

3. ULSAB Phase 2 Package

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3.1. General Approach

Discussions with OEMs about Phase 1 findings provided valuable input and guidance for the more detailed Phase 2 package layout created at the start of Phase 2. The Phase 2 package was defined as a modification of the Phase 1 package without being too specific so the package findings could apply to more than one body structure concept. The most important components, space definitions and dimensions had to be considered by either defining them using engineering judgment, or by using actual component dimensions. Furthermore, secondary mass savings were not considered in order to take a more conservative and more credible approach. This is also reflected in component size and mass, as well as in the crash mass used for the crash analysis.

3.2. Package Definition

The first step in the package phase was to define the vehicle concept type, exterior dimensions, interior dimensions and the main components. With these package definitions, package drawings were revised and structural hard points defined.

3.2.1. Vehicle Concept Type

In Phase 2 the same concept type definition was used as in Phase 1, five passenger and four door midsize sedan.

3.2.2. Exterior Dimensions

Ident.*	Definition	Measurements
W101	Tread - front	1560 mm
W102	Tread - rear	1545 mm
W103	Vehicle width	1819 mm
W117	Body width at SgRP - front	1767 mm
L101	Wheelbase	2700 mm
L103	Vehicle length	4714 mm
L104	Overhang - front	940 mm
L105	Overhang - rear	1074 mm
L114	Front wheel centerline to front SgRP	1447 mm
L123	Upper structure length	2631 mm
L125	Cowl point - X coordinate	2016 mm
L126	Front end length	1281 mm
L127	Rear wheel centerline - X coordinate	4295 mm
L128	Front wheel centerline - X coordinate	1595 mm
L129	Rear end length	654 mm
H101	Vehicle height	1453 mm
H106	Angle of approach	14°
H107	Angle of departure	15°
H114	Cowl point to ground	1001 mm
H121	Backlight slope angle	61°
H122	Windshield slope angle	59°
H124	Vision angle to windshield upper DLO	15°
H136	Zero Z plane to ground - front	112 mm
H138	Deck point to ground	1091 mm
H152	Exhaust system to ground	170 mm
H154	Fuel tank to ground	188 mm
H155	Spare tire well to ground	311 mm

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3.2.3. Interior Dimensions

Ident.*	Definition	Measurements
W3	Shoulder room - front	1512 mm
W4	Shoulder room - second	1522 mm
W5	Hip room - front	1544 mm
W6	Hip room - second	1544 mm
W7	Steering wheel center - Y coordinate	350 mm
W9	Steering wheel maximum outside diameter	370 mm
W20	SgRP - front - Y coordinate	350 mm
W25	SgRP - second - Y coordinate	335 mm
W27	Head clearance diagonal - driver	79 mm
W33	Head clearance diagonal - second	83 mm
W35	Head clearance lateral - driver	136 mm
W36	Head clearance lateral - second	132 mm
L7	Steering wheel torso clearance	418 mm
L11	Accelerator heel point to steering wheel center	412 mm
L13	Brake pedal knee clearance	573 mm
L30	Front of dash - X coordinate	1942 mm
L32	SgRP - second to rear wheel centerline	473 mm
L34	Effective leg room - front	1043 mm
L38	Head clearance to windshield garnish - driver	266 mm
L39	Head clearance to backlite garnish	21 mm
L40	Torso (back) angle - front	25°
L41	Torso (back) angle - second	25°
L42	Hip angle - front	93°
L43	Hip angle - second	86°
L44	Knee angle - front	118°
L45	Knee angle - second	88°
L46	Foot angle - front	78°
L47	Foot angle - second	113°
L50	SgRP couple distance	780 mm
L51	Effective leg room - second	894 mm
L52	Brake pedal to accelerator	48 mm
L53	SgRP - front to heel	832 mm

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3.2.3. Interior Dimensions (Cont'd)

Ident.*	Definition	Measurements
H5	SgRP - front to ground	519 mm
H6	SgRP - front to windshield lower DLO	495 mm
H10	SgRP - second to ground	529 mm
H11	Entrance height - front	798 mm
H12	Entrance height - second	810 mm
H13	Steering wheel to centerline of thigh	67 mm
H14	Eyellipse to bottom of inside rearview mirror	40 mm
H17	Accelerator heel point to steering wheel center	645 mm
H18	Steering wheel angle	23°
H25	Belt height - front	446 mm
H26	Interior body height - front at zero Y plane	1011 mm
H27	Interior body height - front at SgRP Y plane	1220 mm
H29	Interior body height - second at SgRP Y plane	1033 mm
H30	SgRP - front to heel	245 mm
H31	SgRP - second to heel	303 mm
H32	Cushion deflection - front	49 mm
H33	Cushion deflection - second	66 mm
H35	Vertical head clearance - driver	75 mm
H36	Head clearance vertical - second	49 mm
H37	Headlining to roof panel - front	7 mm
H38	Headlining to roof panel - second	7 mm
H40	Steering wheel to accelerator heel point	468 mm

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3.2.3. Interior Dimensions (Cont'd)

Ident.*	Definition	Measurements
H41	Minimum head clearance - driver	88 mm
H42	Minimum head clearance - second	21 mm
H49	Eyellipse to top of steering wheel	17 mm
H50	Upper-body opening to ground - front	1317 mm
H51	Upper-body opening to ground - second	1339 mm
H53	D-point - front to heel	137 mm
H54	D-point - center passenger - front to tunnel	105 mm
H55	D-point - center passenger - second to tunnel	43 mm
H56	D-point - front to floor	182 mm
H57	D-point - second to floor	72 mm
H60	D-point to heel point - second	19 mm
H61	Effective head room - front	1019 mm
H63	Effective head room - second	972 mm
H64	SgRP - front to windshield upper DLO	796 mm
H69	Exit height - second	743 mm
H70	SgRP - front - Z coordinate	631 mm
H71	SgRp - second - Z coordinate	641 mm
H75	Effective T-point head room - front	994 mm
H76	Effective T-point head room - second	932 mm
H77	Seatback height - front	868 mm
H78	Seatback height - second	781 mm
H94	Steering wheel to cushion - minimum	223 mm

