Technical Transfer Dispatch #3

Description of ULSAB-AVC

Benchmarking and Target Setting

November 1999

FOREWORD

Program Background

The ULSAB-AVC program follows the UltraLight Steel Auto Body (ULSAB) program, the results of which were announced worldwide in March 1998. Both are part of the global steel industry's series of initiatives to offer steel solutions to the challenges facing automakers, government regulators and environmentalists around the world to increase the fuel efficiency of automobiles while improving safety, performance and maintaining affordability.

ULSAB-AVC takes a holistic approach to the development of a new architecture for a family of advanced steel-intensive vehicles. The scope of this concept study is intended to go beyond ULSAB, which produced a lightweight, steel body-in-white. ULSAB-AVC will produce complete design concepts that meet 2004 vehicle requirements and include closures, suspensions, engine cradle and all structural and safety-relevant components, for which steel offers mass and/or cost efficient solutions.

Scheduled for completion in early 2001, ULSAB-AVC is intended to present advanced vehicle concepts that help automakers use steel more efficiently and provide a structural platform for achieving:

- Anticipated crash safety requirements for 2004,
- Significantly improved fuel efficiency,
- Optimized environmental performance regarding emissions, source reduction and recycling, and
- High volume manufacturability at affordable costs.

Technical Transfer Dispatches (TTD)

The purpose of TTDs is to provide periodic communications to key contacts within the automotive industry and keep key expert automotive staff informed about the ULSAB-AVC Program, thus developing and maintaining a valuable dialogue.

This TTD discloses program benchmarking information and design targets.
For more information or to provide feedback, please contact your local ULSAB-AVC member company or ULSAB-AVC program management as follows:

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1. Benchmarking

Porsche Engineering Services (PES), Inc., collected benchmarking data from current production C-class and PNGV-class vehicles, as well as vehicles with a curb mass in the 900 kg range. Additionally, to gather the newest and most accurate data for the program, two (2) vehicles were purchased, evaluated and dismantled. The purchased vehicles are:

a. Ford Focus – C-Class vehicle

b. Peugeot 206 – 900 kg class vehicle

The Ford Focus was chosen as a recent example that meets current safety standards and is a C-Class size vehicle. The Peugeot 206 was chosen because it is approximately a 909 kg (2000 lb.) vehicle and provided good examples of detailed component mass benchmarks.

For PNGV-class vehicles, ULSAB-AVC references PNGV size and performance criteria. It should be noted that, for comparison purposes, PNGV's specified safety requirements are based on early/mid 1990 vehicle standards. Vehicles designed to achieve PNGV goals at these older safety standards (from both a regulatory and competitive perspective) will, therefore, need to be upgraded to satisfy current and future, in this case 2004, safety standards.

The following benchmarking and reference data was used to establish ULSAB-AVC targets:

C-Class Vehicle

- Benchmarking Report, Teardown Ford Focus/Peugeot 206
- Benchmarking Report, NVH
- Benchmarking Report, One-Wheel Drop Test
- Vehicle Dimensions Benchmarking
- Star Rating Benchmarking
- Porsche Internal Database

PNGV-Class Vehicle

- PNGV Reference Vehicle Data
- Porsche Internal Database

Each member steel company holds a CD-ROM copy of the complete ULSAB-AVC Benchmarking Report prepared by Porsche Engineering Services (PES). A reference table of contents of the complete PES Benchmarking Report is detailed in the Appendix.

2. Target Setting

2.1 Introduction

The objectives of the ULSAB-AVC program are set forth in the Foreword of this document. The main enablers to achieve these objectives are:

- Application of new steels and innovative manufacturing processes
- Design of an advanced vehicle structure and vehicle package
- Reduction of vehicle mass
- Inclusion of state-of-art powertrain technology
- Inclusion of state-of-art aerodynamics and rolling resistance

For the ULSAB-AVC Program, the targets have been set on the basis of the following assumptions:

- Use of advanced steels and manufacturing processes, which are estimated technically feasible in the year 2004.
- Retain capability for high-volume manufacturing.
- Maintain affordability advantages of steel.

