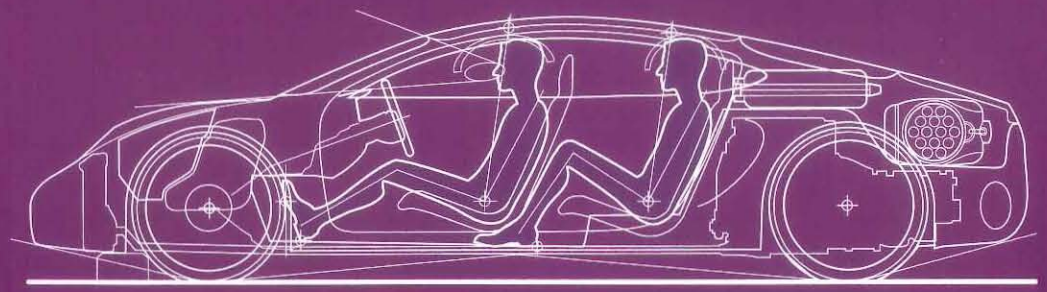


"Without question, the most critical elements in every vehicle package are the occupants. If you get the occupant positions and postures wrong, the entire architecture may need to be redesigned. Because the manikin geometries are constant and represent the customers, the vehicle bodies are scaled around them."

OCCUPANT PACKAGING | 05

OCCUPANT MANIKIN INTRODUCTION

It cannot be overemphasized how critical the driver and passenger packaging is to the overall architecture. The occupants directly or indirectly influence every aspect of the vehicle's design.

It is often said that cars and trucks should be designed from the inside out. This refers more to the occupant package than the interior systems.

The main objective is to set up the driver and passengers to be comfortable and safe, then create an envelope around them and use key reference data within their geometries to set up the rest of the vehicle package.

The most important reference point in the package is the driver's hip (H) point. This is also referred to as the Seating Reference Point (SgRP). Almost every element of the package will be influenced by its location and if modified, the effects may be seen throughout the vehicle.

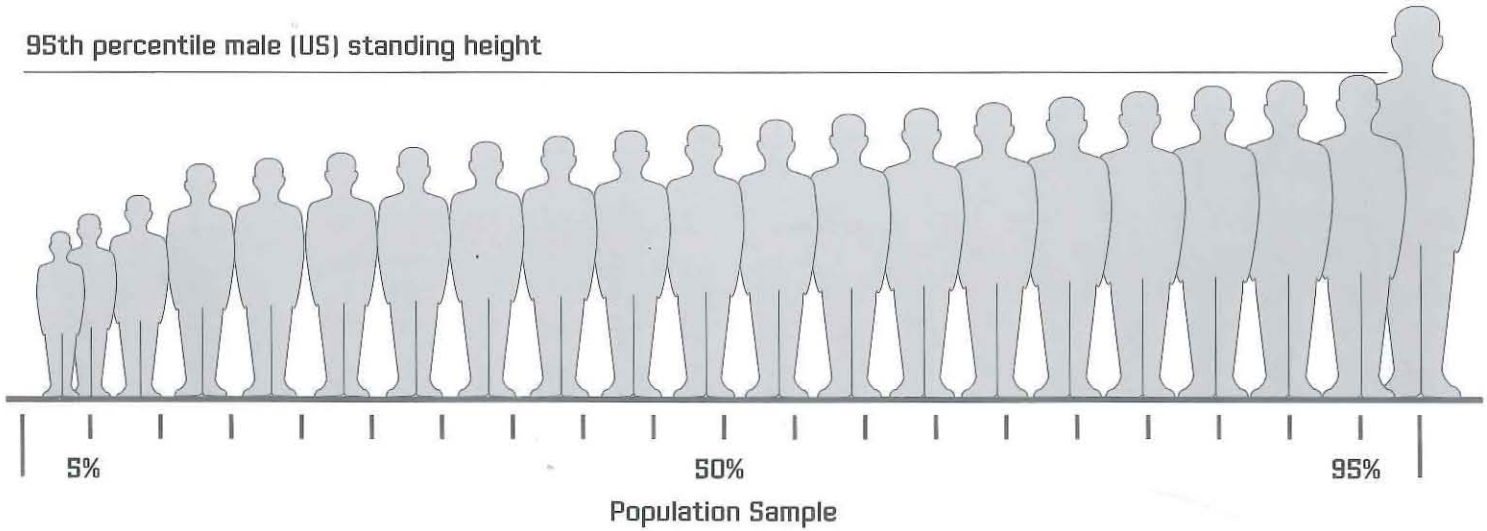
Each car company will use several manikins that suit their purpose. One of the most popular occupant packaging tools is the SAE 95th percentile male manikin, which is ideal for setting up the initial interior space, ensuring that the vast majority of the global population will fit into the package envelope.