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3.2.4. Main Component Definition

Component	Description	Remarks
Engine	V6 ~3000 ccm	Average size
Engine Mounts	Total of 3	2 on top of front rail 1 on subframe
Radiator Size	.252 m ²	With single fan
Exhaust System	Single routing, 1 catalytic converter, 1 muffler	Vol 2.8 catalytic converter 21 ltr. muffler, LHS
Battery L x W x H	280mm x 170mm x 170 mm	LHS front of engine compartment
Drive Train	Transverse front wheel drive	
Transmission	Automatic - manual	G-shift for manual included in package
Suspension Type, Front	McPherson	Mounted to front subframe
Suspension Type, Rear	Twist beam	With separate spring shock absorber
Tire Size Front-Rear	195/60R15	Winter tires 185/60R15
Spare Tire	Space saver	Tub to fit full size tire
Fuel Tank volume	~65 ltr	Located under rear seat
Fuel Filler	On RHS	Routing in package
Bumper Front-Rear	Bolt-on	Crash boxes included
Steering	Rack & pinion	Steering rack housing on top of crossmember dash
Cargo Volume	490 ltr	VDA method with 200 x 100 x 50 mm module
Hinges	Similar to Porsche 911 / Boxster	Weld through type
Head Lamps	Part of front end module	
Interior	Front and rear seat concept	In package drawing
Cockpit	Basic concept with I/P beam	In package drawing
Pedals	Unit with integrated foot-parking-brake	In package drawing

3.2.5. Underfloor Clearance

The underfloor clearance of a vehicle depends on the vehicle load. The determination of the underfloor clearance relative to the road surface was crucial for the body structure design, styling, selection of components and their positioning in the vehicle structure. Underfloor clearance is defined as the summary of five different parameters. These are:

- Curb Clearance Front / Rear
- Angle of Approach / Departure
- Ramp Brakeover Angle
- Oil Pan Clearance
- Ground Clearance

To define these parameters, three vehicle positions, which then depended on three specific load cases, needed to be determined. The three load cases applied to the vehicle were:

- Curb weight:
The weight of a vehicle equipped for normal driving conditions. This includes fluids such as coolant, lubricants and a fuel tank filled to a minimum of 90%. Also included are the spare tire, tool kit, and car jack.
- Design weight:
Vehicle curb weight plus the weight of three passengers (68 kg each, with luggage 7 kg each) with 2 passengers in the front seat and 1 passenger in the rear seat.
- Gross vehicle weight:
Vehicle curb weight plus maximum payload (5 passengers plus luggage).

To determine the vehicle position relative to the road surface under these load conditions, the vehicle is positioned relative to zero grid Z-plane.

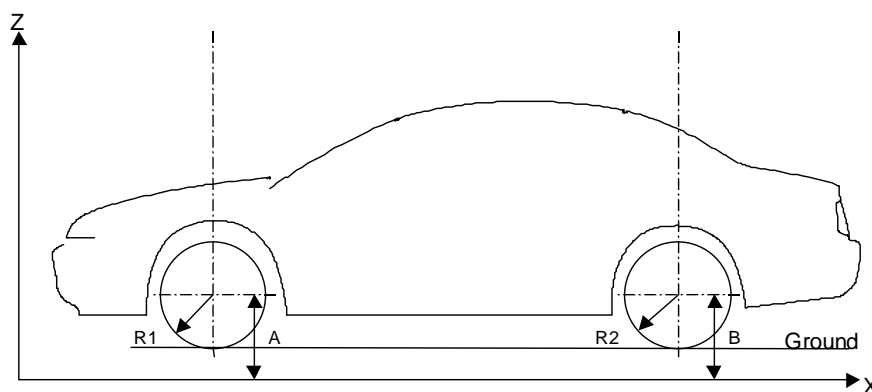


Figure 3.2.5-1 ULSAB Vehicle Position Relative to Zero Grid Z-Plane

Using the ULSAB data and the weights of the three load cases, the road surface positions relative to the zero grid Z-plane and to the vehicle were calculated.

ULSAB Data		
Number of Seats		5
Wheelbase		2700 mm
Tires	Front	195/60-R15
	Rear	195/60-R15
Pressure	Front	2.5 bar
	Rear	2.5 bar

Calculation of Road Surface Positions Relative to the Vehicle

Load Case	Distance from Zero Grid Z-Plane		Static Tire Radius		Weight
	A (mm)	B (mm)	R1 (mm)	R2 (mm)	
Curb Weight	395	392	301	308	1350 kg
Design Weight	413	417	301	305	1575 kg
Gross Vehicle Weight	415	462	303	300	1850 kg

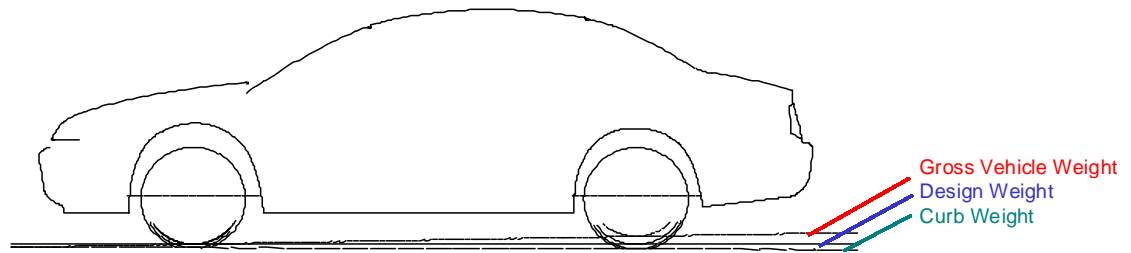


Figure 3.2.5-2 Road Surface Relative to Vehicle

With the road surface positions relative to the vehicle, the underfloor clearance was determined.