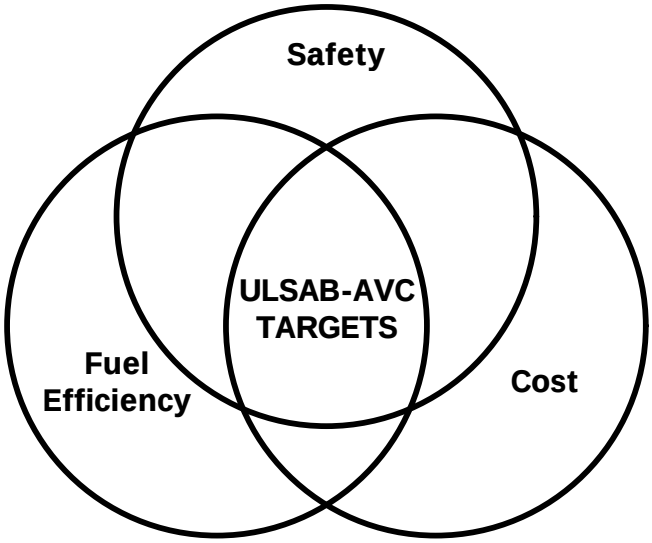
The targets for the ULSAB-AVC program focus on anticipated safety requirements for the year 2004 as the first priority. Emission requirements and cost are also high priorities within a steel-based design.

2.2 Approach

Prioritization

In the target setting approach, various factors had to be taken into account in order to establish realistically achievable targets. First, the program targets were prioritized in the following order:

- Meet safety requirements for the year 2004.
- Produce steel-based designs with reduced mass that would provide for improved fuel efficiency and emission performance.
- Maintain a low cost base that is compatible with high volume manufacture. While cost is also a high priority, there is no model available at this initial stage of the program with which to perform a realistic evaluation. However, a cost model will be developed as the program progresses. The general cost target that will guide these early design stages is to avoid cost increases or, if unavoidable, keep increases to a minimum.



Component Material Specifications

ULSAB-AVC material specifications, as defined by the Consortium, reflect the program's goal to develop vehicle concepts with the lowest possible curb mass through optimized steel designs. (See chart below.)

Main Component	Material Specified for ULSAB-AVC
Body Structure	Steel Only
Closures Structure	Steel Only
Chassis	Steel Only
Wheels	Steel Only
Fuel Tank	Steel Only
Interior Structure	Steel and/or alternative materials
Other Components	Not specified

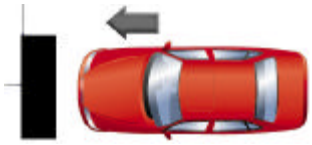
Boundary Conditions

All targets have been set based upon PES's experience, engineering judgment and current, publicly available data, as well as benchmarking data. Targets set for mass, static performance, frequencies and crash performance are based on assumptions made with today's knowledge. Targets for exhaust emissions are based on future emission requirements and specific considerations requested by the ULSAB-AVC Consortium.

2.3 Crashworthiness

The following crash event targets have been set for ULSAB-AVC's crashworthiness evaluation. Details regarding the approach for the CAE analysis and assessment for star ratings are available in TTD #2 – CAE Analysis for Crashworthiness. These are structural targets. See TTD #2 for the program approach concerning occupant safety.

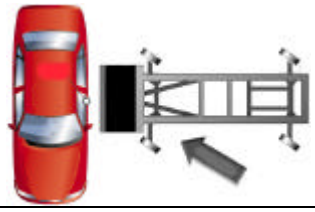
US-NCAP Front Impact

Crash Event	Crashworthiness Targets
US-NCAP Front Impact 35mph (56km/h) full face rigid barrier, zero degree impact 	• Overall dynamic deformation ≥ 650mm • Steering column displacement ≤ 80mm in X direction

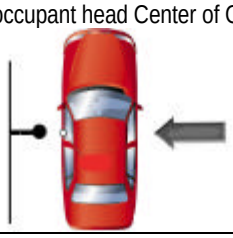
EuroNCAP Frontal Impact

Crash Event	Crashworthiness Targets
EuroNCAP Front Impact 64km/h (40 mph), 40% overlap offset deformable barrier, zero degree impact 	• A-pillar displacement < 50mm • Footwell intrusion < 150mm • Steering column displacement ≤ 80mm in X direction

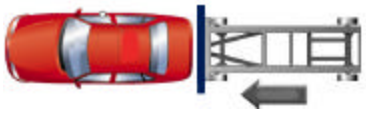
Side Impact – SINCAP

Crash Event	Crashworthiness Targets
US - SINCAP 38.5 mph (61.6km/h) impact by 1370 kg trolley moving at 63 degrees to longitudinal axis of the vehicle 	• Maximum intrusion velocity 6 -7 m/sec

