"Ideally, the package starts from the inside and works its way out. If the architecture is driven by cargo, innovative seating or telematics, the concept will be heavily influenced by the interior design."

INTERIORS | 06

INTRODUCTION TO INTERIORS

The interior components can be divided into about seven systems, shown on the opposite page. These are typically developed and manufactured by various suppliers who work with the major auto companies from the beginning of the design process. They will often be delivered to the assembly line complete and ready to install.

The interior design on most projects will follow the exterior. There are exceptions, particularly if the vehicle interior has special features which will affect the overall package, such as rotating or stowing seat systems or special cargo needs. These will drive the initial package together with the occupants, creating hard points to work around.

An important concept to understand is that *the interior must be safe*, so each component is designed to reduce injury to the occupants during a collision.

Some parts contain the active and passive safety systems, such as the air bags, seat belts and knee blockers. They can be attached directly to the vehicle structure to aid their function.

Other items, such as the headrests and roof linings are designed to prevent head and neck injuries as well as trauma, in the event of severe impacts.

Trim

The trim features extensively in early package studies because it is designed to reduce head trauma if the occupants strike the upper body structure during an impact or rollover. As the roof rail, pillar and header sections are developed, they always include the trim. The door trims are set up relative to the occupant's H-point to establish the armrest height, the location of door release levers and various switches for power windows and locks.

Controls, Instruments & Switches

The steering wheel, shifter, hand brake and turn-signal stalks all have to be located where the driver can use them effectively and also allow easy ingress/egress. Some of these primary controls may be set up with the initial package if they influence other key systems. The instrument cluster is usually seen through the steering wheel, so accurate vision studies are crucial. The illuminated screen should also be shrouded from reflecting in the windshield by the cluster brow. Other switches and controls will need to be located within reach of the driver and front passenger.

The Instrument Panel (I.P.) & Consoles

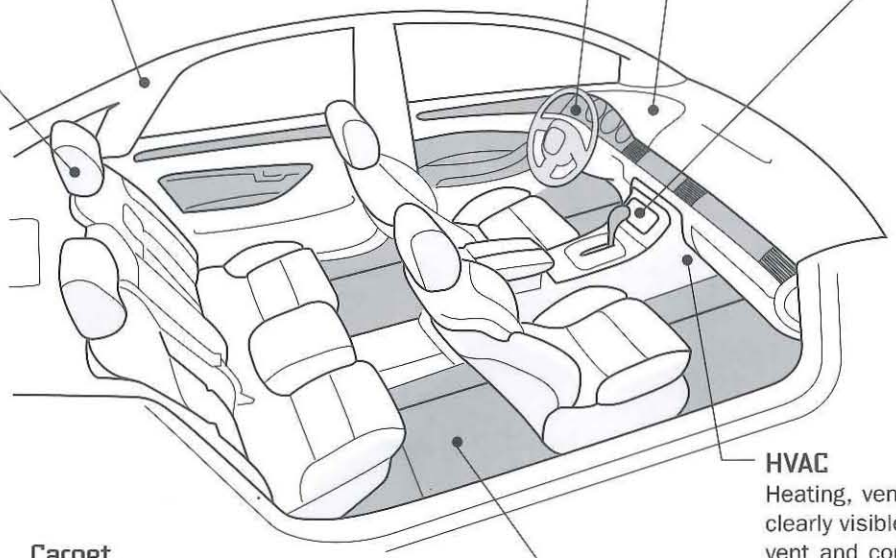
Generally, the I.P. will not influence the exterior proportions of the car, so its design can follow the exterior. However, many of the key components are directly related to the driver location and posture to provide reach, visibility and safety. If the occupant package changes, it will tear up the I.P. and console design. This is one reason why the interior design is not started until the exterior development is quite advanced. Overhead consoles will help redistribute some components and free up "real estate" on the I.P. but their size is often limited by the sunroof.

Telematics

The telematics may have a dramatic effect on the layout of the vehicle package. For some cars it may just be a navigation screen and an mp3 dock, but others may have a 50" flat screen TV with a full home theater system. This was not possible a few years ago, so new technology may redefine what a vehicle represents to the mass market.

Seats & Seat Belts

The seats are designed around the occupants' package location and posture. They occupy a large volume and adjustment ranges have to be factored into the location of adjacent components. Special seat systems that rotate or stow will require studies at the initial stage. The front seat belts will normally be attached to the B pillar. In some vehicles there is no B pillar and the belts are attached directly to the lower body structure and/or the seat structure. Attaching belt anchors to seats adds considerable stress loads to the seat structure.



Carpet

The carpet does not influence the package too much other than raising the heel points. Luxury cars may have a lot of sound insulation which can stack up to become significant to the packaging of the heel point.

HVAC

Heating, ventilation and air conditioning systems are clearly visible in all cars because of the air distribution vent and controls. What are hidden are the modules that heat and cool the air and pump it through the cabin. These units can be quite large and are usually located between the foot wells, behind the center stack.

INSTRUMENT PANEL & CONSOLES

The instrument panel (I.P.) is one of the most complex assemblies in the car. On most conventional interiors the area around the instrument cluster is very crowded, with the steering column, instruments, I.P. structure and HVAC ducting all competing for the volume. The center stack layout also needs to be carefully prioritized and organized so that vent outlets, HVAC controls, telematics (navigation, radio, CD, etc.), cup holders, switches and storage trays all fit and are ergonomically positioned.

Additional consideration must be given to safety because much of the instrument panel is within the head impact zone. This means that the contours, radii and hardness of all surfaces have to be designed to pass all interior safety legislation and testing procedures. Also, during a high-speed frontal impact the occupants rely on the knee blockers and air bags to restrict their forward travel and cushion the impact. For this reason the relationship of the I.P. and controls to the driver and front passengers is critical, with everything set up for reach, vision and safety.

Special consideration should be given to vehicles in global markets where both left- and right-hand drive configurations are required.