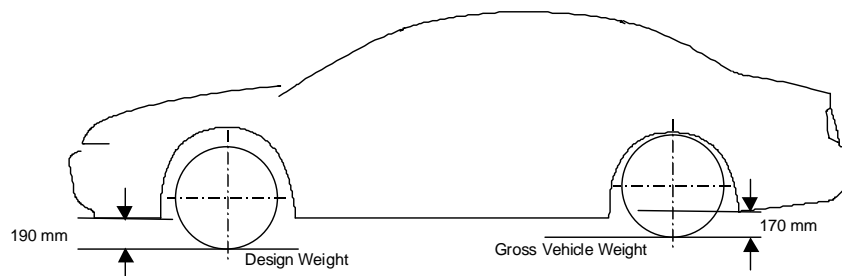


Figure 3.2.5-3 Curb Clearance Front/Rear

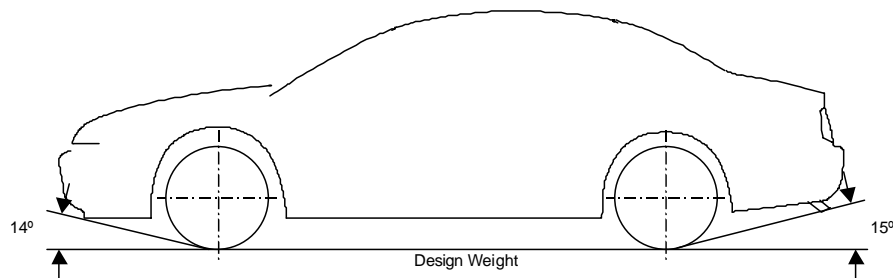


Figure 3.2.5-4 Angle of Approach/Departure

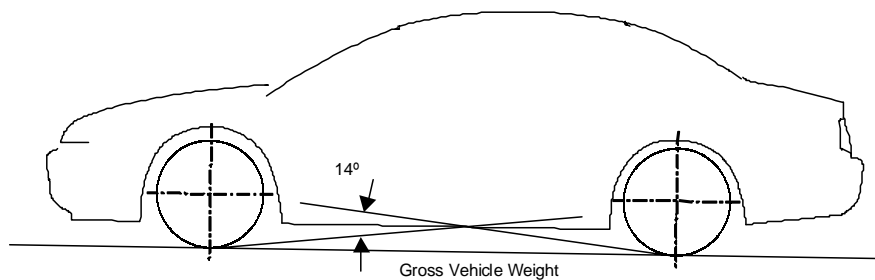


Figure 3.2.5-5 Ramp Breakover Angle

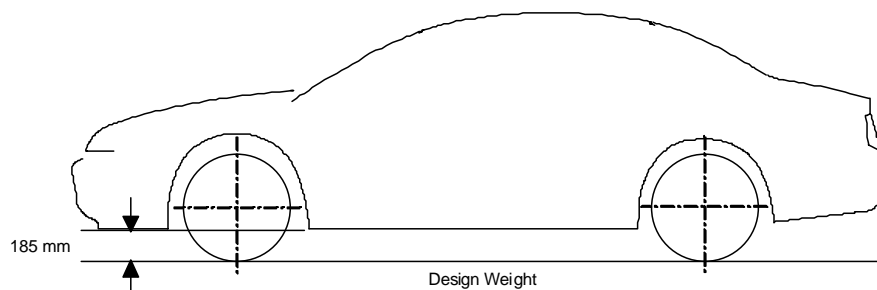


Figure 3.2.5-6 Oil Pan Clearance

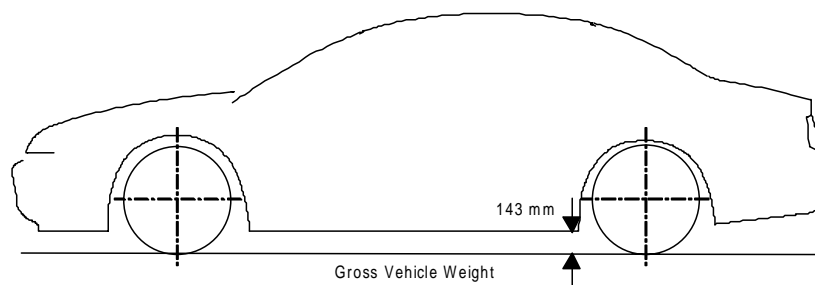


Figure 3.2.5-7 Ground Clearance

3.2.6. Seating Position

At first the 2-D manikins (spelling taken from SAE) were aligned in a comfortable seating position taking into consideration the angles between joints such as hip, knee, and foot. When the seating position was defined, verification was made that the operating parts like steering wheel, gearshift lever and pedal were in reach. This was important for ergonomic reasons. Two types of 2-D manikins were used: The small female, 5th percentile with a height of 147.8 cm; and the tall male, 95th percentile with a height of 185.7 cm. (5th percentile means that 5% of the population is smaller or equal in size and 95% is taller. 95th percentile means that 95% of the population is smaller or equal in size and 5% is taller.)

For the dash panel layout the tall male 2-D manikin was used because it is more difficult to reach, since the seat position of the taller person is more rearward than it is for a shorter person.