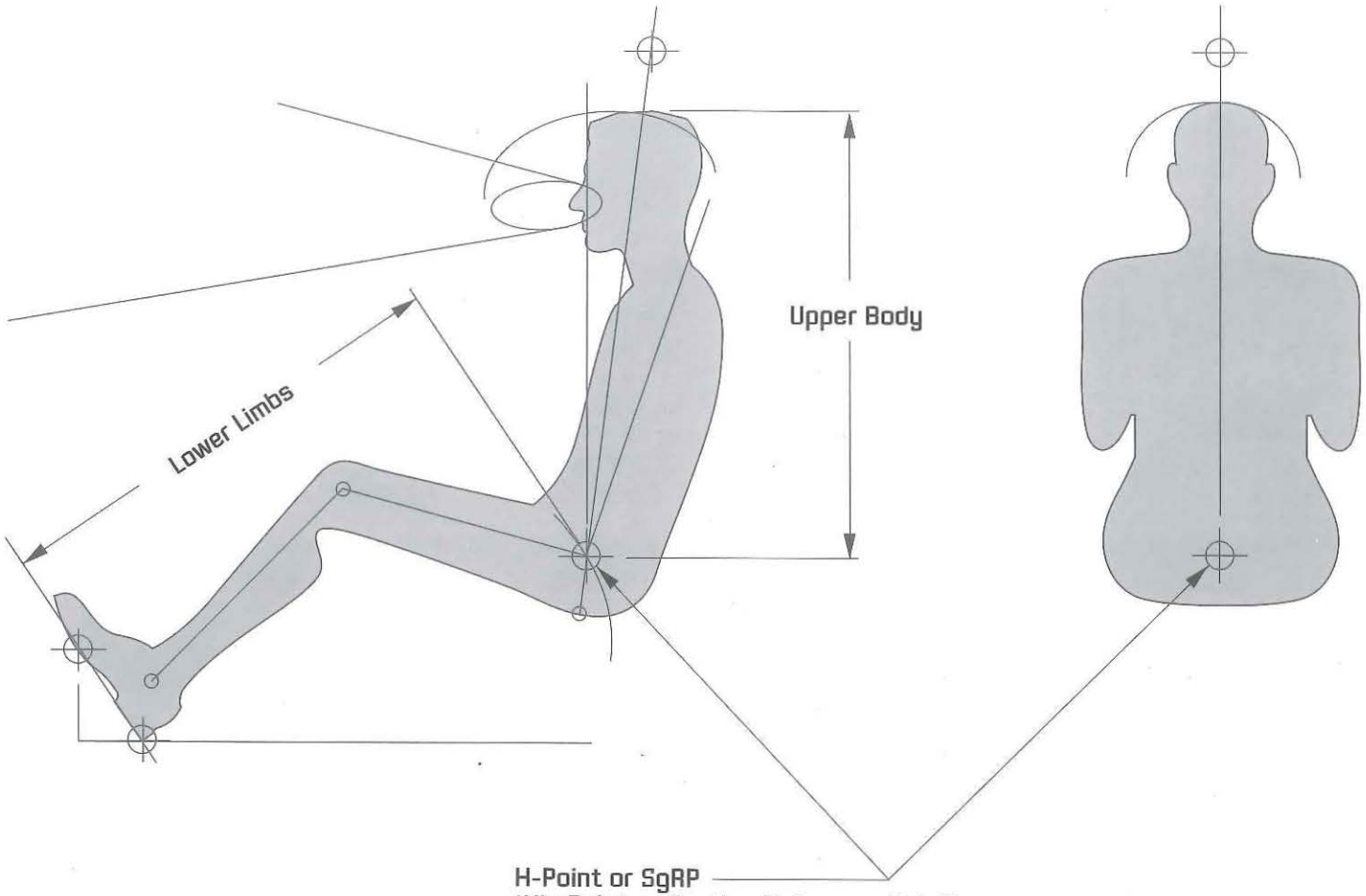
The SAE has worked with various groups to establish anthropomorphic (size, proportion and movement) data which represent the volumes occupied by drivers and passengers as they sit and operate vehicles. The results of this data have been converted into sets of geometry that represents the stature of a 95th percentile US male (97.5% of the total US population, including females) sitting in a car seat.

