PORSCHE
Engineering Services, Inc.

4 Package

Component material specifications, targets for crashworthiness and vehicle dimension specifications had a major influence on packge.

4.1 BACKGROUND

Packaging is the most important task in any vehicle development program. In the package development, important directions for component designs are established. ULSAB-AVC boundary conditions, such as component material specifications, targets for vehicle crashworthiness and vehicle dimension specifications, had a major influence on the direction taken for the vehicle package.

During the ULSAB-AVC Program, the package was iterated several times because of the continuous design optimization for crashworthiness and ongoing component design that were necessary before the package could be finalized.

4.2. Package Approach

The main influencing factors for the package concept were defined, analyzed and the first direction for the main component design was established with the following priorities.

- Crashworthiness Targets
- Total Vehicle Mass Target
- Vehicle Dimensions (exterior and interior)
- Body Structure Platform Concept
- Modular Vehicle Assembly Approach
- Material Specifications

The main drivers of the package development were the considerations to achieve the crashworthiness targets and all component mass targets, as well as the target for total vehicle mass. Therefore, special attention was given to the development of the body structure, which was the key to the successful execution of this Program.

The Program encompassed a two vehicle concept (C-Class and PNGV-Class) to be developed utilizing a platform approach, sharing as many common components as possible, including engines and suspension components. The vehicles' class and type, as specified reflect the international assembly of the ULSAB-AVC Consortium and the special interests of the involved regions of the world.

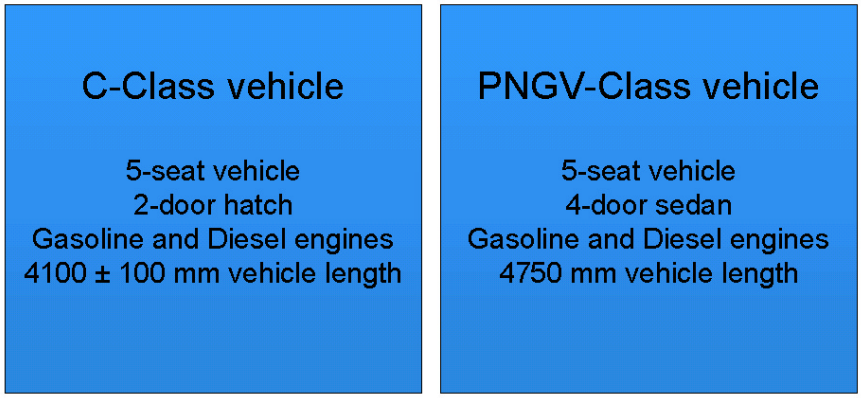


Figure 4.2-1 Specified vehicle class and type

The ULSAB-AVC Consortium specified the materials for main components during the Program Target Setting. For the development of components specified with steel, new steel materials and technologies and their impact on the component design, such as cross section size of structural members and part manufacturing feasibility had to be considered.

Another consideration was the modular assembly approach, reducing assembly time and reducing cost of ownership with enhanced servicing by creating a module consisting of powertrain and suspension. This module gives greater ease for disassembly in the body shop/service center, therefore reducing servicing time.

4.3. Engine Bay Package

Prior to the beginning of the engine bay package concept, several ideas were developed and analyzed for suitability. Mass reduction and safety were the main drivers for the engine bay package.

One of the first decisions was to design both vehicles with front wheel drive front engine as typical for state of the art vehicles in both classes and preferred by customers.

Another early consideration for package development was crashworthiness including specifically pedestrian head injury and frontal crash performance (US-NCAP and Euro-NCAP) with a reduced front vehicle overhang and the optimization of dynamic vehicle crash length by avoiding stack-up of the powertrain and its auxiliaries. Another important design consideration was to improve the load distribution to the front and rear axle and to lower the center of gravity. This design consideration creates better vehicle handling dynamics than a conventional front wheel drive front engine vehicle design, where the powertrain is located on top, or in some cases in front of the front axle (center of front wheels).

In summary, this engine bay package was chosen because of its potential for:

- Safety
  - No footwell intrusion of powertrain for US-NCAP
  - Increase of dynamic frontal crash length
  - Engine/Auxiliaries can be packaged further below the hood (head injury pedestrian)
- Vehicle Mass Distribution
  - Short front overhang
  - Reduced front axle load compared to typical front wheel drive vehicles
- Auxiliary Mass
  - Short exhaust system (less mass)
  - Catalytic converter can be packaged close to the exhaust manifold
- Body Structure Mass
  - More freedom to design lightweight front end with engine packaged below the front rails
- NVH
  - Possibility to close off engine bay above the rails, thus avoiding sound emissions through openings for ducting and cable routing
- Package space
  - Space above the front rails can be used for packaging of components which are usually packaged inside the vehicle

- Wheelbase
  - Possibility to increase interior package space resulting from the possibility to maximize the wheelbase

In the ULSAB-AVC vehicles' engine bay package shown in Figure 4.3-1, the engine was located almost flat with the crankshaft in transverse direction and the cylinder head facing rearwards into the tunnel and the transmission forward of the engine.

