Master Thesis

Homologation and Packaging Study of E-Mila Student

O.Univ.Prof. Dipl.-Ing. Dr.techn. Steffan Hermann,
Head of Vehicle Safety Institute

Dipl.-Ing. Dr.techn. Sinz Wolfgang,
Vehicle Safety Institute

Dipl.-Ing. Stefan Kirschbichler,
Vehicle Safety Institute

Praveen Kumar Madeshi

Vehicle Safety Institute
Member of Frank Stronach Institute

Graz, 2010

STATEMENT OF INDEPENDENCE

Hiermit erkläre ich, dass diese Diplomarbeit mein eigenes Werk ist und auf meinen eigenständigen Untersuchungen basiert. Beiträge Anderer (beispielsweise Ideen, Abbildungen, Textpassagen, Tabellen) sind an den entsprechenden Stellen durch einen Quellverweis gekennzeichnet. Weiters erkläre ich, dass diese Arbeit von mir noch nie als Abschlussarbeit oder zur Erlangung eines akademischen Grades eingereicht wurde.

I declare that this diploma thesis is my own work, based on my original research and expressed in my own words. Any use made within it of works of others in any form (e.g. ideas, figures, text, tables) is properly acknowledged at the point of use. I have not submitted this thesis for any other course or degree.

[Ort] [Datum] [Unterschrift]

ABSTRACT

The design and development of lightweight electric vehicles is becoming increasingly important in present day strategies, as it is one possibility to enable mobility under the view of compatibility of environment and sustainability. The lightweight electric vehicle can be one of the sources for reduction in greenhouse gases and it can be a convenient mode of transport for people living in cities.

The focus of this thesis is to describe the different regional law requirement and to develop a common vehicle platform based on it. The results of the thesis are the list of different regional legal requirement, list of required test, list of regulations applicable to electric vehicle of this class, H-point of occupants, seating reference point and a part of interior packaging of a concrete lightweight electric vehicle. The purpose behind this is to use this thesis as a ground work further developments and the construction of a prototype vehicle.

Der Entwurf und die Entwicklung von kleinen kompakten Elektrofahrzeugen werden zunehmend wichtiger, da dies eine Möglichkeit ist, die Mobilität unter Berücksichtigung der Umweltverträglichkeit und Nachhaltigkeit beizubehalten. So können diese Fahrzeuge zur Reduktion von Treibhausgasen, bei gleichzeitiger Beibehaltung der Individualmobilität in den Stadtgebieten, beitragen.

Der Fokus dieser Diplomarbeit ist die Darstellung der regional unterschiedlichen Gesetzgebungen und die Entwicklung einer darauf basierenden allgemeinen Fahrzeugplattform. Die Ergebnisse dieser Arbeit sind die Zusammenstellung der regionalen Gesetze, der zu erfüllenden Tests, einer Zusammenstellung von notwendigen Zulassungstests für kleinen kompakte Elektrofahrzeuge, die H-Punkte der Insassen, die Sitzreferenzpunkte und ein Teil des Interieurs für ein konkretes Fahrzeug. Somit stellt diese Arbeit die Grundlage für weitere Entwicklungen und den Bau eines Prototyps dar.

ACKNOWLEDGEMENT

My sincere thanks to members of Magna, members of Institute of Vehicle Safety and members of Production Science and Management at Technical University of Graz for helping me to accomplish this work.

Further I would like to thank and extent my gratitude to Mr. Schafschetzy Gernot HOD Homologation department at Magna Steyr and Mr. Winster Wolfgang former Head of Governmental Affairs at Magna E-Car Systems for their kind support and guidance for the development of homologation requirements of the E-Mila Student.

I also like to thank Mr. Kemmler Helmut of EGI- Fahrer platzauslegung department at Magna Steyr for RAMSIS analysis and valuable inputs for the development of driver and rear seat occupant positioning and vehicle packaging.

I also like to thank and extend my gratitude to Dipl.-Ing. Dr.techn. Sinz Wolfgang and Dipl.-Ing. Stefan Kirschbichler from Institute of Vehicle Safety for helping me in appropriate content selection for the thesis and for valuable suggestions and remarks for representation of thesis.

Finally, I would like to thank to all those who indirectly help me to accomplish the thesis work and also to my family members and friends for their help and support throughout the project.

Abbreviations

OEM	Original Equipment Manufacturer
MSIA	Magna Steyr India Asia
LHD	Left Hand Drive
RHD	Right Hand Drive
UNEEC	United Nations European Economic Community
UNECE	United Nations Economic Commission of Europe
ECWVTA	European Committee Whole Vehicle Type Approval
SVA	Single Vehicle Approval
VOSA	Vehicle Operator Services Agency
STU	Separate Technical Unit
FMVSS	Federal Motor Vehicle Safety Standard
COP	Conformity of Production
Cd	Candela
dB(A)	Decibel (Used to approximate the human ears response to sound)
NHTSA	Highway Traffic Safety Administration
DOT	Department of Transport.
KMPH	Kilometres per hour
LSV	Low Speed Vehicles
NGCMA	National Golf Car Manufacturers Association
CMVSS	Canada Motor Vehicle Safety Standards
TSD	Technical Standard Document
VIN	Vehicle Identification Number
NPRM	Notice of Proposed Rulemaking
EV	Electrical Vehicle
SAE	Society of Automotive engineers
2D	2 Dimensional
HPM	Hip Point Machine
RPO	Regular Production Options
CAD	Computer Aided Designing
H-Point	Hip point
SgRP (R)	Seating Reference point
ISO	International Organization for Standardization
BOM	Bill of Materials
GVWR	Gross Vehicle Weight Rating
SI	System International
BOF	Ball of Foot
BOFPR	Ball of Foot Reference Point
FOV	Field of Vision
AHP	Acceleration Heal Point

TABLE OF CONTENTS

1 Introduction

1.1 Project Idea of the E-Mila Student

In present day scenario it is very crucial to think about the environment and the sustainable technologies which lead to the comfort and convenient mode of transport system. Growing prices of conventional fuel used for transportation and growing rate of greenhouse gases emphasis to think about the alternative mode of transport which reduces the urban air traffic pollution and more convenient way for city transportation. The micro electric car can be one of the sources for reduction in green house gases and it can be convenient mode of transport for people leaving in cities, though it is arguable about the utilization of pure source of electricity generation depending upon regional power resources.

The initial idea of the project came from one of the student Mr. Wechselbergar Lukas and later idea is to work on this project is generated by the group of six Magna sponsored students studying Production Science and Management at Technical University of Graz. The main idea beyond this vehicle is to create a compact city car which is easy to park and easy to move in the traffic zones and which can be used to make short city trips for leaving children to schools, shopping and for daily travelling to workplace purposes. To have a vehicle which is environment friendly and can be recyclable and which is suitable for wide classes of people.

The group of students presented the idea to Magna Steyr and Technical University of Graz management. Initially there was a plan to generate the prototype out of the thesis work and due the time constraint it is later decided to have only virtual vehicle. The name of this project is given as E-Mila Student and it is an electric light weight vehicle with cooperation of Magna Steyr and Technical University of Graz, which falls under the category of L7e.

As the E-Mila Student project is supported by the Magna Steyr, the following chapter explains about the Magna International, Magna group of companies,

Magna Steyr and also its support for the internal development of employees through education and training.

1.2 About the Magna [1]

Magna is the most diversified automotive supplier in the world. Magna posses the competence in design, develop and manufacture automotive systems, assemblies, modules and components, and engineer and assemble complete vehicles, primarily for sale to original equipment manufacturers (OEMs) of cars and light trucks in the three geographic segments - North America, Europe, and Rest of World (primarily Asia, South America and Africa). Magna capabilities include the design, engineering, testing and manufacture of automotive interior systems; seating systems; closure systems; metal body & chassis systems; mirror systems; exterior systems; roof systems; electronic systems; powertrain systems as well as complete vehicle engineering and assembly.

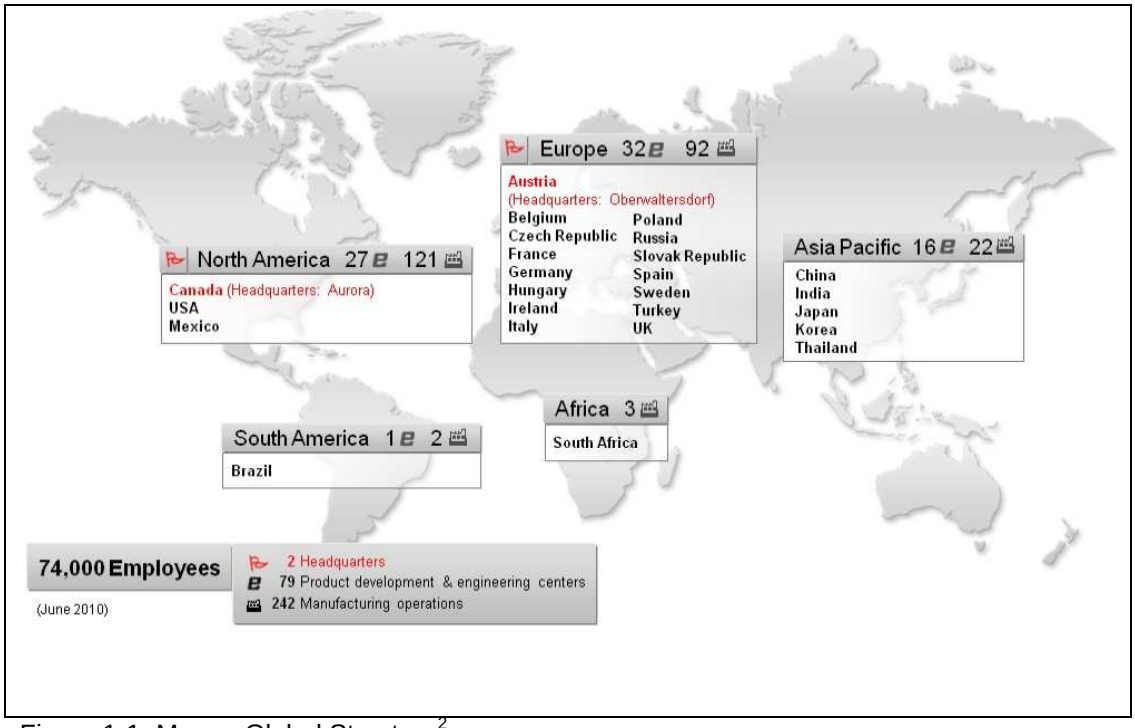


Figure 1-1: Magna Global Structure[2]

[1] Cf: http://www.magna.com/magna/en/about/ , 23.09.2010

[2] Cf: Magna Steyr marketing and communication document

Magna has a diversified presence in the world having 242 manufacturing operations and 79 product development, engineering and sales centres in 25 countries on five continents as of June 2010.

1.2.1 About Magna Steyr

MAGNA STEYR is one of the multinational companies under the Magna group of companies. It is one of the biggest automotive manufacturing organizations in Europe under its own brand and having the world class flexible and automated manufacturing facility. Over the 100 years of experience in automotive industry and the leading global engineering and manufacturing partner to automakers.

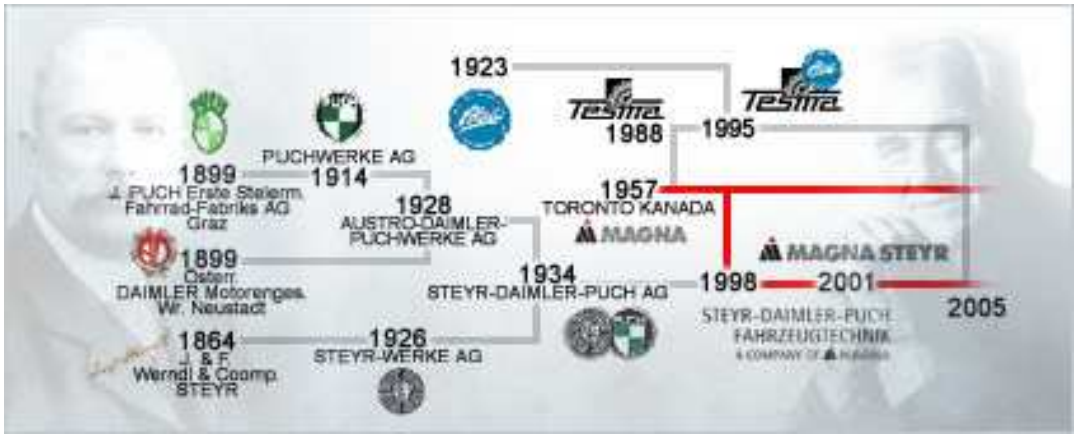


Figure 1-2: Magna Steyr Chronological Development [3]

The company offers OEMs solutions for a wide range of services with highly flexible development and assembly strategies, from individual systems like door modules or roof systems to complete vehicles and from extra-low volume through peak volume production.

All these years Magna Steyr has gone through many changes as the owners of the company and merging with other companies keep on changing.

[3] Cf: http://www.magnasteyr.com/xchg/complete_vehicle/XSL/standard.xsl/-/content/148_906.htm?rdeLocaleAttr=en, 24.09.2010

Indeed, its family tree traces its lineage back to Puch, Steyr, Daimler and Magna. In the view of past development it shows that the only success way for the organization is to join the hands with others. The Figure 1-2 shows the chronological developments of Magna Steyr.

Magna Steyr India (MSIA) was established in the year 1996 and earlier it was known as Steyr India. Magna Steyr India is a co-operation between Magna Steyr and Magna Powertrain and MSIA bring the dynamic combination of over 100 years of vehicle and drivetrain engineering experience to India, where it offers world-class technology, skill and experience, in Pune, India.

Magna Steyr India is a complete vehicle engineering service centre having the wide range of services starting from the engineering to sourcing. The vision of company is to be the partner of choice in the markets for the services to provide, built upon superior technical capabilities of Magna Steyr & Magna powertrain.

The strength of the company is 170 heads as on June 2010, and is growing. Magna India provides World-Class Engineering services to all leading OEM's.

Trim, Body-in-White, Seating, Embedded & Electronic Systems, Engine and Driveline, supported by Magna India specialist CAE and simulation group, additionally, Magna India can support domestic and overseas customers with Cost Engineering, Local Sourcing, Purchasing and Supplier Quality Assurance.

1.3 Scope of the Thesis

The scope of this thesis is to built a light weight ultra compact electric vehicles for multiple regions based on the regulatory requirements as per the local authorities and to establish the packaging of the vehicle to accommodate the occupant with safety and comfort ability. It is very important to build a vehicle for multiple markets with or without very minor changes, to ensure that the overall cost of vehicle construction should be as low as possible. Therefore it makes sense to find a vehicle concept which fulfils all regulatory requirements.

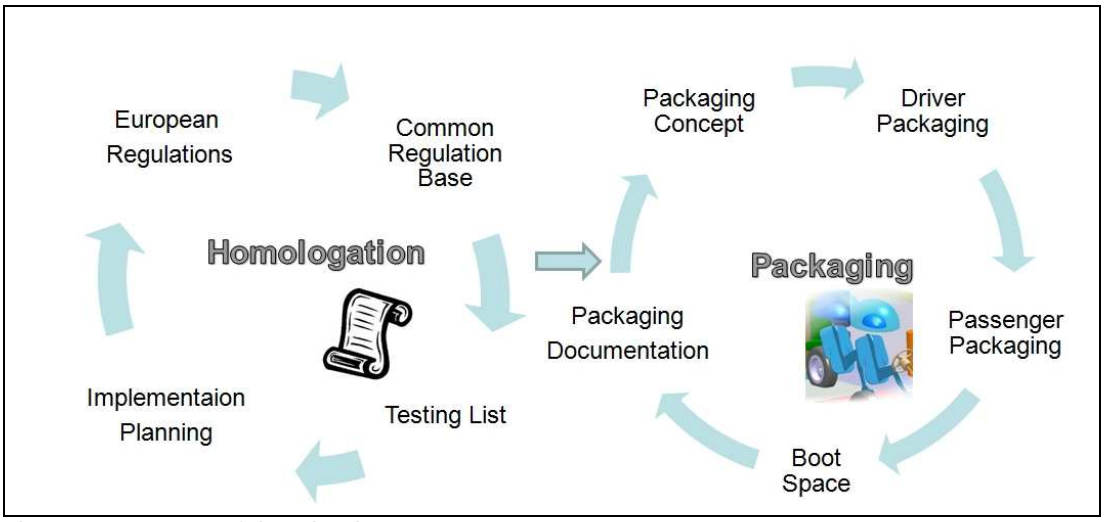


Figure 1-3: Scope of the Thesis

This thesis describes the homologation requirement based on the national authorities and the common factors for the consideration of building a vehicle in the concept phase to accommodate it in different parts of the world. The concept phase is the first part of the production development process. This process is shown in figure 1-4. Also the “position” of this thesis is showed in this figure.

As it is shown there are some activities carried out before development process and these are input parameters for the development process but also parallel activities are carried out within the concept development process, which results a active linking of the results (harmonization) and have finally results which are inputs for the later stages in the process chain. One such example is the results of the marketing analysis are considered as inputs for this thesis (see the diploma thesis *“Market Study for an Electric City Car”* by D.I. (FH) Michael Karl Preiss for more information).

Interlink between the homologation and packaging as been considered to full fill the legal requirement to sell the car in the market and packaging has to be done in coordination with the chassis and drivetrain layout for an electric vehicle (see the diploma thesis *“Chassis-, Drivetrain and Energy Storage-Layout for an Electric City Vehicle “by* D.I. (FH) Stefan Eitzinger for more information).

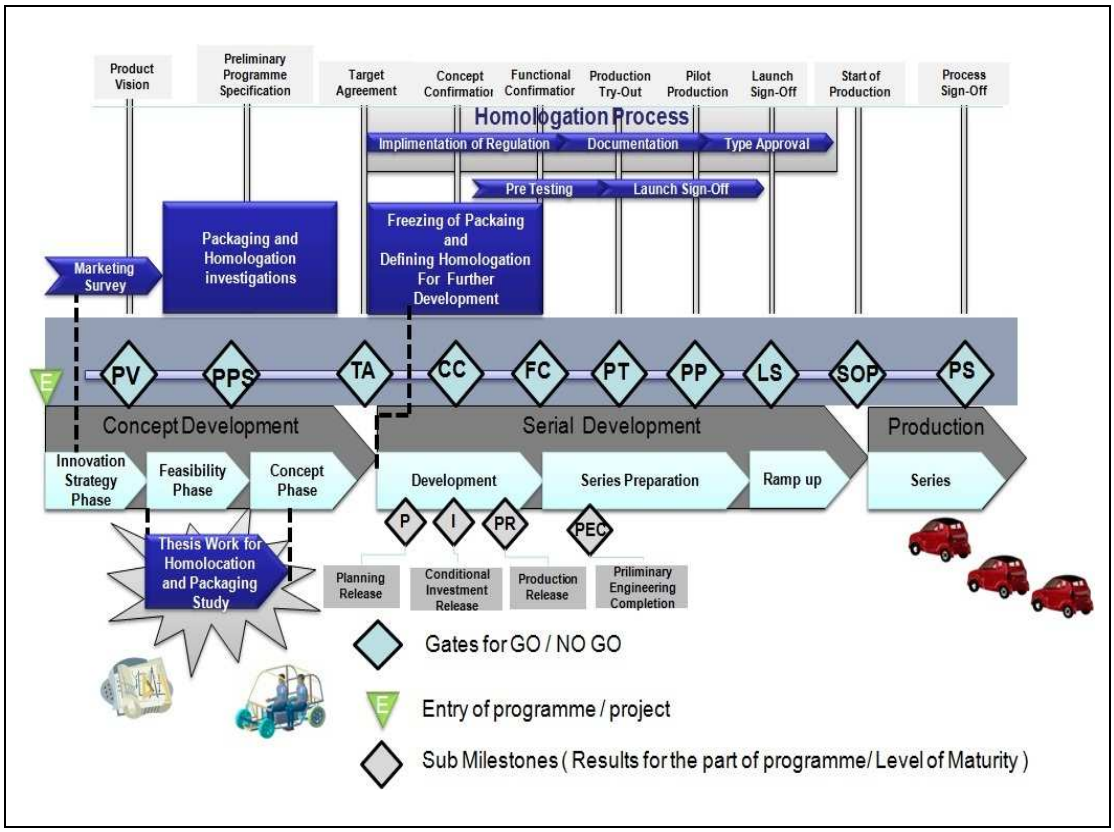


Figure 1-4: Thesis Scope in Product development process (ref Concept development phase of E-Mila Student. Figure 2-6) [4]

This thesis is very important considering the homologation requirements of the vehicle as it is very expensive to rework on the project at the later stages of the development process to meet the homologation requirements and the design of any vehicle is also depends on the homologation requirements of the regions. Therefore the better the concept from the beginning, the better is the work afterwards.

The outcome of the thesis is common platform for the different regional legal requirement, List of required test, List of regulations applicable to EV under the segment, H-point of occupants, Seating reference point (SgRP/R point) and interior packaging of E-Mila student. The purpose behind this is to use the study report as a ground work to build the prototype of the vehicle and followed by further developments.

[4] Cf: Based on Magna's Internal Document.

2 E-Mila Student Project

E-Mila Student is a small electric car under the L7e category of vehicles. E-Mila student has the advantage over the other vehicles of M category classes as there are certain regulation relaxations and the overall cost of the vehicle can be achieved to produce a vehicle at low cost and at acceptable under this L7e category. The aim of the project is to have a vehicle with good stability and safety standards in this sector of vehicles as well as the comfortable packaging for the occupants for given compact overall size of the vehicle for urban commuters. The objective is to provide the virtual development of the EV by the group of students, which can pave the path for the future development of the vehicle.

