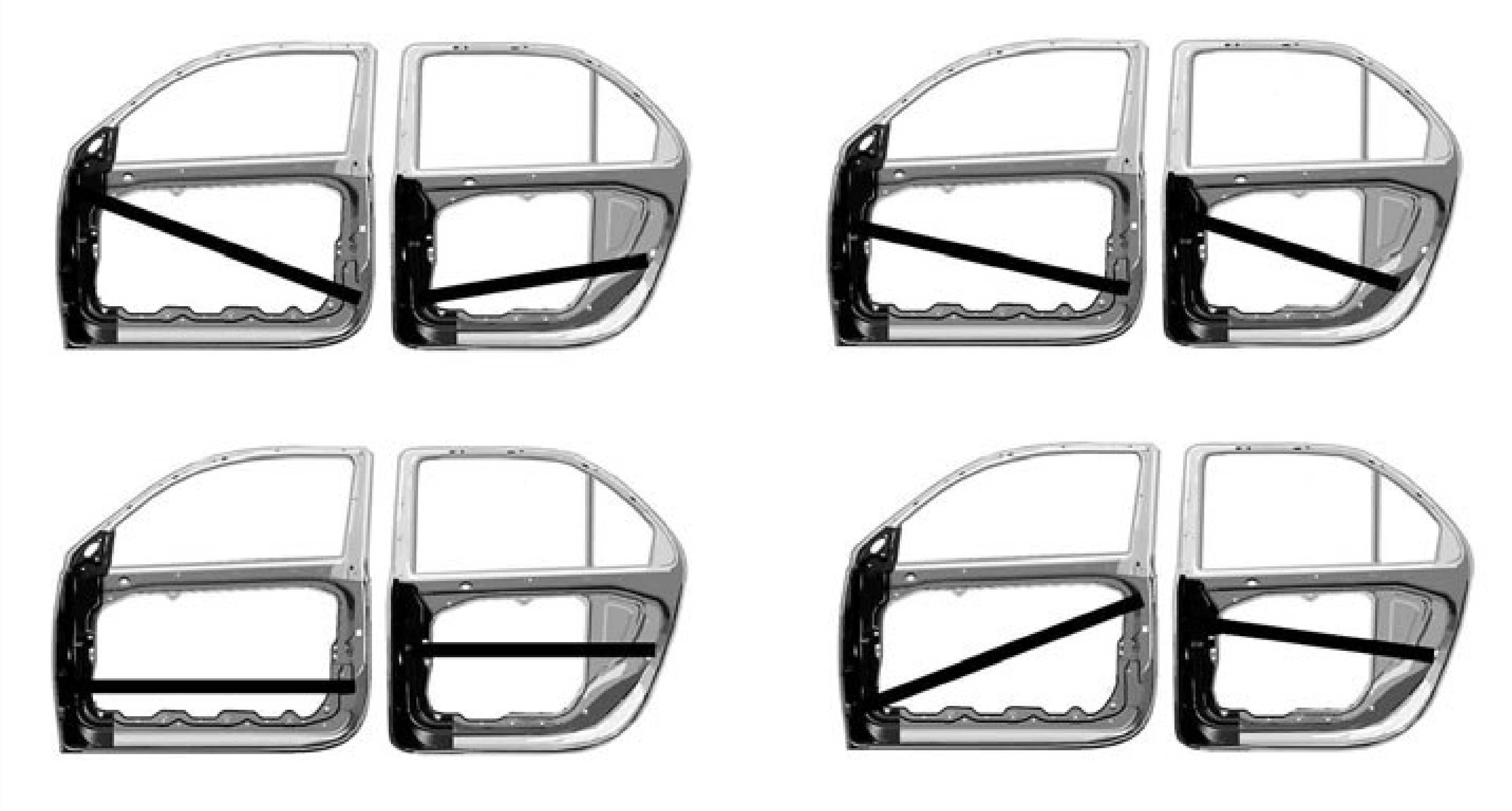
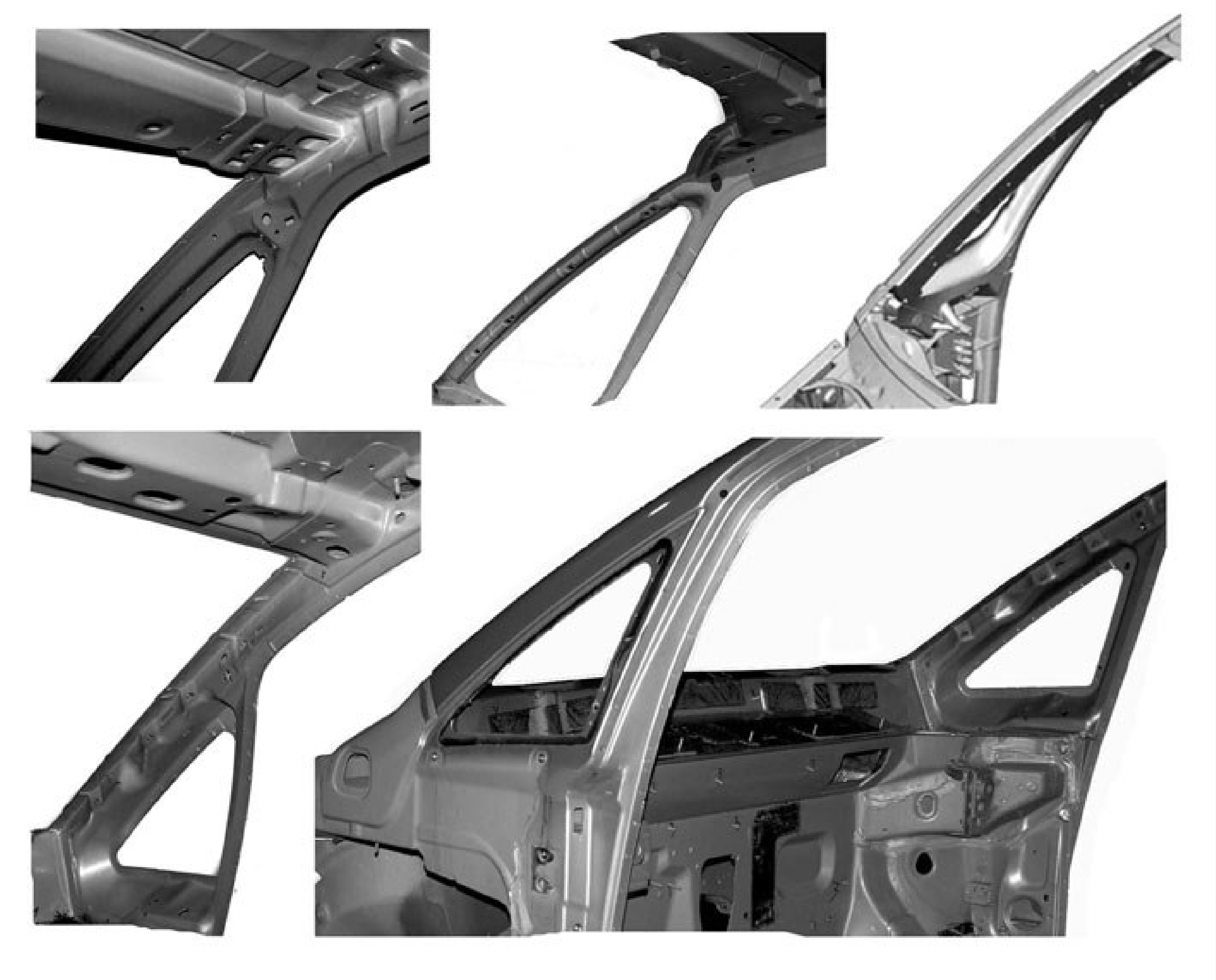
Impact strength



Visibility

First and foremost, driving visibility is a safety factor. For that reason, the visual angles