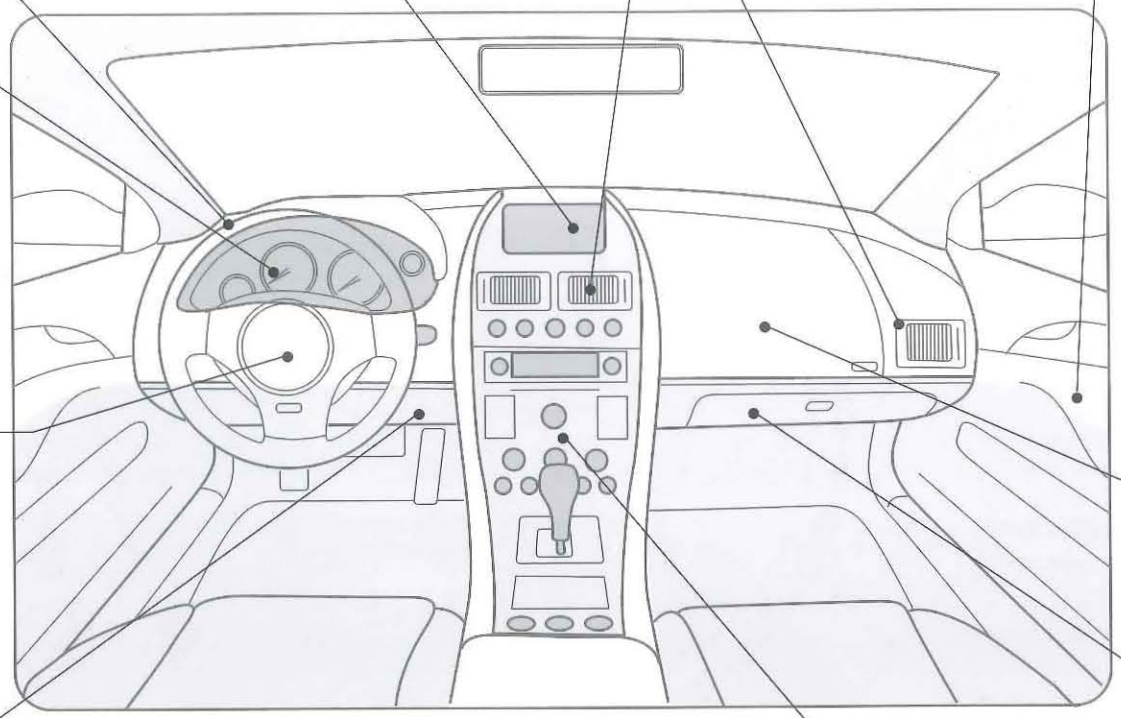
STEERING WHEEL
Mounted on the steering column which is usually adjustable and attaches to the main I.P. structure.

TELEMATICS SCREEN
Primarily for navigation, providing TV & video in the I.P. is illegal in most countries.

AIR DISTRIBUTION VENTS
Positioned to blow conditioned air at the occupant's face and torso.

DOOR TRIMS
The door trims are usually designed to flow into the I.P., so these are often modeled and sketched at the same time. These also relate closely to the occupants and set up the "shoulder room" and "hip room" dimensions. The armrests, release levers and switches should be set up appropriately to the occupant. The door trims are also designed to help minimize injury during a side impact.

INSTRUMENT CLUSTER
Usually housed behind the steering wheel, occasionally in the center stack, the instruments usually include the speedometer, tachometer, fuel gauge, engine temperature, battery charge, and warning lights.



DRIVER'S SIDE AIR BAG
Packaged in the center of the steering wheel it works more effectively if the steering wheel is angled toward the driver's face.

PASSENGER SIDE AIR BAG
Can be mounted in the top pad or on the front of the instrument panel.

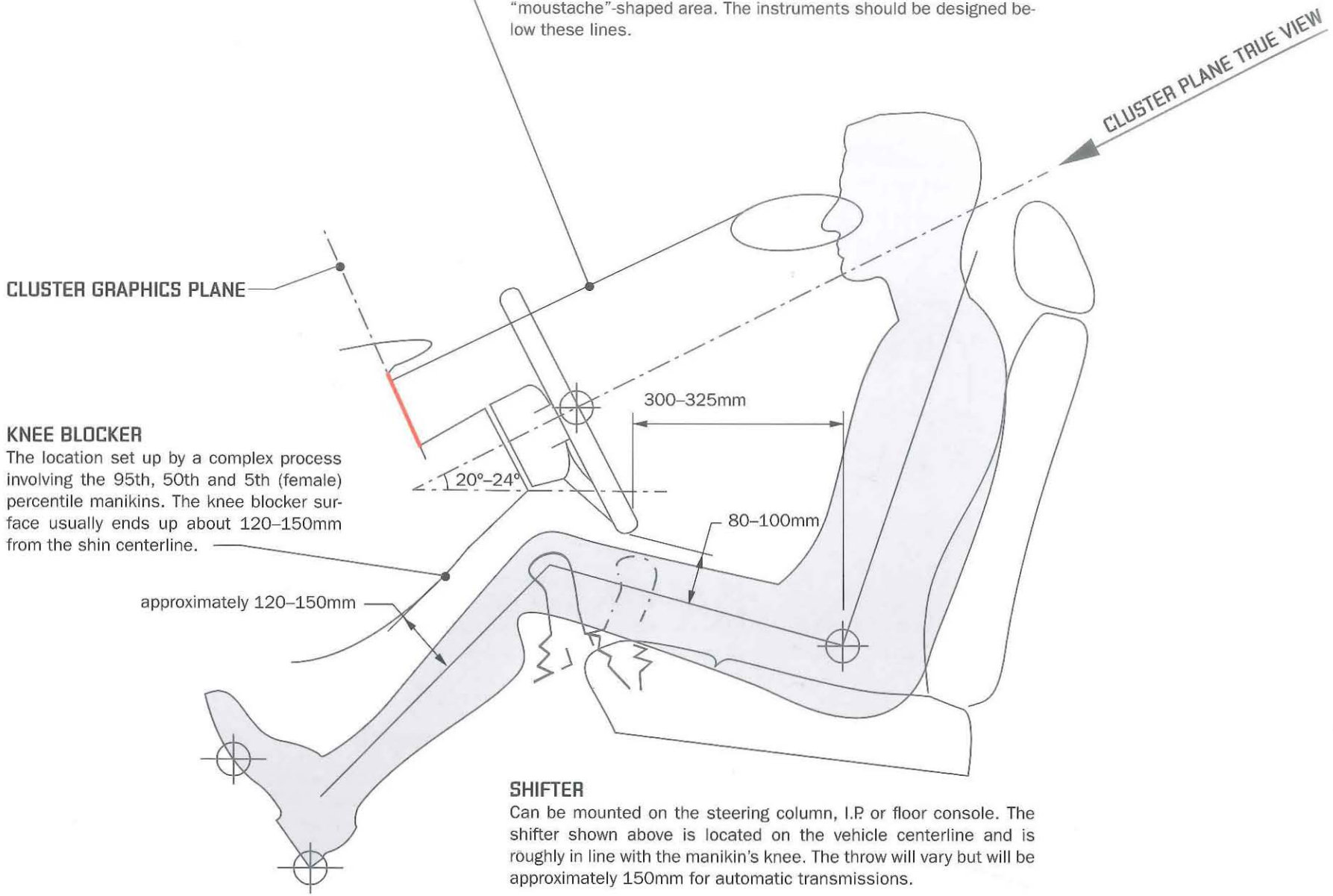
KNEE BLOCKER (GLOVE-BOX DOOR)
Working in a similar fashion to the driver's knee blocker, it utilizes the glove-box door to provide a solid pad to prevent forward travel off the seat.

KNEE BLOCKER
Working in conjunction with the air bag, it is a component of the active safety restraint system (SRS). Its relative location to the occupant is critical to prevent an unbelted occupant from "submarining" during a frontal impact. It is connected directly to the main I.P. structure to provide a solid pad.