2.1 Literature Review of Light Weight Electrical Vehicles

Currently there is a trend in industries and markets, which are focusing on the electric vehicles, which have the potential to contribute to significant reductions in both carbon emissions and the world‘s dependence on oil as its prime transport fuel. Even when the electricity itself is far from low carbon, such as when the generation mix contains a large proportion of unabated coal-fired power stations, the greater energy conversion efficiency of the electric motors mean overall life cycle emissions (known as well-to-wheel) are often lower than conventional petrol and diesel alternatives.[5]

For the purposes of this study, electric vehicle*s* include both hybrids and purely-electric vehicles are taken into consideration. Hybrid vehicles combine electric power from an on-board battery with an internal combustion engine. Different degrees of hybridization are possible. A mild hybrid switches the engine off when the vehicle is stationary and then restarts when the accelerator is pressed. Energy from braking is stored and can be used to support the internal combustion engine during acceleration. A full hybrid is capable of running on battery power alone, although usually for short distances only. The vehicle runs on electric power at low speeds and under low loads and switches to the internal combustion engine for higher speeds and hard acceleration. This maximizes the overall efficiency. A plug-in hybrid

can be charged directly from the grid and can run on electric power for longer distances. This requires greater battery capacity than other hybrids. An extended range hybrid uses a small internal combustion engine to charge the battery rather than drive the wheels.

Purely-electric vehicles run on battery power only and do not use an internal combustion engine or liquid fuel. The current generation tends to be smaller vehicles with a limited range and performance, and the battery often takes as much as 7 hours to recharge. Mitsubishi MIEV is one such example which take approximately 7 hours to charge the vehicle with power supply of 200V(15A), which is shown in Figure: 2-1. However, recent developments in battery technology suggest that batteries could offer acceptable range, performance and charging time in the longer term.[5(1)]

Figure: 2-1 Mitsubishi Innovative Electric Car [6]

In Europe this light weight electric vehicles are marketed under the quadricycle segments. Though many vehicles are in the market under such segment, more vehicles will enter in to the market in near future. To name some of them are the French car makers Axiam mini eclectic cars are already in market under the name Axiam Megacity car. The Italian car

[5] Cf : Electric vehicles: Review of type-approval legislation and potential risks - TRL

[6] Cf: http://www.mitsubishi-motors.com/special/ev/whatis/index.html on 30.11. 2010

manufacturers Tazzari zero emission cars is unveiled already. The Figure 2-2 below shows such cars from the two manufacturers.

Figure 2-2: Electric Quadricycles in Europe [7]

[7] Cf : http://www.tazzari-zero.com/ accessed on 30.11.2010
http://www.aixam.co.uk/legislation.html accessed on 30.11.2010

There are some concept cars which are similar to the E-Mila Student which are either complete electric or hybrid with three seater and central steering position. To name some of them are the hybrid concept from Italian car makers Piaggio Nt3 and Gorden Murrey's T25 concept car as shown in the Figure 2-3, but E-Mila student is distinguished from them in terms of overall size and occupant space inside the vehicle. Apart from them this vehicle also focus on crash safety by using the innovative structure (see the diploma thesis *"Concept for the development of an urban electric vehicle"* by Lukas Wechselberger for more details) to fulfil the requirements of frontal crash as per the Japanese market (see the chapter 7 for more details).

Figure 2-3: Similar Concepts to E-Mila Student [8]

2.2 Description of the E-Mila Student Vehicle

The E-Mila Student is a three seater city vehicle and is considered as the A-class vehicle as per the SAE vehicle classification based on the dimensions of the vehicle (see Table 9-2 for details). To fulfil the requirements of individual regions, E-Mila Student is independent of the LHD and RHD system by placing the driver in the centre of the vehicle with central steering system. The other advantage of it is to have a strong multifunctional central

[8] Cf: http://www.dailymail.co.uk/sciencetech/article-1292956/Drink-drive-We-road-test-British-car-old-plastic-bottles-does-90mph.html accessed on 30.11.2010
http://forums.treehugger.com/viewtopic.php?f=14&t=19883&p=120164 accessed on 30.11.2010

beam on chassis in the centre running over the vehicle to support the stability of the vehicle, to carry battery and even front seat can be installed on that. The concept of the vehicle is shown in the Figure 2-4. This shows the positioning of the driver seat and occupant in the centre of the vehicle.

Figure 2-4: E-Mila Student Basic Concept Overview

The general and technical specifications are defined by the marketing survey and basic concept study is also considered for the further investigations (more information can be found at “Concept for the development of an urban electric vehicle” by Lukas Wechselberger). Table 2-1 and Table 2-2 shows the main general and Technical specification of the E-Mila Student required for the homologation and Packaging Study. For detailed information see Appendix I and Appendix II.

E-Mila Student General Specifications	
Drive	Electric
Type of drive	Rear Wheel Drive
Number of Seats	3
Number of Wheels	4
Number of doors	3
Driver Position	Central

Table 2-1: E-Mila Student General Specification

E-Mila Student Technical Specifications	
Dimensions	
Height [mm]	1545
Length [mm]	2550
Width [mm]	1475
Wheel base [mm]	1850
Wheel Track front [mm]	1300
Wheel track rear [mm]	1300
Ground clearance [mm]	130
Overhang rear/front [mm]	50/50
Trunk Volume [l]	180
Weight	
Vehicle weight without battery [kg]	400
Battery Weight [kg]	250
Curb Weight [kg]	650
Max. Weight kg inc. Bat+ Person + Freight [kg]	950
Weight distribution front/rear [%]	40/50
Tires	145/70 R13
Driving Performance	
Power [kW]	15
Top Speed [kph]	85
Top Speed limited USA [kph]	40

Table 2-2: Technical Specifications of E-Mila Student

The E-Mila Student is based on the four different markets though out the world. The emphasis is given to develop the vehicle as per the legal and technical requirements of the Europe, United States, Canada and Japan. The global network of the vehicle is shown in the figure below.

Figure 2-5: Global network of E-Mila Student

2.3 Overview about the E-Mila Student Concept Development

The overall phase of the project will be concept development in which each group member is having the individual responsibility to deliver the project to the next phase of the development process. The output of this phase can be used for design development and process planning of the product as the inputs.

During the innovation strategy phase the definition of the product idea is defined (see Figure 2-6). Definition of the project content, budgeting and risk assessment and potential identification are the key activities of this phase. (See the diploma thesis *"Concept for the development of an urban electric vehicle"* by Lukas Wechselberger for more details)

Checking for results from the market survey can be used for the product vision and can be utilized as the inputs for the feasibility checking the values provided by the marketing survey is the base for crosschecking the homologation requirements of the different regions. This topic covers the part of the thesis work. Based on these results the concept development and technical feasibility will be carried.

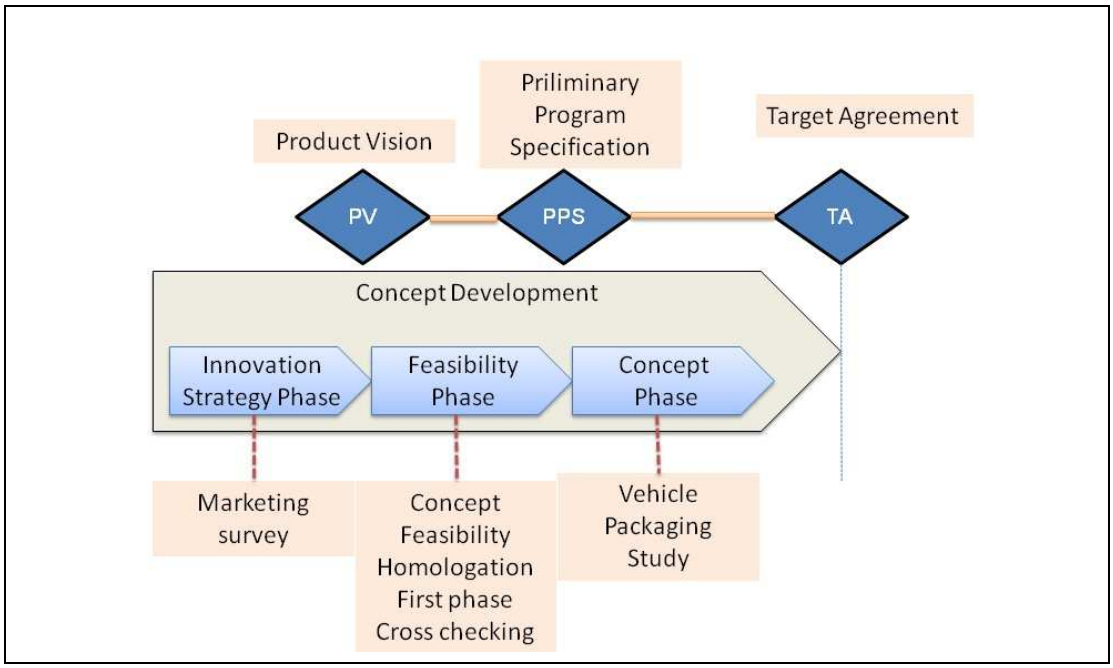


Figure 2-6: Concept development phase of E-Mila Student.

The marketing analysis describes and identifying the potential markets, customers, Vehicle segments, benchmarking and estimation of volume and price. This identification of potential markets is the basis for defining the regions and identifying the local vehicle regulations.

The results of this thesis are the input for the development phase and designing of the vehicle can be start based on the results and also utilized for the part of concept development and for the chassis layout. The results can be also used to check for the possibilities of different market penetrations based on the regulatory requirements.

3 General Aspects of Homologation

Before developing any new vehicle it is essential to know the homologation requirements as per design requirement. It essential to homologate the vehicle to sell it in the prescribed market, without doing it will result in rework and lot of cost is involved in rework and restructure of the process. Every market in the world is having its own regulatory acts and it's very important to build a vehicle with common design feature to meet the requirements of the respective markets.

For the purpose of EU legislation, motor vehicles are grouped by categories. The following table shows the motor vehicle categories in brief.

Category	Definition	Represents
L	Mopeds, Motorcycles, Motor Tricycles and Quadricycles	 http://www.tazzari-zero.com/
M	**Motor vehicles with at least four wheels designed and constructed for the carriage of passengers.**	
M_1	Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat.	 http://www.chevrolet.com/
M_2	Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tones.	 http://www2.mercedes-benz.co.uk
M_3	Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tones.	 www.volkswagen-commercial-vehicles.com
N	**Motor vehicles with at least four wheels designed and constructed for the carriage of goods.**	
N_1	Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tones	 www.renault.co.uk/vans

N_2	Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tones but not exceeding 12 tones.	 www.mantruckandbus.com
N_3	Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tones.	 www.mantruckandbus.com
O	**Trailers (including semi-trailers)**	
O_1	Trailers with a maximum mass not exceeding 0.75 tones.	 www.mulchandtrailers.com
O_2	Trailers with a maximum mass exceeding 0.75 tones but not exceeding 3.5 tones.	 www.koegel-trailer.com
O_3	Trailers with a maximum mass exceeding 3.5 tones but not exceeding 10 tones.	 www.koegel-trailer.com
O_4	Trailers with a maximum mass exceeding 10 tones.	 www.koegel-trailer.com

Table 3-1: Classification of Vehicle Categories [9(2)]

As the part of the thesis is based on the homologation of L category vehicle, a separate table describing the different vehicle segments under the L category is shown in Table 3-2.

At present there are no regulations for the electric safety of the L category vehicle, thought there are certain regulations to fulfil the basic requirements of the vehicle main functional parts. The following chapters explain in detail the individual requirements of the each regulatory act and the common features to be considered for the development of E-Mila student.

There is a roadmap for M and above category electric vehicles in European legislation but there is no roadmap yet for the L category electric vehicles. Some of the highlights of the roadmap on regulations and standards for the electrification of cars are as follows. There are proposals for the type approval of the electric vehicles to amend the directive 2007/46/EC.

[9] Cf: Type Approval Directive 2007/46/EC

Low Weight Vehicle Categories							
Type	**No. of Wheels**	**Class**	**Top Speed (Km/h)**	**Power for Motor (KW)**	**Engine Capacity (CC)**	**Mass Kg (excluding batteries)**	**Remarks**
Moped	2	L1e	≤45		≤50		
	3	L2e	≤45	4	≤50		
Motor-cycle	2	L3e	>45		>50		
	3	L4e	>45		>50		With Side car
Tricycle	3	L5e	>45		>50		Symmetric
Light quadricylce	4	L6e	≤45	4	≤50	≤350kg	need to full fill L2e requirements
Quadricycle	4	L7		15		≤400kg	55 Kg for carrying goods
Note : Same color indicates that the vehicle shall full fill the requirements of previous category unless otherwise specified separately							

Table 3-2: Classification of Low weight Vehicles [10(3)]

The emphasis is given for the elements of a harmonized legislative framework for the approval of electric vehicles. Regulation No. 100 provides for appropriate requirements to ensure a high level of public safety related to electric vehicles.[11]

[10] Cf : Directive 2002/24/EC Type approval

[11] Cf:

http://ec.europa.eu/enterprise/sectors/automotive/files/pagesbackground/competitiveness/roadmap-electric-cars_en.pdf accessed on 10.12. 2010

4 Vehicle Homologation in Europe

Every vehicle on road, whether imported, sold or used must comply with the relevant regulations of the local authorities. This comply with regulations is done by the homologation process approved by the certificate issuing authority. In Europe vehicle homologation is based on European economic community (EEC) and Economic Commission of Europe (ECE). The EEC directives are authorize the local states to amend the regulations and to implement the amended standards, whereas the ECE regulations are accepted globally and in all the member states as well.

In 1957 EEC Treaty was signed in Rome whose aim is to achieve the integration of European states with trade with a view to economic expansion. After forming the European Community, the member states decided to expand the community's power to non member states.[12]

In 1958 ECE treaty was signed in Geneva for the Conditions of Approval for Motor Vehicle Equipment and Parts. 51 member states participated and 88agreed upon the agreement of standardized vehicle regulations.

Figure 4-1: E-Mark for Type Approval Certificate numbering.

Certain member states in the economic commission for Europe are the self-certification in which the manufacturer certifies, without any preliminary

[12] Cf:http://europa.eu/legislation_summaries/institutional_affairs/treaties/treaties_eec_en.htm accessed on 12.10.2010

administrative control. The product in the market has to confirm the regulations by the state. (4)[13]

The uniform international homologation is represented by e-mark. The typical example of the E- mark from UNEEC and UNECE is shown in the Figure 4-1.

The general method for certification in most of the cases is based on the coordination between manufacturer, testing and certification service providers and the approving authority of certification unit. The general homologation approach is shown in the Figure 4-2.

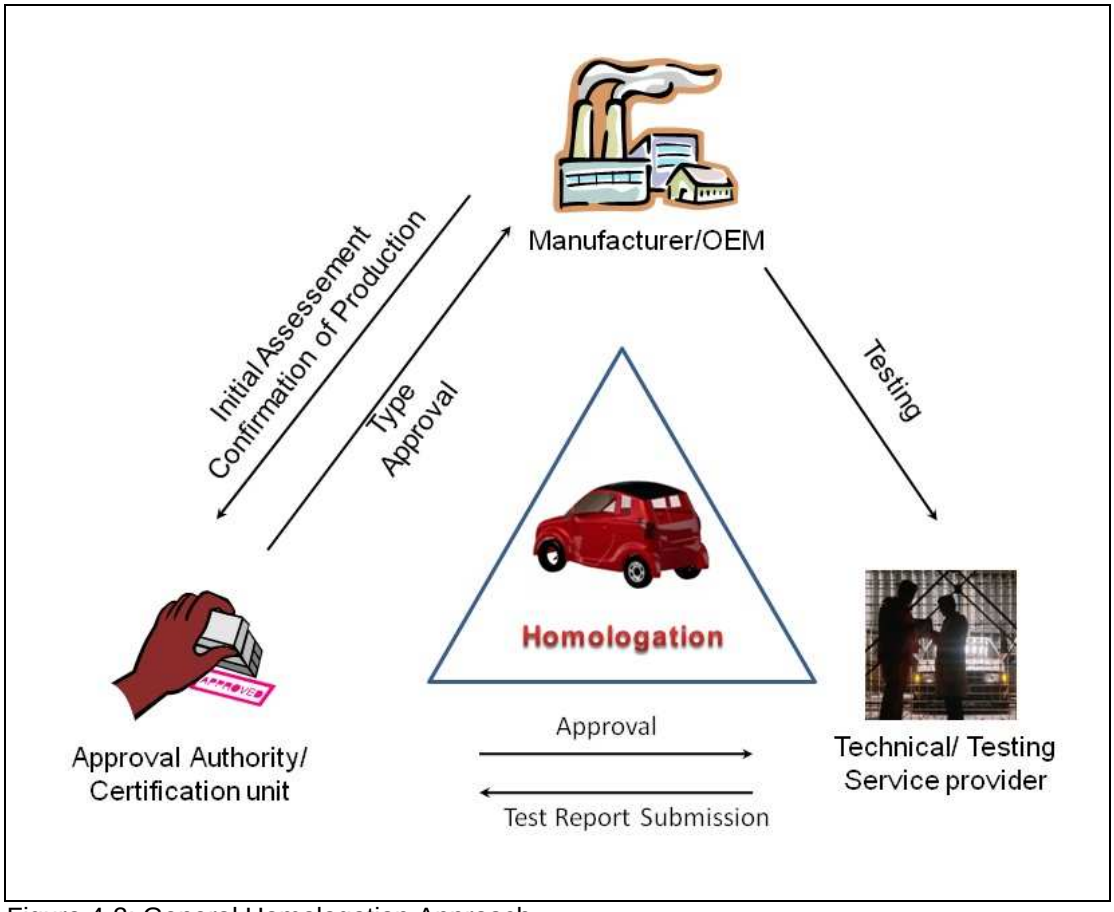


Figure 4-2: General Homologation Approach

The initial assessment will be initiated by the manufacturer well beginning of the project and Conformity of Production (COP) has to be approved by the approval authority. Some of the terms has to be confirmed by the manufacturers themselves and other terms are certified by the approval

[13] Cf: Agreement concering Uniform technical perception, Geneva 1958, E/ECE/324

authority, which will be discussed in details in the vehicle type approval process in the next chapters. Manufacturer required submitting the documentation for the initiation of process at approval authority and needing to specify the schedule for the testing of components well in advance. Manufacturer is responsible for the coordination with technical and testing service providers. The technical service providers will be responsible for submission of all test reports and to get confirmation from the approval authority. This test reports are later documented by the OEM during the complete homologation process. It has to be ensured that every vehicle coming out of production is marked with the homologation type approval certification numbering to sell the vehicle in the market. The approval process also includes an assessment of the production and quality control procedures of the manufacturer and COP to ensure the procedures maintained during the production life of the vehicle.

The L category vehicle are low weight and low power vehicles compare to the other categories and have some exemption in legislative law such as frontal crash, side impact test, safety requirements to name few of them. The following Table 4-1 provides the list of directives required to fulfil the different vehicle category according to European Legislations.

Subject	Vehicle Category			
	M1	N1	L5e	L7e
Type Approval	2007/46/EC	2007/46/EC	2002/24/EC	2002/24/EC
Masses and Dimensions	92/21/EEC	97/27/EEC	93/93/EEC	93/93/EEC
Statutory inscriptions	76/114/EEC	76/114/EEC	93/34/EEC	93/34/EEC
External Projections	74/483/EEC	-	97/24/EC Chapter 3	97/24/EC Chapter 3
Wheel Guards	78/549/EEC	78/549/EEC	-	-
Rear registration plate	70/222/EEC	70/222/EEC	93/94/EEC	93/94/EEC
Safety Glazing and Glazing Materials	92/22/EEC	92/22/EEC	97/24/EC Chapter 12	97/24/EC Chapter 12
Audible warning device	70/388/EEC	70/388/EEC	93/30/EEC	93/30/EEC
Vehicle Noise	70/157/EEC	70/157/EEC	97/24/EC Chapter 9 (5)	97/24/EC Chapter 9 (5)
Maximum speed, engine power	80/1269/EEC	80/1269/EEC	95/1/EC	95/1/EC
Air Pollution	70/220/EEC	70/220/EEC	97/24/EC Chapter 5 (5)	97/24/EC Chapter 5 (5)
Diesel Engine Emissions	72/306/EEC	72/306/EEC	-	-
Fuel Consumption	80/1268/EEC	80/1268/EEC	-	-

Evaporative emission gasoline engine (Otto-Motor)	70/220/EEC	70/220/EEC	-	-
Forward Field of Vision	77/649/EEC	-	-	-
Wiper and Washer System	78/318/EEC	-(2)	97/24/EC Chapter 12	97/24/EC Chapter 12
Defrost and Demist	78/317/EEC	-(1)	97/24/EC Chapter 12	97/24/EC Chapter 12
Heating System	2001/56/EC	2001/56/EC	-	-
Type-approval of devices for indirect vision	2003/97/EC	2003/97/EC	97/24/EC Chapter 4	97/24/EC Chapter 4
Steering/ Steering Equipment	70/311/EEC	70/311/EEC	-	-
Braking	71/320/EEC	71/320/EEC	93/14/EEC	93/14/EEC
Tires	92/23/EEC	92/23/EEC	97/24/EC Chapter 1	97/24/EC Chapter 1
Speedometer	75/443/EEC	75/443/EEC	2000/7/EC	2000/7/EC
Anti Tampering	74/6/EEC	74/6/EEC	97/24/EC Chapter 7 93/33/EEC	97/24/EC Chapter 7 93/33/EEC
Radio suppression EMC	72/245/EEC	72/245/EEC	97/24/EC Chapter 8	97/24/EC Chapter 8
Interior fittings (identification of controls, tell-tales and indicators)	78/316/EEC	78/316/EEC	93/29/EEC	93/29/EEC
Interior parts of passenger compartment	74/60/EEC	-	-	-
Installation of lighting and light-signalling devices	76/756/EEC	76/756/EEC	93/92/EEC	93/92/EEC
Head Lights	76/76/EEC	76/76/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Fog Lights	76/762/EEC	76/762/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Direction Indicators	76/759/EEC	76/759/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Stop and Brake lights	76/758/EEC	76/758/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Central High Mounted Stop Lamp (CHMSL)	76/758/EEC	76/758/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Rear registration plate Light	76/760/EEC	76/760/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Rear Fog Lights	77/538/EEC	77/538/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Reverse Lights	77/539/EEC	77/539/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Reflectors	76/75/EEC	76/75/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Parking Lights	77/540/EEC	77/540/EEC	97/24/EC Chapter 2	97/24/EC Chapter 2
Interior Fittings	74/60/EEC	74/60/EEC	-	-
Seat Anchorage, Seat Firmness, Seat Hardness	74/408/EEC	74/408/EEC	-	-

Headrests	78/932/EEC	78/932/EEC	-	-
Seat Belt Anchorages	76/115/EEC	76/115/EEC	97/24/EC Chapter 11	97/24/EC Chapter 11
Seat Belt Mounting	77/54/EEC	77/54/EEC	97/24/EC Chapter 11	97/24/EC Chapter 11
Doors, Door locks and Hinges	70/387/EEC	70/387/EEC	-	-
Side Impact	96/27/EC (4)	96/27/EC (4)	-	-
Steering Column, Head and Chest Impact	74/297/EEC	74/297/EEC (6)	-	-
Frontal Impact Occupant Protection	96/79/EC (3)	-	-	-
Occupant Safety	96/79/EEC	96/79/EEC	-	-
Fuel Tanks	70/22/EEC	70/22/EEC	97/24/EC Chapter 6	97/24/EC Chapter 6
Coupling / Towing Device	77/389/EEC	77/389/EEC	-	-
Mechanical Coupling / Towing Device	94/20/EC	94/20/EC	-	-
Pedestrian Safety	2003/102/EC 2004/90/EC	2003/102/EC 2004/90/EC	-	-
Recycling	2000/53/EC	2000/53/EC	-	-
Maximum speed, engine power	-	-	95/1/EC	95/1/EC
Air Conditioning	2006/40/EC	2006/40/EC	-	-
Motor Vehicle and Trailers for Transportation of Dangerous goods	-	98/91/EC	-	-
Hydrogen Powered Motor Vehicles	79/2009/EC	79/2009/EC	-	-
-	Regulation Not Available			

(1) Vehicles are fitted with an adequate windscreen defrosting and drying device.