This geometry can be used to set up the interior systems, locate controls, complete vision studies, position the powertrain, establish the wheel/tire package and even place the bumper beams.

The limbs, torso and head of the population sample are measured individually to create a manikin that is built from 95th percentile male parts. The sitting manikin can be utilized in two halves, from the H-point to the feet (to establish leg room) and from the H-point to the head (to set up the head environment).

After the initial package has been built, other smaller manikins (5th percentile female and 50th male) are used to ensure that smaller people will be able to drive in comfort and safety.





H-Point or SgRP
(Hip Point or Seating Reference Point)
The most important reference datum in the package.

THE ANATOMY OF THE SAE (J826) 95th PERCENTILE MALE DRIVER MANIKIN

H-POINT (HIP POINT) or SgRP (SEATING REFERENCE POINT)
The main reference point for the occupants and one of the major datum points for the vehicle package. Often referred to as the "Seating Reference Point" (SgRP or R-point in Europe), it is always located on the comfort (accommodation) curve.

ACCOMMODATION CURVE (SAE J1516–1517)
This curve maintains the correct relationship between the H-point and foot to ensure a comfortable posture for the driver's legs while operating the foot pedals.

ACCELERATOR HEEL POINT
The heel-point location is often referenced to define the floor and step-in height.

BALL OF FOOT POINT
Located on the accelerator plane. A main reference point for frontal impact crush space measurement.

ACCELERATOR FOOT PLANE
This plane rotates about the ankle pivot and is usually locked at 87° to the shin centerline.

TORSO LINE
Defines the back angle inclination.