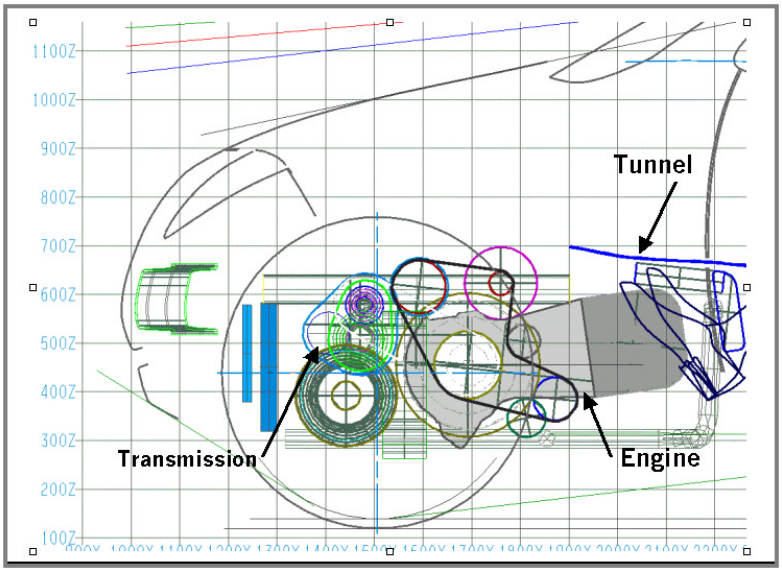
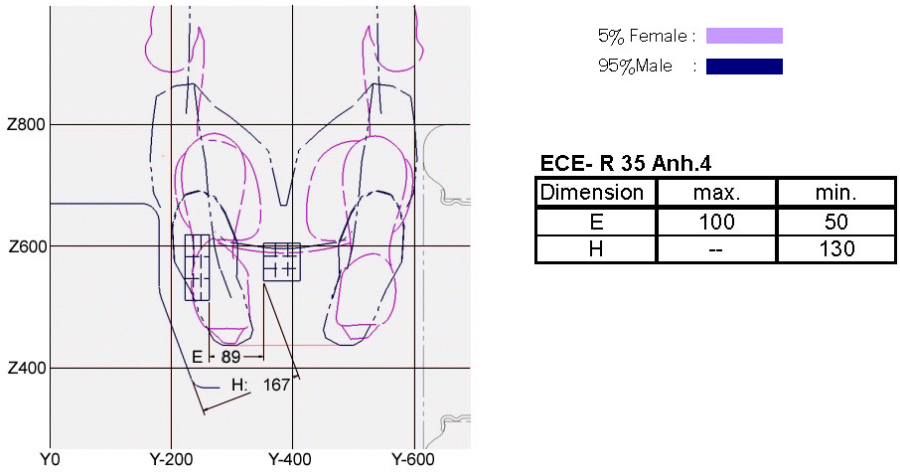


Figure 4.3-1 Engine bay package

For the engine bay package development, wheel envelopes respecting kinematics and elastokinematic movements of the wheels, tolerances of all suspension parts and tire deformations were used to account for adjustments in a further development phase (detailed design and vehicle testing).

4.4. Seating Packaging Concept

Once the engine location and estimated dimensions were defined, a relatively large tunnel width was necessary to accommodate the selected engine (See Section 8.4), which was a VR 3-cylinder for width reduction reasons. Figure 4.4-1 shows that even with these tunnel dimensions, sufficient clearance in accordance with ECE R 35 Anh. 4 between the accelerator pedal and tunnel wall was achieved with the defined seating position.



ECE- R 35 Anh.4

Dimension	max.	min.
E	100	50
H	--	130

Figure 4.4-1 Pedal arrangement

This pedal arrangement position would allow the width of the tunnel to be increased by approximately 30 mm on each side, but was chosen for comfort reasons.

Very early in the Program, an assumption was made that the seating concept integrating a cross car beam transferring loads from right to left hand side of the vehicle would enhance crashworthiness in side impact crash events. This concept would allow a body structure design with less mass added to the rocker and the lower B-pillar area especially for the Side Pole crash event. The challenge in the packaging of this concept was to find the right position of the beam and to integrate the beam in a seating concept providing for the required rear passenger legroom, standard for the vehicle classes in the ULSAB-AVC Program.

With a fixed front seat, several measures to assure ergonomic compliance were necessary to make this concept feasible. The first step was to investigate the necessary movement of the steering wheel in both longitudinal and height position and to define the necessary movement of the pedal system and to verify the vision angles. Therefore, a package investigation was performed using the large male 95% manikin and the small female 5% manikin positioned in the fixed seating concept which were considered as the worst case scenarios.

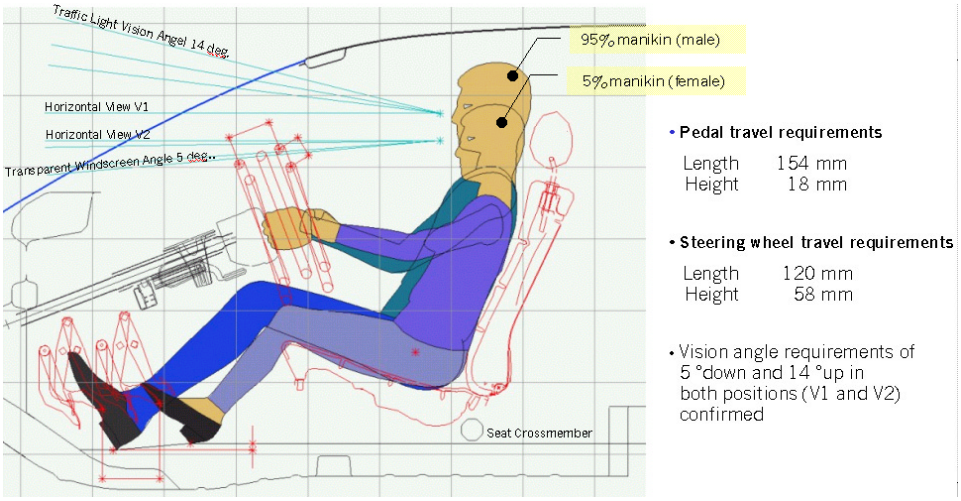


Figure 4.4-2 Pedal travel requirements

The results of this investigation confirmed the concept feasibility and the resulting requirements were used for steering column and pedal system development. In addition, to enhance comfort, the seat would be equipped with an adjustable seat cushion with a travel of 40-45 mm in height.