(2) Vehicles are fitted with adequate windscreen and washer.

(3) Maximum permissible weight when loaded up to 2.5 tones

(4) Applies only to vehicles with a "seating reference point (SgRP, R-points) of the lowest seat 700mm above the ground.

(5) Does not apply to electrically powered vehicles

(6) vehicles in category N1 with a maximum mass at least 1.500 kg

Table 4-1: List of Directives based on the Vehicle Categories.

The subsequent chapters describe about the vehicle type approval directive of L category and the highlights of list of individual directives described in it.

4.1 Frame Work Directive 2002/24/EC Vehicle Type Approval [14(3)]

The frame work directive 2002/24/EC is for the type-approval of two or three-wheel motor vehicles (including the quadricycles) and repealing council directive 92/61/EEC. This directive is very important for listing out of the relevant directives related to the respective vehicle category. This directive is based on the treaty establishing the European Community, and in particular on article 95, proposal from the commission and the opinion of the Economic and Social Committee. This Directive does not apply to the following vehicles:

a) Vehicles with a maximum design speed ≤ 6 km/h
b) Vehicles intended for pedestrian control
c) Vehicles for the physically handicapped;
d) Vehicles intended for use in competition, on roads or in off-road conditions;
e) Vehicles already in use before the application date of Directive 92/61/EEC
f) Tractors and machines, used for agricultural or similar purposes;
g) Vehicles designed primarily for off-road leisure use having wheels arranged symmetrically with one wheel at the front of the vehicle and two at the rear
h) Cycles with pedal assistance which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0,25 kW, of which the output is progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h.

It does not apply to the approval of single vehicles except that member states granting such approvals shall accept the type-approval of components and separate technical units as per the requirements of this directive. For the approval procedure OEMs need to submit all the documents and follow the procedures described in the type approval directive.

[14] Cf : Directive 2002/24/EC Type approval

The vehicle components and characteristics on the exhaustive list below are followed by ‘CONF’ if their conformity with the manufacturer's data has to be checked or by ‘SD’ if their conformity with requirements described in community legislation has to be checked. Following Table 4-2 shows the list of requirements for the purpose of Vehicle type approval.

Heading No	Subject	Term	Directive number (if applicable)
1	Make	CONF	
2	Type/variant/version	CONF	
3	Name and address of vehicle manufacturer	CONF	
4	Name and address of vehicle manufacturer's authorized representative, if any	CONF	
5	Category of vehicle (*)	CONF	2002/24/EC
6	Number of wheels and their position in case of three-wheel vehicle	CONF	
7	Outline drawing of frame	CONF	
8	Name and address of engine manufacturer (if different from vehicle manufacturer)	CONF	
9	Make and description of engine	CONF	
10	Type of engine ignition	CONF	
11	Engine operating cycle (**)	CONF	
12	Type of engine cooling	CONF	
13	Type of engine lubrication (**)	CONF	
14	Number and configuration of cylinders or stators (in the case of rotary-piston engine) in the engine (**)	CONF	
15	Bore, stroke, cylinder capacity or volume of combustion chambers (in the case of rotary-piston engine) in the engine (**)	CONF	
16	Full diagram of the engines induction system (**)	CONF	
17	Engine compression ratio (**)	CONF	
18	Maximum torque and maximum net power of engine, whether this is: — of the spark-ignition or compression-ignition type, or electric	SD CONF	95/1/EC
19	Anti-tampering measures for mopeds and motorcycles	SD	97/24/EC C7

20	Fuel tank (**)	SD	97/24/EC C6
21	Traction battery/is	CONF	
22	Carburettor or other engine fuel supply system (type and make) (**)	CONF	
23	Electric system (nominal voltage)	CONF	
24	Generator (type and maximum output) (**)	CONF	
25	Maximum design speed of the vehicle	SD	95/1/EC
26	Masses and dimension	SD	93/93/EEC
27	Coupling devices and their attachment	SD	97/24/EC C10
28	Anti-air pollution measures (**)	SD	97/24/EC C5
29	Tires	SD	97/24/EC C1
30	Transmission	CONF	
31	Braking system	SD	93/14/EEC
32	Installation of lighting and light-signalling devices on the vehicle	SD	93/92/EEC
33	Lighting and light-signalling devices on the vehicle the mandatory or optional presence of which is laid down in the installation requirements under heading No 32	SD	97/24/EC C2
34	Audible warning device	SD	93/30/EEC
35	Position for the mounting of rear registration plate	SD	93/94/EEC
36	Electromagnetic compatibility	SD	97/24/EC C8
37	Sound level and exhaust system (**)	SD	97/24/EC C9
38	Rear-view mirror(s)	SD	97/24/EC C4
39	External projections	SD	97/24/EC C3
40	Stand (except in case of vehicles having three or more wheels)	SD	93/31/EEC
41	Devices to prevent un authorized use of the vehicle	SD	93/33/EEC
42	42 Windows; windscreen wipers; windscreen washers; devices for de-icing and de-misting for three-wheel mopeds, motor tricycles and quadricycles with bodywork	SD	97/24/EC C12
43	Passenger hand-hold for two wheel vehicles	SD	93/32/EEC
44	Anchorage points for safety belts and safety belts for three wheel mopeds, motor tricycles and quadricycles with bodywork	SD	97/24/EC C11
45	Speedometer	SD	2000/7/EC

46	Identification of controls, telltales and indicators	SD	93/29/EEC
47	Statutory inscriptions (content, location and method of affixing)	SD	93/34/EEC
(*) In the case of twin-propulsion vehicles, if the two systems of propulsion are such that the vehicle falls within the definition either of a moped or of a motor cycle, motor tricycle or quadricycle, the latter definitions shall apply to it.			
(**) Electrically-propelled vehicles are not subject to the requirements relating to this heading. This does not apply to twin-propulsion vehicles in which one of the systems of propulsion is electric and the other thermo.			

Table 4-2: List of Requirements For The Purpose of Vehicle Type Approval

4.1.1 Type-Approval Certificate Numbering System

The type-approval number shall consist of:

— Four sections for vehicle type-approvals and
— Five sections for system, component, and separate technical unit approvals, as detailed below. In all cases, the sections shall be separated by the '*' character.

The following tables describes the section procedure of numbering system

Section Number	Description
Section 1:	The lower case letter 'e' followed by the distinguishing code (number) of the Member State issuing the type-approval:
Section 2:	The number of the base Directive.
Section 3:	The number of the latest amending Directive applicable to the type-approval.
	If a base directive has not been amended, its number is retaken in Section 3.
	Directive should contain different implementation dates referring to different technical standards, an alphabetical character shall be added to specify to identify which standard, the approval was granted.

	The number of the separate directive shall be followed by the number of the Chapter 1 (1), Annex (2) and Appendix (3) in order to indicate the subject of the type-approval. In all cases, these numbers shall be separated by the '/' character. (1): In Arabic characters (2): In Roman characters (3): In Arabic characters and capital letters, where applicable.
Section 4:	A four-digit sequential number (with leading zeros as applicable) to denote the base type-approval number. The sequence shall start from 0001 for each base Directive.
Section 5:	A two-digit sequential number (with leading zeros if applicable) to denote the extension. The sequence shall start from 00 for each base type-approval number

Table 4-3 Section Description for Type – Approval Numbering.

As described in the Section 1 each lower case letter e must be followed by the distinguishing code of the member state. Each member state is distinguished by the code number for identification. The marking should be done as per this code numbers by respective state members for the vehicle produced in their country.

Code Number	Member State	Code Number	Member State	Code Number	Member State
1	Germany	11	the United Kingdom	26	Slovenia
2	France	12	Austria	27	Slovakia
3	Italy	13	Luxembourg	29	Estonia
4	The Netherlands	17	Finland	32	Latvia
5	Sweden	18	Denmark	36	Lithuania
6	Belgium	20	Poland	M2 49	Cyprus
7	Hungary	21	Portugal	M2 50 for	Malta
8	The Czech Republic	23	Greece		
9	Spain	24	Ireland		

Table 4-4: Code Numbers for Member States

Example of the ninth type-approval (extension 4) granted by the United Kingdom according to Directive 93/29/EEC as amended by Directive 2000/74/EC is shown below

e11*93/29*2000/74*0009*04

4.1.2 TYPE-APPROVAL MARK

The approval mark consisting of a rectangle surrounding a lower case letter ‘e’, followed by the distinguishing number of the issuing Member State as described in the Table 4-4. Issued under certain number which will follow the each letter for the marking has to be under certain dimension proportion. It is shown in the Figure 4-3 below.

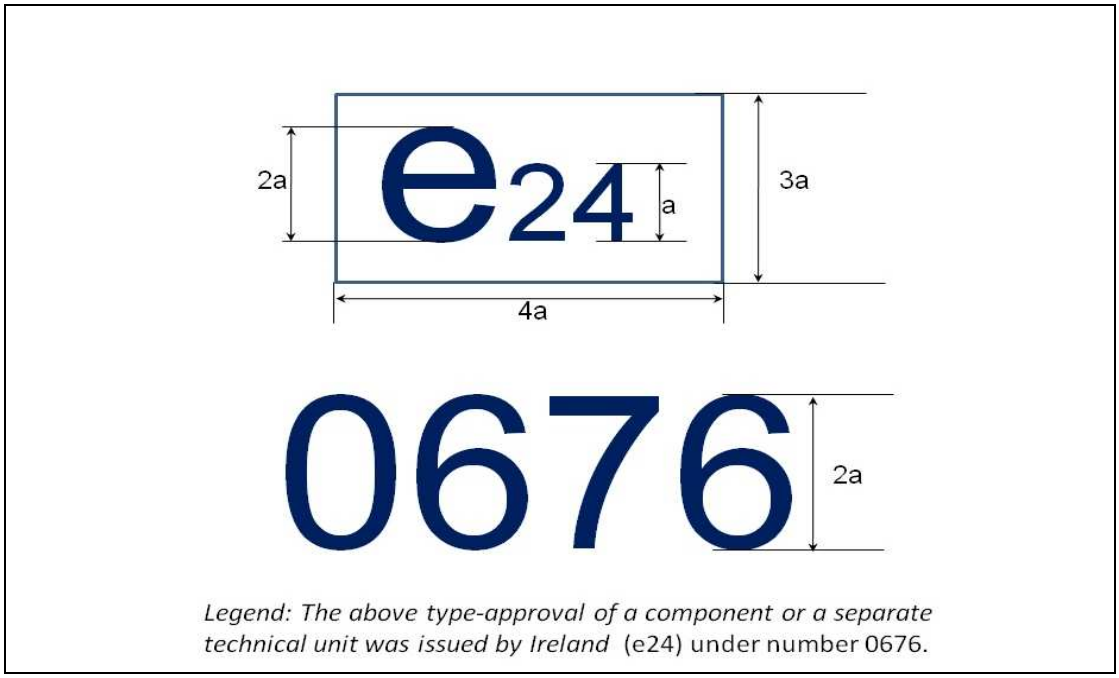


Figure 4-3: Example of a Type Approval Mark

4.1.3 PROVISIONS RELATING TO CHECKING THE CONFORMITY OF PRODUCTION

Following provision apply to Vehicles, separate technical units, components and modules to comply with the type approval.

a) The Type approval certificate holder must ensure that product quality monitoring procedure has to be placed at every level.

b) Must have access to the inspection equipment for checking the vehicles, technical units, components and modules which have been type approved.

c) To ensure to document all the test results and to preserve the documents for the period of 12 months after the completion of production.

d) Record and compare the type of test results for monitoring and ensure to maintain consistency of the characteristics of the product to maintain the variation within the permissible limits

e) Each type of product must comply with the test procedure described in the respective directives.

f) For any non conformity for the type of test must consider with new test to ensure the compatibility with COP.

g) The approval authorities for type approval may check the procedures and methods for conformity at any time.

h) All the inspection and the test reports and production records must be conveyed to the inspector.

i) Minimum numbers of samples are based on the results of the manufacturer and the inspector is liable to check the parts randomly.

j) For the entire unsatisfactory quality test, inspector may take some samples and will be sent to the technical body which has to perform the tests for the type approval.

k) The competent authorities may perform all the tests prescribed in the
    a. Separate Directive(s) applying to the product(s) concerned.

l) The authorities must conduct one inspection per year and numbers of inspections are as per the respective directives specifications. For all the negative results the competent authority must ensure that re-establishment of COP will be taken as early as possible.

4.2 Framework Directive 93/93/EEC (Masses and Dimensions) [15] (5)

This framework directive defines the standards for the masses and dimensions of two, three and quadricycles. Initially it is important to consider this directive from the list mentioned in vehicle type approval to identify the required dimensions and masses of any vehicle as per the legislative law. The mass of the rider by convention is taken as 75 kg for all other weight considerations.

Some of the important definitions which can be later on traced for the implementation of the standards are as follows:

Unladen Mass: "Unladen Mass" means the mass of vehicle ready for normal use and equipped as follows:

- Additional equipment for the normal use of the vehicle.

- complete electrical equipment, including the lighting and light-signalling devices supplied by the manufacturer,

- Instruments and devices required by the laws under which the unladen mass of the vehicle has been measured,

- The appropriate amounts of liquids in order to ensure the proper operation of all parts of the vehicle.

4.2.1 General Requirements

During checking for the measurements, the following requirements must be fulfilled.

a) The vehicle has to be measured at unladen mass and the tire pressure inflation as to be maintained as recommended by the manufacturer.

[15] Cf : Directive framework 93/93/EC

b) The wheels are to be in a straight line aligned with the vehicle position.

c) All the wheels must be on the plane surface (exceptional for the spare wheel)

4.2.2 Specific Requirements

The specific requirements of the vehicle are shown in the Table 4-5 includes the maximum permissible mass of the vehicle and the maximum pay load declared by the manufacturer. The weight of traction batteries is not taken into account in all the cases of electric powered vehicles. The maximum permissible dimension for the vehicle is shown in the Figure 4-4.

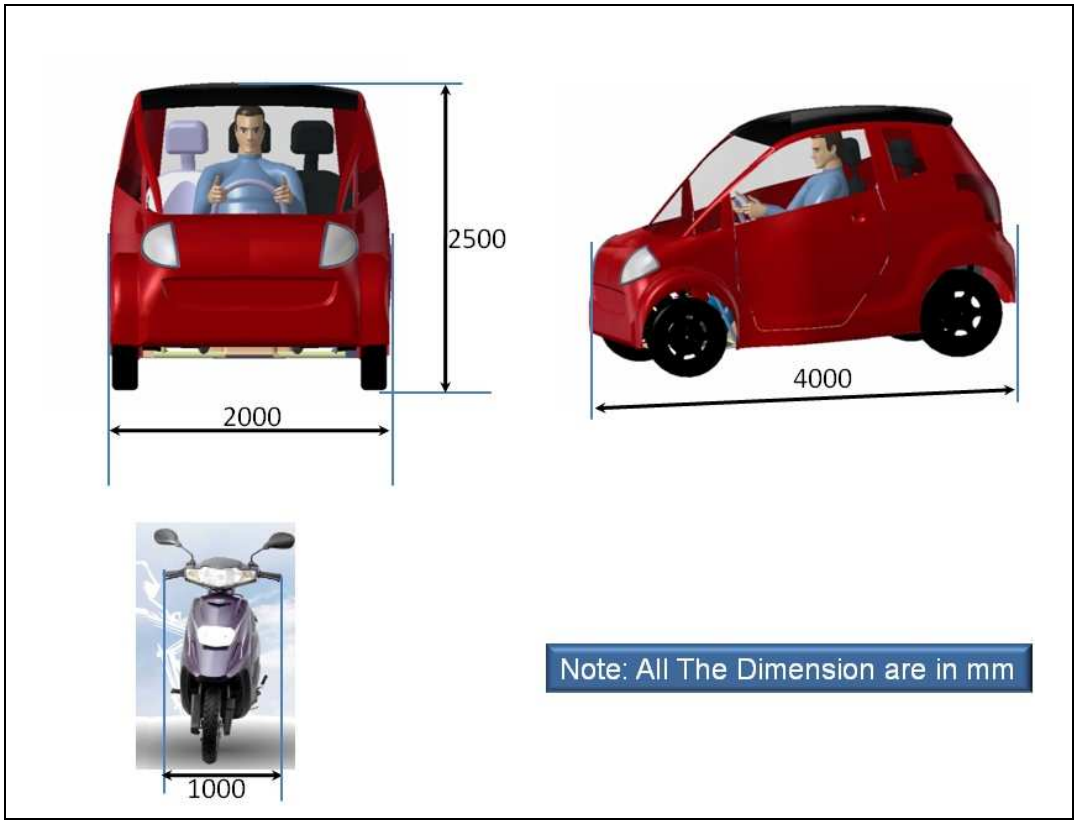


Figure 4-4: Maximum Permissible Dimensions for Two, Three and Four Wheelers

The dimension shown in Figure 4-4 for four wheeler vehicles is also applicable to the three wheelers vehicles. The width dimensions for the two wheelers are limited to one meter only. (See the Figure 10-1, which fulfil the regulatory requirements of homologation).The maximum permissible weights and their payloads are as show in the Table 4-5.

Vehicle Type	Max. Permissible Mass (Kg)	Max. Permissible Payload (Kg)	Representation
Two Wheeler			
Two Wheeler	As per technical permissible mass by OEM	-	 www.peugeot.com
Three Wheeler			
Three Wheeler Mopeds	270	300	 www.piaggiomp3.com
Three Wheeler Tricycle	1000 *	1500 (For Goods) 300 (For Persons)	 www.3wheelers.com
Four Wheeler			
Four Wheeler Light Quadricycle	350*	200	 http://wn.com/Light_Quadricycle
Quadricycles other than light for transport of persons;	400*	200	 Magna Steyr
Quadricycles other than light for transport of goods	550*	1000	 http://www.piaggio.com/en/
*** No account is taken of the mass of traction batteries for electric vehicles**			
Two, three or four-wheel motor vehicles can be authorized to tow a mass declared by the manufacturer not exceeding 50 % of the unladen mass of the vehicle.			

Table 4-5: Maximum permissible Unladen Mass and Pay Load for different vehicle Types

4.3 Framework Directive 95/1/EC (Maximum Design Speed, Maximum Torque and Maximum Net power of Engine)

This directive frame work is a part of vehicle type approval and describe about the maximum design speed of mopeds and light quadricyles and there is no information given for quadricycles with 400kg and the power requirement for electrical vehicles is given as 15kw. See the Table 3-2 for the information related to speed and power of the engine. It is based on the annexure II of the framework directive 2002/24/EC.

The test specification for maximum speed, maximum torque and the maximum power is defined for the SI and CI engines only. There is no specification provided for the electric power driven vehicles in the directive. Only the maximum power limit is defined for the other than light quadricyles. See the framework directive for the information related to the test requirements of the vehicles.

The anti tampering measures for the engines speed and power is described in the framework directive 97/24/EC Chapter 7 and general instructions are given for the internal combustion engines only. So, there is no testing specification defined for the Electric Vehicles and in all respects the maximum power has to be less than or equal to 15kw only.

4.4 Framework Directive 93/14/EEC Amend 2006/21/EC Braking of two or three-wheel motor vehicles [16] (6)

Every vehicle must be designed to have the proper braking system to stop the vehicle whenever and wherever it is required. This directive describes the general requirements and application of braking system for two or three wheel motor vehicles which is also applicable to the quadricycles. This chapter only describes the general requirements of the quadricycles as per the directive.