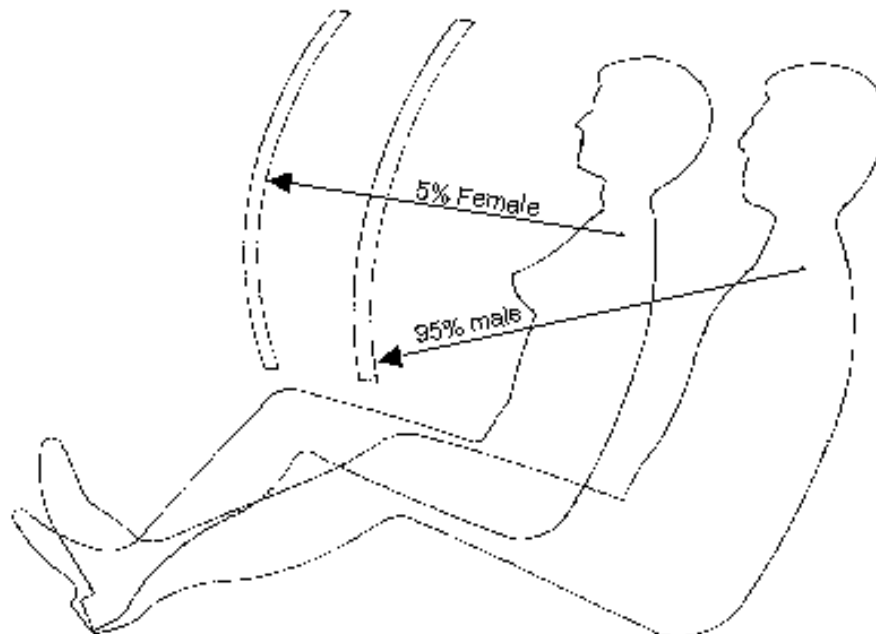


Figure 3.2.6-1 Distance to Operating Parts of the 5% Female and the 95% Male

3.2.7. Visibility Study

3.2.7.1. Horizontal and Vertical Obstruction

For the study of horizontal, vertical and A-pillar obstruction of the driver's visibility, the following positions needed to be defined:

- **Seating Reference Point (SgRP)**
It was necessary to determine the seating reference point (SgRP) in order to position the eyellipse (spelling taken from SAE) template and the eyepoints V1 / V2. For adjustable seats, the SgRP is defined as the hip-point (H-Point) relative to the driving seat in its most rearward position. The H-point is defined as the pivot center of the torso and thigh center lines.

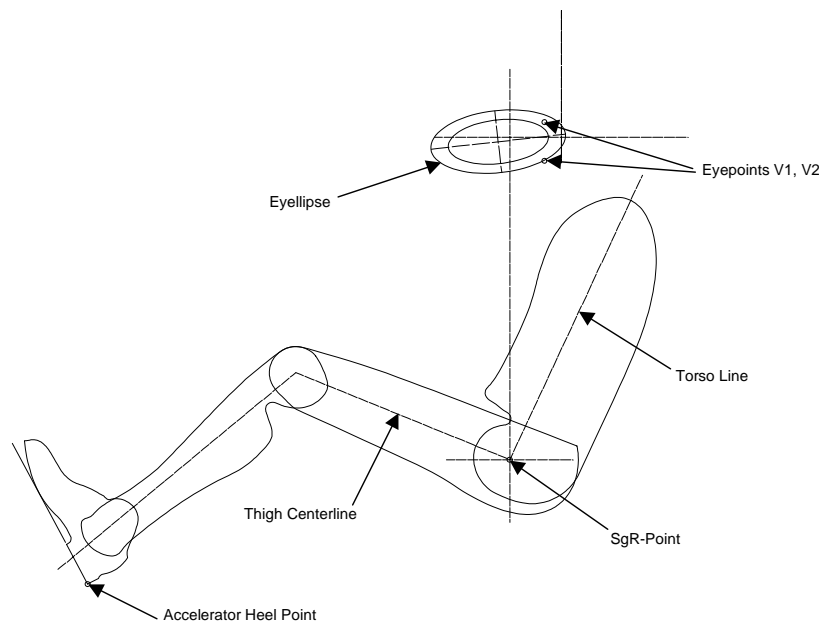


Figure 3.2.7-1 SgRP, Eyellipse, Eyepoints

- **Eyellipse (SAE J941)**
The eyellipse is a tool to describe the vision of a driver. The template with the eyellipse is positioned with its horizontal reference line 635 mm above the SgRP and with the vertical reference line through the SgRP. Two types of templates, with two eyellipses, take the different seat track travel

ranges into consideration. For the ULSAB vehicle, with a seat track travel of 240 mm, a template for seat track travel of more than 130 mm was used.

- Eye Points V1 / V2 (RREG 77/649)
The coordinates of the eye points V1 / V2 relative to the SgRP were determined by using the following dimensions:

Point	X	Y	Z
V1	68	-5	665
V2	68	-5	589

Using vision lines through the eye points, the following vision areas are described:

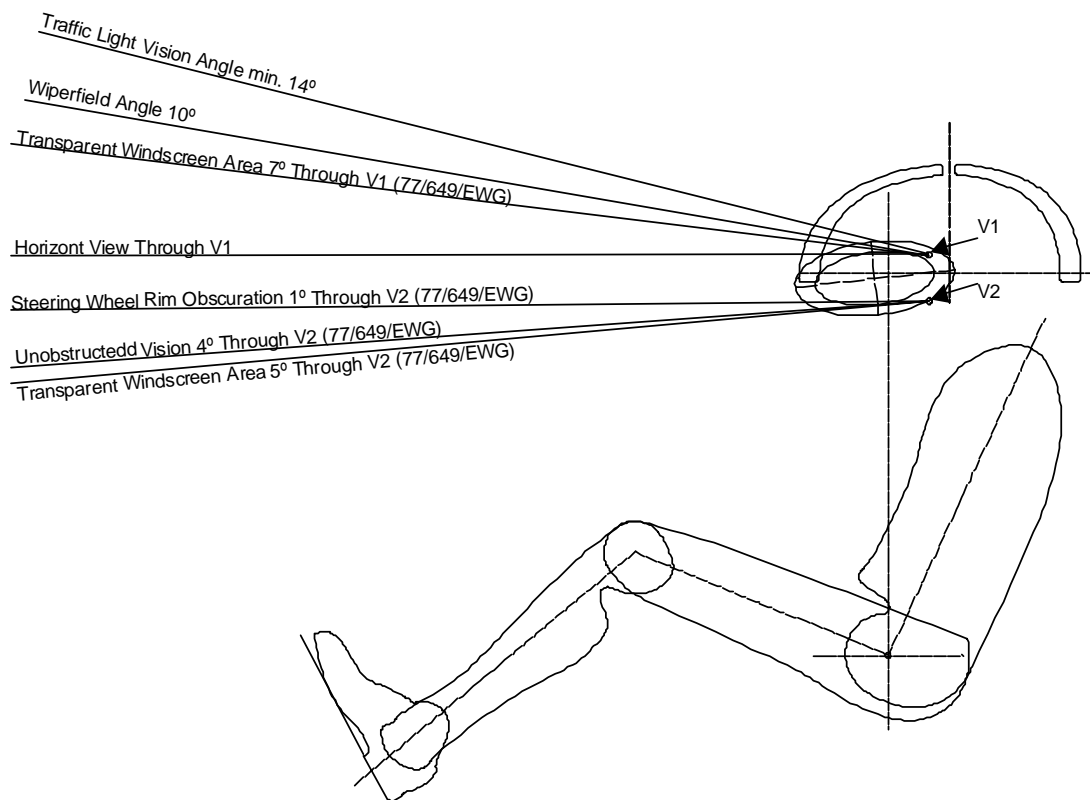


Figure 3.2.7-2 Horizontal Vision

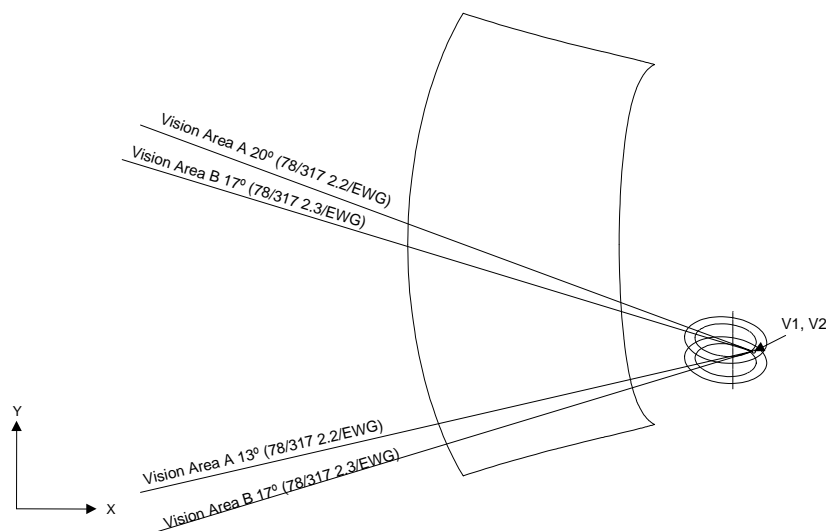


Figure 3.2.7-3 Vertical Vision

3.2.7.2. A-Pillar Obstruction

In order to determine the A-pillar obstruction, points P1 and P2 have to be determined first. The coordinates for these points related to the SgR-point are:

Point	X	Y	Z
P1	35 mm	-20 mm	627 mm
P2	63 mm	47 mm	627 mm

The ULSAB structure has a seat track travel of 240 mm. Therefore the X-value has to be corrected by -48 mm.

Since the torso back angle is 25 degrees, no further correction is necessary for the X-value and Z-value.

The new coordinates for the P-points are:

Point	X	Y	Z
P1	-13 mm	-20 mm	627 mm
P2	+15 mm	47 mm	627 mm

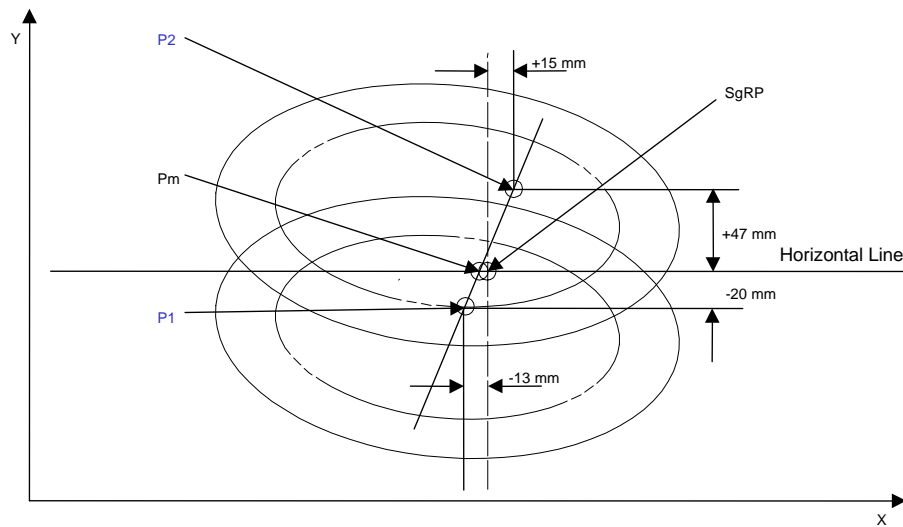


Figure 3.2.7.2-4 Distance of the P-Points Relative to the SgR-Point

Two planes are cutting the A-pillar in an angle of 2 and 5 degrees. In the front most intersection, the horizontal planes S1 and S2 cut the A-pillar (Figure 3.2.7-5).

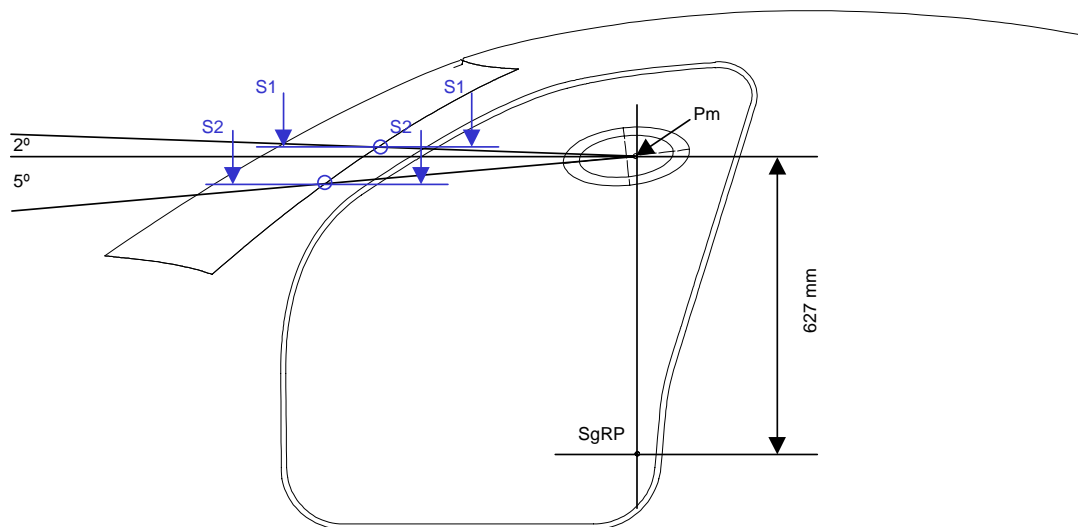


Figure 3.2.7.2-5 Determination of the Sections S1 and S2

The sections in the plan view are shown in Figure 3.2.7-6.