Side Impact - Pole Test

Crash Event	Crashworthiness Targets
Side Impact – Pole Test 32km/h (20 mph) impact with diameter 254mm rigid pole aligned with the occupant head Center of Gravity 	• Maximum Pole intrusion velocity when striking occupant < 8m/sec

Rear Impact

Crash Event	Crashworthiness Targets
US-FMVSS 301 Rear Impact 30mph (48km/h) rigid moving barrier 4000lb (1814kg) impact with rear of vehicle in brakes-off condition 	• Minimal deformation in region of fuel tank • Movement of rear seat R-point < 50mm

Roof Crush / Rollover

To account for anticipated future dynamic rollover requirements, the ULSAB-AVC target is defined as:

- Under same loading conditions as defined in FMVSS 216, the structure is to support 2.5 times the vehicle curb mass and roof deformation is to be limited to 127mm.

  (FMVSS 216 specifies roof deformation is limited to 127mm of crush and the structure to support 1.5 times the vehicle curb mass or 5000 lbs., whichever is less.)

15 km/h 0° Front Crash Front Rail Analysis

The target is to absorb the energy entirely with the bumper system (including crash box) with no buckling of the front rails.

2.4 Target Setting - Mass - Main Components

Categories for mass targets are in accordance with the Gewichts Austausch Deutscher Hersteller (GADH) number system. This numbering system is a European automobile manufacturers' system used to evaluate vehicle mass and to consistently compare data.

Using engineering judgment, targets are set based on reference to benchmarked data and PES internal data. Explanations can be found in the remarks column for each table, where additional explanation is needed.

2.4.1 Body Structure

The body structure design will be based on a platform concept using common elements such as a front structure, rear structure, and hinge pillars.

The structure elements are designed to take into account the crash requirements using the highest crash mass resulting from the highest total vehicle mass (PNGV or C-Class) and estimated mass for optional safety and comfort features. The body structure designs will be based on one specific engine/gearbox size envelope similar to the approach taken by DaimlerChrysler for the A-Class or Smart Car where the engines are specially designed in a given envelope to enhance crashworthiness with a specific package. The design does not account for any hybrid powertrain solutions at this stage of the program, since that approach would require a different architecture and increased costs.

PNGV-Class Vehicle

The ULSAB-AVC PNGV-Class target is to aim for a 203 kg body structure, which is equivalent to the ULSAB mass. However the targets also acknowledge that the more severe crash requirements for the year 2004 could cause the body structure mass to increase by an estimated 25 kg (See table below). The goal is to offset this potential mass increase using advanced steels, innovative manufacturing and joining technologies, and further related innovations.

Estimated added mass to ULSAB to achieve 2004 crashworthiness

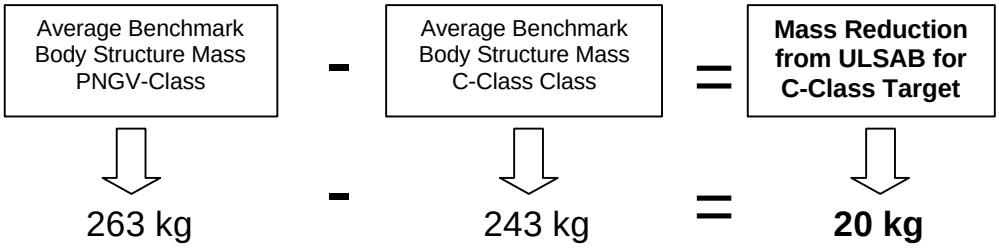
Added crash events to ULSAB	Estimated additional mass to ULSAB
40% Offset Crash	7 kg
Side Impact	8 kg
Pole Test	8 kg
Roof / Rollover	2 kg
Total	**25 kg**

C-Class Vehicle

The ULSAB-AVC C-Class target is to aim for a 183 kg body structure, which is based upon the best-in-class ULSAB body structure mass minus the difference of the mass of the body structures of the benchmarked PNGV and C-Class vehicles (See next section). As with the PNGV-class vehicle, these targets also acknowledge that the more severe crash requirements for the year 2004 could cause the body structure mass to increase by an estimated 25 kg (See table above). The goal again is to offset this mass increase as previously described.