The rear seating concept for the C-Class vehicle features a foldable seatback with a 1/3:2/3 split and is a standard arrangement in today's C-Class vehicles. For the PNGV-Class vehicle, this system was used. The rear seat arrangement, both folded and unfolded is shown in Figure 4.4-3.

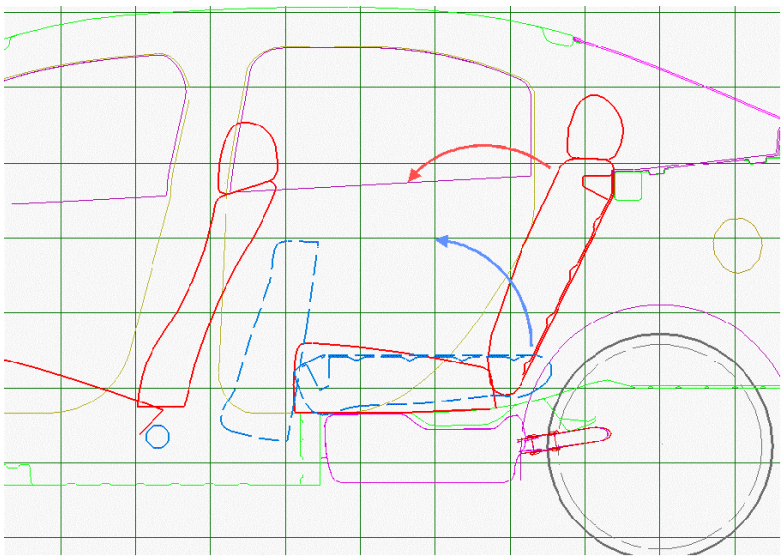


Figure 4.4-3 Rear seat arrangement (folded/unfolded)

4.5. Rear End Package

It was decided early in the Program to package the vehicle without a spare tire, which is becoming more common in the market. Vehicles on the market without a spare tire instead, include a tire fit kit.

4.5.1. Luggage Compartment Volume

The rear seat position (seat back) determines the resulting luggage compartment volume, which was calculated for both vehicle classes according to ECIE Volume definition using VDA guidelines (cubes). Compartment volumes were determined according to ECIE V210 with the seat in an unfolded position. C-Class was also calculated using V214 with the seat in a folded position. Figures 4.4-4 and 4.4-5 show a representation of this luggage compartment volume calculation. The results are shown in Table 4.4-1.

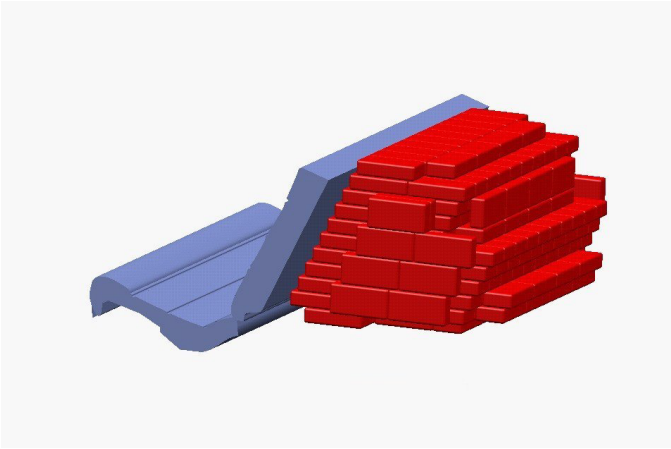


Figure 4.5.1-1 C-Class unfolded seat luggage compartment volume (3/4 rear view)

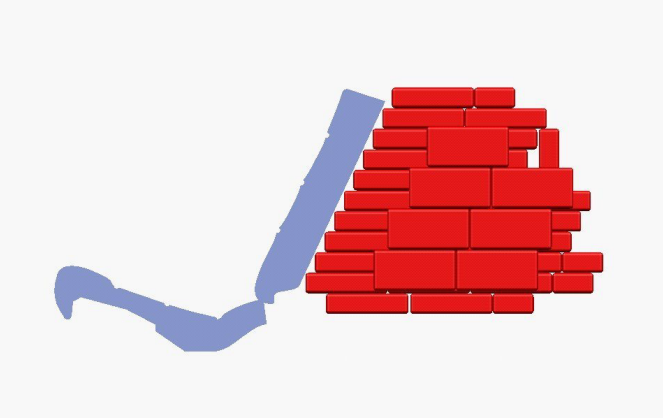


Figure 4.5.1-2 C-Class unfolded seat luggage compartment volume (side view)

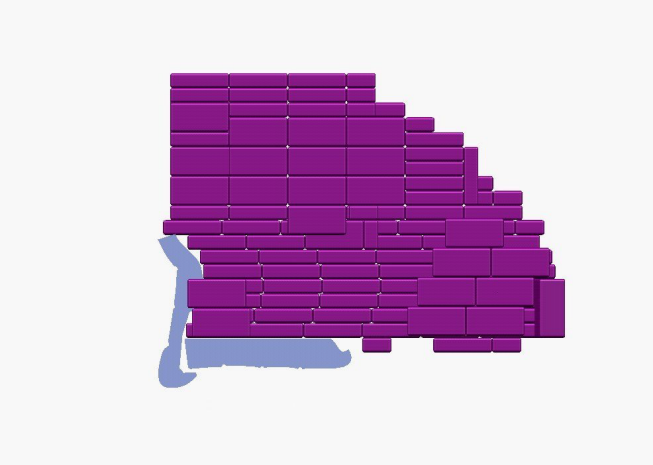


Figure 4.5.1-3 C-Class folded seat luggage compartment volume (side view)