enabled by the windshield and pillars, and the area cleaned by the windshield wiper must comply with the international regulation



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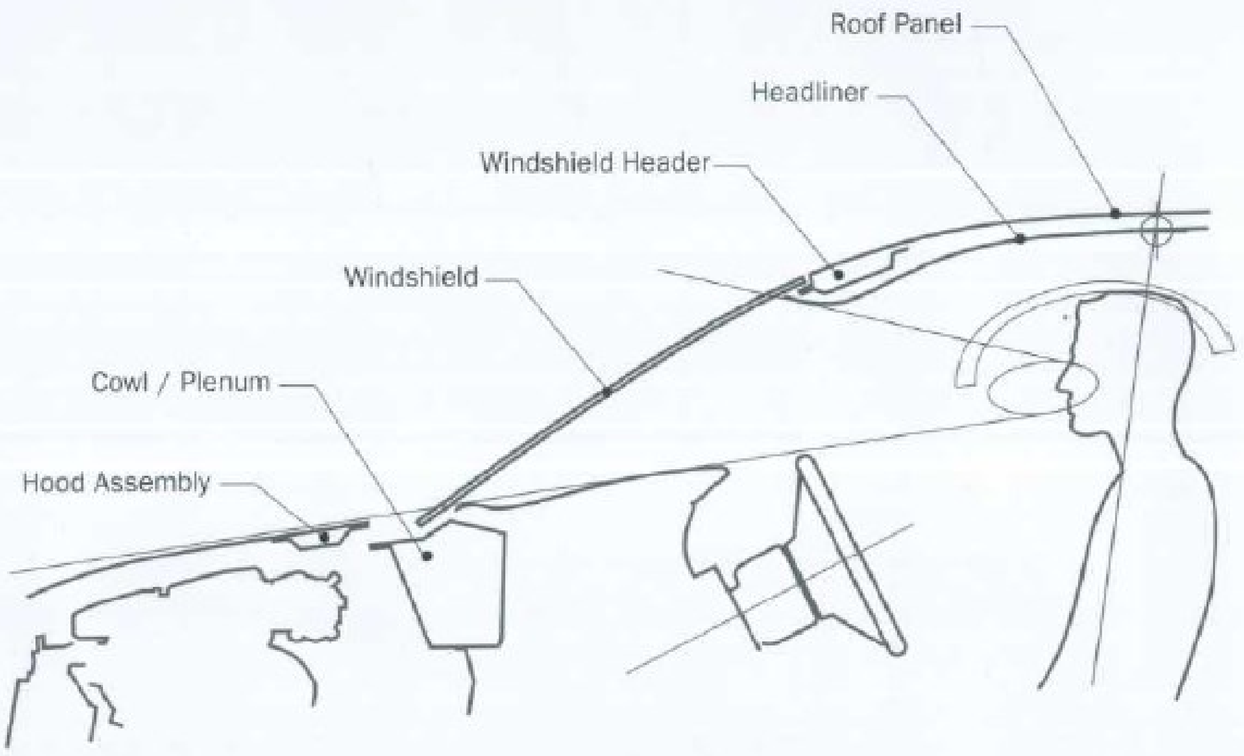