Mass reduction from ULSAB to C-Class vehicle

Since ULSAB is used for the body structure benchmark, it is necessary to account for the difference in size and architecture of these two vehicles (PNGV = 4-door sedan, C-Class = 3-door hatchback) in order to determine a mass target for ULSAB-AVC's C-Class concept. To determine the mass impact of the different architecture and size, the following formula was used to calculate the mass reduction for the C-Class vehicle.



2.4.2 Closures

The targets set for the ULSAB-AVC closures take into account the difference in size of the AVC closures versus the benchmarked best-in-class closures. The goal is to reach the targets set in the UltraLight Steel Auto Closures (ULSAC) program, which were specified in kg/m^2.

At present, the potential increase in mass resulting from additional reinforcements for doors (Front and Rear) needed for increased side impact crash energy absorption cannot be estimated and is dependent on the body structure performance in the Side Impact Crash event.

PNGV -Class Closure Structures

Closure Structure	Benchmarked Best-In-Class kg	Target PNGV-Class kg	Target PNGV-Class kg/m²	Remarks
Door Front	30.0	27.0	15.5	*
Door Rear	24.5	22.0	15.5	*
Hood	17.0	16.0	8.0	*
Deck Lid	11.0	10.0	8.0	*
Fenders	6.7	4.0	-	*
Total	**89.2**	**79.0**		*****

*Targets are based on the ULSAC program, with adjustments for different sizes due to vehicle styling.

PNGV -Class Closure Assembly Parts (e.g. Hinges, Brackets, Springs, Etc.)

Closure Assembly Parts	Benchmarked Average kg	Target PNGV-Class kg	Remarks
Door Front	9.6	8.0	
Door Rear	5.7	4.0	
Hood	3.6	1.0	Same as C-Class
Deck Lid	4.4	4.0	
Elec. Window Reg.	8.0	8.0	Aluminum tracks
Total	**31.3**	**25.0**	

PNGV-Class - Closures/Summary

	Target PNGV-Class kg
Structure Closures	79.0
Assembly Parts	25.0
Closure Total	**104**

C-Class Closure Structures

Closure Structure	Benchmarked Best-In-Class kg	Target C-Class kg	Target C-Class kg/m²	Remarks
Door Front	31.0	26.0	15.5	*
Hood	13.5	16.0	8.0	*
Hatch	11.0	10.0	14.0	*
Fenders	6.0	4.0	-	*
Total	**61.5**	**56.0**		*

* Targets are based on the ULSAC program, with adjustments for different sizes due to vehicle styling.

C-Class Closure Assembly Parts (e.g. Hinges, Brackets, Springs, Etc.)

Closure Assembly Parts	Benchmarked Average kg	Target C-Class kg	Remarks
Door Front	9.8	8.0	
Hood	1.5	1.0	Same as PNGV-class
Hatch	2.6	2.5	
Elec. Window Reg.	4.0	4.0	
Total	**17.9**	**15.5**	

C-Class - Closures/Summary

	Target C-Class kg
Structure Closures	56.0
Assembly Parts	15.5
Closures Total	**71.5**

2.4.3 Glazing

The target setting is based upon the average of C-Class and the average of PNGV-Class. Targets were set assuming no mass reduction in front and side glazing due to NVH requirements.

Component Name	Avg. C-Class kg	Avg. PNGV kg	C-Class Target kg	PNGV-Class Target Kg
Front	12.3	12.3	12.3	12.3
*Side 2 Door	15.0	-	15.0	-
**Side 4 Door	-	14.7	-	14.7
Rear	6.0	7.3	4.8	5.8
Total	**33.3**	**34.3**	**32.1**	**32.8**

2.4.4 Chassis/Suspension

Component Name	Avg. Peugeot & Focus Kg	Target C-Class kg	Target PNGV-Class kg	Remarks
Front Suspension ind. Subframe	54.5	50.0	50.0	
Rear Suspension incl. Subframe	48.3	42.0	42.0	
Pedals Main Brake Cylinder Parking Brake Gear Shift	7.7	5.7	5.7	Approx. -25%
Wheels (4)	31.5	20.0	20.0	Size 6x15 in steel (w/steel co. tech) 5 kg each
Tires (4)	26.2	26.2	26.2	Size165/65 R15
Brake System hydraulic/ABS	9.2	8.5	8.5	Approx. -10%
Steering incl. Power System	17.6	16.0	16.0	Approx. -10%
Front Brake System	17.0	15.5	15.5	Approx. -10%
Rear Brake System	16.0	14.5	14.5	Approx. -10%
Total	**228.0**	**198.5**	**198.5**	**-13% Reduction**