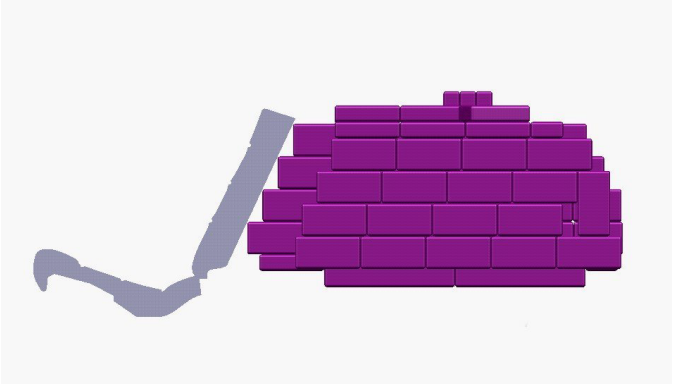


Figure 4.5.1-4 PNGV-Class unfolded seat luggage compartment volume (side view)

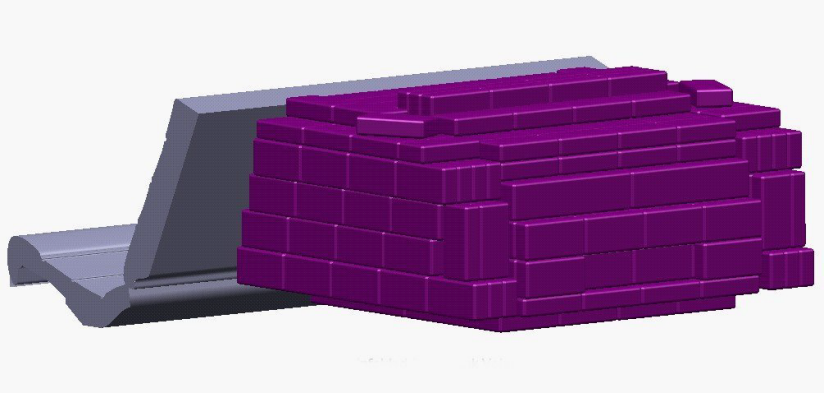


Figure 4.5.1-5 PNGV-Class unfolded luggage compartment volume (3/4 rear view)

Table 4.4-1 Luggage compartment volume

		Luggage Volume (L)	
ECIE Index	Seat Position	C-Class	PNGV-Class
V210	Unfolded	298	570
V214	Folded	1186	---

4.6. Fuel Tank, Charcoal Filter and Battery Package

The fuel tank (see Figure 4.5-1) was packaged on the right hand side of the vehicle between the Kick-up Cross Member and the torsion section of the Twist Beam Rear Suspension. It is foreseen that both vehicles would utilize the same fuel tank and the same fuel filler routing. The fuel filler routing had to be integrated into the body structure design with the different rear end structures (hatchback/sedan).

Opposite the fuel tank, the charcoal filter was positioned behind the battery tray.

Package space was allocated for a conventional battery in case alternative smaller and lighter batteries (e.g. lithium) were unsuitable for cost reasons. The battery is located behind the Kick-up Cross member on the left hand side of the vehicle with the battery accessible from inside the vehicle. This concept was chosen to create more packaging freedom in the front structure and for an equalized load distribution between front and rear suspensions. One disadvantage could be a longer battery cable necessary for routing from the battery to the engine than in a front-end battery package.

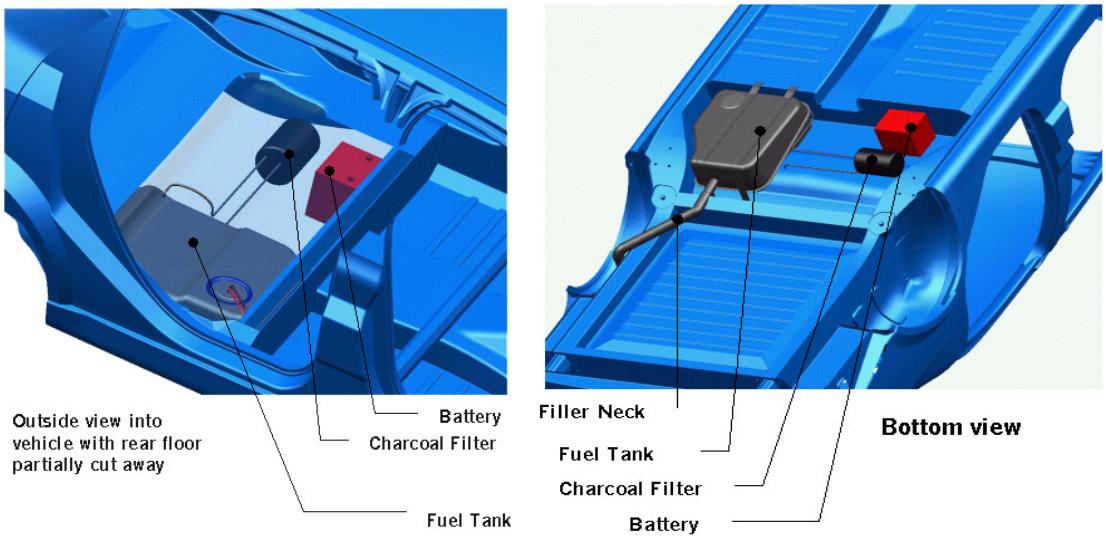


Figure 4.6-1 Fuel tank, charcoal filter and battery package

4.7. Engine Cover Module

As already mentioned, the extra package space above the engine bay could be used to package components traditionally packaged in other areas. Figure 4.7-1 shows the engine cover module concept. The HVAC system was packaged in this upper front- end area, whereas traditionally it is packaged inside the vehicle. More information can be found in Chapter 12 – Subsystems.