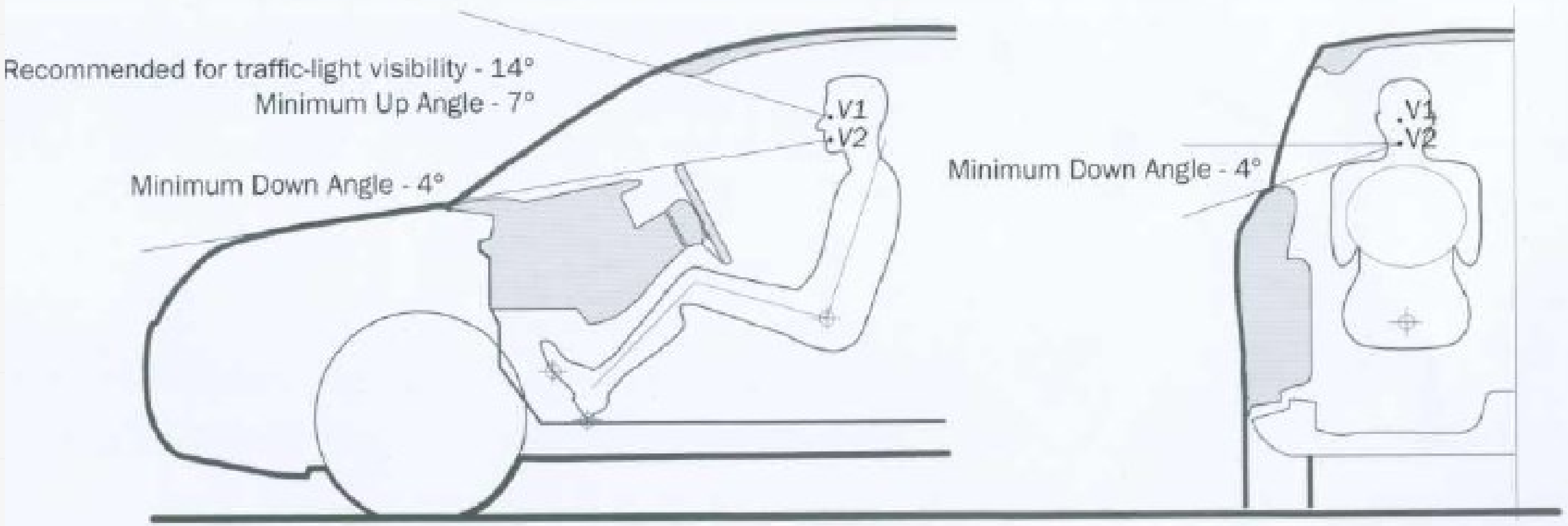
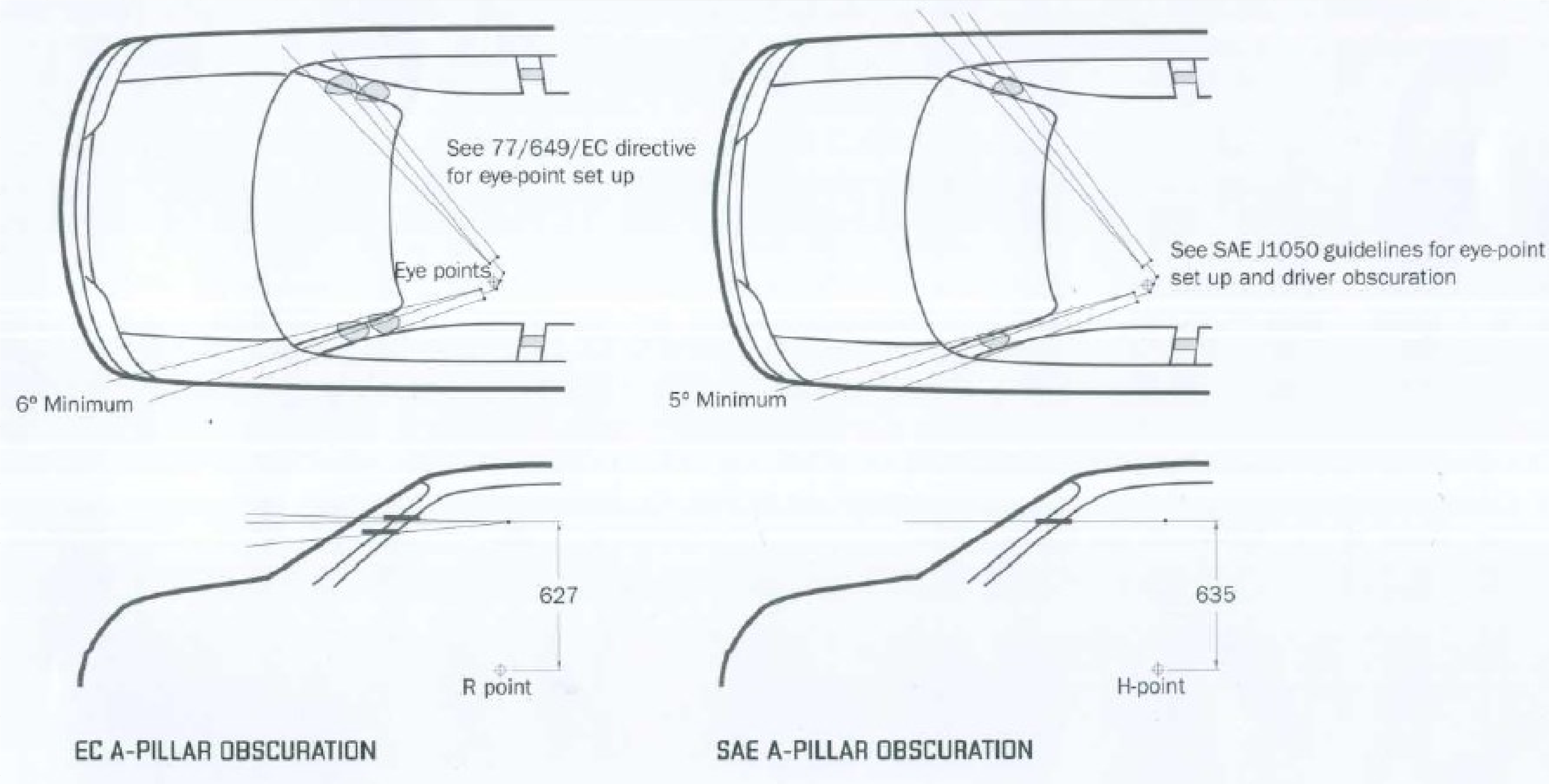
Visibility



EC FORWARD & SIDE VISION REQUIREMENTS (UP & DOWN)



Visibility


See 77/649/EC directive