2.4.5 Engine

Component Name	Avg. Peugeot & Focus kg	Target C-Class kg	Target PNGV-Class kg	Remarks
Engine Gasoline	105.8	100.0	100.0	
Engine Diesel	-	(135.0)	(135.0)	
Cooling System	8.5	8.0	8.0	Fan & Radiator
Fuel Pump	2.6	2.6	2.6	Carryover Part – Focus
Fuel Tank incl. Filler	8.0	10.0	10.0	40 L – Steel
Fuel System	3.5	3.5	3.5	Assembly
Exhaust System incl. Catalytic Converter	14.6	15.0	16	Heavier catalytic converter for lower emissions
Exhaust System Diesel		(20.0)	(21)	
Active Carbon Filter	0.75	0.75	0.75	
Heat Shield Exhaust System	2.63	2.5	2.5	
Engine Electrical Control unit	1.8	1.0	1.0	
Total Gasoline	**148.2**	**143.5**	**144.5**	
Total Diesel	**-**	**183.5**	**184.5**	

2.4.6 Gear box

Component Name	Avg. Peugeot & Focus Kg	Target C-Class kg	Target PNGV-Class kg	Remarks
Gear box	52.35	40.0	40.0	Semi-automatic
Drive Shafts	11.8	10.0	10.0	
Total	**64.15**	**50.0**	**50.0**	

2.4.7 Interior

The targets set for the interior are based on the average of PNGV and C-Class vehicles. It is assumed that the same dash panel is used for both vehicle concepts. Heating, ventilation, and air-conditioning systems will be the same for both classes. Due to engine package and platform strategy (same front end), the PNGV system will be used for C-class.

Component Name	Avg. B-marked C-Class kg	Avg. B-marked PNGV kg	Target C-Class kg	Target PNGV-Class kg	Remarks
Carpets Instrument Panel Restraint system Interior Panels	68.0	79.0	65.0	73.0	
Seat system F & R	63.0	69.0	63.0	69.0	
Heating & Ventilation	11.5	15.5	14.0	14.0	Carryover Part - PNGV
Sound Damping	16.6	20.0	16.6	20.0	
Air Conditioning	13.8	16.2	16.2	16.2	Carryover Part - PNGV
Total	**173.0**	**199.7**	**174.8**	**192.2**	

2.4.8 Exterior

Trim, mirrors, cables, and license plate brackets are estimated for typical components.

Component Name	Peugeot 206 kg	Ford Focus kg	Target C-Class kg	Target PNGV-Class kg
Exterior	4.9	9.9	**4.5**	**6.5**

2.4.9 Electrics

Component Name	Avg. C-Class kg	Avg. PNGV kg	Target C-Class kg	Target PNGV-Class kg
Windshield Wipers (Front & Rear)	6.0	3.8	6.0	3.8
Lights (Front & Rear)	7.6	9.7	7.5	7.5
Electrics & Cables	15.1	19.5	13.0	15.0
Batteries (36 AH/ILV)	12.3	18.5	12.3	12.3
Radio (2 speakers & antenna)	2.9	2.9	2.9	2.9
Total	**43.9**	**54.4**	**41.7**	**41.5**

2.4.10 Automotive Fluids

Fuel tank capacity fuel (40 L) is based on 600 km range at maximum fuel consumption plus four-liter reserve. Engine oil capacity is increased to account for the dry sump lubrication system needed for a new engine package.

Component Name	Peugeot 206 kg	Ford Focus Kg	Target C-Class Kg	Target PNGV-Class kg
Oil	3.0	2.9	5.0	5.0
Cooling Water	6.5	5.1	5.0	5.0
36 LGasoline*	39.5	41.8	27.0	27.0
36 L Diesel*			30.0	30.0
Gear oil	1.9	1.6	2.5	2.5
Washing water	2.9	3.2	1.5	1.5
Total Diesel			**44.0**	**44.0**
Total Gasoline	**53.8**	**54.6**	**41.0**	**41.0**

* 90% fuel in 40 L tank. Specific average mass of gasoline = 0.75 kg/L
Specific avg. mass of diesel = 0.84 kg/L