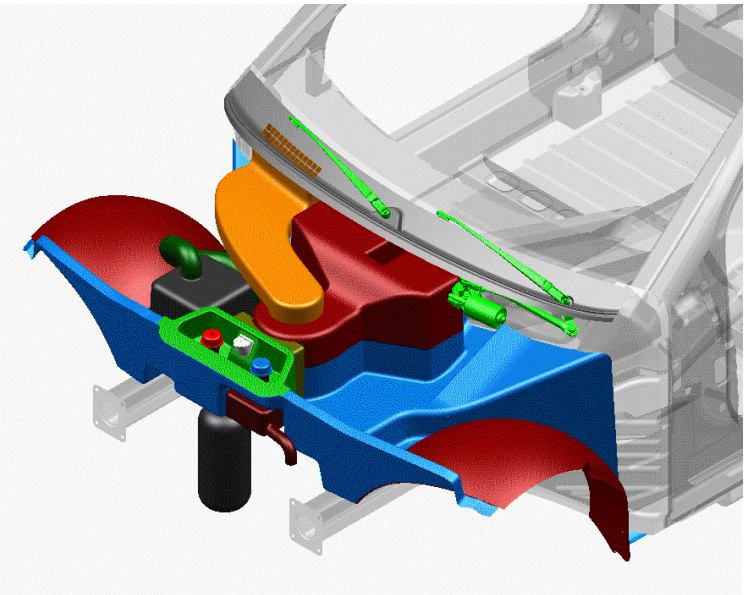


Figure 4.7-1 Engine cover module

4.8. Vehicle Dimensions

4.8.1. Measuring System

The measurement indices are defined according to the European Car Manufacturers Information Exchange Data (ECIE) with measurement unit values according to the "Système International d'Unités" (SI) and rounded according to DIN 1333 part 2. The ECIE code numbers are similar to the Society of Automotive Engineers (SAE) code numbers.

Measuring System

Measurement	Units
Lengths/widths/heights	mm
Areas	m^2
Volumes	m^3
Angles	degrees

Code Numbers

1-99	Interior Dimensions
100-199	Exterior Dimensions
200-299	Luggage Compartment Dimensions

4.8.2. ECIE Dimensions – C-Class Vehicle

Table 4.8.2-1 C-Class vehicle measurements

ECIE Code	Definition	C-Class Measurements
H 5	R-point to ground - front	498
H 10	R-point to ground - rear	501
H 19	Steering column in Y-plane	22.6º
H 25	Belt height	410
H 30	R-point to heel point - front	272
H 31	R-point to heel point - rear	348
H 35	Head clearance vertical - driver	50
H 36	Head clearance vertical - second	68
H 50	Upper body opening to ground - front	1256
H 61	Effective head room - front	976
H 63	Effective head room - rear	980
H 74	Steering wheel to seat cushion	121
H 75	Effective T-point head room - front	978
H 76	Effective T-point head room - second	977
H 100	Vehicle height	1453
H 106	Angle of approach	19º
H 107	Angle of departure	22.3º
H 110	Vehicle height - tailgate open	2005
H 114	Cowl point to ground	895
H 115	Step Height - front	342
H 124	Vision angle to windshield upper DLO	14.5º
H 130	Step Height - front	374
H 147	Ramp angle	10.8º
H 156	Ground clearance	117
H 195	Liftover height	599
H 201	Luggage height	871
H 202	Rear opening height	721
H 251	Height of open tailgate	1863
H 252	Luggage compartment height	565
H 253	Luggage compartment floor to ground	413
H 297	Front seatback to luggage floor	544
H 298	Second seatback to luggage floor	606

Table 4.8.2-1 C-Class vehicle measurements (continued)

ECIE Code	Definition	C-Class Measurements
L 13	Brake pedal - knee clearance	580
L 18	Foot clearance - front	396
L 19	Foot entrance clearance - second	127
L 26	Steering wheel to centre of front wheel	1184
L 34	Effective leg room - front	1130
L 40	Torso angle - front	25
L 41	Torso angle - second	25
L 48	Knee clearance - rear	11
L 50	R-point distance - rear	781
L 51	Effective leg room - rear	841
L 52	Brake pedal to accelerator pedal	50
L 53	R-point to heel point - front	833
L 101	Wheelbase	2950
L 103	Vehicle length	4179
L 104	Overhang - front	620
L 105	Overhang - rear	609
L 111	Body overhang - rear	550
L 114	Front wheel C/L to front R-point	1535
L 121	Backlight angle	49.1º
L 122	Windscreen angle	61.1º
L 206	Boot opening	864
L 212	Luggage floor length - first	1310.05
L 213	Luggage floor length - second	737
L 215	Luggage length at belt - second	437
D 9	Steering wheel diameter	375

Table 4.8.2-1 C-Class vehicle measurements (continued)

ECIE Code	Definition	C-Class Measurements
W 3	Shoulder room - front	1448
W 4	Shoulder Room - rear	1418
W 7	Y-coordinate of the steering wheel	385
W 10	Elbow width - front	1492
W 11	Elbow width - rear	1418
W 20	Y-coordinate of the front R-point	385
W 25	Y-coordinate of the second R-point	365
W 27	Head clearance diagonal - driver	38
W 33	Head clearance diagonal - second	56
W 101	Track - front	1540
W 102	Track - rear	1540
W 103	Vehicle width	1789
W 117	Body width	1765
W 120	Vehicle width - front doors open	4026
W 122	Tumblehome - side glass	22.2º
W 123	Side glass radius	1275
W 125	Opening angle - front door	65º
W 200	Max luggage compartment width	1001
W 202	Wheelarch width	1162
W 205	Rear opening width - upper	971
W 206	Rear opening width	1001
W 207	Rear opening width - lower	896