for eye-point set up
Eye points
6° Minimum
627
R point
EC A-PILLAR OBSCURATION
See SAE J1050 guidelines for eye-point
set up and driver obscuration
5° Minimum
635
H-point
SAE A-PILLAR OBSCURATION

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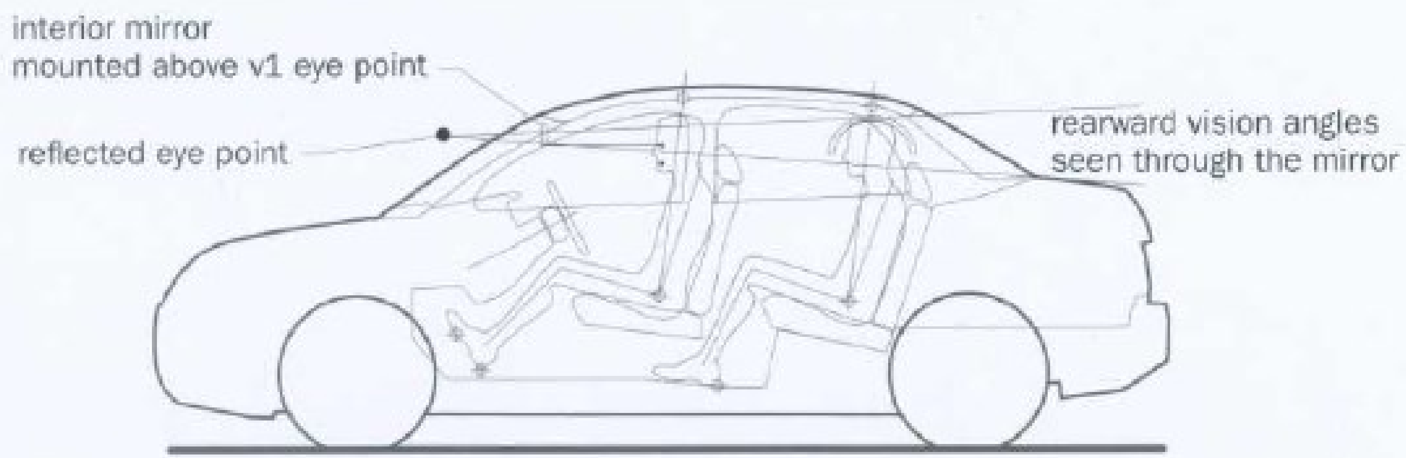
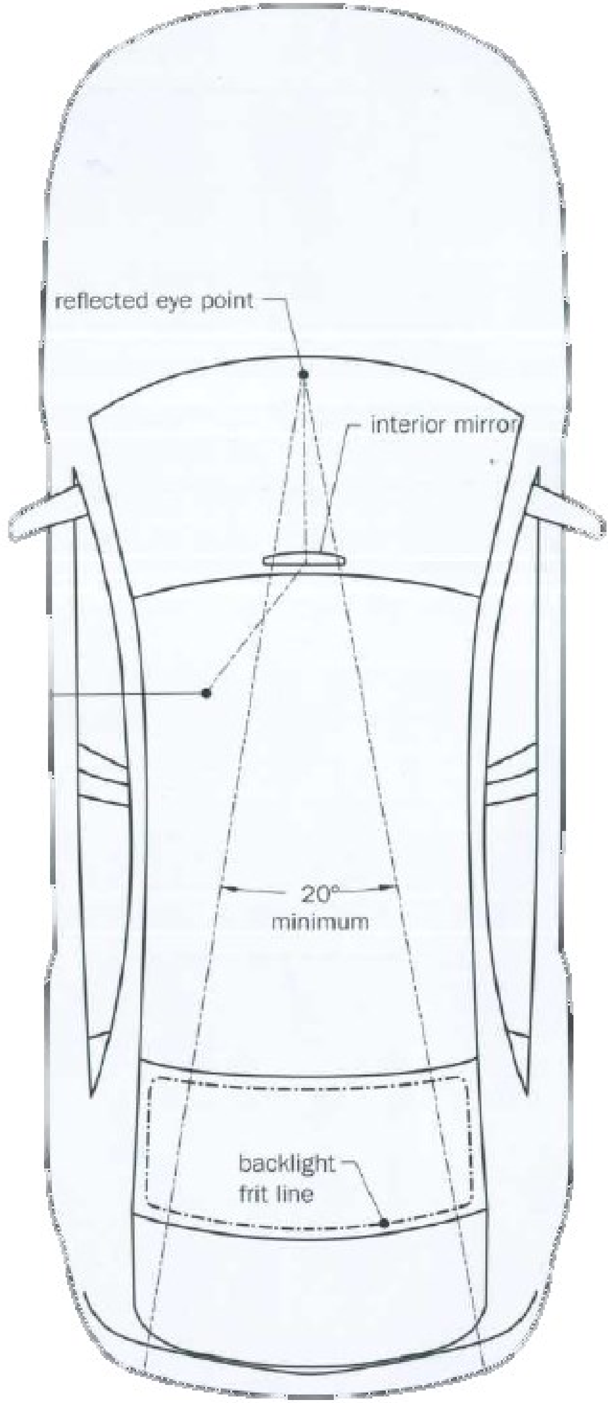
Visibility





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