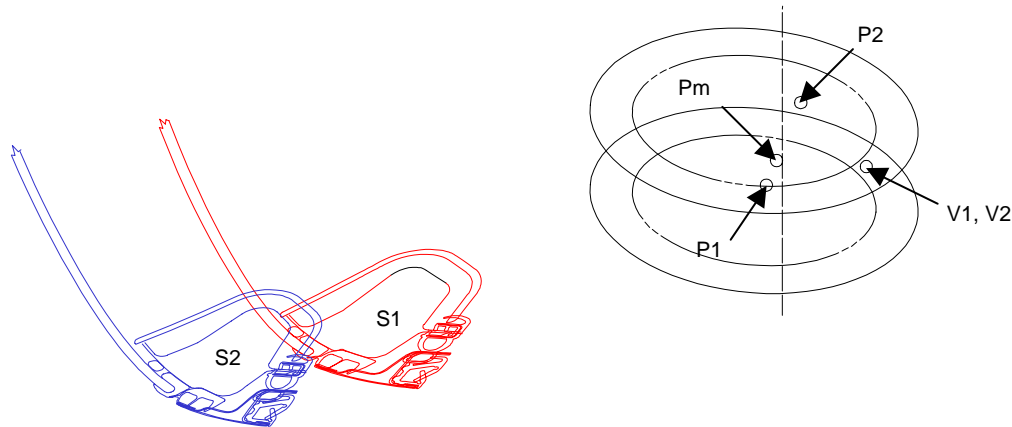


Figure 3.2.7-6 Sections S1 and S2 in Plan View

The point P1 is necessary to determine the A-pillar obscuration for the left side (for a left hand drive vehicle). P2 is necessary for the right side. If P1 fulfills the requirements, it is not necessary to determine the obscuration for the right A-pillar, since the right pillar is farther away from the driver.

The template to determine the obstruction is shown in Figure 3.2.7-7.

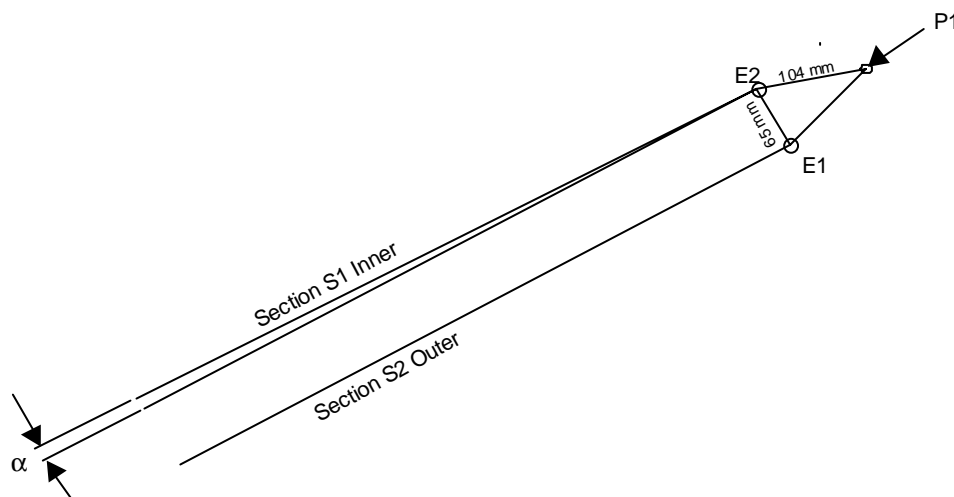


Figure 3.2.7-7 Template for A-Pillar Obstruction

The point P1 on the template is aligned to the point P1 on the drawing. The line “Section S2 Outer” is laid tangent to the most outer edge of the A-pillar section (S2), including trim, door frame and door seal. The second tangent line “Section S1 inner” is laid to the most inner edge of the A-pillar section (S1), including trim, seal and dot matrix. (Figure 3.2.7-8).

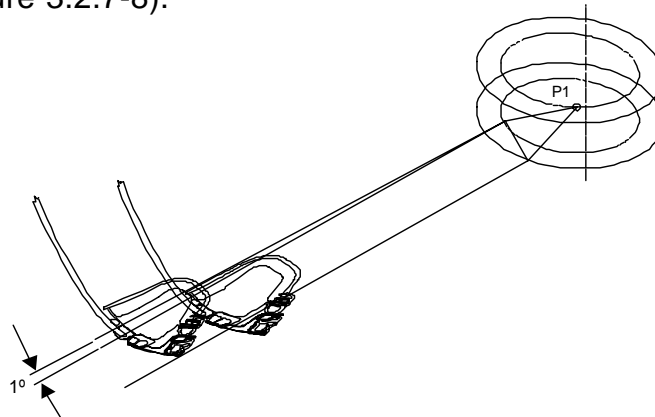


Figure 3.2.7-8 Template in Position

3.2.8. Gear Shift Lever Postion

The position of the gearshift lever depends on the SgRP-position and on the torso back angle. The position of the gearshift lever in the side view is shown in Figure 3.2.8-1.