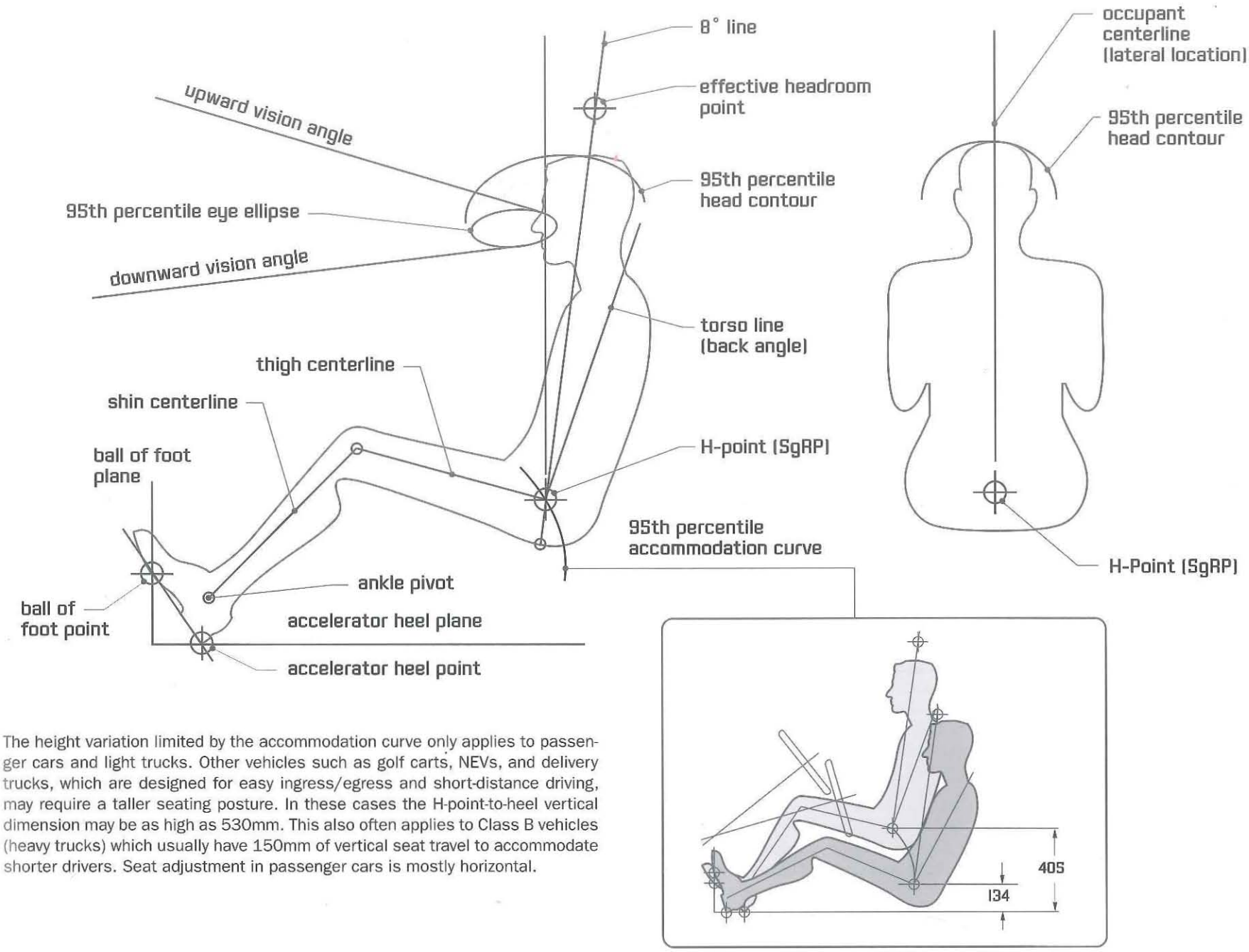
95th EYE ELLIPSE (J941)
The 95th eye ellipsoid represents a three-dimensional volume within which 95 percent of driver's eyes will be contained. Its location remains constant to the head contour.

95th PERCENTILE HEAD CONTOURS (SAE 1052)
The head contours are defined by three-dimensional surfaces and represent the areas within which the 95th percentile occupant heads are contained. They incorporate seat-track travel and head movement. The position of the head contour is determined by the H-point and back angle.

VISION ANGLES
The upper and lower vision angle lines are constructed tangentially to the 95th percentile eye ellipse and touch the first elements in front of the driver which obscure upward and downward vision. These are instrumental in the set up of the windshield aperture.

EFFECTIVE HEADROOM POINT (SAE J1100)
The intersection of the headliner trim and a line 8° from vertical, through the H-point. These are used to set up hard points on the roof surface above the headliner trim or sunroof.

LOWER LIMBS
The leg geometry consists of the shin and thigh centerlines, which are constrained by the ankle pivot and the H-point. Their configuration is automatically updated as the H-point to heel relationship is changed. The thigh centerline is used to set up the steering wheel location and the shin determines the knee-blocker surface on the instrument panel.



The height variation limited by the accommodation curve only applies to passenger cars and light trucks. Other vehicles such as golf carts, NEVs, and delivery trucks, which are designed for easy ingress/egress and short-distance driving, may require a taller seating posture. In these cases the H-point-to-heel vertical dimension may be as high as 530mm. This also often applies to Class B vehicles (heavy trucks) which usually have 150mm of vertical seat travel to accommodate shorter drivers. Seat adjustment in passenger cars is mostly horizontal.