[16] Cf: Framework directive 93/14/EEC Braking System

Every vehicle must be constructed with different braking systems and all the braking system fitting requirements of the vehicles has to be as per the directive requirements.

- The design of the braking system must be constructed and fitted as to enable the vehicle in normal use and as per the directive irrespective of the operating conditions.

- The braking device must be corrosion resistance under all circumstances.

- Brake lining must be free of asbestos.

- The service braking must control the movement of the vehicle at up and down gradients irrespective of load and mass of the vehicle at quickly and efficiently. The driver must operate the brake sitting in the driving position.

- The secondary brakes must stop the vehicle at acceptable distance in case of failure of service brakes. The driver must operate the brake sitting in a driving position and with other hand on the steering wheel. It is assumed that only one service brake failure occurs at a time.

- The parking brakes must be able to halt the vehicle at any gradient position and must be purely by mechanical devices and driver must be in a position to operate the brake from driving seat.

Every three wheel motor cycle (also applicable to quadricycle) must be equipped with

a) A foot controlled service brake on all wheels i.e. on the both axels.

b) A secondary brake which can be parking brake also

c) A parking braking device at least acting on the one axle and it operating it must be independent of the service brake.

Forces applied to service brake controls are as follows:

Hand control < 200 N Foot control < 500 N (tricycles).

Forces applied to the parking brake control (if applicable)

With manual control < 400 N With foot control < 500 N.

The stopping distance from the accelerating the pedal until the moment when the vehicle stops the initial vehicle speed v1 shall be the speed at the moment when the driver begins to actuate the control of the braking system; the initial speed shall not be less than 98 % of the prescribed speed for the test in question. The mean fully developed deceleration, (dm), shall be calculated as according to the following formula:

$$d_m = \frac{v_b^2 - v_e^2}{25{,}92\ (s_e - s_b)}$$

(Equation 1)

Where:
dm = means fully developed deceleration
v1 = as defined above
vb = vehicle speed at 0,8 v1 in km/h
ve = vehicle speed at 0,1 v1 in km/h
sb = distance travelled between v1 and vb in meters
se = distance travelled between v1 and ve in meters

4.5 Framework Directive 93/92/EEC-C2 Amend 2009/67/EC Installation of lighting and light-signalling Devices [17] (7)

The lighting and light-signalling devices must comply with directive and must be constructed in such a way that under normal conditions subjected to vibrations must retain the performance. In particular, it must not be possible for the adjustment of the lamps to be inadvertently disturbed.

Requirements Concerning Three-Wheel Mopeds and Light Quadricycles:

- In the case of three-wheel mopeds and quadricycles with a maximum width exceeding 1 300 mm, two main-beam headlamps are required.

- The edges of the illuminating surfaces furthermost from the median longitudinal plane of the vehicle must not be more than 400 mm from the outermost edge of the vehicle

- The internal edges of the illuminating surfaces must be at least 500 mm apart. This distance may be reduced to 400 mm if the maximum width of the vehicle is less than 1 300 mm.

- The height of the headlamp must be minimum of 500 mm and a maximum of 1 200 mm above the ground.

There must be a minimum distance between the illuminating surfaces of the nearest indicators and dipped-beam headlamps of:

- 75 mm in the case of a minimum indicator intensity of 90 cd,
- 40 mm in the case of a minimum indicator intensity of 175 cd,
- 20 mm in the case of a minimum indicator intensity of 250 cd,
- ≤20 mm in the case of a minimum indicator intensity of 400 cd.

Where cd is Candela, unit of luminous intensity.

[17] Cf: 93/92/EEC Installation of lighting and light-signaling devices

The figure below shows the minimum and maximum dimensions of positioning head and tail lamps on vehicle.

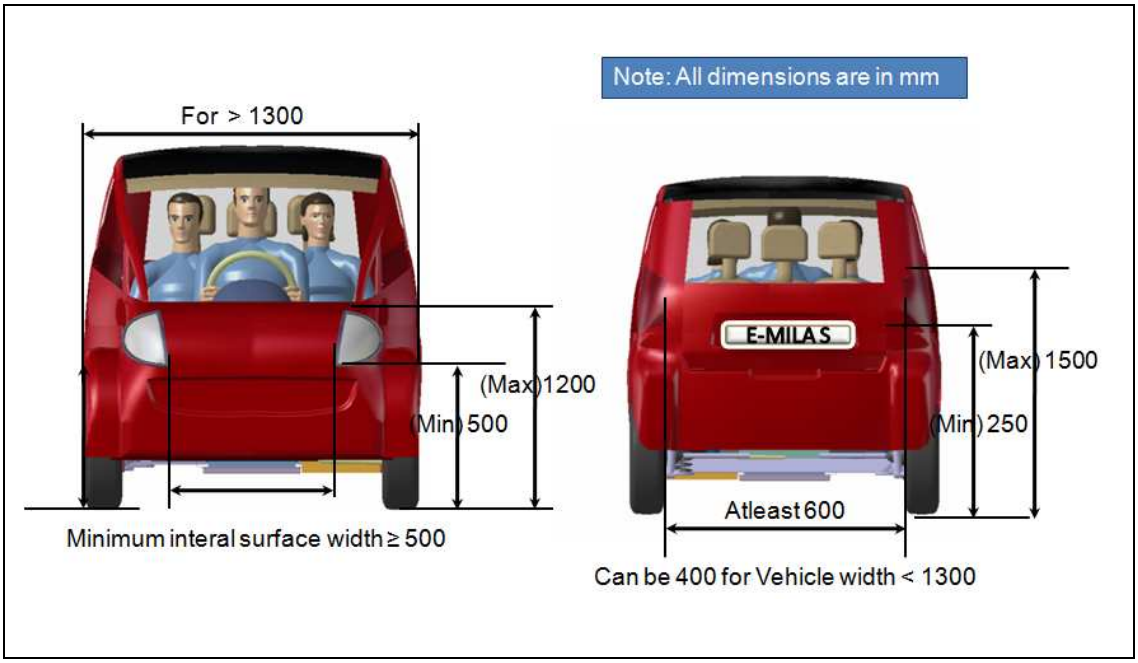


Figure 4-5: Minimum and Maximum Dimensions for Installation of Lamps

Direction indicator lamps must switch on independently of the other lamps. All direction indicator lamps on one side of a vehicle must be switched on and off by means of one control.

- The flashing-light frequency must be 90±30 times per minute

- The flashing frequency must be between 90 +30 and 90 -45 times per minute,

If there is only one stop lamp its centre of reference must lie within the median longitudinal plane of the vehicle, or if there are two stop lamps they must be symmetrical to the median longitudinal plane of the vehicle. In the case of vehicles with two rear wheels: at least 600 mm between the two lamps. The distance may be reduced to 400 mm of the maximum width if the vehicle is less than 1 300 mm. The minimum height above the ground level is 250 mm and the maximum is 1500 mm.

4.6 Framework Directive 93/30/EEC Audible Warning Devices [18] (8)

Audible warning device is an acoustic signal, which is intended to give warning signal to the road traffic by a vehicle driver in a dangerous road traffic situation. It has to be ensured by the manufacturers to mount the audible warning devices on vehicle properly and sound level measurements must comply with the directive norms.

Following requirements has to be fulfilled by each vehicle on the road. The resistance of the electrical conductor for audible warning devices receiving direct current, including the resistance of the terminals and contacts, must lie as closely as possible to:

- 0,05 Ohms for a nominal voltage of 6 V,
- 0,10 Ohms for a nominal voltage of 12 V,
- 0,20 Ohms for a nominal voltage of 24 V.

The audible warning device must have a support, which have a mass at least 10 times greater than that of the warning device to be tested and at least 30 kg. Moreover, the support must be arranged in such a way that the reflections off its walls and the vibrations have no significant effect on the results of the measurements while testing the device. Under the conditions set out above the A-weighted sound level must not exceed the following values:

a) 115 dB(A) for audible warning devices intended mainly for mopeds, motorcycles and tricycles developing a power of not more than 7kW;

b) 118 dB(A) for audible warning devices intended mainly for motorcycles and tricycles developing a power of more than 7kW.

Durability test has to be done on the device to check the number of cycles the device can withstand before having any problem. The device has to be supplied with nominal voltage at the conductor resistance as specified above. 50.000 times in the case of warning devices intended mainly for motorcycles

[18] Cf: 93/30/EEC Audible warning devices for two or three-wheel motor vehicles

and tricycles developing a power of more than 7kW respectively. Following conditions must be met during the test.

- The audible warning device must be exposed to a forced draught having a speed of roughly 10 m/s.

- Electro-pneumatic audible warning devices may be lubricated with the oil recommended by their manufacturer for every 10.000 operations

- When measured under the conditions specified above, the maximum sound level value of the audible warning under test must be at least: 93 dB(A) and at the most 112 dB(A) for motorcycles and tricycles developing a power of more than 7kW.

4.7 Council Directive 93/94/EEC Relating To the Space for Mounting the Rear Registration Plate of Two or Three-Wheel Vehicles [19](9)

The mounting for the rear registration plate of a motorcycle, motorcycle combination or tricycle and quadricycles plate can be positioned within the longitudinal planes passing through the outer extremities of the vehicle.

The rear registration plate must be at right angles to the median longitudinal plane of the vehicle. It may be inclined from the vertical by not more than 30°, when the backing plate for the registration number faces upwards and must not be inclined more than 15° to the Vertical.

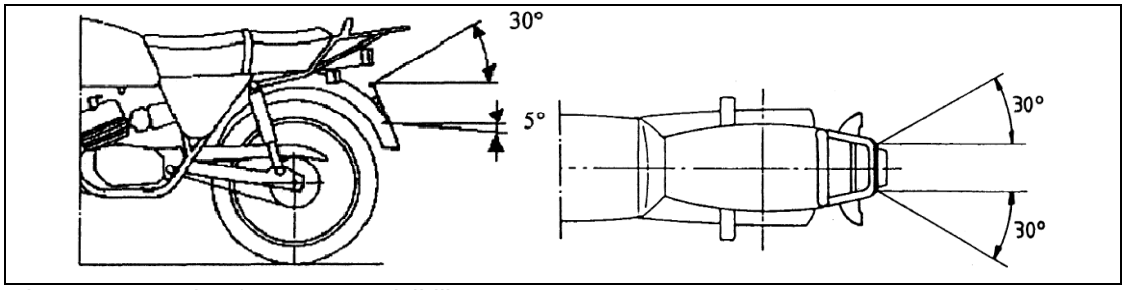


Figure 4-6: Angle of Geometry Visibility

[19] Cf: Directive **93/94/EEC Relating to the space for mounting the rear registration plate**

The space for mounting the plate must be visible with a horizontal edge defined by two planes passing through the upper and lower horizontal edges of the space for mounting the plate, the angles of which in relation to the median longitudinal plane of the vehicle are shown in Figure 4-6. The dimensions of the space for mounting the rear registration plate of two or three-wheel motor vehicles and quadricycles are show in the Table 4-6.

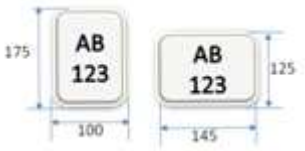
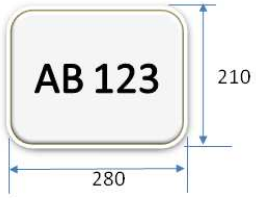
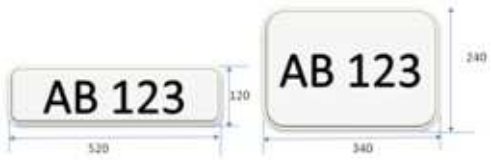
Vehicle Type	Width	Height	Representation
Mopeds and Light Quadricycles Without Body	100/145	175/125	
Motorcycles, Tricycles (Power <= 15KW) and Quadricycles Without Body	280	210	
Tricycles (Power > 15KW) , Light Quadricycles and Quadricycles With Body*	520/340*	120/240 *	
* The provisions for passenger cars as set out in Directive 70/222/EEC shall apply Note All the Dimensions are in mm			

Table 4-6: Dimension of the space for Registration Plate

Figure 4-7: Positioning of Rear Registration plate from the Ground

The height of the lower edge of the plate from the ground shall not be less than 0,30 meters and the height of the upper edge of the plate from the ground shall not be more than 1,20 meters. However, it is impossible in practice to comply with this latter provision, the height may exceed 1,20 meters but it must then be as close to that limit as the constructional characteristics of the vehicle allow and must in no case exceed 2 meters. The Figure 4-7 above shows the dimensions for positioning of the number plate.

4.8 Framework Directive 97/24/EC C8 Electromagnetic compatibility [20(10)]

Electromagnetic compatibility is the ability of a vehicle and its electrical/electronic modules to function satisfactorily in its electromagnetic environment without introducing unsustainable electromagnetic disturbances in that environment. A Separate Technical Unit (STU) consist of electronic or electrical components provided for installation in a vehicle, together with all electrical connections and associated wiring for the execution of several specific functions must not be disturbed by the electromagnetic compatibility. The marking on all the STU's must be marked with manufacturer name and the trade description. These marks must be legible and clear.

The component type approval as to be approved either for the complete installation of the vehicle, or via individual STU tests. This individual tests granting the STU's to install or fit the components on any vehicle.

The following requirement and measurement methods must be carried out by the each vehicle for type approval.

All the vehicles and STU's under normal conditions of the use must meet the conditions laid down in this framework and the immunity of the vehicle must be valid for next three years from the date of entry into force.

[20] Directive 97/24/EC - C8 Electromagnetic compatibility of two and three wheeled vehicles

Figure 4-8: Delphi Electromagnetic Compatibility Testing Facility at Luxemburg [21]

If measurements as per the method described in Annex II of this directive, in respect of a vehicle-antenna distance of 10,0 ± 0,2 m, the radiation reference limit will be 34 dB microvolt's/m (50 microvolt's/m) in the 30-75 MHz frequency band and 34 to 45 dB microvolt's/m (50 to180 microvolt's/m) in the 75 to 400 MHz frequency band. In the 400 to1.000 MHz frequency band the limit remains constant at 45 dB (180 microvolt's/m). The measured values in dB (microvolt's/m) must be at least 2,0 dB below the reference limit for the vehicle submitted for testing.

As per the measurements in Annex V of this directive, the radiation reference limit will be 64 to 54 dB (microvolt's/m) within the 30 to 75 MHz frequency band, this limit decreasing by the frequency logarithm, and 54 to 65 dB microvolt's/m) in the 75-400 MHz band, this limit increasing by the frequency logarithm, as shown in Appendix 5 to this Annex. In the 400 to 1.000 MHz frequency band the limit remains constant at 65 dB (1 800 microvolt's/m).

[21] Cf: http://delphi.com/manufacturers/testing-services/luxembourg-technical-center/electromagnetic-compatibility/ dated 22nd Nov 2010.

If measurements are as per Annex VI of this directive, the radiation reference limit will be 54 to 44 dB (microvolt's/m) in the 30 to 75 MHz frequency band, this limit decreasing by the frequency logarithm, and 44 to 55 dB (microvolt's/m) in the 75 to 400 MHz band, this limit increasing by the frequency logarithm, as shown in Appendix 6 to this Annex. In the 400-1 000 MHz frequency band the limit remains constant at 55 dB (560 microvolt's/m). According to Annex VII of this directive, the immunity test reference levels will be 48 volts/m for the 150 mm stripline testing method, 12 volts/m for the 800 mm stripline testing method, 60 volts/m for the TEM cell testing method, 48 mA for the Bulk Current Injection (BCI) testing method and 24 volts/m for the Free Field testing method. The test equipment and site by Delphi is shown in Figure 4-8.

The testing procedures and the antenna positioning is described for only two wheelers in this directive and which is applicable to three wheelers and quadricycles as well. For more details see the directive.

4.9 Framework Directive 97/24/EC C4 Rear View Mirrors 22**(11)**

The aim of rear view mirror is to guarantee a clear view of the rear of the vehicle to the driver. The general requirement of the rear view mirrors is that all the rear view mirrors shall be attached in such a way that they remain in a stable position under normal driving conditions.

There are two types of rear view mirrors, one is inside rear view mirror and the other is outside rear view mirror. These rear view mirrors are classified into two classes, Class I for the inside mirrors and Class L for the outside mirrors. This directive provides the information on number of rear view mirrors required by the different vehicle types.

[22] Cf: Frame work Directive 97/24/EC Rear View Mirrors

Vehicle Type Without Body	Inside Mirrors (Class I)	Main Outside Mirror (Class L)	Representation
Two Wheeler			
Two Wheeler Moped	0	1	 www.peugeot.com
Two Wheeler Motor Cycle	0	2	 www.peugeot.com
Three Wheeler			
Three Wheeler Tricycle	0	2	 www.peugeot.com
Vehicle Type With Body	**Inside Mirrors (Class I)**	**Main Outside Mirror (Class L)**	**Representation**
Four Wheeler Quadricycles	1	1	 http://wn.com/Light_Quadricycle
Four Wheeler Quadricycles	0	2	 Magna Steyr
Three Wheeler Mopeds (Tricycle)	1 0	1 2	 www.184sports.com
No inside rear-view mirror is required if the visibility conditions referred to in Item 4.1in this directive cannot be met. In this case two outside rear-view mirrors are required, one on the left and one on the right hand side of the vehicle.			

Table 4-7: Minimum Number of Mirrors for Vehicles with and without Bodies.

The rear-view mirrors for un-bodied vehicles must be fitted in such a way that the centre of the reflecting surface is at least 280 mm towards the outside of the median longitudinal plane of the vehicle. Before the measurement the handlebars must remain in the position corresponding to the vehicle's

travelling in a straight line and the mirrors must be set in normal position of view. Under all normal conditions driver must have the clear rear view of the road. Exterior rear view mirrors must be visible from the side window or the portion of the windscreen which is swept by the wiper. In the case of any vehicle which is in chassis/cab form when the field of vision is measured, the minimum and maximum body widths shall be stated by the manufacturer and, if necessary, simulated by dummy headboards. All vehicles and mirror configurations taken into consideration during the test shall be shown on the EC type-approval certificate for a vehicle with regard to the fitting of rear-view mirrors (See the Appendix 2 of the directive).The minimum number of rear view mirrors required by the vehicles with and without body is show in the Table 4-7.

As per the directive the "un-bodied vehicle" means a vehicle for which the passenger compartment is not bounded by at least four of all of the following features: windscreen, floor, roof and side and rear walls or doors. However, the bodied vehicle has to at least bind with above mentioned features. The representation of the pictures in Table 4-7 shows the different bodied and un-bodied vehicles.

The prescribed exterior rear-view mirror on the driver's side of the vehicle must be so located that an angle of not more than 55° is formed between the vertical longitudinal median plane of the vehicle and the vertical plane passing through the centre of the rear-view mirror and through the centre of the straight line 65 mm long which joins the driver's two ocular points. See Appendix III and Appendix IV for the field of vision of Class I and Class L mirrors.

The complete assembly of rear view mirrors fitted on the vehicle must undergo the behaviour impact test. The test device shall comprise a pendulum which is able to swing about 2 horizontal axes at right angles to each other and one of which is at right angles to the plane containing the release trajectory of the pendulum. The end of the pendulum shall comprise a hammer consisting of a rigid sphere having a diameter of 165 ± 1 mm, covered by 5 mm of rubber having a Shore A-hardness of 50. For detailed test procedure see the directive.

4.10 Framework Directive 97/24/EC C3 Amended by 2006/24/EC External Projections [23(12)]

The purpose of this directive is to safeguard all the external objects coming in contact with the vehicle in event of collision. All the outer parts of the vehicle must be according to directive in terms of shape, dimensions, direction of travel and hardness of the outer parts of the vehicle.

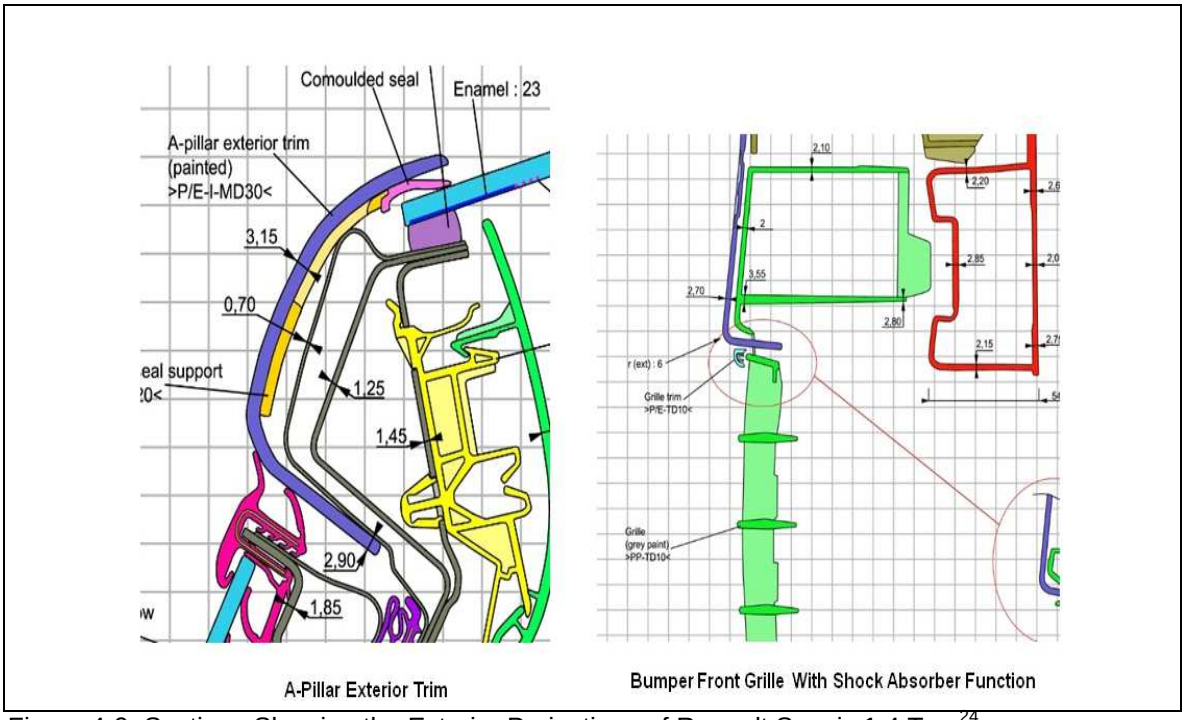


Figure 4-9: Sections Showing the Exterior Projections of Renault Scenic 1.4 Tce [24]

The Figure 4-9 shows the different radius and dimensions of the external projected surfaces and edges as per the directive requirements.