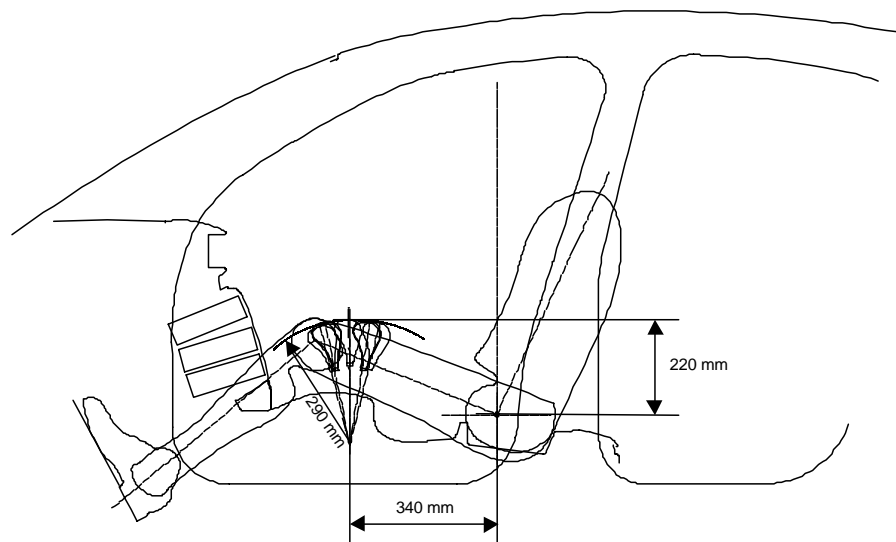


Figure 3.2.8-1 Distance of Gearshift Lever Relative to SgR-Point

3.2.9. Pedal Position

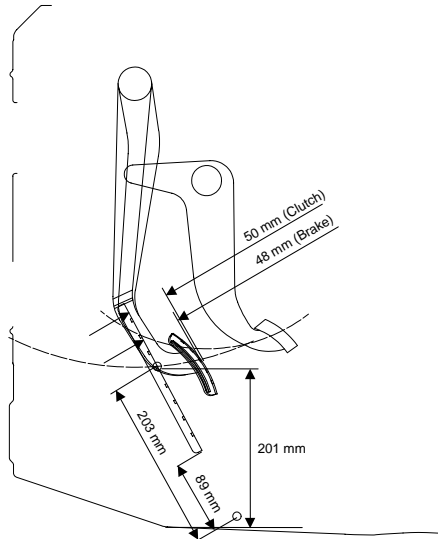


Figure 3.2.9-1 Pedal Position Side

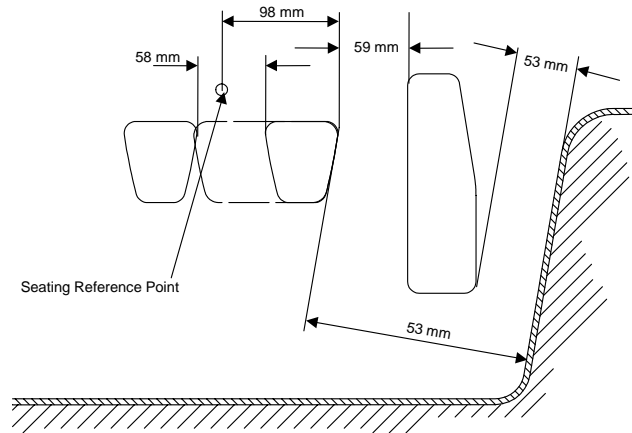


Figure 3.2.9-2 Pedal Position Rear

3.2.10. Bumper Height Definition

ECE R42 for the bumper height definition requires a pendulum 445 mm above the curb weight vehicle position and the design weight vehicle position. At the same time an overlapping of 35 mm of the pendulum to the bumper is required.

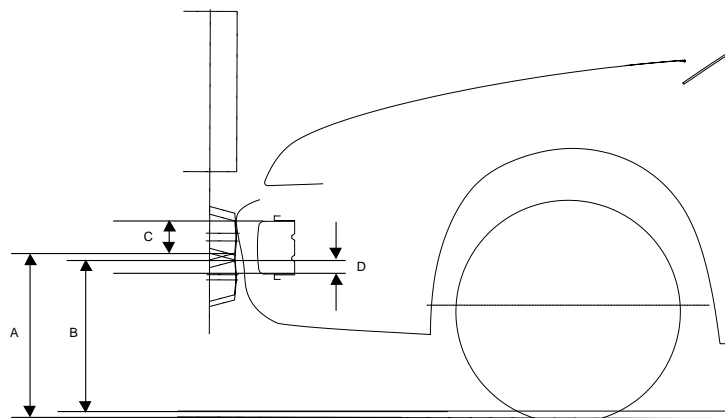


Figure 3.2.10-1 Pendulum in the Extreme Height Position

- A: Lower edge of the pendulum in the most upper level to the curb weight vehicle position.
- B: Upper edge of the pendulum in the most lower level to the design weight vehicle position.
- C: Overlapping of the pendulum to the bumper in extreme high position.
- D: Overlapping of the pendulum to the bumper in extreme low position.

	A	B	C	D
Front	467 mm	431 mm	91 mm	40 mm
Rear	467 mm	402 mm	89 mm	38 mm

3.3. Package Drawings

Since package drawings are orthographic projections of the vehicle contour in side view, plan view, front view and rear view, these views include all essential parts of the interior such as seats, seat position, seating reference point (SgRP), operating parts and the door openings. To define the interior of the vehicle including the seat position, visibility, and obstruction by the pillars, roof, hood and deck lid positions were determined. It was also important to define positions of the steering wheel, pedals, and gearshift lever. Other criteria were visibility to the instrument panel, and head clearance to the front, top and side. In the engine compartment, the engine, gearbox, exhaust system, radiator and battery were used in defining the space for the structural members of the front body structure. Components such as the fuel tank with the fuel filler system, the catalytic converter and exhaust system, and spare tire tub were also included in the package drawings. The package drawings were the starting point for the Phase 2 design.