CENTER STACK & CENTER CONSOLE
The shifter, telematics, HVAC controls, vents, radio, cup holders and banks of switches may be housed in the center stack and should be within easy reach of the driver and passenger. The SAE J287 recommended reach zones should be utilized to place these items.

CLUSTER VISIBILITY

The instrument cluster visibility is set up through the steering wheel using the 95th percentile left and right eye ellipses which project binocular vision lines onto the cluster plane resulting in a "moustache"-shaped area. The instruments should be designed below these lines.



KNEE BLOCKER

The location set up by a complex process involving the 95th, 50th and 5th (female) percentile manikins. The knee blocker surface usually ends up about 120–150mm from the shin centerline.

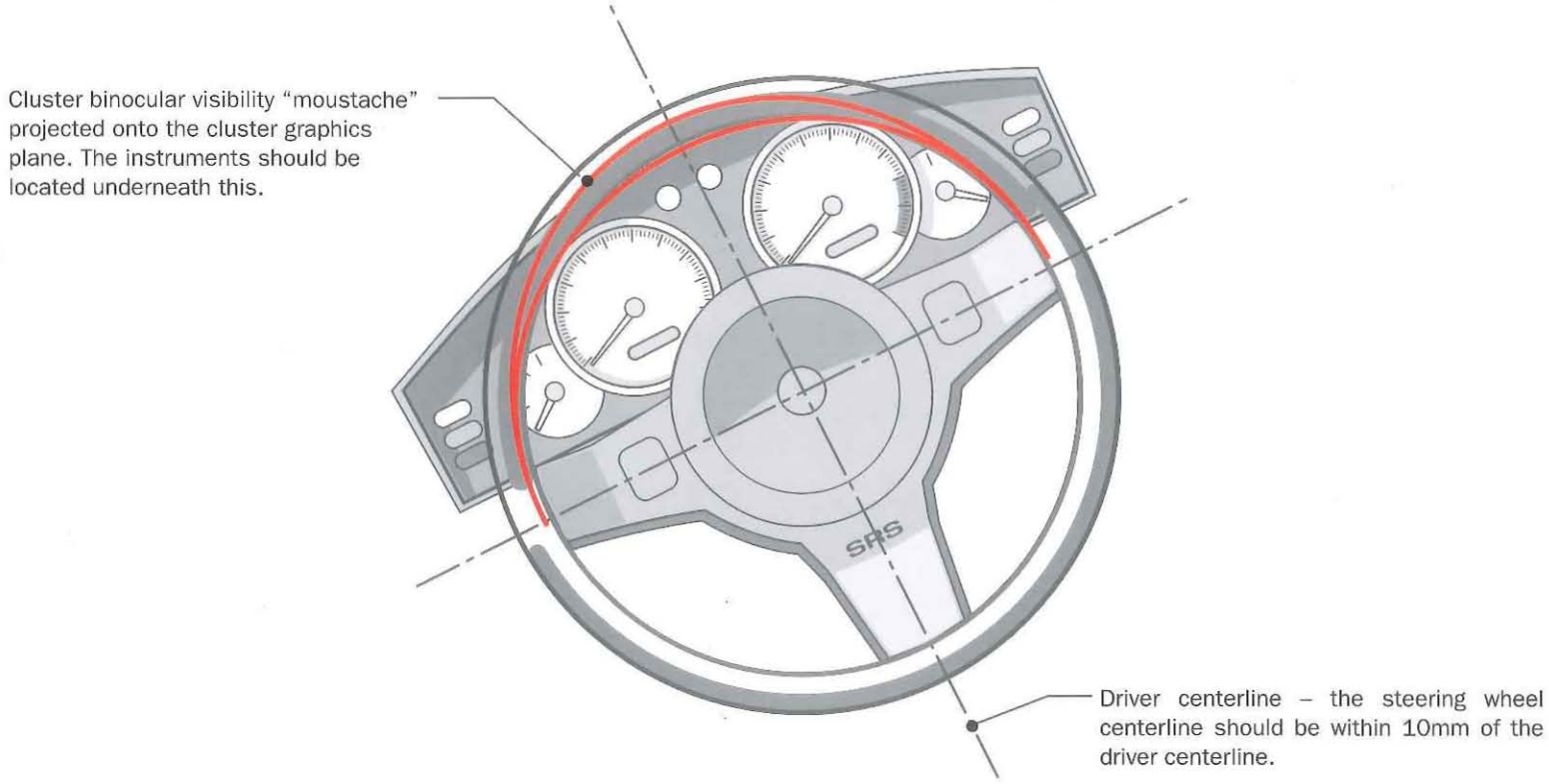
SHIFTER

Can be mounted on the steering column, I.P. or floor console. The shifter shown above is located on the vehicle centerline and is roughly in line with the manikin's knee. The throw will vary but will be approximately 150mm for automatic transmissions.