2.4.11 Target Setting - Mass - Main Components – Summary

The total vehicle mass is the summation of the weight of all components. The two vehicle mass targets are based upon:

- C-Class vehicle- 3-door hatch (overall length = 4100 ± 100mm)
- PNGV-class vehicle - 4-door sedan (overall length = 4750mm)

Component Name	C-Class		PNGV-CLass	
	Diesel kg	Gasoline Kg	Diesel Kg	Gasoline kg
Body Structure		183 (+25)*		203 (+25)*
Closures Structure		71.5		104.0
Glazing		32.1		32.8
Chassis		198.5		198.5
Engine	183.5	143.5	184.50	144.5
Gear box		50.0		50.0
Interior		173.0		192.0
Exterior		4.5		6.5
Electrics		41.7		41.5
Automotive Fluid	44.0	41.0	44.0	41.0
Paint		16.0		20.0
Total	**998 (+25)***	**955 (+25)***	**1077 (+25)***	**1034 (+25)***

* See page 8 (PNGV-class) and page 9 (C-Class) for explanation of (+25kg).

Total Vehicle Mass Targets

	C-Class		PNGV-Class	
	Diesel	**Gasoline**	**Diesel**	**Gasoline**
*Total/Vehicle Mass/kg	998 (+25)	955 (+25)*	1077 (+25)*	1034 (+25)*
Benchmarking Vehicle/ kg	NA	1147 (Focus)	NA	1470 PNGV Ref. Vehicle
Difference/kg		-192 (+25)*		-436 (+25)*

* See note above.

2.5 Target Setting - Structural Performance - Body Structure

C-Class

The structural performance targets for C-class are based on benchmarking results. The benchmarking results show lower rigidity figures for hatchback vehicles compared to a 4-door sedan due to their lack of a cross car connection in the package tray area. The performance targets for C-class are set with priority to mass reduction, not for maximum stiffness.

PNGV-Class

The structural performance targets for the PNGV-class vehicle reference ULSAB benchmarking data and are set the same as they were for ULSAB.

Body Structure Rigidity

Performance*	C-Class	PNGV-Class
Static Torsional Rigidity Nm/deg.	≥12000	≥13000
Static Bending Rigidity N/mm	≥11000	≥12020

* Body Structure with glass

Body Structure Frequencies

Frequencies*	C-Class	PNGV-Class
First Global Mode Hz	≥35	≥40
First Global Mode Torsion Hz	≥35	≥40
First Global Mode Bending Hz	≥48	≥48
Local Mode: Lateral Front End Hz	≥55	≥55

* Body Structure without Glass

2.6 Target Setting - Fuel Economy - Exhaust Emissions

Carbon Dioxide (CO_2) Exhaust Emissions

The CO_2 exhaust emissions are directly related to a vehicle's fuel consumption and the fuel type used (i.e. gasoline or diesel). The 2004 EUCAR specified the CO_2 emissions for a fleet average of 140 g/km.

Fuel Consumption

The target for fuel consumption relates directly to the target for $C0_2$ emissions. The $C0_2$ emissions-related fuel consumption is different for gasoline and diesel-powered vehicles. For ULSAB-AVC (C-Class and PNGV-Class vehicle), the $C0_2$ EUCAR Fleet Average Target is adopted as a single vehicle target that will comply with future requirements

Other Exhaust Emissions

The PNGV target for exhaust emissions refers to the US EPA tier 2 Requirements. This requirement is a fleet average and for that reason it is considered as a target for the ULSAB-AVC Program. The European EU4 requirements are single values for one vehicle and will therefore be the emission target for ULSAB-AVC. It is assumed that achieving the EU4 Exhaust Emissions Targets also fulfills the EPA Tier 2 Requirements. The overall emission target of the ULSAB-AVC Program is to fulfill the limited values of EU4. These values will be required in Europe by the year 2005.

Current technologies on the market do not provide solutions to achieve these targets with vehicles using gasoline or diesel powered engines. For vehicles using gasoline-powered engines, auto OEMs are confident that solutions to achieve the targets can be developed by the year 2005.

For vehicles using diesel-powered engines, solutions to achieve the targets are only possible if low sulfur diesel fuel (approx. 10 ppm) will be available by 2004 and if the development of the catalytic converter/particle filter technology will progress as assumed today.