The general requirements of the directive are as follows:

- All external projections made of soft rubber or plastic having a hardness of less than 60 Shore A are considered to meet the requirements set out in this directive.

[23] Cf: Directive 97/24EC External Projections of Two and Three Wheeled motor Vehicles

[24] Cf: http://www.a2mac1.com/support/shareddocuments/download.asp?fid=28-10-2010_15-20-45.highlights_renault_grand_scenic_uk.pdf

- However, the following specifications shall not apply to the space between the side-car and motorcycle in motorcycle combinations.

- In case of mopeds, motorcycles with pedals are exceptional and external projections of the vehicle must be taken care of.

- In case of two wheeler vehicles mounted with external panels or structures

- The corners of a single plate shall have a radius of curvature of at least 3 mm and the edges of a single plate shall have a radius of curvature of at least 0,5 mm.

- Stems shall have a diameter at least 10 mm the edges on the end of a stem shall have a radius of curvature of at least 2 mm and shall not be longer than half of the diameter of the stem if that diameter is less than 20 mm. The radius of curvature of the edges at the end of a stem shall be at least 2 mm if the diameter of the stem is at least 20 mm.

The specific requirements of the directive are as follows:

- The windscreen edge shall have a radius of curvature of at least 2 mm or else be covered with an edge-protection material.

- The clutch and brake levers shall be perceptibly spherical and have a radius of curvature of at least 7 mm. The outer edges of these levers shall have a radius of curvature of not less than 2 mm.

- The leading edge of the front mudguard shall have a radius of curvature of at least 2 mm.

- The surface of the filler cap to the body surface has to be more than 15 mm.

- The ignition keys shall have protective cap. This requirement does not apply to folding keys or keys which are flush with the surface.

- All muskets radius of curvature shall not be less than 2.5 mm radius and shall not be projected more than 5mm from the adjacent surface.

- Ornamental motifs, trade symbols, trade-logo letters and digits projecting by more than 10 mm from the surrounding surface shall retract, fold back under a force of 10 daN exerted on their most projecting point

- Projecting peaks and surrounds shall be permitted on headlamps provided that they do not project by more than 30 mm from the outer transparent surface of the headlamp and that their radius of curvature is at no point less than 2.5 mm and this is also applicable to the pop-up headlamps.

- Grill components shall have radii of curvature of

  - at least 2.5 mm if the distance between consecutive components exceeds 40 mm
  - at least 1 mm if that distance lies between 25 mm and 40 mm
  - at least 0.5 mm if that distance is less than 25 mm.

- The above mentioned devices shall be mounted in such a way that the wiper-blade spindle is covered with a protector having a radius of curvature of at least 2.5 mm and a minimum area of 150 mm^2 measured in the form of a projection over a section which is at the most 6.5 mm from the most projecting point.

- Nozzles edges for windscreen wiper and headlamp must not be less than 2.5 mm and for those which are protruding less than 5 mm must have smooth edges.

- For the wings if fitted all the edges outside must have the radius of at least 5 mm.

- The edges of all the front protective devices must have the radius of at least 5mm.

- Accessories protruding out must have the radius of at least 2.5 mm.

- Push buttons shall not protrude by more than 30 mm; grab handles and bonnet-locking grips by more than 70 mm or any other cases by more than 50 mm. Their radius of curvature shall be at least 2, 5 mm.

- Side air and rain deflectors which are protruding outside must have the radius of curvature at least 1 mm.

- Sheet metal edges shall be permitted provided that they are covered with a protector having a radius of curvature of at least 2, 5 mm.

- Wheel nuts, hubcaps and protective devices must have the radius of at least 5mm and should not be protruded more than 30 mm.

- Jacking points and exhaust pipe(s), if any, shall not extend more than 10 mm beyond either the vertical projection of the floor line or the vertical projection of the intersection of the reference plane with the outer surface of the vehicle.

  All this requirements must be taken care during the design and development phase of vehicle.

4.11 Directive 97/24/EC C12 Glazing, Windscreen Wipers, Washers, De-Icers and De-Misters [25] (13)

This directive describes the design and testing requirements of the windscreen wipers, washers, deicers, demisters and glazing material, which are mandatory for a vehicle having a maximum design speed of more than 45 Km/h. The requirements of the vehicle are as defined here under:

- Transparent area of a windscreen means the part of the surface the light transmission factor of which, measured at right angles to the surface, is at least 70 %.

[25] Cf: 97/24/EC C12 Glazing, Windscreen Wipers, Washers, De-Icers And De-Misters

- It must also cover at least 90 % of field of vision A as defined in section 2.2 of Appendix 1 of this directive.

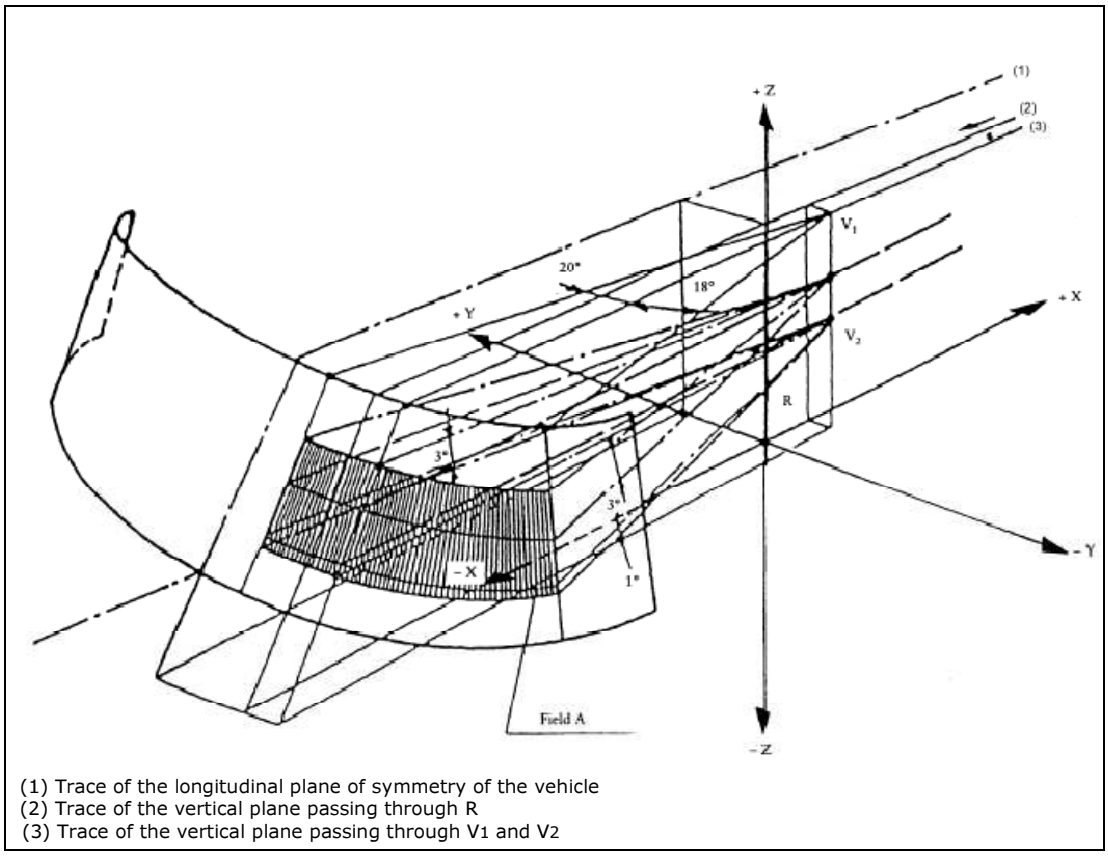
- The system must be capable of withstanding stalling for a continuous period of 15 seconds, with the windscreen wiper arms restrained in their vertical position and the windscreen-wiper control set at the maximum sweep frequency.

- The windscreen washer must be able to supply enough liquid to clear 60 % of the area defined in section 2.2 of Appendix 1 under the conditions described in 3.2.4. of this directive.

- The capacity of the liquid bottle must be at least one litre.

- All vehicles must be equipped with a windscreen de-icer and de-mister enabling any ice or frost covering the windscreen and any mist covering the inner surface of the windscreen to be removed. However, this device is not required for bodied three-wheel mopeds having an engine developing not more than 4 kW or for vehicles where the windscreen is fitted such that there is no any supporting or other structure or panel attached to the windscreen extending rearwards for more than 100 mm. The device is required for any vehicle having a roof that is either permanent or detachable or retractable.

The following test are required by the vehicle are windscreen washer test, test involving exposure to low temperatures, exposure to high temperatures, windscreen washer efficiency test. See the directive for more details of test requirements. Procedure to find the field of vision is defined in the Appendix 1 of the directive. The Figure 4-10 below shows the field of vision A.



(1) Trace of the longitudinal plane of symmetry of the vehicle
(2) Trace of the vertical plane passing through R
(3) Trace of the vertical plane passing through V1 and V2

Figure 4-10: Field of Vision A (see directive for more details)

4.12 Directive 97/24/EC C11 Amended by 2006/27/EC Safety-Belt Anchorages and Safety-Belts [26(14)]

Whenever safety belt anchorages are fitted, these must comply with the prescriptions in this directive. The general requirements of the seat belt anchorages and safety belts are:

- Safety belt anchorages must be fitted for all seats of three-wheeled mopeds, tricycles, light quadricycles and quadricycles

- Anchorage points suitable for three-point belts are required for all seats that meet the following two conditions:

[26] Cf: 97/24/EC C11 Amended by 2006/27/EC Safety-Belt Anchorages And Safety-Belts

- when the seat has a back or when a support helps to determine the back rest angle of the dummy and may be considered as a seatback, and

- When there is a lateral or transversal structural element behind the H point at a height of more than 450 mm measured from the vertical plane of the H point.

o For all other seats, anchorages suitable for lap belts are acceptable.

o Safety belt anchorages are not mandatory for three-wheeled mopeds or quadricycles having an unladen mass of not more than 250 kg.

o To reduce the risk of deterioration of the strap as a result of contact with the rigid sharp parts of the structure of the vehicle or seat;

o Under normal conditions of use, the vehicle must fulfil all the requirements of this directive.

o Where anchorages adopt different positions in order to enable persons to enter the vehicle and in order to retain the occupants, the specifications of this directive apply to anchorages in their effective retention position.

o Safety-belt anchorages are not required for bodied three-wheel mopeds or quadricycles having an unladen mass of not more than 250 kg. Where such vehicles are fitted with anchorages, however, those anchorages must meet the requirements of this directive.

The minimum numbers of belt anchorage points required are as follows:

Two lower and one upper anchorage must be provided for the front seats. However, two lower anchorages are considered sufficient for the front centre seats, if fitted, where there are other front seats and the windscreen is located outside the reference zone defined in Annex II to Directive 74/60/EEC. The windscreen is considered as forming part of the reference zone for the anchorages should the windscreen enter into static contact with.

Figure 4-11: Seat Belt attachment for NEV and Quadriclyle [27]

The device for testing in accordance with the method described in Annex II to directive 74/60/EEC on the interior fittings of motor vehicles. The Figure 4-11 shows the seat belt and buckle in the quadricycles

Dimensions of threaded holes for anchorages must be of the 7/16-20 UNF 2 B type in accordance with ISO Standard TR 1417. The position of the seats must be stated in the report. If its angle is adjustable the backrest must be locked in position in accordance with the manufacturer's instructions or, in their absence, in a position corresponding to an effective seat angle as close as possible to 15° and in the case of a quadricycle to 25°.

[27] Cf: Pictures of Tango and Tazzari Zero cars.

5 FMVSS Regulations in United States of America

FMVSS stands for Federal Motor Vehicle Safety Standards and it is applicable and mandatory to fulfil these regulation requirements to all the vehicles which are on road in United States of America. These standards are established by the agency called as National Highway Traffic Safety Administration (NHTSA), DOT.

E-Mila Student as is called as “Neighbourhood electric vehicle” (NEV) as per US regulations. “Neighbourhood electric vehicle" means any 4-wheeled electric vehicle whose. Some of these vehicles look more like a passenger car than a conventional golf car. As low-speed vehicles, these 20 to 25 mile-per-hour vehicles are subject to a new Federal Motor Vehicle Safety Standard No. 500 (49 CFR 571.500) established by this final rule. To avoid the accidents and to prevail the safety of occupants and pedestrians on the road by this low speed vehicles which are subjected to the limited speed of 25 miles per hour (40 kmph) and believes that the new standards is needed to address the crashes of the vehicle under high speeds . In contrast Sun City in Arizona allows the golf cars with top speed of 35 mph (56 Kmph). [28]

The purpose of FMVSS 500 is to ensure that low-speed vehicles operated on the public streets, roads, and highways are equipped with the minimum motor vehicle equipment appropriate for motor vehicle safety. The requirements of this standard are that low-speed vehicles to be equipped ten specific items of safety equipment and with speed limit as specified in above paragraphs and some general requirements are described below.

a) The maximum speed attainable in 1.6 km (1 mile) by each low-speed vehicle shall not be more than 40 kilometres per hour (25 miles per hour).
b) Must have 4 wheels in contact with the ground in normal operation.
c) Must have a gross vehicle weight rating (GVWR) of less than 1,361kilograms (3,000 pounds).
d) The vehicle must not more than 4 seating capacity.

[28] Cf: http://www.nhtsa.gov/cars/rules/rulings/lsv/lsv.html 27.09.2010

e) Each low-speed vehicle shall be equipped with:

(1) Headlamp

(2) Front and rear turn signal lamps,

(3) Tail lamps,

(4) Stop lamps,

(5) Reflex reflectors: one red on each side as far to the rear as practicable, and one red on the rear,

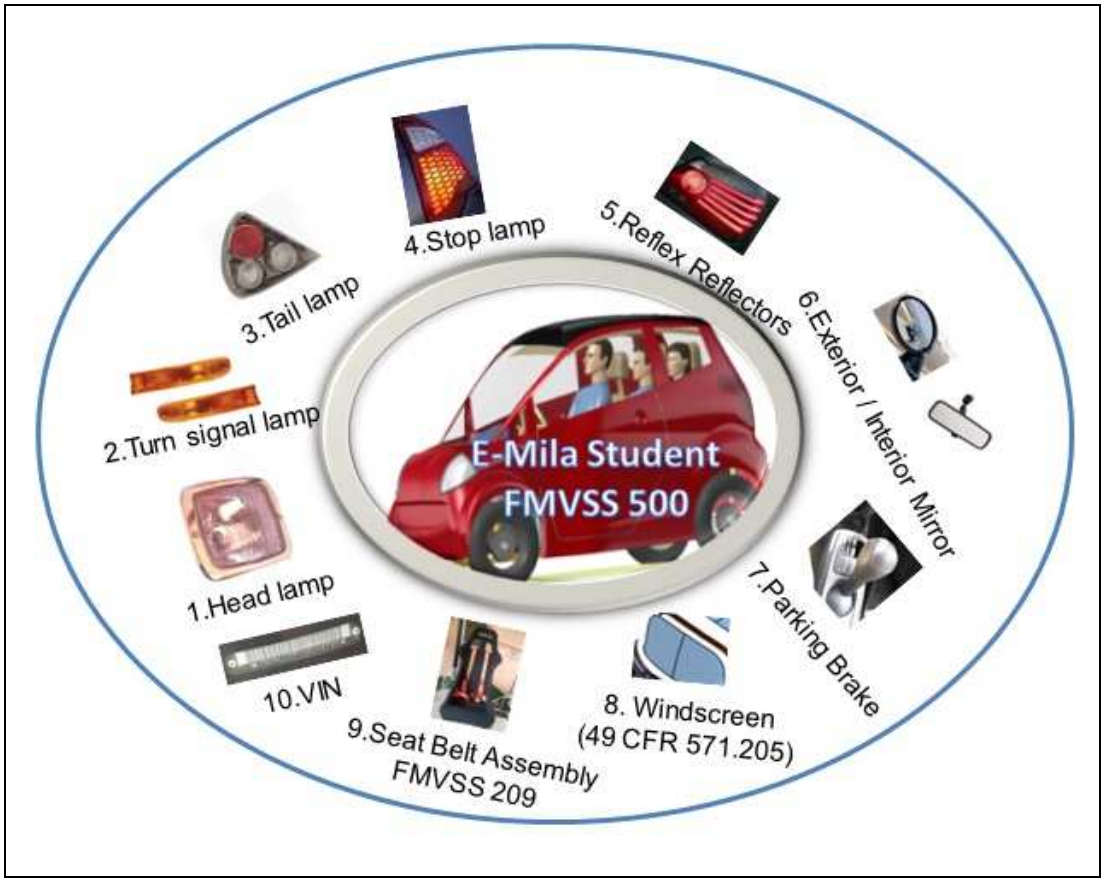


Figure 5-1: FMVSS 500 Necessary Safety Equipment

(6) An exterior mirror mounted on the driver's side of the vehicle and either an exterior mirror mounted on the passenger's side of the vehicle or an interior mirror,

(7) A parking brake,

(8) A windshield that conforms to the Federal motor vehicle safety standard on glazing materials (49 CFR 571.205)

(9) A VIN that conforms to the requirements of part 565 Vehicle Identification Number of FMVSS 115.

(10) A Type 1 or Type 2 seat belt assembly conforming to Sec. 571.209 of this part, Federal Motor Vehicle Safety Standard No. 209, Seat belt assemblies, installed at each designated

The GVWR is the value specified by the manufacturer as the loaded weight of a single vehicle. (15)[29] The agency believes that these requirements appropriately address the safety of low-speed vehicle occupants and other roadway users. (16)[30]

Apart from the safety equipment requirements of the vehicle, there is a special requirements related to the windshield glazing material and the seat belt assembly, which have to fulfil the requirements of FMVSS 205 and FMVSS 209 respectively are described in detail in the following chapters.

5.1 FMVSS 205 Glazing Material for Windshield

The purpose of this standard is to ensure the proper visibility to the driver through glazing material and to ensure the lower impact of occupant to the windshield in case of any collision. This standard describes about the general requirements for the glazing material for use in motor vehicles and motor vehicle equipment.

This standard is incorporated by the reference the ‘‘American National standard for safety glazing materials for glazing motor vehicles and motor vehicle equipment operating on land highways-safety standard’’. The Society of Automotive Engineers (SAE) Recommended Practice J673, revised April 1993, ‘‘Automotive Safety Glasses’’ (SAE J673) and ” The Society of Automotive Engineers (SAE) Recommended Practice J100”.

[29] Cf: Report on *LABORATORY TEST PROCEDURE FOR FMVSS 500.* Washington DC

[30] Cf: FMVSS 500 Low-speed vehicles, (49 CFR 571.500) US Department of Transport.

Windshields of low speed vehicles must meet the ANSI/SAE Z26.1–1996 specifications for either AS–1 or AS–4 glazing. Item 4A glazing may be used in all areas in which Item 4 safety glazing may be used, and also for side windows rearward of the ‘‘C’’ pillar. I.e., Item 4A glazing may be used under Item 4A paragraph (b) of ANSI/SAE Z26.1–1996 only in side windows rearward of the ‘‘C’’ pillar.(17) [31]

5.2 FMVSS 209 Seat Belt Assembly

Neighbourhood Electric Vehicle in US needs to have either a Type 1 or Type 2 seat belt assembly conforming to Sec.571.209 of Federal Motor Vehicle Safety Standard No. 209, Seat belt assemblies. This standard specifies the requirements of the seat belts. Whereas the terminologies are defined as

Type 1 seat belt assembly is a lap belt for pelvic restraint.

Type 2 seat belt assembly is a combination of pelvic and upper torso restraints.

Type 2a shoulder belt is an upper torso restraint for use only in conjunction with a lap belt as a Type 2 seat belt assembly.

Seat belt assembly means any strap, webbing, or similar device designed to secure a person in a motor vehicle in order to mitigate the results of any accident, including all necessary buckles and other fasteners, and all hardware designed for installing such seat belt assembly in a motor vehicle.

All the ends of the seat belt assembly shall be protected or treated to prevent ravelling and should not have sharp edges protruding out in contact with the occupant.

Each seat belt assembly must be permanently marked with year of manufacture, model, and name or trademark of manufacturer or distributor, or of importer if manufactured outside the United States. A model shall consist of a single combination of webbing having a specific type of fibre weave and construction, and hardware having a specific design.

[31] Cf: FMVSS 205 49 CFR Part 571.205Glazing Materials

Usage and maintenance written instructions are to be mentioned. Apart from this they should have proper performance and technical requirements to safeguard the occupant.[32]

The complete information about the FMVSS 500 can be found in the official document.

5.3 FMVSS 500 Effects on State and Local Law

The states in US and local laws are having liberty to amend or repose the existing norms of FMVSS 500 apart from the general and some specific requirements. The following points are addressed by NHTSA concerning the issue of FMVSS 500 related to state and local law.

(1) The final rule of FMVSS 500 does not alter the ability of states and local governments to decide for them whether to permit on-road use of golf cars and LSVs.