STEERING WHEEL SET UP & INSTRUMENT CLUSTER VISIBILITY

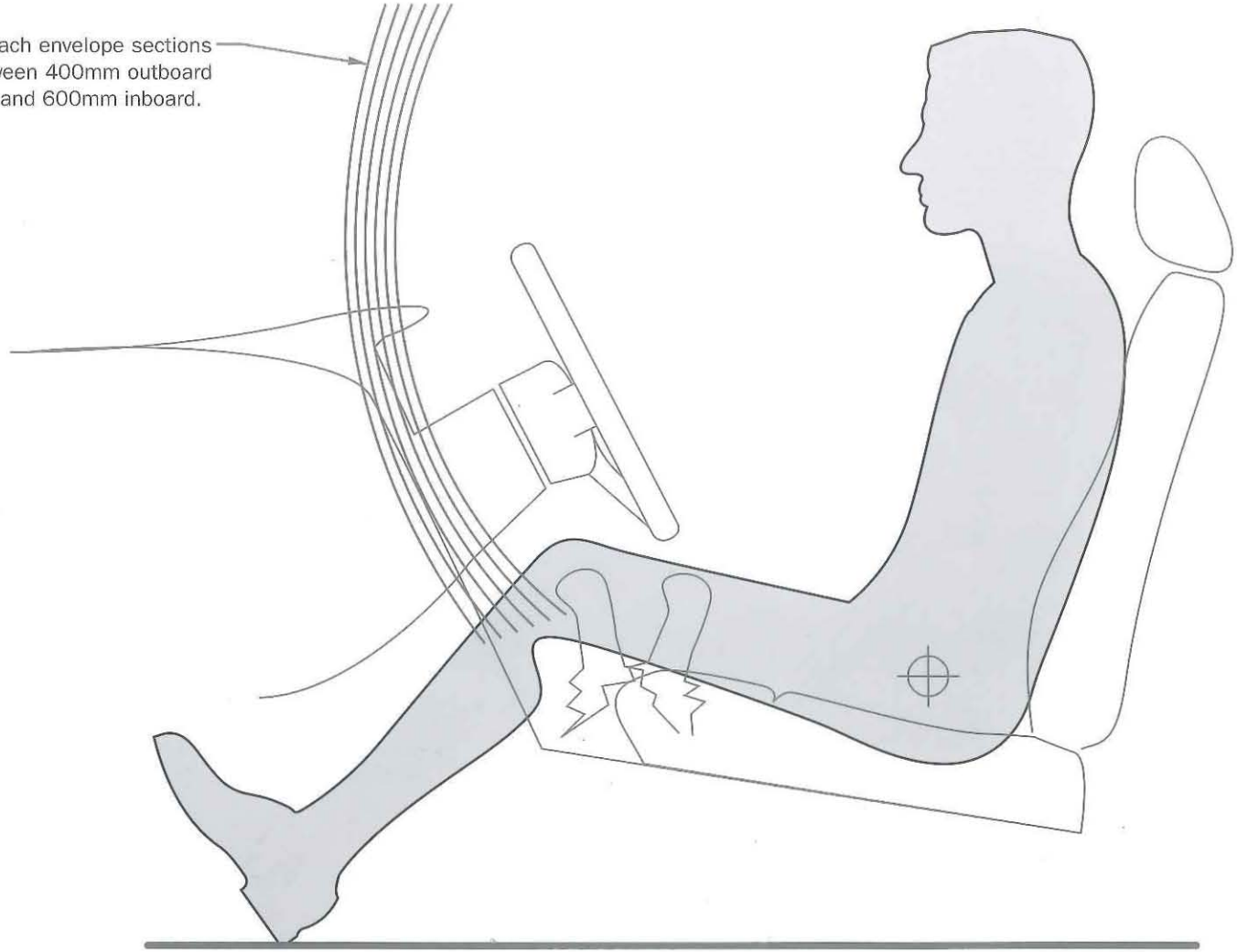
The steering wheel center is mounted on or close (within about 10mm) to the driver centerline and usually has a diameter of about 380–400mm. In side view it is set up to the occupant relative to the thigh and H-point. The angle of the steering wheel is roughly 90° to the column which is itself normally between 20°–24° from the horizontal.

The bottom of the steering wheel to the thigh centerline is usually between 80–100mm. The distance between the base of the steering wheel to the H-point is usually between 300–325mm horizontally.



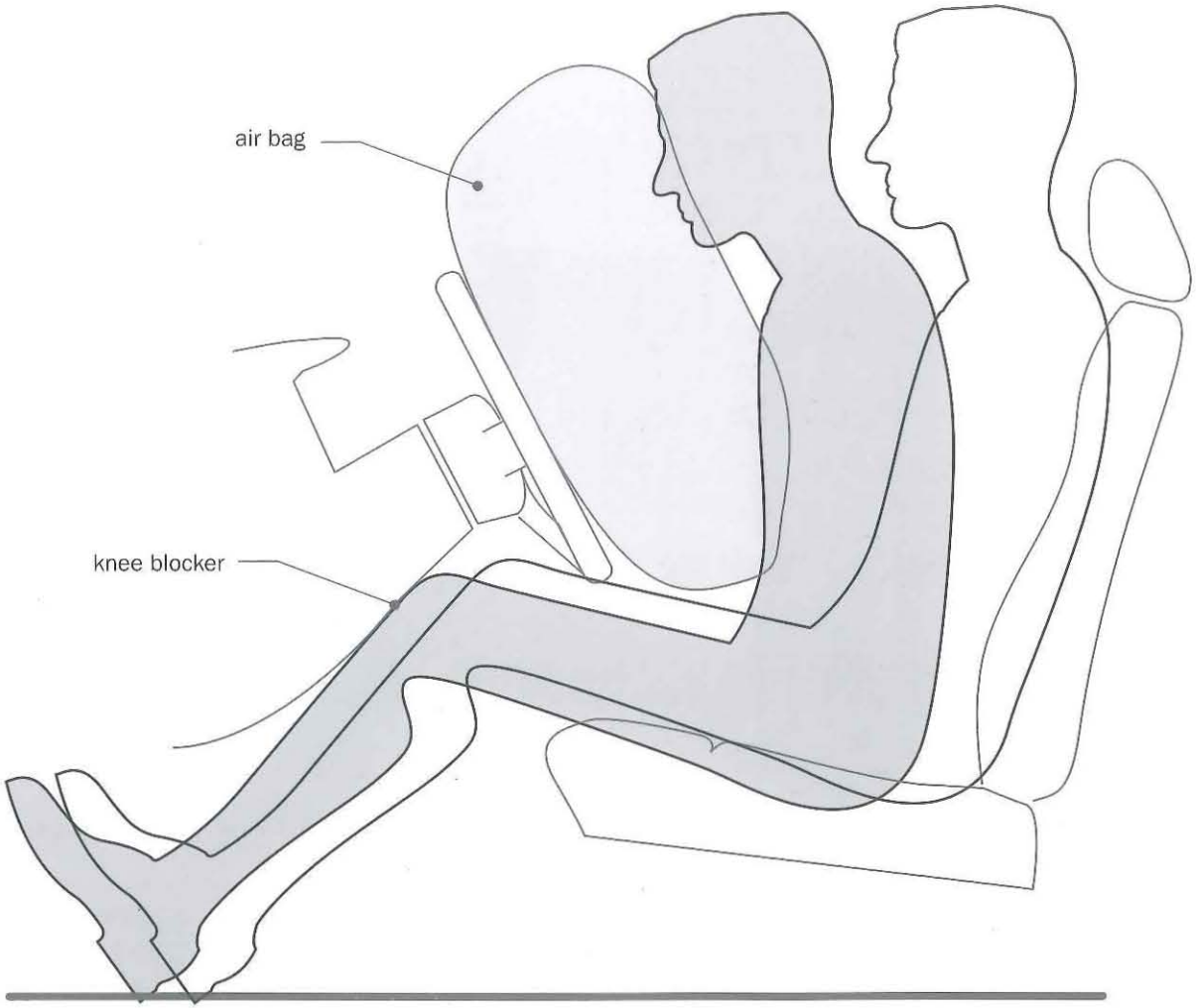
REACH ENVELOPES

The objective of the reach envelopes is to provide recommended zones to locate each control lever or knob that the driver may need to adjust while driving with a seat belt fastened. The geometry for these envelopes is given in SAE J287. The envelopes are represented by a series of sections cut every hundred millimeters, from 400mm outboard of the driver centerline to 600mm inboard. These sections relate to the H-point location in x, y and z directions.



AIR BAG DEPLOYMENT

The active restraint systems are designed to protect the front occupants in a high-speed frontal impact, even if they are not wearing seat belts. Notice that the momentum of the driver causes the manikin to slide forward until the knees hit the knee blocker on the instrument panel. The air bag deploys in a split second to cushion the impact and protect the driver from hitting the steering wheel. The passenger side air bag deploys from either the top or rear of the instrument panel in a similar fashion. Side curtain and seat bolster air bags also deploy from the side rail and seat cushions to protect the driver's head and torso in side impacts.