4.8.3. ECIE Dimensions – PNGV-Class Vehicle

Table 4.8.3-1 PNGV-Class vehicle measurements

ECIE Code	Definition	PNGV-Class Measurements
H 5	R-point to ground - front	498
H 10	R-point to ground - rear	501
H 19	Steering column in Y-plane	22.6º
H 25	Belt height	410
H 30	R-point to heel point - front	272
H 31	R-point to heel point - rear	348
H 35	Head clearance vertical - driver	50
H 36	Head clearance vertical - second	60
H 50	Upper body opening to ground - front	1256
H 51	Upper body opening to ground - second	1229
H 61	Effective head room - front	976
H 63	Effective head room - rear	971
H 74	Steering wheel to seat cushion	121
H 75	Effective T-point head room - front	978
H 76	Effective T-point head room - second	967
H 100	Vehicle height	1455
H 106	Angle of approach	19º
H 107	Angle of departure	12º
H 110	Vehicle height - tailgate open	1819
H 114	Cowl point to ground	895
H 115	Step Height - front	345
H 116	Step Height - second	341
H 124	Vision angle to windshield upper DLO	14.5º
H 130	Step Height - front	374
H 147	Ramp angle	10.6º
H 156	Ground clearance	117
H 195	Liftover height	608
H 201	Luggage height	495
H 202	Rear opening height	448
H 251	Height of open tailgate	1715
H 252	Luggage compartment height	607
H 253	Luggage compartment floor to ground	413
H 297	Front seatback to luggage floor	544
H 298	Second seatback to luggage floor	606

Table 4.8.3-1 PNGV-Class vehicle measurements (continued)

ECIE Code	Definition	PNGV-Class Measurements
L 13	Brake pedal - knee clearance	580
L 18	Foot clearance - front	396
L 19	Foot entrance clearance - second	238
L 26	Steering wheel to centre of front wheel	1184
L 34	Effective leg room - front	1130
L 40	Torso angle - front	25
L 41	Torso angle - second	25
L 48	Knee clearance - rear	92
L 50	R-point distance - rear	781
L 51	Effective leg room - rear	918
L 52	Brake pedal to accelerator pedal	50
L 53	R-point to heel point - front	833
L 101	Wheelbase	3035
L 103	Vehicle length	4749
L 104	Overhang - front	620
L 105	Overhang - rear	1094
L 111	Body overhang - rear	1061
L 114	Front wheel C/L to front R-point	1535
L 121	Backlight angle	67.8º
L 122	Windscreen angle	61.1º
L 206	Boot opening	604
L 212	Luggage floor length - first	1773
L 213	Luggage floor length - second	1198
L 215	Luggage length at belt - second	
D 9	Steering wheel diameter	375

Table 4.8.3-1 PNGV-Class vehicle measurements (continued)

ECIE Code	Definition	PNGV-Class Measurements
W 3	Shoulder room - front	1448
W 4	Shoulder Room - rear	1408
W 7	Y-coordinate of the steering wheel	385
W 10	Elbow width - front	1492
W 11	Elbow width - rear	1512
W 20	Y-coordinate of the front R-point	385
W 25	Y-coordinate of the second R-point	365
W 27	Head clearance diagonal - driver	38
W 33	Head clearance diagonal - second	39
W 101	Track - front	1540
W 102	Track - rear	1540
W 103	Vehicle width	1814
W 117	Body width	1765
W 120	Vehicle width - front doors open	3706
W 121	Vehicle width - rear doors open	3744
W 122	Tumblehome - side glass	22.2º
W 123	Side glass radius	1275
W 125	Opening angle - front door	65º
W 126	Opening angle - rear door	65
W 200	Max luggage compartment width	1515
W 202	Wheelarch width	1162
W 205	Rear opening width - upper	1171
W 206	Rear opening width	1218
W 207	Rear opening width - lower	1193