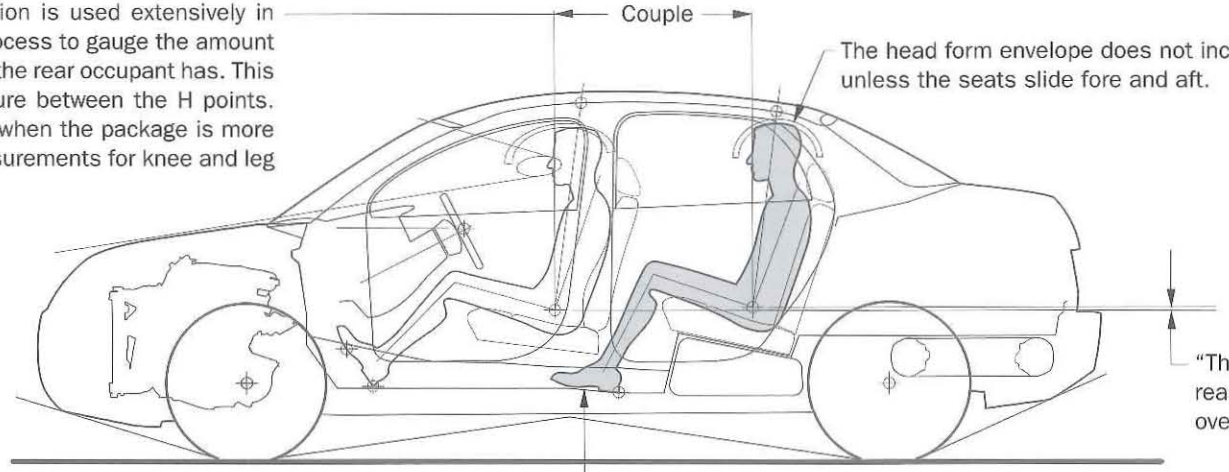
SETTING UP THE DRIVER HEIGHT & POSTURE

The driver's height and posture are governed by several factors, namely: center of gravity, aerodynamics, ingress/egress, comfort and visibility. The vehicle height should be established by a combination of these factors. The graphic on the following page shows how the driver height and posture varies with the functionality of each vehicle type. The dimensions provide an approximate range to help set up the driver in a traditional package.

For crossover vehicles, think about combining the attributes. For example a sporty off-road vehicle may have a high heel point for ground clearance and structure, but may need a low chair height to keep the roof height as low as possible. If the engine is in the rear, forward visibility over the hood won't be a problem.

SETTING UP THE REAR OCCUPANTS

The "couple" dimension is used extensively in the initial package process to gauge the amount of leg and knee room the rear occupant has. This is a horizontal measure between the H points. Later in the process, when the package is more mature, specific measurements for knee and leg room are recorded.