(2) The local governments may supplement Standard No. 500 in some respects. They can include the additional installation of safety equipment which is not in the standard. The local agency can decide that manufacturers need not comply with the performance of required standard equipment except it is mandatory for seat belts (standard no. 209, Seat Belt Assembly).

(3) FMVSS 500 is not applicable to the current golf cars having top speed between 20 and 25 mph. The retrofitting of golf cars with standard equipment that are already on the road remains in the domain of state and local law.

Installation of polycarbonate windshield is allowed in response to a request of the National Golf Car Manufacturers Association (NGCMA), the final rule permits a choice between either AS-5 polycarbonate glazing or AS-1 safety glass for LSV windshields.[28 above]

[32] Cf : http://www.fmcsa.dot.gov/rules-regulations/administration/fmcsr/fmcsrruletext.aspx?section=571.209 29.09.2010

5.3.1 Local Laws Requiring Safety Equipment on NEV's

The 12 states that have implemented the legislation permitting all-purpose on-road use NEVs believe that there is a need for safety requirements. Nine of those 12 states have mandated that those vehicles have specified safety equipment if they are used on-road and a tenth state authorized its local governments to adopt safety requirements. The table 5-1 below shows the states and their safety equipment requirement. The state officials in California, Arizona, and Iowa indicated that they believe that the issuance of federal safety requirements is warranted.

STATE	ROADS ON WHICH OPERATION IS PERMITTED	REQUIRED SAFETY EQUIPMENT
California	On private and public roadways designated by local government.	Local government may require safety devices. Headlamps, tail lamps, reflectors, stop lamps, and brakes for nighttimes operation
Nevada	On public roadways designated by local government.	Headlamps, tail lamps, reflectors, stop lamps, mirror, brakes and an emblem placard for slow moving vehicles.
Arizona	On roadways with posted speed limit of 35 mph or less.	Headlamps, tail lamps, reflectors, stop lamps, mirror, brakes, and a notice of operations and restrictions in full view of driver.
New Mexico	On private and public roadways designated by local government. Carts may not be operated on state highways.	An emblem placard or flashing yellow light for slow moving vehicles is required.
Colorado	On private and public roadways designated by local government.	Headlamps, tail lamps, reflectors, stop lamps, mirror, and brakes.
Wyoming	On public streets and roadways designated by local government.	Local government may require safety devices.
Illinois(1)	On roadways designated by local governments	Steering apparatus, rear view mirror, front and rear red reflectorized warning devices, slow moving vehicle emblem, headlight, brake

		lights and turn signals
Minnesota	On roads designated by local government.	Slow moving vehicle emblem and a rear view mirror.
Iowa	On private and public roadways designated by local government. Carts may not be operated on primary roads.	Slow moving vehicle emblem, bicycle safety flag, adequate brakes. Local government may require other safety equipment.
Florida	On private and public roadways designated by local government and in self-contained retirement communities.	Efficient brakes, reliable steering apparatus, safe tires, rear view mirror, and red reflectorized warning device in front and rear. Headlamps, tail lamps, and stop lamps for nighttime's operation.
Georgia	On private and public roadways designated by local government.	None
Texas	On private and public roadways designated by local government.	None

Table 5-1: States Safety equipment requirements

Some exceptional local laws are still there in US cities. For example the City of Palm Desert has the separate speed zones lines for the 25 mph vehicles where as Sun City, under state law, allows golf cars to operate in the same lanes as larger traffic on any road with a maximum speed of 35 miles per hour. NHTSA recognizes that and recommends the city of Palm Deserts separate path way system. The agency encourages other states and municipalities to study the features of the City of Palm Desert's plan, and to adopt those features to the extent practicable.

6 CMVSS 500 Regulations in Canada

CMVSS stands for Canada Motor Vehicle Safety Standards and Low speed vehicles and NEV's has to fulfil the regulation standard TSD 500 (Technical Standard Document 500). TSD 500 is the enhancement of the FMVSS 500. As per the Act, the Motor Vehicle Safety Regulations may alter or override some provisions contained in a TSD or specify additional requirements.

All the general requirements of the TSD 500 are similar to the FMVSS 500 with minor alteration in reference sections of Windshield, VIN and Seat Belt Assembly and all the references are pointed towards the Motor Vehicle Safety regulations of Canada.

Following are the General Requirements of the TDS 500

- When tested the maximum speed attainable in 1.6 km (1 mile) by each low-speed vehicle shall not be more than 40 kilometres per hour (25 miles per hour).

- Each low-speed vehicle shall be equipped with:

    a) Headlamps,

    b) Front and rear turn signal lamps,

    c) Tail lamps,

    d) Stop lamps,

    e) Reflex reflectors: one red on each side as far to the rear as practicable and one red on the rear,

    f) An exterior mirror mounted on the driver's side of the vehicle and either an exterior mirror mounted on the passenger's side of the vehicle or an interior mirror,

g) A parking brake,

h) A wind shield that conforms to section 205, Glazing Materials, of the Motor Vehicle Safety Regulations (MVSR) the Federal motor vehicle safety standard on glazing materials (49 CFR 571.205).

i) A VIN that conforms to the requirements of section 115, Vehicle Identification Number, of the MVSR part 565 Vehicle Identification Number of this chapter, and

j) A Type 1 or Type 2 seat belt assembly conforming to section 209, Seat Belt Assemblies, of the Motor Vehicle Safety Regulations Sec. 571.209 of this part, Federal Motor Vehicle Safety Standard No. 209, Seat belt assemblies, installed at each designated seating position. (18)[33]

[33] Cf: Technical Standard Document No. 500, Transport Canada

7 "Kei – Jidousya" Regulations in Japan (K – Cars)

Kei Jidousaya (Japanese for light motor vehicle), Kei cars are the small cars or mini cars in Japan, which have the government subsidies for the road tax and the insurance. The ultra mini car was introduced in Japan during 1940's to answer the economic need under the Japanese law and standards. Currently the Kei Jidousya cars are having the huge demand in the Japanese market and almost all the car manufacturers in Japan are producing these cars.

Figure 7-1: Various Kei cars in Japan

As per the NPRM information the limits length, width and engine displacement of Kei cars have been steadily eased over the last 20 years. Limit on engine displacement has increased from less than 360 cc prior to 1976, to less than 550 cc in 1976, to less than 660 cc in 1990. Length limits have increased slightly, from approximately 3.2 m in 1976, to 3.3 m in 1990 to 3.4 m in October 1998. Width limits have slightly increased from less than 1.4 in 1976 to less than 1.48 in October 1998. So, the overall dimensions, displacement and power of the Kei cars currently is restricted to Length 3400 mm, maximum width to 1480 mm, maximum height is less than 2000mm, displacement of the engine is 660 cc and maximum power to 60 HP.[34]

[34] Cf: http://www.zenkeijikyo.or.jp/statistics/4kakuho-e.html accessed on 29.11.2010

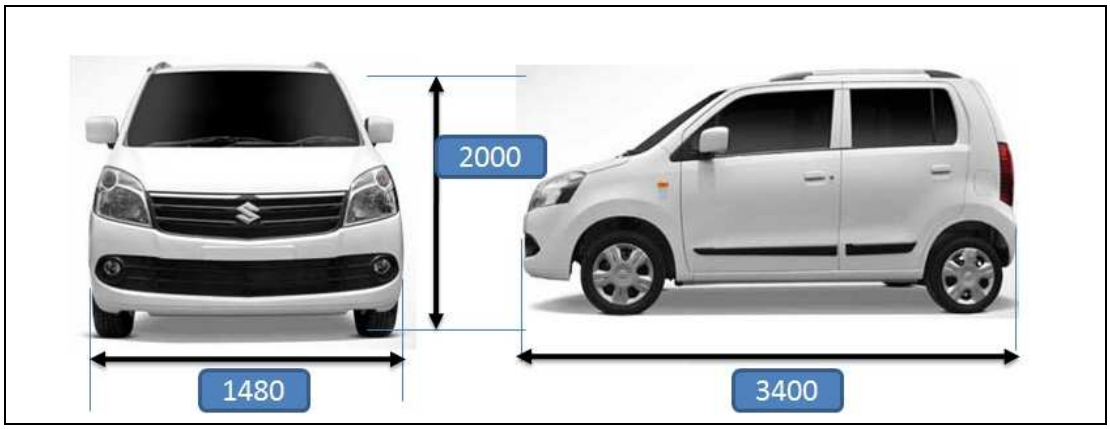


Figure 7-2: Maximum Overall Dimensions for Kei Cars

The test speed for the frontal crash protection requirements will become the same (50 km/hr) for Kei cars and passenger cars in October 2010. [35] The following safety exceptions are given for mini cars compared to other category calls.

a) The over speed alarm is to activate at 80 km/h. (100 km/h for small-size vehicles)
b) The belt anchor strength is to be 80% of that for small-size vehicles.
c) The door latch strength is to be 80% of that for small-size vehicles.
d) The fuel leak test speed is to be 40 km/h. (50 km/h for small-size vehicles) [36] (19)

The urban area parking houses made some entry restrictions for the vehicles which are the deciding factors for the overall dimensions of the vehicle.

Japanese Urban Parking Place Requirements				
Remark	Old Common Type	New Type	Limited Luxury Type	Limited SUV Type
	Type 1	**Type 2**	**Type 3**	**Type 4**
Height (mm)	1550	1550	1550	2000
Width (mm)	1800	1850	1950	1950
Length mm)	4850	5000	5250	5250
Weight (Kg)	1700	1700	2000	2000

Table 7-1: Japanese Urban Parking Place Requirements

[35] Cf: http://www.nhtsa.gov/cars/rules/rulings/lsv/lsv.html accessed on 29.11. 2010

[36] Cf: Japanese and Their Minicars (Kei Jidoushya) Technical Characteristics SAE paper 830942

8 Homologation of E – Mila Student

The present thesis describes the common platform with regard to regulation and standardization activities both at the European and international level and set out a strategy to eliminate the identified obstacles in a manner to fulfil the legal requirements of the local authorities and to fulfil the base requirements of the stakeholders. The present thesis covers regulations and standards needed for pure electric propelled vehicles under L7e categories of UNEEC and UNECE regulatory act. The focus is also on the FMVSS, CMVSS and Kei Jidousaya for the vehicle marketing in the respective regions of US, Canada and Japan.

The manufacturing of any new vehicle is based on the marketing survey and as per the customer specific requirements and followed by the homologation of the vehicle in different stages of the project and is well defined in the product development process of the organization (for different stages of the homologation see Figure 1-4 and Figure 2-6). The homologation of the vehicles is required to complete, adapt and simplify the Internal Market regulatory framework within the European states and to promote the global technical harmonization of the vehicle to strengthen the export market worldwide.

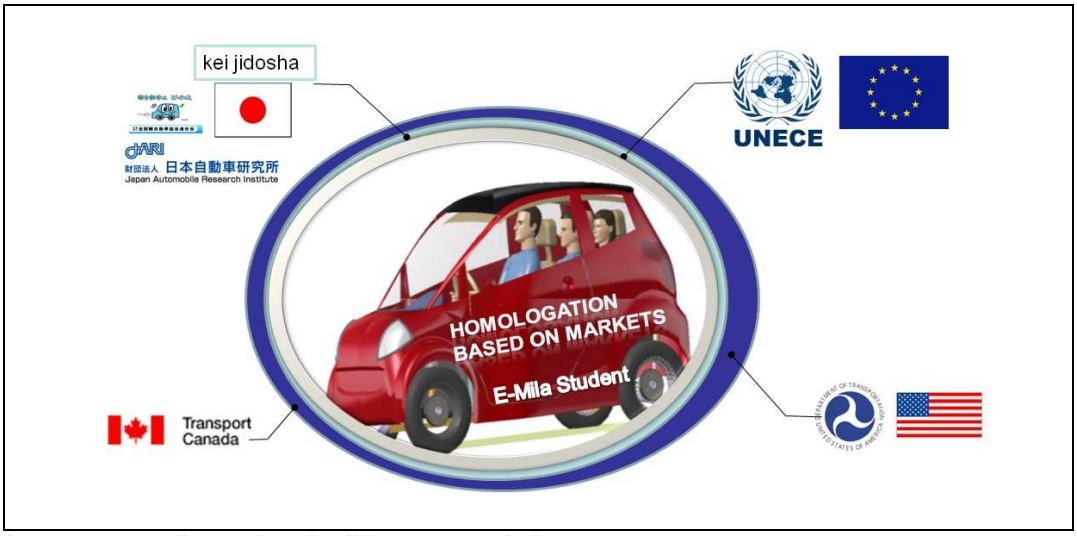


Figure 8-1: E-Mila Student in different Regulation Zones

Well before the concept phase, design and development phase it is necessary to check for the feasibility of the product in terms of cost, market, functionality and legal requirements to sell the product in market. Any modifications in the advanced phases of the product development lead to cost addition of the overall product. The engineering cost alone is subjected to 60 percent of the overall product cost. So, it is very essential to check for the homologation feasibility immediately after marketing survey as a part of feasibility check, in order to achieve the proper concept and design development of the product.

8.1 UN EEC/ECE Regulations List for E-Mila Student

Under European legislative regulations, E-Mila Student comes under Quadricycles, L7e category. The focus of this chapter is on general guidance and provides details of legislative regulations in Europe for the quadricycles. The general guidelines pay attention on brakes, tires, steering, speedometer, lighting and noise.

European Whole Vehicle Type Approval (ECWVTA) is a system for technical requirements assessment is applicable to this vehicle (See chapter 4 Vehicle Homologation in Europe). In accordance with the procedures given in a framework directive 92/61/EEC, recently repealed and replaced by 2002/24/EC (as amended). As this directive is valid for all the powered quadricycles, the Table 8-1 list shows only abstract for electric vehicles and is suitable for E-Mila Student.

Abstract of Directive 2002/24/EC for E-Mila Student				
Subject	**Term (1)**	**Directive No. EEC**	**Amendment**	**R ECE**
category of vehicle	CONF	2002/24/EC		
Maximum torque and maximum net power of engine	SD	95/1/EC (2)	2006/27/EC	
Anti-tampering measures for mopeds and motorcycles	SD	97/24/EC C7 (3)		
Maximum design speed of the vehicle	SD	95/1/EC	2006/27/EC	

Masses and dimension	SD	93/93/EEC		
Coupling devices and their Attachment	SD	97/24/EC C10		
Tires	SD	97/24/EC C1		
Braking system	SD	93/14/EEC	2006/21/ EC	78
Installation of lighting and light-signalling devices on the vehicle	SD	93/92/EEC		48,53, ,74 ,50 ,38 ,20 , 19
Lighting and light-signalling devices on the vehicle the mandatory or optional presence	SD	97/24/EC C2	2009/67/ EC	
Audible warning device	SD	93/30/EEC		28
Position for the mounting of rear registration plate	SD	93/94/EEC	2009/62/ EC	
Electromagnetic compatibility	SD	97/24/EC C8		10
Rear-view mirror(s)	SD	97/24/EC C4		81
External projections	SD	97/24/EC C3		
Stand (except in case of vehicles having three or more wheels)	SD	93/31/EEC		
Devices to prevent unauthorized use of the vehicle	SD	93/33/EEC	99/23/EC	62
Windows; windscreen wipers; windscreen washers; devices for de-icing and de-misting for three-wheel mopeds, motor tricycles and quadricycles with	SD	97/24/EC C12		
Anchorage points for safety belts and safety belts for three wheel mopeds, motor tricycles and quadricycles with bodywork	SD	97/24/EC C11		
Speedometer	SD	92/61/EEC	2000/7/E C	39
Identification of controls, telltales and indicators	SD	93/29/EEC	2009/80/ EC	60
Statutory inscriptions (content, location and method of affixing)	SD	93/34/EEC	2009/139/ EC	
(1) CONF if their conformity with the manufacturer's data has to be checked or by 'SD' if their conformity with requirements laid down in Community legislation has to be checked				
(2) 15 KW Max. Power for E-Mila Student				
(3) Mentioned only for IC Engines. No clear picture yet for EV's				

Table 8-1: Abstract of Directive 2002/24/EC for E-Mila Student

The cells with red text indicates that there is no information for the electric vehicles testing measures but still need to consider them for any future amendments in the relevant directive which can be applicable to the electric vehicle. The above list consisting of only directives which are completely applicable to the electric vehicles (see Table 4-2: List of *Requirements For The Purpose of Vehicle Type Approval*") for the complete list of directives for ECWVTA. For E-Mila Student all the directives of 2002/24/EC can be used as alternative to the UNECE Regulations for certification. The remaining directives which full fill the requirements for ECWVTA can be used by the individual states for the certification of the vehicle. The common list of EEC directives and ECE regulations are shown in the following table.

Subject	Directive	Amendment	Regulation	Y/N
Braking Device	93/14/EC	2006/27/EC	R78	Yes
Tires	97/24/EC C1	-	R75	Yes
Audible warning device	93/30/EEC	-	R28	Yes
Radio suppression / Electromagnetic compatibility	97/24/EC C8	-	R10	Yes
Rear View Mirrors	97/24/EC C4	-	R81	Yes
Positioning lamps	97/24/EC C2	2009/67/EC	R53	Yes
Headlamps motorcycle	97/24/EC C2	2009/67/EC	R57	Yes(R113 also)
Rear fog lamp	97/24/EC C2	2009/67/EC	R38	Yes
Front fog lamp	97/24/EC C2	2009/67/EC	R19	Yes
Daytime running lamps	97/24/EC C2	2009/67/EC	R87	Yes
Retro reflecting devices	97/24/EC C2	2009/67/EC	R3	Yes
Registration plate: Illumination	97/24/EC C2	2009/67/EC	R2	Yes
Controls, telltales	93/29/EEC	2009/80/EC	R60	Yes
Speedometers	92/61/EEC	2000/7/EC	R39	Yes

Table 8-2: List of Directives as Alternatives to Regulations.

The above mentioned list consisting of relevant directives and regulations for E-Mila Student except the fog lamps are optional for the Japanese market,

which is need to be confirmed after consulting the local authorities in Japan for authentication. The other regulations which cannot be used as alternatives to directive in L category vehicles is regulation R88 for the reflective tires, which is no more valid for E-Mila Student as now a day's radial tires are normally used. See the Appendix VI for the entire list of Regulations which cannot be used as alternatives to the directives

8.2 Feasibility check based on Marketing Survey

The feasibility check is necessary before starting any further steps in the project to decide on go/no-go for the next level or phase of the project. Which is not only avoids the rework but also saves the cost and improves the quality of the product. The initial marketing survey results has been provided by Mr. Preiss Michael (see the master thesis "*Market Study for an Electric City Car E-Mila Student*") and fallowed by Mr. Wechselberger Lukas (see the master thesis *"Concept for the development of an urban electric vehicle"*) to add further missing figures and to meet the target customer requirements. This is where the initial entry into product development process has started.

Specifications	Market Survey by Preiss	Market Survey by Wechselberger	Europe UNECE/EEC	US/ CANADA	Japan (1)	E-Mila Student
Vehicle Category/Standards						
Vehicle Class	L7e/FMVSS / Kei Cars	L7e/FMVSS / Kei Cars	L7e /L5e	FMVSS 500/TSD 500	Kei - Jidousaya	L7e
Maximum Overall Dimensions (mm)						
Height	1600-2000	1560	2500	-	2000	1545
Length	3000	2550	4000	-	3400	2550
Width	max 1480	1475	2000	1828*	1480	1475
Wheel Track Front	No info	1238	-	-	-	1300
Wheel Track Rear	No info	TBD	-	-	-	1300
Wheelbase	TBD	TBD	-	-	-	1850
Vehicle Weight(Kg)						
Unladen Mass (Without	400	400	400	-	-	400

battery)						
Battery weight	~250	250	-	-	-	150
Curb weight	~650	650	-	-	-	650
Gross Vehicle weight	950	950	1000	1361	-	950
Seats	3-4	3	Seat belts(3)	Seat Belts	Seat Belts	3
Powertrain						
Power (KW)	15	15	15	-	44(2)	15
top Speed km/h	80	85	-	40	-	85
Battery						
Battery type	LION or LMP	LION or LMP	-	-	-	LION
* SAE Standard J2258 Recommendations						
(1) Need to clarify with local authorities for details						
(2) 60 hp in Japan						
(3) With 3 anchorage points						

Table 8-3 : E-Mila Student Feasibility Check With Marketing Survey Results

Some of the key figures from Mr. Preiss were given in the range of existing vehicles in the market, where has Mr. Wechselberger provided the figures for E-Mila Student. After cross checking with the homologation regulatory requirements, it has been decided to fix some initial dimensions, weight, some other technical and general specifications based on the regulatory requirements of all four regions for this project. Table 8-3 above shows the feasibility check. Freezing of dimensions for E-Mila Student is discussed in the packaging chapters. The above table shows only the required figures for the homologation from marketing survey. See Appendix V for more information.

8.3 Common Regulation Base for E-Mila Student

As E-Mila Student is based on the four different regions it is very important to construct the vehicle on common regulations base to avoid any additional cost. Though some of the components and technical requirements are not necessary in one particular region, but which are mandatory by other regional

laws need to be included in the vehicle to overcome the additional process and efforts for the later inclusion. The following table shows the different regional requirements for the same category vehicle.