4.9. Package Drawings

4.9.1. C-Class

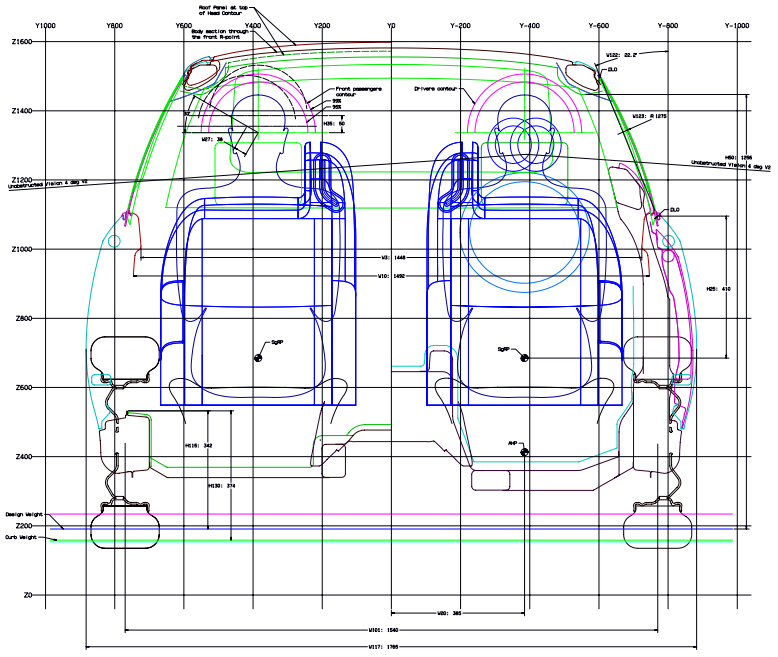


Figure 4.9.1-1 C-Class package drawing front view

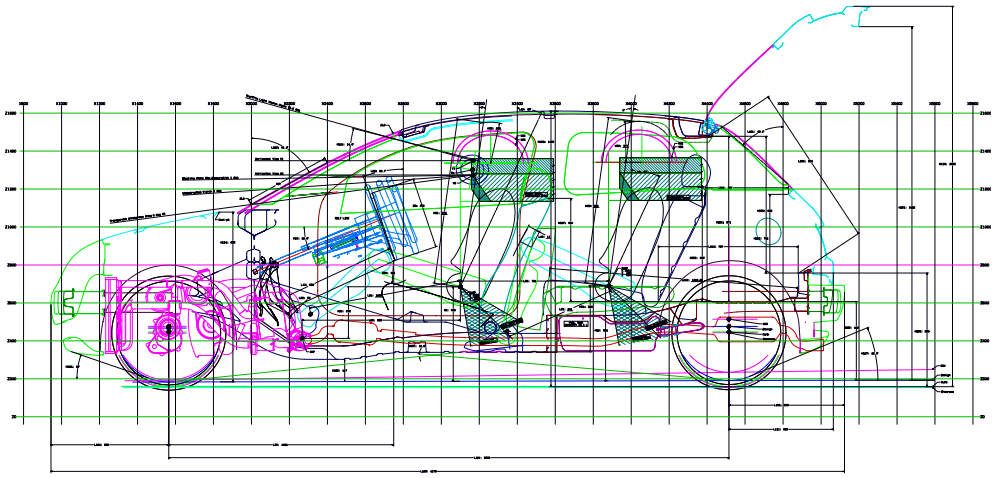


Figure 4.9.1-2 C-Class package drawing side view

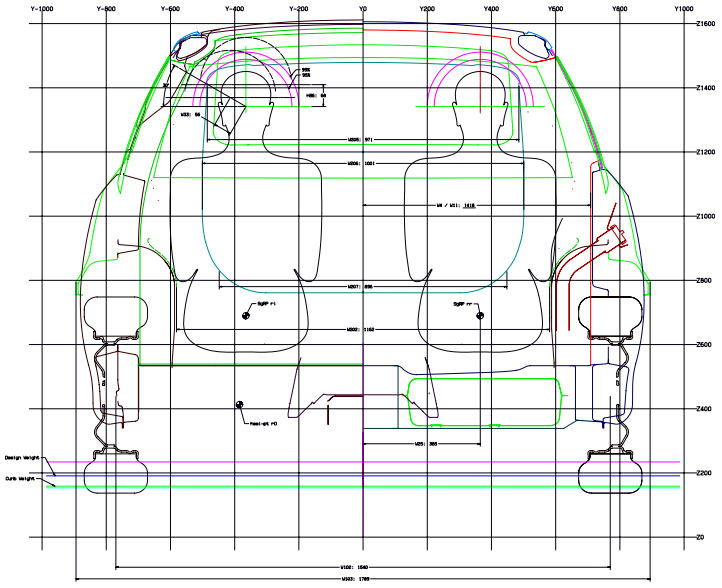


Figure 4.9.1-3 C-Class package drawing rear view

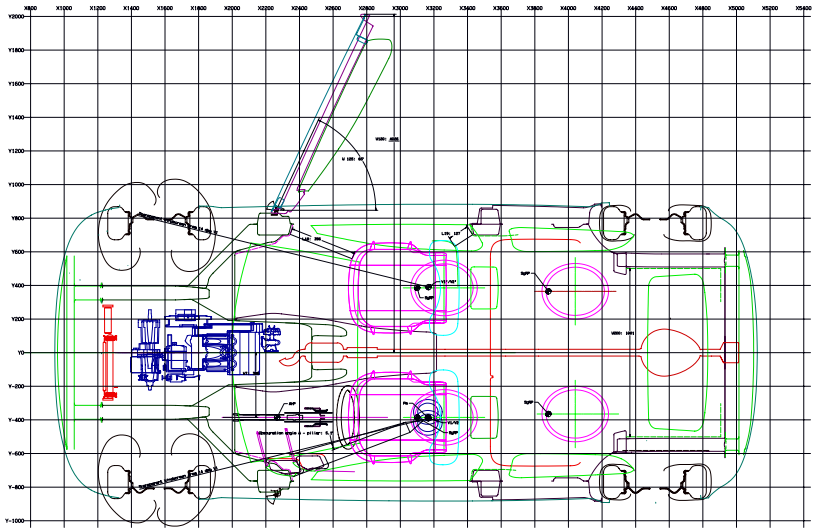


Figure 4.9.1-4 C-Class package drawing top view