SEAT CONTOUR & CONSTRUCTION

Most car seats are made from cloth or leather-covered foam, supported by a sprung steel frame mounted to adjustable tracks which sit either on the floor or on risers as shown opposite.

Establishing a relationship between the H-point and the seat is important but difficult to control. The seat cushion foam and occupant flesh combined will compress about 50mm, so the seat should be drawn intruding into the occupant. After the seat has been manufactured, the 3D H-point machine (SAE J826, 76kg) can be placed to check the accuracy of the final H-point location.

The headrest is designed to prevent whiplash injuries during a rear impact and is required to be at least 730mm above the H-point and 315mm behind, with the torso back angle set to a nominal 22°.

SEAT PACKAGING

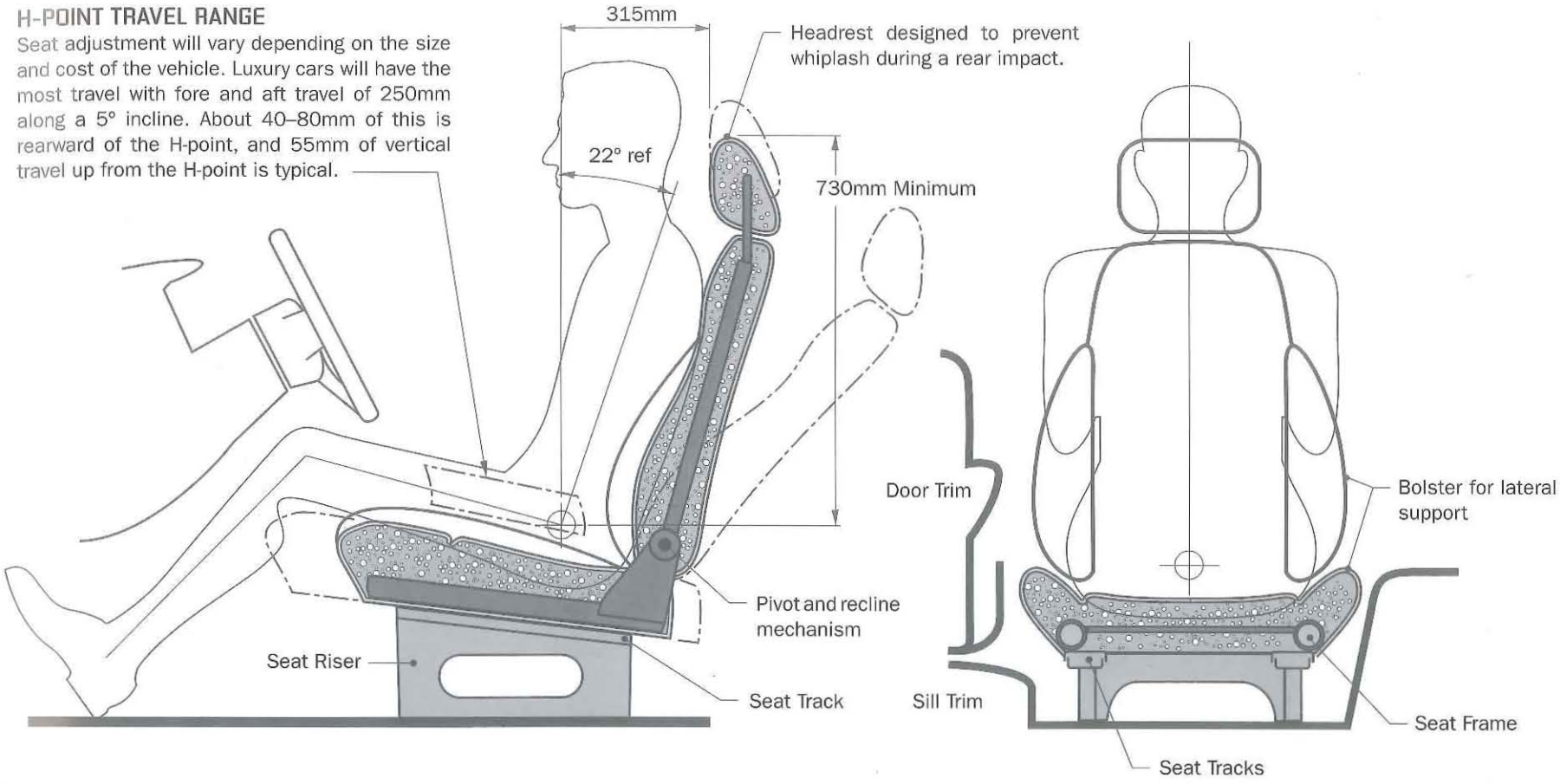
Seats take up a large portion of the interior volume, especially when their full range of adjustment is taken into consideration.

Always ensure that adequate clearance (15mm) is designed between the movable seat components and the adjacent systems—i.e., door trims and center console.

Note: On vehicles with very low chair heights, the seat tracks may be mounted vertically on the sill and console to help make the seat height compact.