3.3.1. Side View

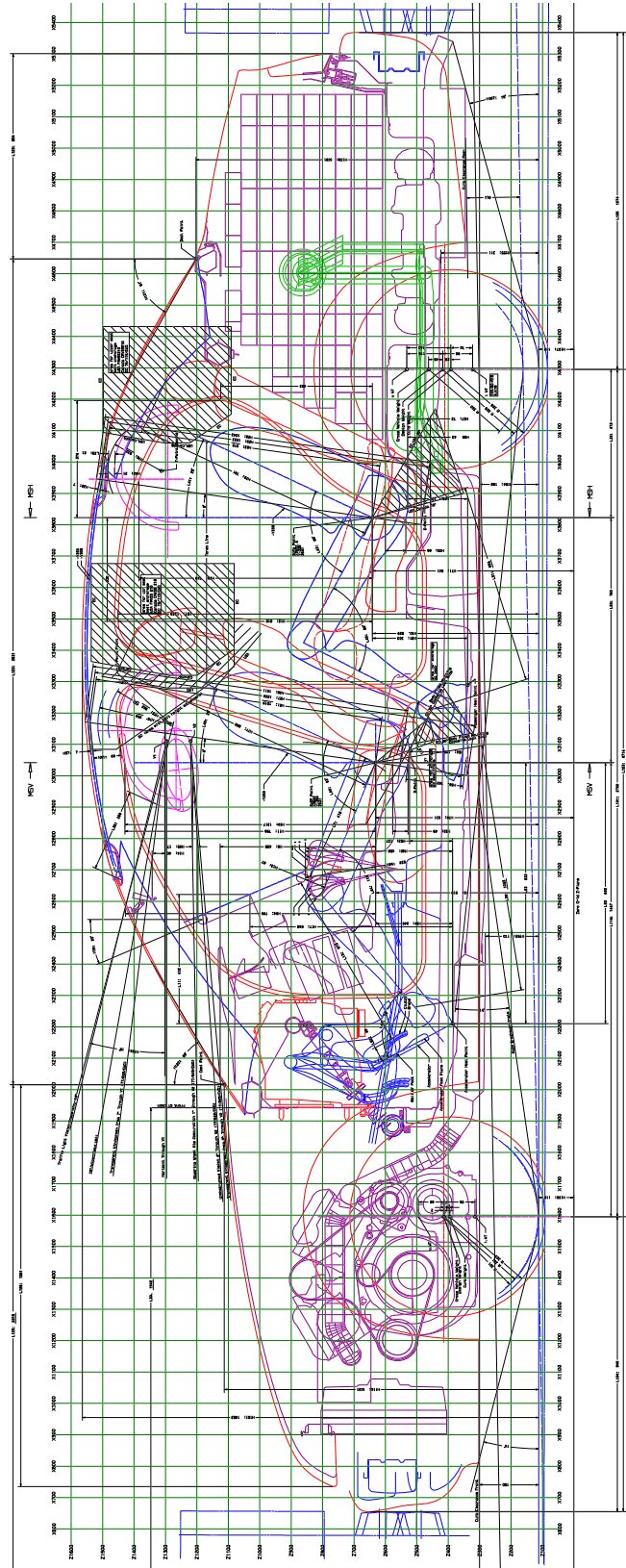


Figure 3.3.1-1 Packing Drawing Side View

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Figure 3.3.2-1 Package drawing Plan View

3.3.3. Front and Rear View

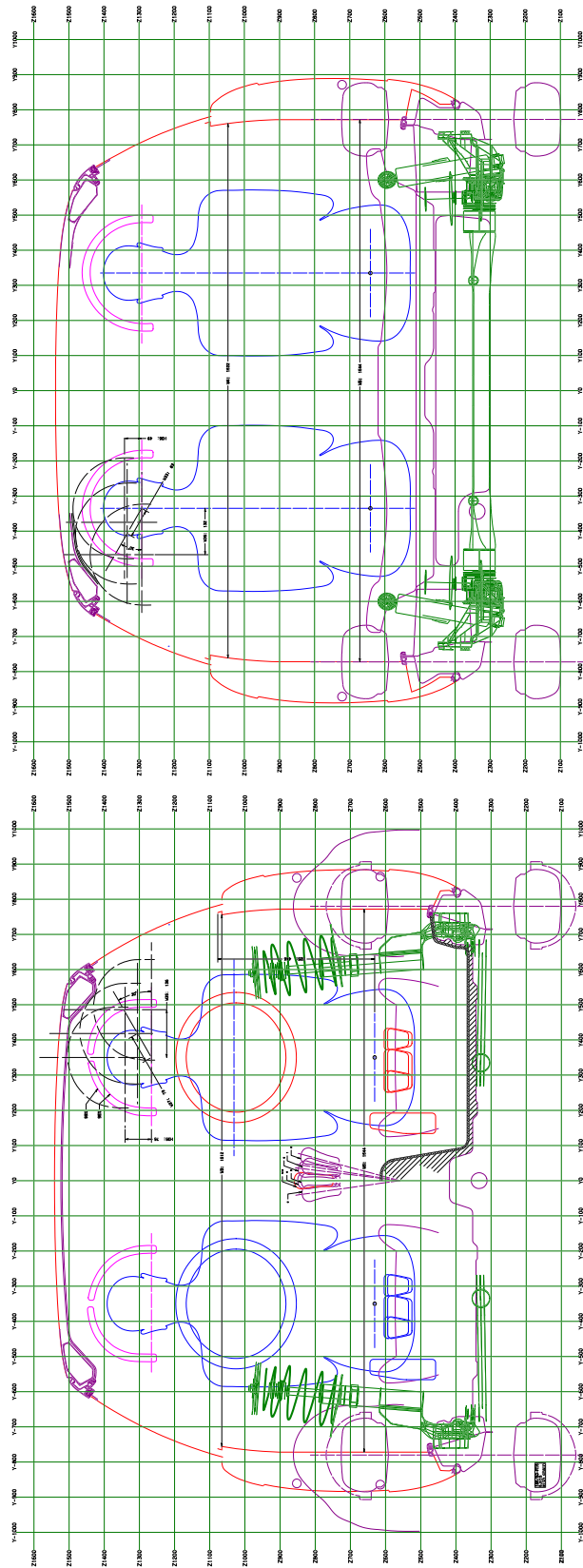


Figure 3.3.3-2 Package Drawing Rear View

Figure 3.3.3-1 Package Drawing Front View