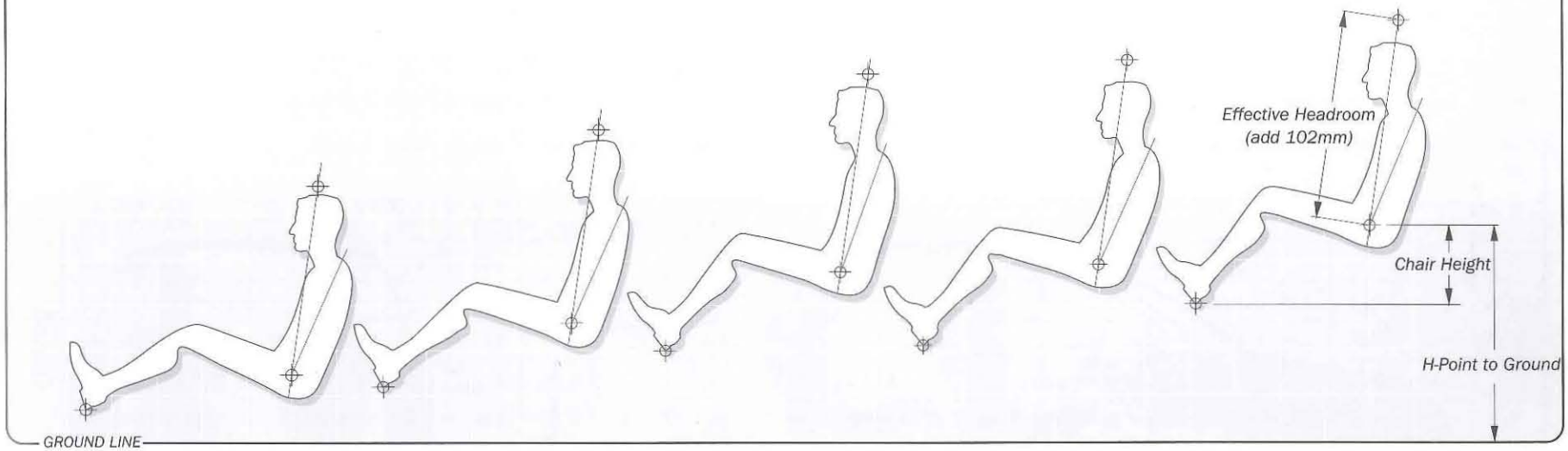


Because the rear occupants do not control the vehicle, their leg posture is not controlled by the accommodation curve. Notice how the knee angle is quite different to the driver and their feet are flat on the floor. Second, the demographics for the rear occupants may be different to the front occupants. They may be children or people who are shorter in stature to the driver, so headroom, for example, may be less.

Lastly, the function of the rear compartment will often be quite different to the front, so space may be needed for reclining passengers, swiveling or stowing seats, video monitor viewing, etc. These will all affect the spacial requirements and H point location. Other factors to consider are: roof height fuel tank size, rear cargo, three across seating, rear suspension and rear tire requirements.

VARIOUS DRIVER HEIGHTS FROM GROUND AND POSTURES

H-Point to Ground	*300 - 350**	*400 - 500*	*700 - 750*	*700 - 800*	*700 - 950*
Chair Height	*135 - 180*	*200 - 250*	*300 - 350*	*300 - 350*	*300 - 350*
Effective Headroom	*950 - 960*	*970 - 1000*	*990 - 1010*	*1010 - 1020*	*1010 - 1020*
Back Angle	*28° - 30°*	*22° - 25°*	*22° - 24°*	*22° - 24°*	*22° - 24°*



SPORTS CARS
The driver height is kept as low as possible to lower the center of gravity and reduce drag. Getting in and out of the car may be difficult but that is a compromise sports car owners will accept.

PASSENGER CARS
Most passenger car H-points are set up for a combination of easy ingress/egress and low center of gravity. Although not as extreme as most sports cars, they are relatively low.

MINIVANS
Usually set up quite high to provide a sense of security and good visibility. The tall chair height also helps to create an efficient package and provides excellent ingress and egress.

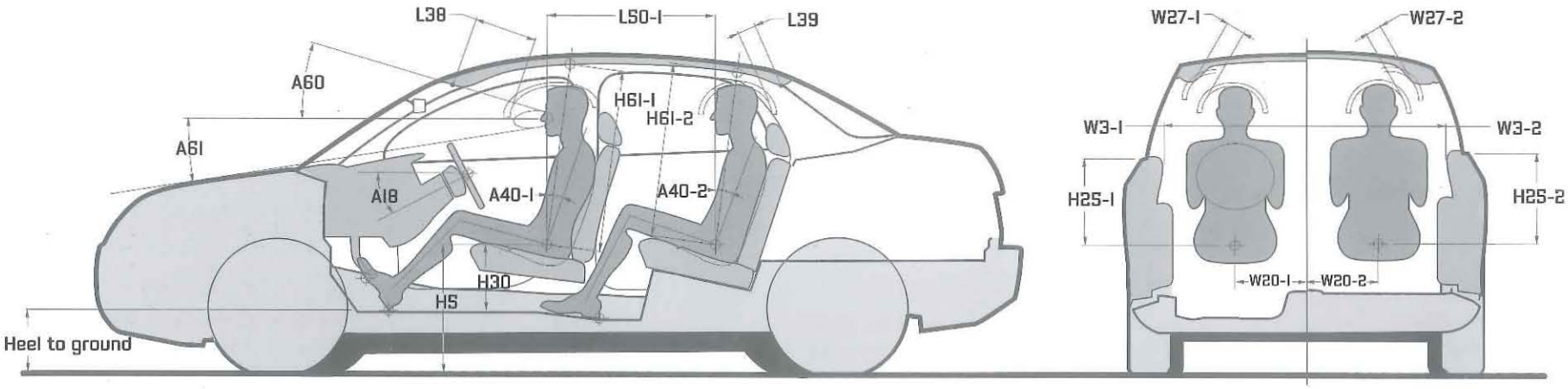
SUVs
A combination of high ground clearance and a durable underbody structure push the heel height up. The chair height is also tall to help the driver see over the engine, which is usually mounted high above the front axle.