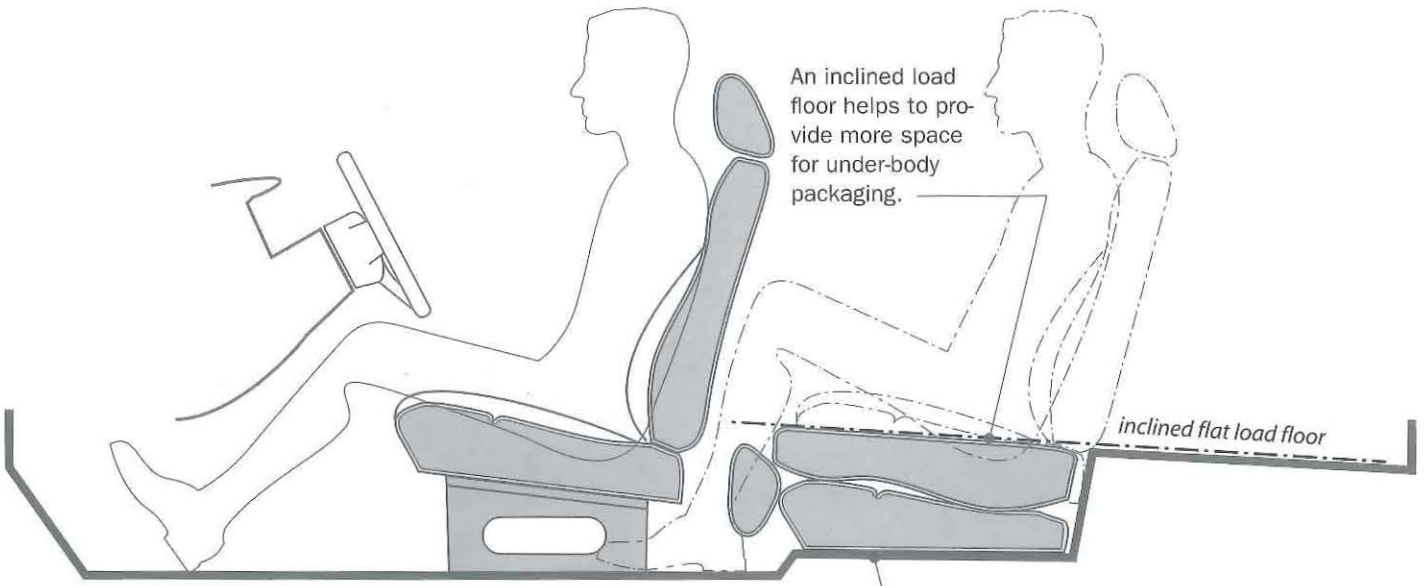
H-POINT TRAVEL RANGE

Seat adjustment will vary depending on the size and cost of the vehicle. Luxury cars will have the most travel with fore and aft travel of 250mm along a 5° incline. About 40–80mm of this is rearward of the H-point, and 55mm of vertical travel up from the H-point is typical.



TYPICAL HATCHBACK & SUV FOLDING REAR SEAT

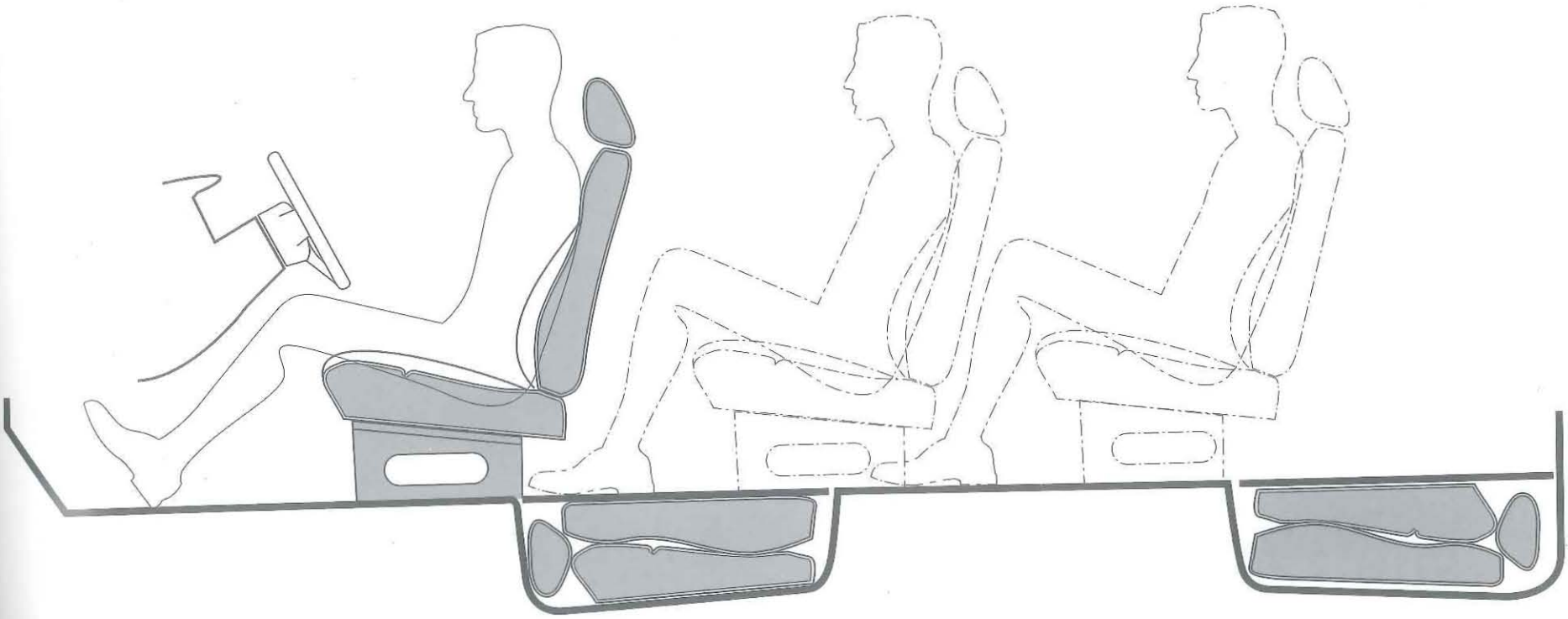
Ideally, the seat should be designed to provide comfortable seating in the upright position and also to stow efficiently in the foot well (with the headrest in place) to provide a flat load floor. Achieving this will depend on the under-floor packaging of the suspension, final drive system, fuel tank, exhaust, spare tire and body structure. An inclined rear floor will help to create a flat load floor with the seat in a higher position.



The rear floor design is driven by the packaging of the suspension, final drive system, fuel tank, exhaust, spare tire and body structure.

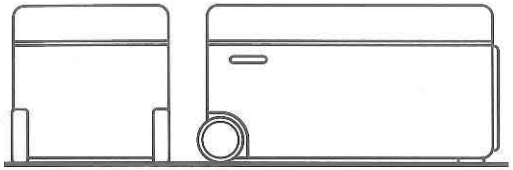
TYPICAL MINIVAN STOWING SEATS

Minivan floors are usually flat and quite high so stowing seats flat into the floor is possible with some creative under-floor packaging. Because the chair height is often high, the seat risers can be used to articulate the seats into their stowed position. When the seats are in their normal, upright position the vacant under-floor storage is an additional bonus for hiding valuables. A feature of this magnitude will have to be considered at the initial package ideation stage.



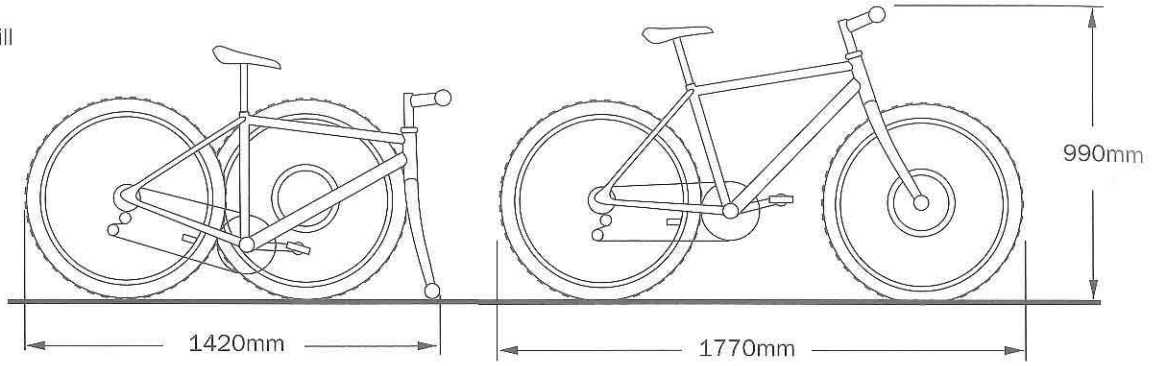
CARGO STORAGE

The customer's lifestyle will dictate the type of cargo he or she will carry. Here are some examples and approximate dimensions.