Requirements	Europe	US	Canada	Japan [1]	Remarks
Vehicle Category/Standards					
Category	Quadricycle	NEV	NEV	Mini Car (Kei Car)	
Standard	L7e	FMVSS 500	TSD 500	Kei Jidousya	
Maximum Overall Dimensions (mm)					
Width	2000	1828 * [2]	X	1480	* SAE Standard J2258 Recommendations
Length	4000	X	X	3400	
Height	2500	X	X	2000	
Masses of the Vehicle					
Unladen Mass (Without battery)	400	-	-	-	-
Curb weight	650	-	-	-	-
Gross Vehicle weight	1000	1361	1361	-	3000 pounds in US
Powertrain					
Power(KW)	15	-	-	44	60 Hp in Japan
Max. Speed (Kmph)	-	40	40	-	20-25 mph in US 35 in Arizona
Safety Requirements					
Frontal Crash	X	X	X	@50 Kmph	
Side Crash	X	X	X	-	Weight Restriction of 400 kgs in Europe is a concern
Seat Belts	√	√	√	√	Attention required for common platform
Parking Brake	X	√	√	√	Parking Brake is not compulsoryy for Qudricycles
General					
Horn	√	–	–	√	
VIN	√	√	√	√	

External Projections	√	-	-	√	
Lamps					
Head Lamps	√	√	√	√	
Turn Signal Lamps	√	√	√	√	
Tai Lamps	√	√	√	√	
Stop Lamps	√	√	√	√	
Reflectors	√	√	√	√	
Fog Lamp	X	X	X	√	
Windscreen					
Wind screen	√	√	√	√	
Glazing	√	√	√	√	
Defog/Demist	√	–	–	√	
Wiper	√	–	–	√	
Washer	√	–	–	√	
Mirror					
Rear View Mirror	√	√	√	√	See individual regulation for details
[(1)] Need to contact Local Authorized for more information					

Table 8-4: Legal Regulatory Requirements in Different Regions

Additional care must be taken in case of Japanese vehicle as the existing Kei cars are having the dominating position in terms of safety, comfort and additional features compare to the L7e category and need to approach the local authorities for more details to build the vehicle.

8.4 Testing List for E-Mila Student

All tests must be conducted in accordance with the UNEEC, ECWVTA directive 2002/24/EC, and the test procedure must follow the instructions given under the directive. The corresponding directive and the respective directives described in it states certain procedures to conduct this test and are described here under the list of test applicable to the E-Mila Student project. The list is further subdivided into Active Safety, Passive Safety, Visibility, Environment and General types according to the nature of the test.

S.No	Subject	Test Y/N	Directive No. EEC	Type of Test	R-ECE
	Active Safety				
1	Braking Device	Y	93/14/EC amend 2006/27		78
2	Tires	Y	97/24/EC C1		75,88
3	Wheel guards	NA			
4	Audible warning device	Y	93/30/EEC (1)		28
4.a				Sound Level Measurement	
4.b				Durability Test	
5	Electric power connection	NA			
6	Radio suppression / Electromagnetic compatibility	Y	97/24/EC C8 (2)		10
6.a		Y	(3)	Wide-Band EMR	
6.b		Y		Narrow-Band EMR	
6.c		Y		Vehicle Immunity to EMR	
6.d		Y	(4)	STU Immunity to EMR	
7	Steering/handle bar	NA			
8	Trailer coupling device	N	97/24/EC C10		
		N		Endurance Test	
	Visibility				
9	Rear View Mirrors	Y	97/24/EC C4 (5)		81
9.a			(6)	Impact-behaviour test	
9.b				Bending test on the protective housing attached to the stem	
9.c				Reflective Test	

10	Glazing/Windows ; wipers; washers; de-icing and de-misting	Y	97/24/EC C12		
10.a				Windscreen Wiper	
10.b				washer	
11	Lighting installation	Y	97/24/EC C2 Amend **2009/67/EC**		48,53,74,50 , 38,20,19
11.a				Stability of photometric performance of headlamps	
11.b				Change in vertical position of the cut-off line under heat	
11.c			(7)	List of test on head lamp	
	Controls				
12	controls, telltales and indicators	Y	93/29/EEC Amend(8) 2009/80/EC		R60
13	Speedometer	Y	92/61/EEC Amend **2000/7/EC**		R39
14	Anti-tampering	N	97/24/EC C7		
15	Anti-theft	Y	93/33/EEC Amend **99/23/EC**		R62
				WEAR TEST ON TYPE 3 PROTECTIV E DEVICES	
	Passive Safety				
16	Passenger hand holds	N	93/32/EEC Amend **2009/79/EC (9)**		
17	Components and characteristics	N	97/24/EC Amend **2009/108/E**		

			C		
18	Safety belts and anchorages	Y	97/24/EC C11		
18.a		Y	(10)	Anchorage restraint Test	
18.b		Y	(11)	Test in three-point belt	
18.c		Y		Test in lap-belt configuration	
	Environment				
19	Air pollution	NA	97/24/EC C5		
20	Noise 3-wheelers	NA			R9
21	Motorcycle noise	NA	97/24/EC C5		
	General				
22	Type Approval	Y	2002/24/EC		
23	External Projections	Y	97/24/EC C3 (12)		
24	Body inscriptions, marking	Y	93/34/EEC Amend **2009/139/EC**		
25	Masses and dimensions	Y	93/93/EEC Amend **2004/86/EC (13)**		
26	Maximum speed, engine power	Y/N	95/1/EC Amend **2006/27/EC**		
26.a		Y		Max. Design speed	
26.b		N	(14)	Max. Torque and Max. Net Power	
27	Rear registration plate		93/94/EEC Amend **2009/62/EC (15)**		
(1)Refer directive for marking and fitting.					
(2)Antenna position instruction given for testing is for motor cycle only					
(3) For electric traction motors, heating system/demister					
(4) 150 mm strip line test: 800 mm strip line test: Bulk current injection TEM-cell test: field STU immunity test:					

[5] Exception for mirrors above 2m from ground					
[6] Pendulum diameter 165 ± 1 mm, covered by 5 mm of rubber having a Shore A-hardness of 50.					
[7] Resistance to temperature changes, Photometric measurements, Resistance to atmospheric agents, Resistance to chemical agents, Resistance to detergents and hydrocarbons, Resistance to mechanical deterioration					
[8] Only Identification Test					
[9] Mentioned only for two wheelers. Need to check for Quadricyles/tricycles					
(10) The tractive force must be applied forwards at an angle of 10°± 5° above the horizontal in a plane parallel to the median longitudinal plane of the vehicle.					
(11)Tractive force of 675 daN ± 20 daN					
(12)Extend of projection is determined by the sketch.					
(13) Permissible L 4m, W 2m, H 2.5m 400 kg - quadricycles, Payload passenger vehicle 200kg , Payload goods vehicle 1000 kg					
(14) Test mentioned only for SI and CI engines. But max power is 15 KW for L7e Vehicles No clear picture for EV's					
(15) Test mentioned only for SI and CI engines. But max power is 15 KW for L7e Vehicles No clear picture for EV's					
	Item Category		No Regulation found		No info for EV's
Text in Red	Not applicable to E Mila Student				

Table 8-5: Test Applicability List For E-Mila Student

The meaning of color coding used in the table is explained in the bottom of the table. The text in red color indicates that the current directives are not completely applicable to the E-Mila Student but either a part of it can be used or may get amend in future considering the importance of it. The authority certification process is simple for this category of vehicles, as the individual component certification can be achieved from the part supplier directly and the entire set of certificates can be used for ECWVTA process.

9 Packaging

9.1 Packaging Concept:

Designing a vehicle involves the large number of consideration to make it into the feasible product. One such consideration is to do the packaging of the vehicle and to fulfil the requirement of the occupant safety and comfort as well as the legal requirement of the regional authorities.

The process for packing as well starts from the researching the intended markets (see the diploma thesis *"Market Study for an Electric City Car "* by D.I. (FH) Michael Karl Preiss), competitors and the customers. Homologation and packaging are interlinked in cases of some regulatory requirements and independent in case of ergonomic requirements. For example overall dimensions, Field of Vision, Location of Rear View mirror, Seat belt anchorage point in case of L category and addition to this it is steering wheel ECE R35 pedal controls, restraint design and collision performance which are also depend on H-point are interlinked to M1 category. H-point is decided by the design department based on which the above discussed topics can be derived. SAE standards which are used in the packaging are only dimensional standards used for studying and construction of the CAD models and also use the H-point manikin for the measurement of seats and interiors.

The primary goals are set for the project phase taking into the consideration of target markets and manufacturing process based on marketing survey. After the initial homologation cross checking the later stage is making the decision on the major components and the features to be involved in it. Benchmarking is required to establish the basic properties of the project (see the diploma thesis *"Concept for the development of an urban electric vehicle"* by Lukas Wechselberger for more details). The freezing of the packing concept is required to carry out the further development process in product development (see Figure 1-4). The Figure 9-1 shows the Packing concept process.

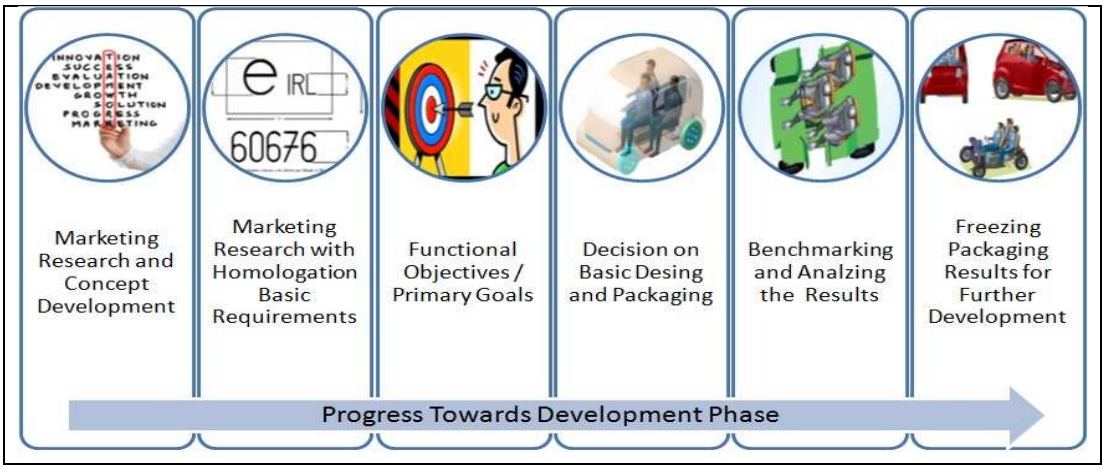


Figure 9-1: Packaging Concept Process

Every vehicle packaging starts with the occupant's position and is based on the overall dimensions of the vehicle. The seating has to follow as per the occupant positioning H/R point and further interior space, boot space, powertrain, wheels and tires, suspension and body packaging can be decided based on it. The driver positioning can be determined by using the 95 percentile 2D manikin by establishing the heel height from the ground and the seating position. Before positioning the manikin it is important to consider the ground clearance, under body structure, overall dimensions and road visibility for the different manikins. After establishing the driver position, the next step is to position the rear seat occupants. Based on this occupant positions the chassis packaging and boot space can be decided. The rough sketches developed by the packaging can be given to the designer for the styling of the vehicles and is the technical surface input for the designer. The overall packing can be taken as input for further phase of development.

The focus in this packaging study is the packaging of vehicle interiors and occupant accessibility and to find the proper seating position using the Catia V5 R19 for the feasibility study. The overall dimensions, which are derived from the marketing survey has been taken for the packaging. These dimensions have been verified by comparing with homologation standard directive 93/93/EEC for masses and dimension of the vehicle. SAE J1100 has been referred for the scope of interior dimensions and measurements.

Before starting the any engineering investigations for the vehicle construction it is very important to consider the occupant positioning and to derive the H-point of the manikin. This can be achieved by placing the occupant 2D

manikin template for all initial investigations as per the SAE standards. The following chapters explain about the SAE recommended standards for the packaging of different vehicle segments.

9.2 SAE Motor Vehicle Standards [37] (20)

This SAE Recommended Practice defines a set of measurements and standard procedures for motor vehicle dimensions. The dimensions are primarily intended to measure the design intent of a vehicle within a design environment (i.e., CAD). All dimensions in this practice can be measured this way. SAE publishes different standards starting from the overall motor vehicle dimensions and procedures about the defining the measurements to the occupant positioning and also defines about the reach, vision, head etc. The following table shows the different SAE publications used of the vehicle architecture development. The similar kinds of publications are issued by the ISO, which are not discussed and considered in this scope of work.

Description	Standard No.
Motor Vehicle Dimensions	SAE J1100
Driver and Passenger Head Position	SAE J1052
Motor Vehicle Fiducial Marks and Three-Dimensional Reference System	SAE J182
Driver Hand Control Reach	SAE J287
Devices for Use in Defining and Measuring Vehicle Seating Accommodation	SAE J826
Motor Vehicle Driver's Eye Locations	SAE J941
Motor Vehicle Driver and Passenger Head Position	SAE J1052
Accommodation Tool Reference Point	SAE J1516
Driver Selected Seat Position	SAE J1517
Motor Vehicle Seat Dimensions	SAE J2732
H-Point Machine (HPM-II) Specifications and Procedure for H-Point Determination—Auditing Vehicle Seats	SAE J4002
H-Point Machine (HPM-II)—Procedure for H-Point Determination—Benchmarking Vehicle Seats	SAE J4003
Positioning the H-Point Design Tool—Seating Reference Point and Seat Track Length	SAE J4004
Describing and Measuring the Driver's Field of View	SAE J1050

Table 9-1: SAE Publications for Motor Vehicles

[37] Cf: SAE International Surface Vehicle Recommended Practice SAE J1100 Nov 2009.

It is intended that the dimensions and procedures described in this practice be generic in their application to both the HPM, described in SAE J826, and the HPM-II, described in SAE J4002. In some circumstances, the figures may only reflect one or the other.

The construction of the vehicle is based on the coordinate system defined in the SAE J182, except ground-related dimensions, which are defined normal to ground. All dimensions are taken with the vehicle at curb weight unless otherwise specified. All dimensions are measured on the base vehicle and do not include Regular Production Options (RPO) or accessory parts, unless otherwise specified.

As per the SAE standard definition E-Mila Student falls under the category of passenger cars, with 3 seat capacity, Class A Vehicles as defined in the Table 9-2. The classification is based on a set of four dimensions for the driver's seated position (H30, A19, W9 and A40). Seat height (H30) is the primary differentiator between the classes. This classification is used to determine the appropriate procedure in other SAE practices (SAE J287, SAE J1516, SAE J1517, SAE J941, etc.).

CLASS A VEHICLES		
Dimension	Code	Range
Seat Height	H30-1	127 to 405 mm
Track Rise Angle	A19-1	> 0 degrees
Steering Wheel Diameter	W9	less than 440 mm
Torso Angle	A40-1	15 to 40 degrees
CLASS B VEHICLES		
Dimension	Code	Range
Seat Height	H30-1	405 to 530 mm
Track Rise Angle	A19-1	= 0 degrees
Steering Wheel Diameter	W9	440 to 560 mm
Torso Angle	A40-1	8 to 18 degrees

Table 9-2: SAE Vehicle Classification

The two main SAE definitions related to the weight of the vehicle are Curb Weight and Gross Vehicle Mass (GVM) or Gross Vehicle Weight Rating (GVWR) is defined as follows.

Curb weight is the weight of the base vehicle (standard equipment only), with all fluids filled to maximum (fuel, oil, transmission, coolant, etc.). For heavy trucks, the curb weight does not include engine fuel.

GVWR is the worst intended loading condition. GVWR is the value specified by the vehicle manufacturer as the maximum loaded weight of a single vehicle. All the measurements must fallow the SI standards and the weight has to be mentioned in kg.

9.3 Dimensional Procedure and Related Codes of SAE Standards [(20)]

Every dimension is assigned with a code, which consists of an alpha numerical number as illustrated in Table 9-2. The letters denote the direction of measurement (e.g., height, width) or type of measurement (e.g., angle), while the numbers denote a general location in or on the vehicle. Some of the dimensions deviate from this schematic such as L26, W90, and H197. The following table shows the alphabetic and numerical codes for the vehicle dimensional procedures.

Letter	Meaning
L	Length measurements (longitudinal distance), or location of X coordinate
W	Width measurements (cross car distance), or location of Y coordinate
H	Height measurements or location of Z coordinate
A	Angular measurements
PL	Lengths associated with pedal and pedal usage
PW	Widths associated with pedal and pedal usage
PH	Heights associated with pedal and pedal usage
SL	Lengths associated with seats
SW	Widths associated with seats
SH	Heights associated with seats
TL	Lengths defining H-point locations/travel
TH	Heights defining H-point locations/travel
PD	Passenger distribution
PV	Passenger volume indices
V	Luggage Volume and Cargo Volume indices

IV	Interior volume indices
S	Surface area measurements
D	Diameter measurements
F	Planar Area measurements

Table 9-3: Alphabetic Dimensional Prefixes [20]

Number Range	Type of dimension
1-99	Interior
100-199	Exterior
200-299	Cargo, luggage, or rear access compartments
400-599	Dimensions unique to trucks, vans, SUV, etc.

Table 9-4: Numerical Codes for Vehicle Dimensioning [20]

The SAE recommended practices describes a procedure for locating the three-dimensional reference system on a motor vehicle as built and all the other dimensioning and positioning of the CAD components in vehicle depends on that global coordinates.

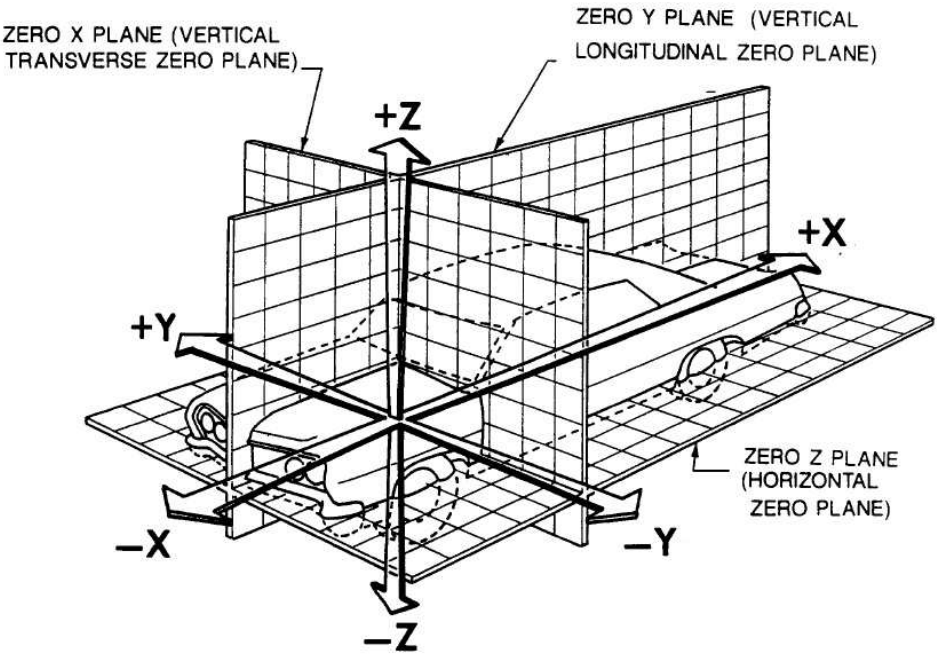


Figure 9-2: Three Dimensional Reference System in Vehicle [38] [21]

38 Cf: SAE J182 Motor Vehicle Fiducial Marks and Three-dimensional Reference System

For complete motor vehicle dimensional checks, a method is required for locating the three dimensional reference system on a motor vehicle so that points of interest such as driver eye location, seating reference point, centerline of motor vehicle, etc can be determined. All points described as coordinate dimensioned from the intersection of the zero planes in the three-dimensional reference system. X, Y, Z coordinates are dimensioned to their respective planes. The figure below shows the three dimensional reference system. Generally the centre of front axle is taken as the origin of zero planes.

9.4 Defining and Measuring Vehicle Seating Accommodation SAE J826 [39(22)]

The whole vehicle interiors are constructed based on the vehicle seating accommodation. All other components in the vehicle have to fallow the SgRP to define the occupant compartment space. The vehicle seating accommodation can be measured by using the H-point 2D template. The description, application and installation procedure for the H-point 2D template is as follows.

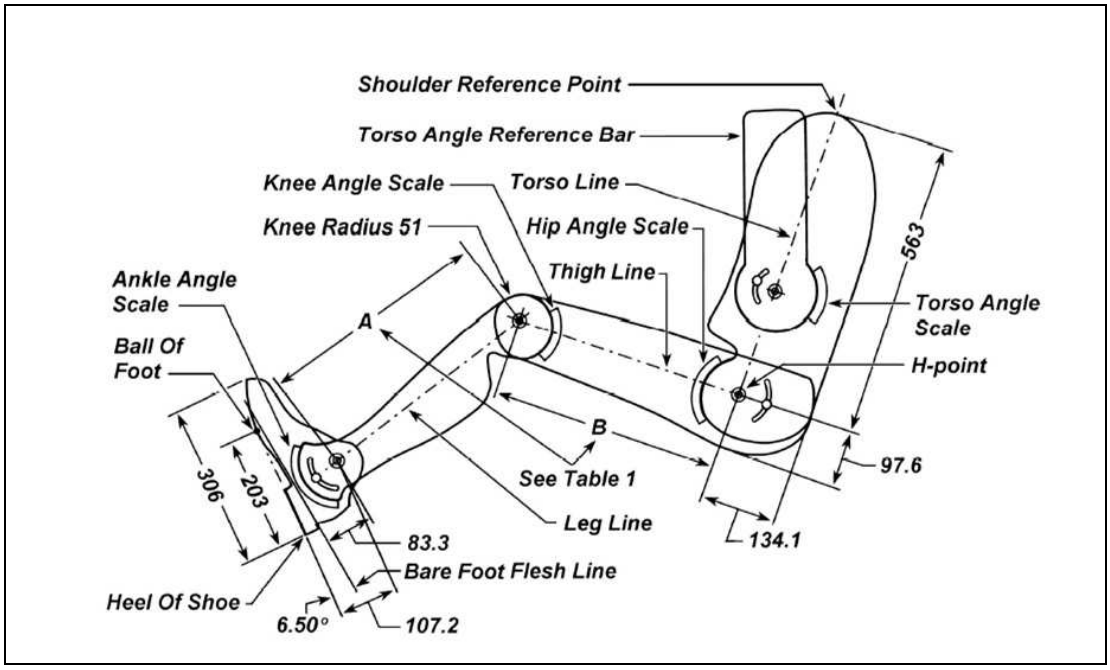


Figure 9-3: H-Point 2D Template [(22)]

[39] Cf: Devices for Use in Defining and Measuring Vehicle Seating Accommodation J826

The H-point template as shown is Figure 9-3 is constructed to represent in profile of adult male wearing shoes and corresponds to the profile of the seat deflection angle also called as torso angle. Individual torso, thigh, lower leg, and shoe segments are provided with locking pivot joints which can be used to fix the angular relationships of the segments. A torso angle reference bar is included to orient the templates torso in relation to the vertical.