4.9.2. PNGV-Class

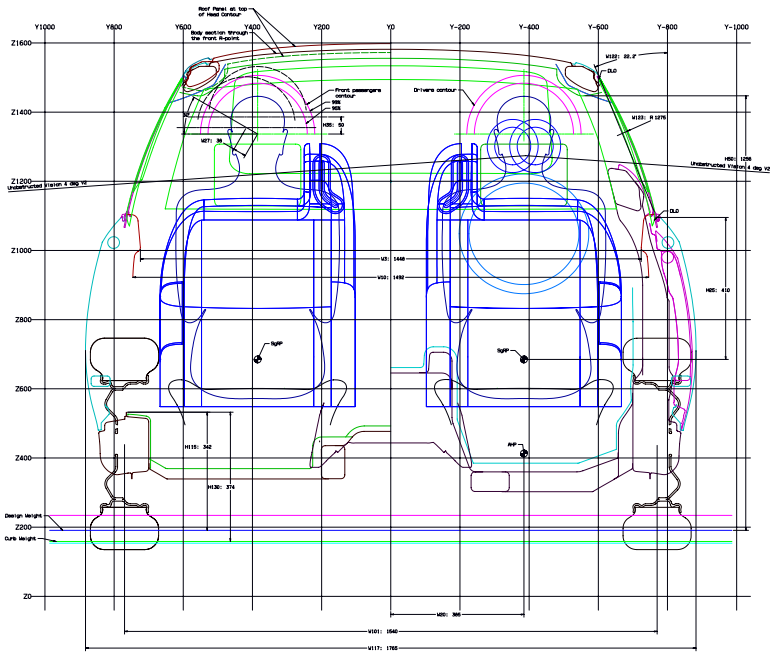


Figure 4.9.2-1 PNGV-Class package drawing front view

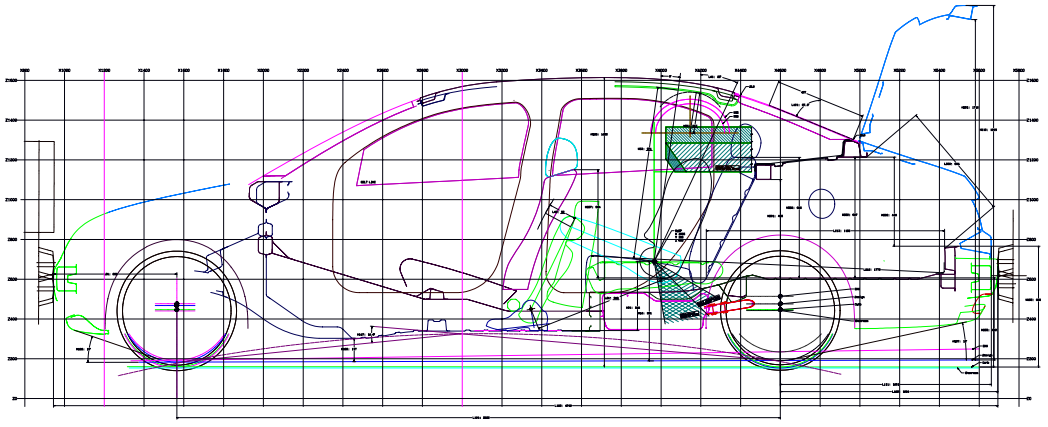


Figure 4.9.2-2 PNGV-Class package drawing side view

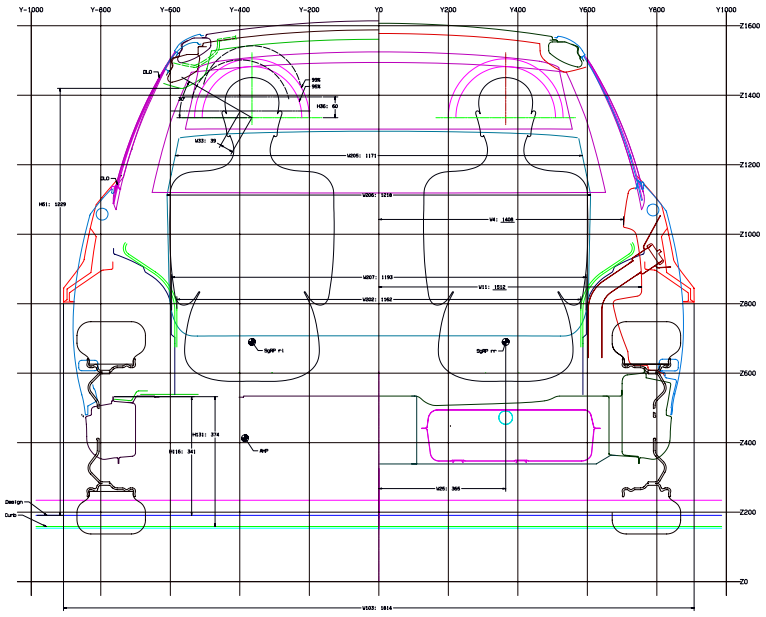


Figure 4.9.2-3 PNGV-Class package drawing rear view

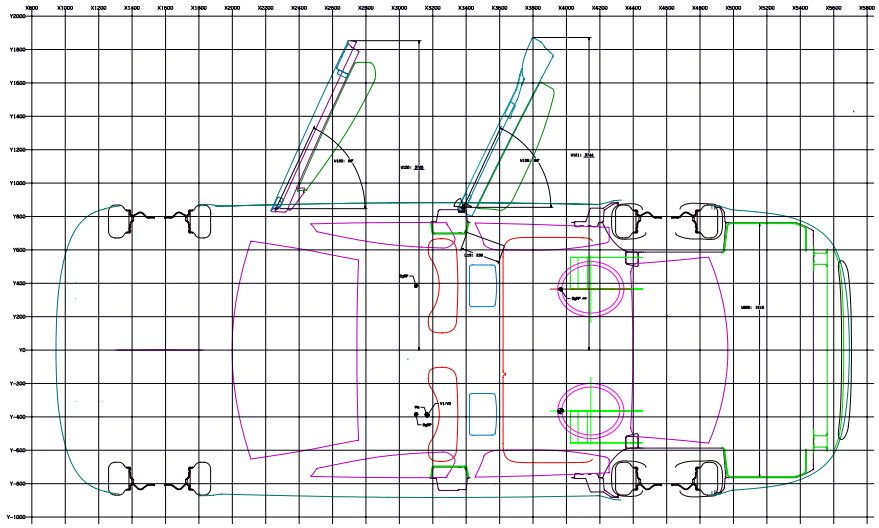


Figure 4.9.2-4 PNGV-Class package drawing top view