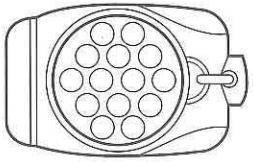
ICE CHEST / COOLER

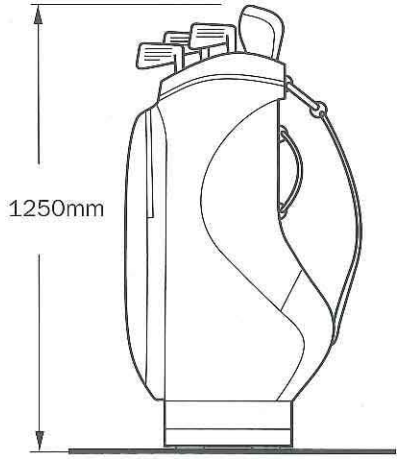
These are sold in various sizes, the larger ones are between 50–100 liters.
50 liter = 700mm x 380mm x 440mm
100 liter = 930mm x 400mm x 440mm



ADULT MOUNTAIN BIKES

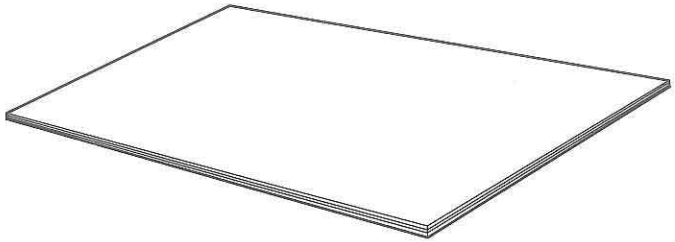
Most bikes have quick-release wheels and saddles which makes them easier to store in a vehicle. The wheel diameters are usually 660mm.





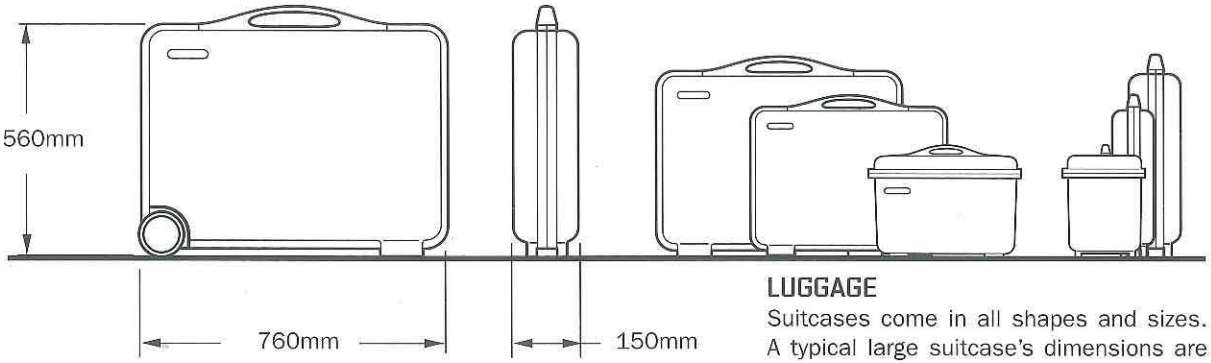
GOLF BAG

These vary quite a bit in plan-view size but are usually about 1250mm high, with the clubs.



PLYWOOD SHEETS

Building materials are sold in standard sizes. Large plywood sheets are 1220mm x 2440mm (4 ft. x 8 ft.).



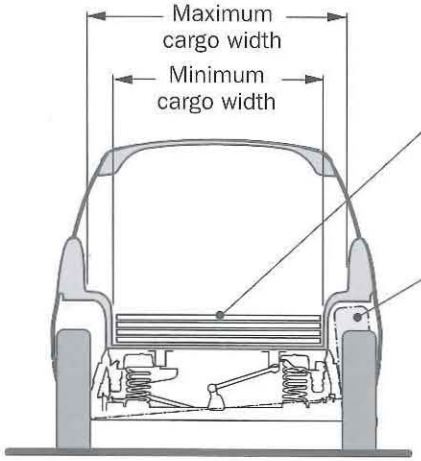
LUGGAGE

Suitcases come in all shapes and sizes. A typical large suitcase's dimensions are illustrated at left.

DESIGNING FOR CARGO

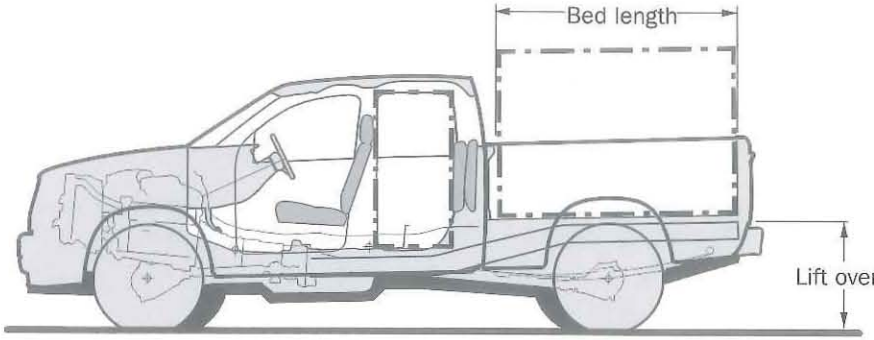
Cargo can take up as much space, or more, than the occupants, so it is worth thinking about from the start. Several factors should be investigated to determine the architecture adjacent to the cargo storage area.

1) Overall dimensions are usually designed around specific items to be carried. This often relates to the customer's lifestyle.
2) Interior volume is a big selling point in passenger cars (see p. 113). If several smaller items are carried, the volume measurement helps to determine how one car compares to another.
3) Aperture size should be as big as possible to allow large items to be fed into the cargo bay.
4) Lift-over height and floor height should be as low as possible. For most vehicles this will be just above the bumper height (530mm). For trucks the load floor may be quite high to allow for the frame rails and suspension travel.
5) Suspension design may need to be compact to help lower the load floor, or very strong to carry heavy loads.
6) Load floors should be flat to make organizing and moving heavy objects easier.
7) Underbody and seat design should be set up for maximum space flexibility.
8) Tumblehome & backlight attitude should be as vertical as possible.
9) Rear wheel placement should be set up for optimal weight distribution.



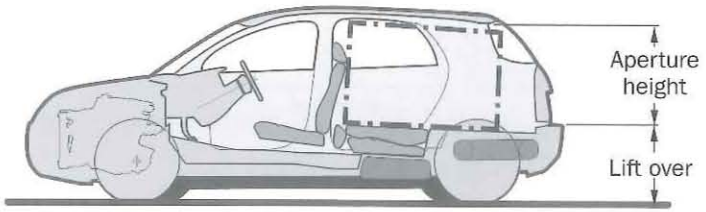
PLYWOOD
4' x 8' plywood sheets stacked between the wheel house trim.