LARGE OFF-ROAD TRUCKS
Similar to SUVs, the occupants often sit very high because of the ground clearance and the separate frame that the body sits on. Because the engines are usually very large and mounted high, the driver's eye point may end up in a very high position.

*All measurements in millimeters unless otherwise noted.

OCCUPANT ENVIRONMENT DIMENSIONS

Below is an illustration of the major dimensions that set up the interior environment around the occupant package. These are part of the SAE J1100 measurement index. Using the same measurement system for every project ensures that there is no confusion and the package database remains consistent.



For steering wheel set up, see p. 102.

APPROXIMATE REFERENCE DIMENSIONS

The table below contains some examples of dimensions taken from current production cars. Use these to set up an initial package, assuming that the criteria that has driven these numbers is similar to your concept. As the design develops and key elements in the package evolve, these may change.

As you work through the process, develop an understanding of the factors that govern these interior environment dimensions.

		DRIVER & FRONT PASSENGER										REAR OCCUPANTS						
		Heel to Ground (Ref)	Chair Height H30	H point to ground H5	Back Angle A40	Effective Head Room H61	Upward Vision Angle A60	Downw'd Vision Angle A61	Shoulder Room W3	Hip Room W5	Lateral Location W20	Couple L50	Chair Height H30-2	Back Angle A40-2	Effective Head Room H61-2	Shoulder Room W3-2	Hip Room W5-2	Lateral Location W20-2
CARS	NEV	325	400	725	15.0	1075	11.0	10.0	-	-	275	-	-	-	-	-	-	-
	SPORTS CAR	175	150	325	28.0	950	8.0	5.0	1350	1275	325/400	-	-	-	-	-	-	-
	MICRO CAR	350	275	625	21.0	1000	14.0	11.0	1200	1150	300	-	-	-	-	-	-	-
	SMALL ELECTRIC CAR	450	250	700	24.0	975	15.0	9.0	1325	1325	350	750	275	26.0	950	1325	1325	325
	SMALL CAR	225	250	475	24.0	975	15.0	7.0	1350	1325	350	750	275	27.0	950	1350	1325	325
	MEDIUM CAR	250	250	500	24.0	975	14.0	7.0	1475	1400	350	850	275	27.0	950	1475	1400	325
	MEDIUM COUPE	250	175	425	24.0	950	13.0	5.0	1375	1325	350	750	200	27.0	875	1375	1325	325
	LARGE CAR	275	250	525	24.0	975	14.0	6.0	1500	1450	375	900	275	27.0	975	1500	1450	400
	LARGE LUXURY CAR	275	275	550	22.0	975	15.0	7.0	1550	1500	400	975	300	28.0	975	1550	1450	375
TRUCKS	MINIVAN	425	350	775	20.0	1010	19.0	11.0	1575	1525	425	850	375	22.0	1000	1575	1525	400
	SMALL SUV	400	350	750	22.0	1010	15.0	9.0	1425	1400	400	800	375	24.0	1000	1425	1375	375
	MEDIUM SUV	450	300	750	22.0	1010	14.0	6.0	1500	1450	400	825	325	24.0	1000	1500	1450	425
	LARGE SUV	450	325	775	22.0	1025	14.0	7.0	1650	1600	375	875	350	24.0	1025	1650	1600	375
	SMALL TRUCK	400	300	700	22.0	1010	14.0	7.0	1475	1450	375	625	325	18.0	950	1475	1425	400
	LARGE 4x4 TRUCK	600	350	950	22.0	1025	15.0	8.0	1700	1650	475	950	375	18.0	1025	1700	1650	475
	COMMERCIAL VAN	725	350	1075	22.0	1010	10.0	10.0	1675	1625	525	900	425	19.0	1000	1675	1625	500