It is unlikely that other options, such as hydrogen fuel cells, will be sufficiently ready for volume production within the required timeframe. Due to the wide variety and generally proprietary nature of hybrid propulsion systems, internal combustion engines were selected rather than hybrid options.

Emission Limited Values for EU4 (g/km)	CO	HC	NOx	(HC+NOx)	PM
Gasoline Engine	1.0	0.1	0.08	-	-
Diesel Engine	0.5	-	0.25	0.3	0.025

2.7 Target Setting - Vehicle Dimensions

Vehicle Dimensions

The vehicle dimensions are secondary targets, which have been set to achieve a good basis for a platform concept that complies with the dimension requirements of PNGV. These secondary targets are taken from PNGV Reference Vehicle Data. In order to give the design some flexibility, the targets have a tolerance range.

Wheelbase

The wheelbase for the C-Class is not specified because the goal is to achieve maximum interior volume at a given vehicle length. The wheelbase for PNGV-class is given at a minimum target for the same reason.

SAE Index	Exterior	C-Class	PNGV-Class	Comments
L103	Overall Length/mm	4100(±100)	4750	
W103	Overall Width/mm	1750(±50)	1822(±50)	
H100	Overall Height/mm	1400(±50)	1374	At Curb Weight
W101	Track – Front /mm	1530(±20)	1529(±20)	
W102	Track – Rear/mm	1530(±20)	1529(±20)	
L101	Wheelbase/mm	TBD	≥2743	C-Class, depend. on pkg.
—	Frontal Area/m²	≤2.0	≤2.0	
W3	Shoulder Room Front/mm	1402	1402	
W4	Shoulder Room Rear/mm	≥1350	1389	Avg. C-Class
—	Interior Volume/m³	≥VW GolfIV	2.70	
—	Trunk Volume/ m³	≥VW GolfIV	0.44	
—	Passenger Capacity	5	5	
	Turning Circle / m	≤11	TBD	*

* PNGV-class, depending on wheelbase, same front suspension layout as C-Class

2.8 Target Setting - Vehicle Performance

Vehicle performance targets were set based on engineering judgment, referencing benchmarking and PES experience, with the requirement to design fuel efficient, lightweight concepts in the PNGV- and C-class range of vehicles.

Main Performances	C-Class	PNGV-Class
Acceleration 0-62 mph (0-100 km/h) / sec	≤14	≤14
Aerodynamic Drag coefficient	≤0.25	≤0.25
Top Speed Continuous/ mph / km/h	100 / 160	100 / 160

2.9 Target Setting - Standard and Optional Equipment

The definition of the standard vehicle equipment is made with the intent to reflect the customer's expectation in most markets of the world. Optional equipment will add mass to the total vehicle mass and must be considered in the calculation of crash mass.

Standard Equipment – Safety

Features	C-Class	PNGV-Class
2 Airbags Front	X	X
2 Airbags Side Front	X	X
2 Seatbelts Front	X	X
3 Seatbelts Rear	X	X
ABS	X	X
First Aid Kit	X	X

Standard Equipment - Comfort

Features	C-Class	PNGV-Class
Power Locks	X	X
Power Windows	X	X
Air Conditioning	X	X
Radio with 2 speakers	X	X

Standard Equipment - Misc.

Features	C-Class	PNGV-Class
Anti-Theft Device	X	X

Optional Equipment

Features	Mass Impact kg
Sound System	2.5
Bigger Wheels and Tires	15
Navigation System	2
Sun / Moon Roof	20
Electrical Seat Adjustment (front)	10
Total options	**49**

2.10 Target Setting - Calculation of Vehicle Crash Mass

PNGV-Class and C-Class Vehicle

The calculated mass of the PNGV-class vehicle within its heaviest specification (standard OEM practice), including optional equipment, will be used in the crash simulations. Due to the platform approach taken for the design of the body structure, the same crash mass will be applied in the analysis for crashworthiness of both vehicle concepts in front crash. The calculated crash mass will be used in the first development stages. As the vehicle progresses, the crash models will use the corrected mass of the components through their development stages. The details are listed below.

Considerations	Mass kg
Total Vehicle Curb Weight	1077 (+25)
2 Dummies (74.5 kg)	149
Luggage	113
Optional Equipment	49
Total Crash Mass	**1388 (+25)***

* See page 8 (PNGV-class) and page 9 (C-Class) for explanation of (+25kg).

Appendix

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