TIRE IN JOUNCE
The rear track and suspension geometry is designed around the cargo width and load-floor height.



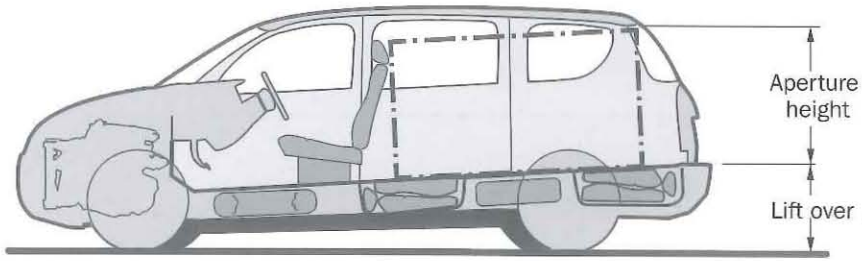
PICKUPS AND COMMERCIAL VEHICLES

These types of vehicles are designed around their capacity to carry cargo. The bed length or cargo bay varies between 1700mm to 2450mm for most commercial trucks. Personal trucks may have beds as short as 850mm.



HATCHBACKS & WAGONS

Designed for multifunction between carrying cargo or rear passengers. Exterior body shapes may compromise cargo-size potential. The seats will usually fold down over the fuel tank.



MINIVANS

The angled floor provides a low step in height for the driver and a lift over at the rear bumper height. Loads are easier to move around if the floor is flat. The underbody components are designed around stowing the seats.

INTERIOR VOLUME MEASUREMENT

The interior volume index is used primarily to determine how much usable space is available for the occupants and cargo. The volume is reported in cubic feet or cubic meters and is the sum of the key interior measurement, shown right.

Target volumes are often set out in the functional objectives. Creating a competitive space becomes an important marketing tool, so these numbers are often used by consumer groups to describe how efficient a package is and how it stacks up against a competitive vehicle.

In the US, the Environmental Protection Agency (EPA) uses the interior volume to determine vehicle-size classifications.

EPA INTERIOR VOLUME INDEX

Class	Mini Compact Car	Subcompact Car	Compact Car	Midsize Car	Large Car	Small Wagon	Midsize Wagon	Large Wagon
Cubic Feet	under 85	85 - 99.9	100 - 109.9	110 - 119.9	over 120	under 130	130 - 160	over 160

EPA INTERIOR VOLUME INDEX

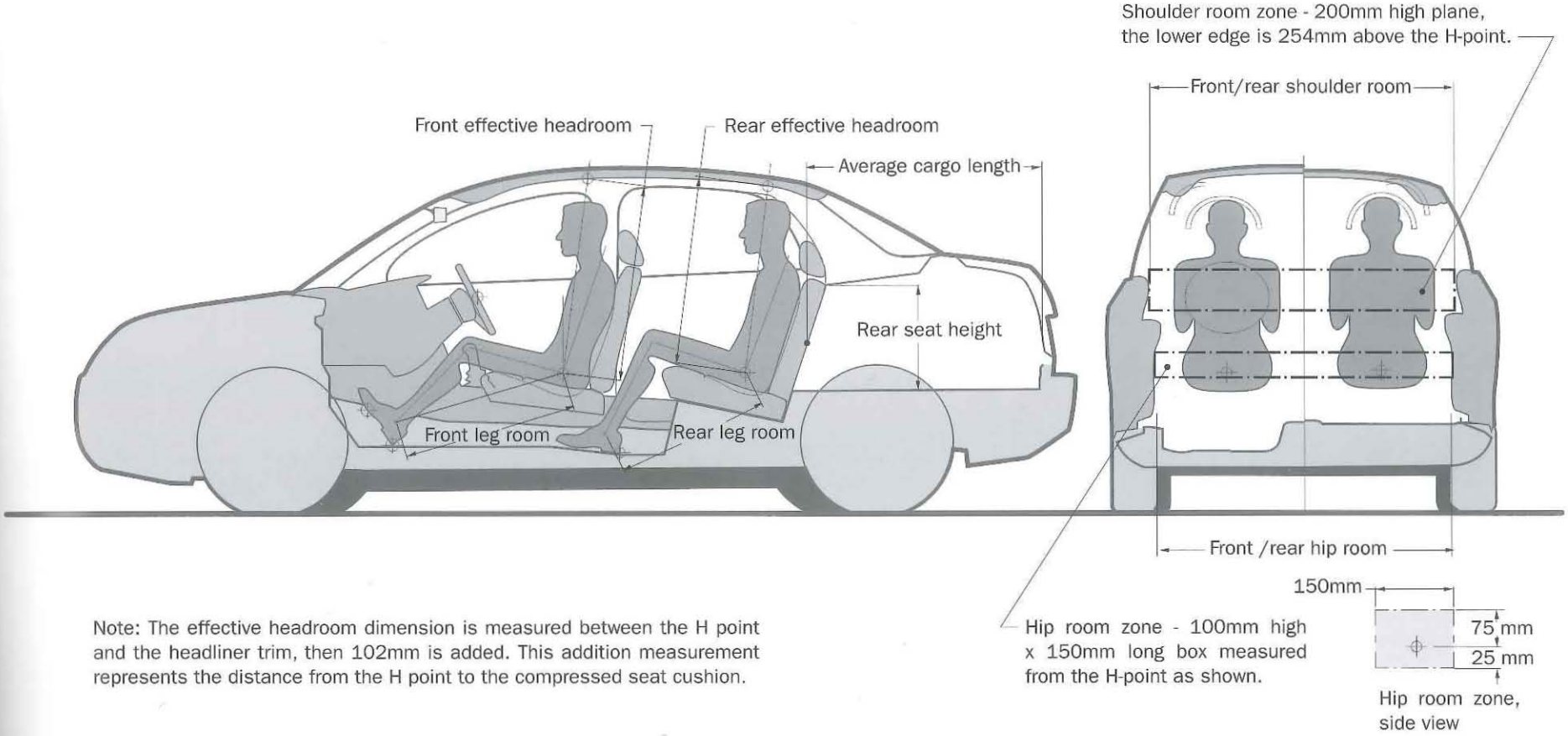
Front Interior volume + Rear Interior Volume + Cargo Volume

FRONT & REAR (PASSENGER) INTERIOR VOLUMES

Head room x Leg room x Shoulder room (Use hip room if it's larger than shoulder room)

CARGO VOLUMES

Rear Seat Height x Average Trunk length x Rear Shoulder room



Note: The effective headroom dimension is measured between the H point and the headliner trim, then 102mm is added. This addition measurement represents the distance from the H point to the compressed seat cushion.