This 2D template is used to determine the driver position, passenger position of front and rear seat. The same template can be used by modifying the dimensions of lower leg segment and thigh segment to different percentile manikins to measure the seating position in the car. The template is also applicable for checking the design specifications, relationship of H-point body structures, seats and controls. The following table shows the leg segment lengths as specified in the SAE standard.

Segments	10th Percentile(1) mm (inches)	50th Percentile(1) mm (inches)	HPM 95th Percentile(2) mm (inches)	Template 95th Percentile(3) mm
Lower leg segment (A)	392.7 (15.46)	417.1 (16.42)	458.7 (18.06)	459.1
Thigh segment (B)	407.7 (16.05)	431.5 (16.99)	455.7 (17.94)	456

Table 9-5: Leg Segment Length for Different Manikins [22]

Dimensions are measured relative to the X and Z bodies zero planes. All interior dimensions are measured with the front seat in the SgRP position as specified by the manufacturer. When the seatback has an angular adjustment separate from the seat cushion, the normal driving or riding torso angle (A40) is specified by the manufacturer. Use 25 degrees if not specified. The cushion tilt adjustment, if available, should be in the design position see Table 9-2 for specified values. The heel of shoe must touch the floor under un-depressed condition of the floor. The codes and the description which are used in the packaging of E-Mila are shown in the table 9-6 below. For more detail information on dimensional analysis of the car see SAE J1100. The subsequent chapter explains about the driver and passenger positioning of the E-Mila Student.

Code	Description
H30	The vertical distance from SgRP to the appropriate heel reference point (AHP or FRP). Measure with floor mats if they are standard equipment
W9	Steering Wheel Diameter
A40	Torso Angle
A18	The angle of a plane tangent to the face of the steering wheel rim (nominal design position), measured from vertical
L34	The distance along a line from the ankle pivot centre to the SgRP –front, plus 254 mm, measured with the right foot on the undepressed accelerator pedal
L38	The minimum distance between the appropriate SAE 95th percentile head position contour and the lowest horizontal tangent point on the windshield garnish molding, weather strip, headlining, or header. Measured using a side view section cut through the ellipse cancroids (occupant centerline).
L39	The minimum distance between the appropriate SAE 95th percentile head position contour and the lowest horizontal tangent point on the backlight garnish molding, weather strip, headlining, or header. Measured using a side view section cut through the ellipse centroid (occupant centreline).
L48	The minimum distance between the knee pivot point (K-Point) and the forward seatback, minus 51 mm (2 in). Measurement is taken within 127 mm to either side of the occupant centreline. The suffix following L48 identifies the designated seating position.
L50	The longitudinal distance between the SgRPs of adjacent rows. The suffix following L50 identifies the designated seating positions.
L51	The distance along a line from the ankle pivot centre to the SgRP, plus 254 mm (10in). Measured within 127 mm to either side of the occupant centreline, with the heel of shoe at FRP. The suffix following L51 identifies the designated seating position.
L53	The horizontal distance from SgRP – front to the accelerator heel point (AHP).
L3	The minimum horizontal distance between the seatbacks of a given row. The measurement is taken at a height tangent to the top of the current row seat cushion, within 127 mm to either side of the outboard occupant centreline. The suffix following L3 identifies the compartment area for measurement.
L7	The minimum distance from the rearmost edge of the steering wheel to the back line.
L11	The horizontal distance between the AHP and the steering wheel centre W7.
L32	The horizontal distance from the SgRP–second to the centreline of the rear wheels
L114	The longitudinal distance between the front wheel centreline and SgRP front.

Table 9-6:Dimension Codes and Description

10 Packaging of E-Mila Student

Taking into consideration the compact overall dimensions of the vehicle is a big challenge to accommodate the driver and passenger position in the vehicle. After freezing the overall dimensions of the vehicle from the survey and crosschecking with the homologation requirements, immediate next step is to package the vehicle. The necessary parameters to compute the driving position of a 95% Manikin including steering wheel and pedals in the vehicle ergonomically taken into consideration for the E-Mila Student are:

- Tire dimensions, Static tire diameter (Rstat) and the load acting on it and the distance from to the coordinate system (XYZ).
- Seating reference point (SRP) in Z (= H5) from a measuring load
- The tire envelope determined by spring suspension and a steering wheel because of the possible measuring load.
- After the Wheelbase (L101), Torso angle (A40), SgRP Y-coordinates (W20), and the seat height (H30) was determined by the client, the distances are determined to vertical distance between the H-point and the steering wheel bottom, Steering Wheel torso clearance (L7) and the Driver's BOF to SgRP (L99) to steering wheel and pedals.

The law ECE R35 pedals controls can be studied with the distance between SgRP and BOF. The overall dimensions are frozen based on the requirements of directive 93/93/EEC for masses and dimensions of the vehicle. Whereas wheel track, Wheel base and ground clearance are frozen for the vehicle, the registration plate location dimension are subjected to change based on the final approved styling of the vehicle.

The basic front tires are 155/70 R13 with 1669 mm of the rolling circumference with static radius of 250 mm and the dynamic radius of 266 mm. The optional rear tire for stability (under steering) due to weight distribution is 165/65 R13 with Rolling circumference of 1661mm. For more information regarding brakes and tires see the diploma thesis "Chassis-, Drivetrain and Energy Storage-Layout for an Electric City Vehicle "by D.I. (FH) Stefan Eitzinger.

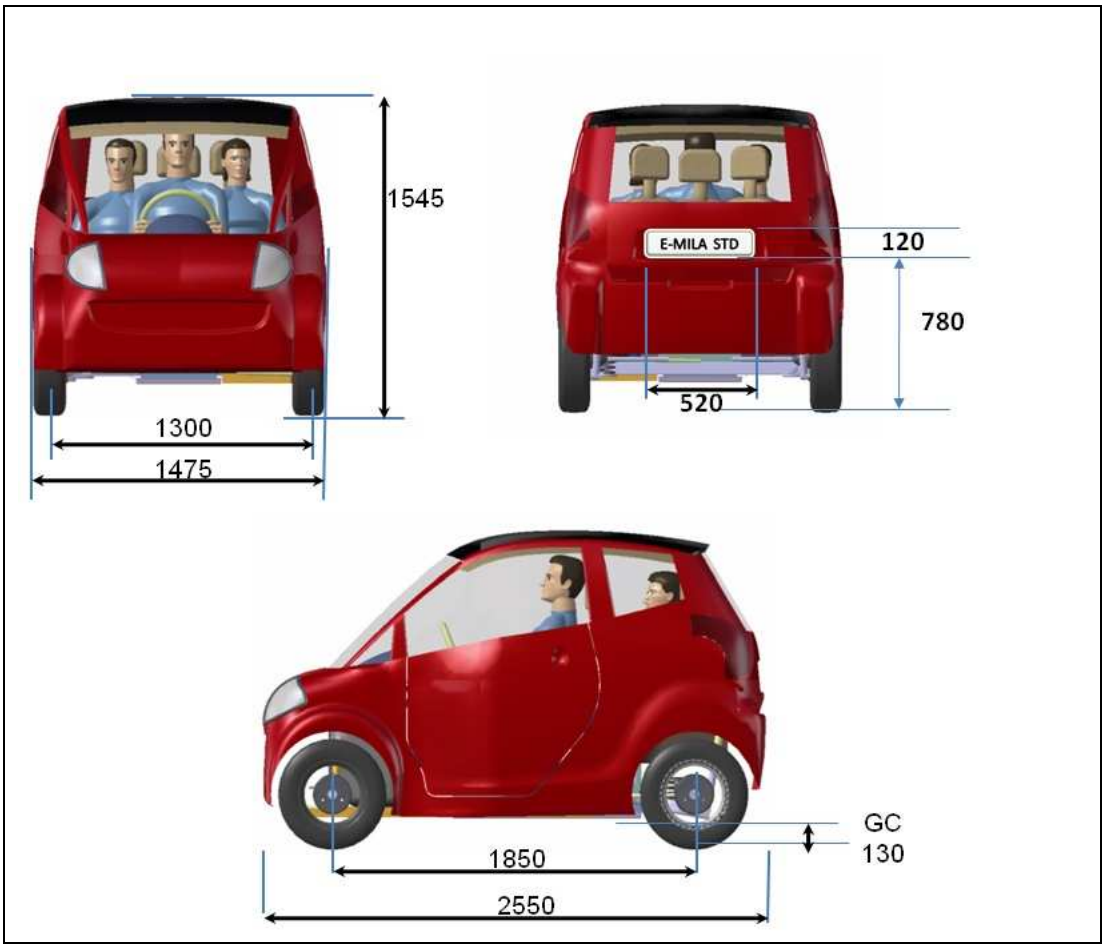


Figure 10-1: Overall Dimensions and Registration Plate positioning of E-Mila Student

Initially the height of the vehicle is considered as the 1560 mm considering the homologation and vehicle stability requirements but after considering the parking cellular requirements in the Japan urban areas (see Table 7-1), the height of the vehicle restricted to 1545 mm to avail the parking facilities in urban area of Japan and the dimension is frozen after crosschecking all the packaging feasibilities of the vehicle. For the list of overall dimensions see the Table 8-3.

10.1 Seating Layout

The conventional method of seating layout of cars in general is in rows, such as first row seat consist of driver and co-driver and second row seats consist of two or three passengers and so on. In case of E-Mila Student it is different, the rear seats are placed just behind the centrally positioned front seat and

the two rear seat passengers share the part of front compartment to take the advantage of utilizing the front seat compartment.

The rear seat occupants can stretch their legs and utilize the space in the driver compartment. The rear seats are tilted 10 degrees towards the outboard to have the comfortable position for the two rear seat passengers within the compact packaged vehicle. Though the vehicle is very compact, the utmost care is taken to provide the driving occupant at ergonomically comfortable position. With the tilted rear seat the occupant have the more freedom for his knee room which is seldom in most of the compact 4 seater cars. The trunk volume can be increased by folding the two rear seats so that the entire flat area can be utilized for boot volume.

The front engross portion of the vehicle near the driver foot is narrowed to an extent to provide the driver access to seating position and the external rear view mirrors at an ease, irrespective of the size of driver. This is one of the general requirements mentioned in the homologation directive 97/24/EC of L7e category. Some of the competitors for the given vehicle category have the similar kind of seating arrangement, though there is difference in the overall dimensions and seating position. One such competitor is Mia-Electric; the figure 1-3 shows the seating layout for the E-Mila Student and the Mia - Electric.

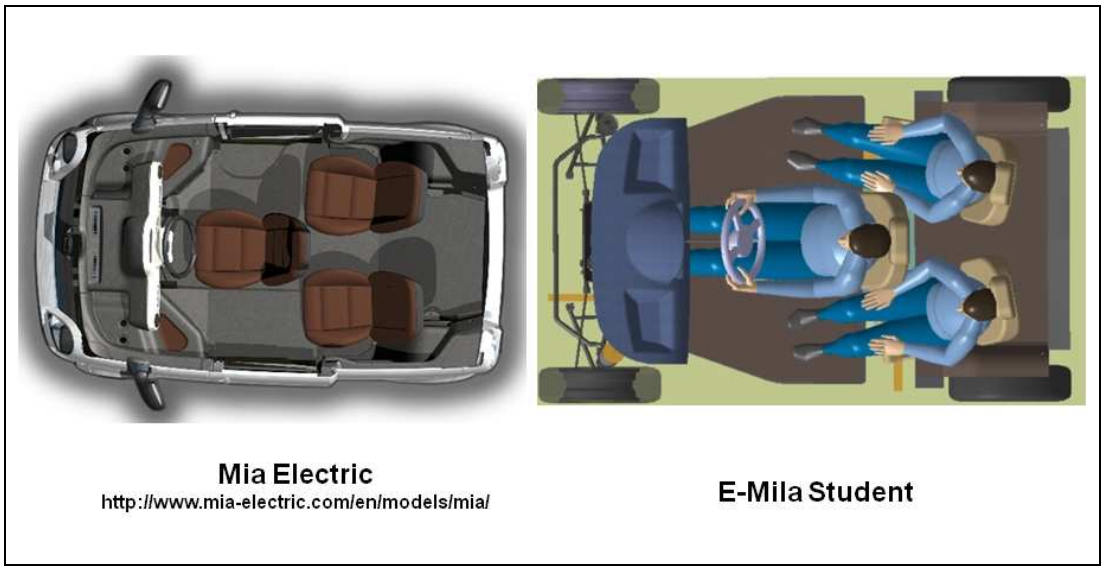


Figure 10-2: Seating layout of E-Mila Student and Mia- electric

The overall dimensions of E-Mila Student are less compared to the Mia Electric and the seating angle is restricted to 10° to the xz plane and the front floor is narrowed for the driver access.

Safety belts and anchorages for any vehicle is based on the H-Point of the vehicle and protection space of the occupant is also depend on the H-point. The standard for belt anchorages and seats is given for the three point belt in the directive 97/24/EC C11 but the driver position in case of the E-Mila Student is in the centre of the vehicle (at Y = 0) and it is ideal to have the four point seat belt for the vehicle. The structure in the rear of the seat can be used for the anchorage point of seat and ideal for four point seat belt. The Figure 10-3 shows the driver seat four point seat belt study for E-Mila Student. The number of minimum anchorage points as per the standard are at least two lower and one upper anchorage must be provided for the front seats. However, two lower anchorages are considered sufficient for the front centre seats, if fitted, where there are other front seats.

Figure 10-3: Four point Seat Belt Anchorage point Study for E-Mila Student

The effective seat angle must be as close as possible to 25°for quadricycles but for this vehicle it is restricted it to the 18° to accommodate the rear seat occupants in a comfortable position and taking into consideration the overall length of vehicle. The seat belt upper anchorage zone is defined for only

three point seat belts in the directive and further investigation and standards need to be explored for the four point seat belt for this project.

10.1 Driver Positioning Scenario

Initially the project started with the rough sketching of all the overall dimensions and the next stage is to decide the H-point coordinates of the driver position. Only the sketch with some assumed dimensions along X direction and ground clearance based on the battery packaging considered, as it takes long time to construct everything in CAD and modifying later everything without analyzing the initial dimensions of the vehicle. The dimensions of the ground clearance, floor, carpet and battery packaging under the seat and the seat cushion thickness are taken into consideration to decide the Z-coordinates and the H5 dimensions of the vehicle only, as the access to the data of wheel positioning and wheel dimensions are not available. The figure below shows the initial sketch for the 95 percentile driver positioning

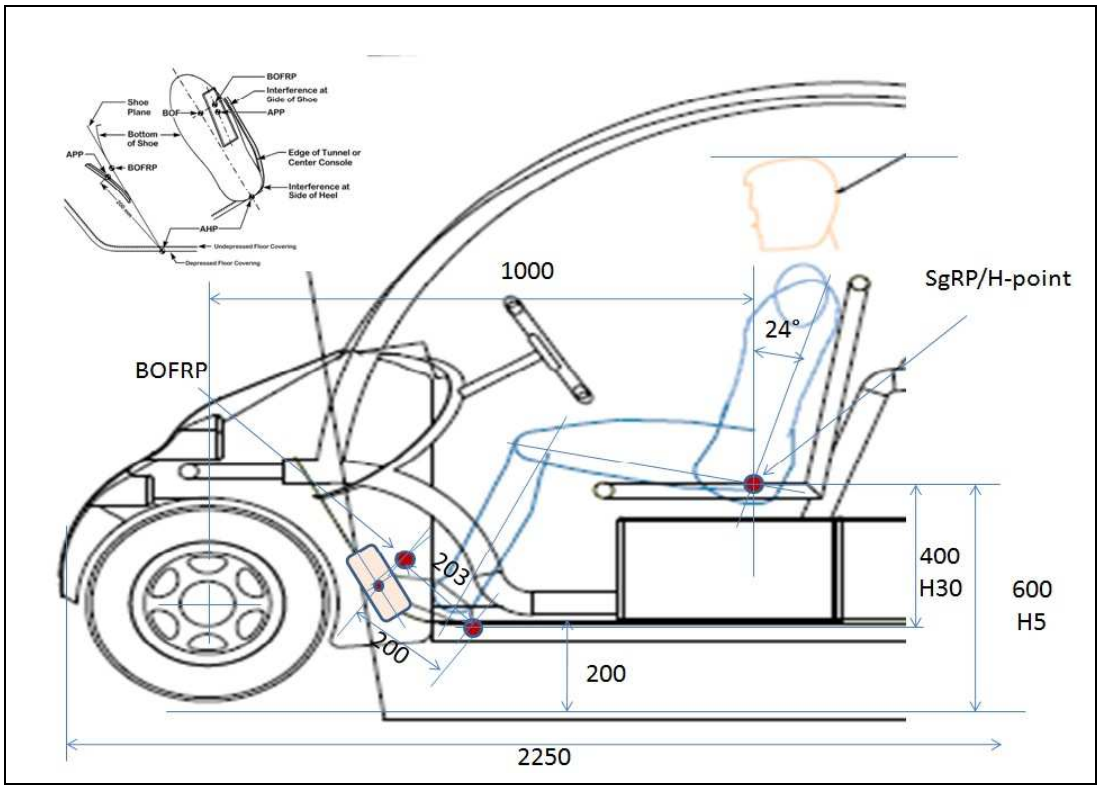


Figure 10-4: Initial Sketch Showing Dimensional Assumptions

As in the figure above the torso angle of the driver is considered as 24 degrees which is common angle for the class A vehicles and the M1 class cars and the driver position is considered very upfront at X 1000 as the data for steering mechanism, pedal mechanism and the firewall data was not available. The following chapters show the positioning scenarios of placing the 95 percentile manikin in driver position and the development of feasible solution in different stages.

10.1.1 Driver Positioning First Scenario

In the first scenario there were many constraints to place the driver foot position and pedal positions with tunnel design running all through the centre of the vehicle and in between the driver foot. This design was suggested to support the vehicle balancing and proper weight distribution (see the diploma thesis *"Chassis-, Drivetrain and Energy Storage-Layout for an Electric City Vehicle "by* D.I. (FH) Stefan Eitzinger for more information). Another problem with the central tunnel was to position the pedals. Under fully depressed condition of pedal there was certainty of pedal contact with the fire wall as the pedal well was located near to the suspension wishbone area; there is no possibility to have depression in firewall to provide clearance to pedals. The figure below illustrates the initial conditions of the driver compartment floor area.

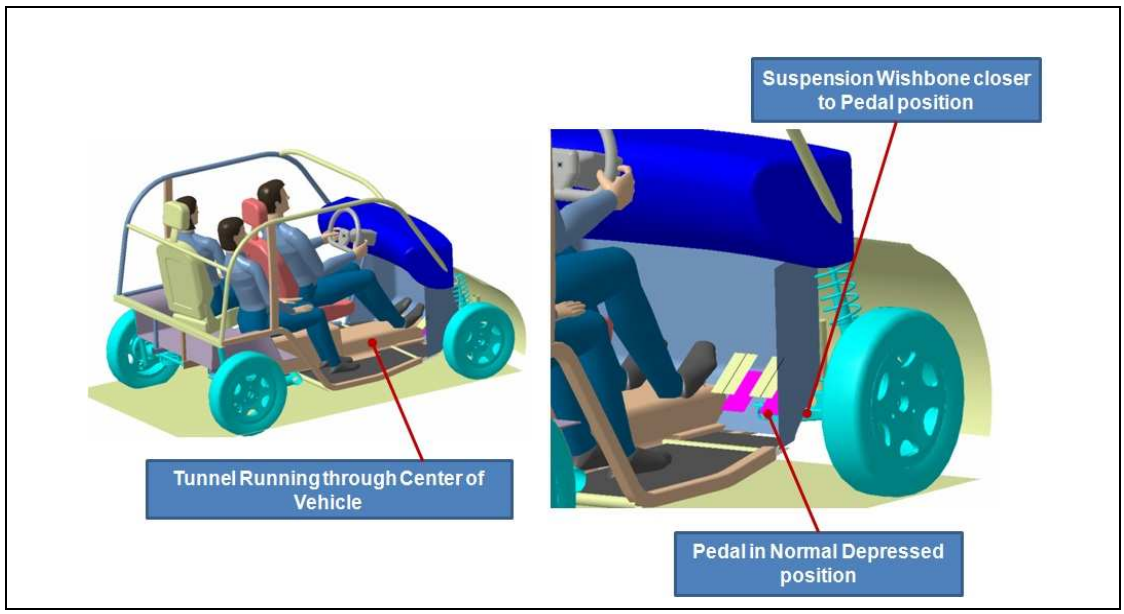


Figure 10-5: Initial Design of Central Tunnel and Pedal Positions in Vehicle

Further investigations need to fix the H-point of the driver position to derive the pedal and steering positions of the vehicle. Following inputs are considered to determine the Z coordinates of the H-Point. The static radius of the tire is considered as 250 mm. The ground clearance is assumed to 135 mm and the dimension from depressed floor to the H-point in Z (H30) is taken as 445 mm considering the battery packaging under seat and assuming the values around 300 from the bottom of battery to the top of battery cover and rest of the dimensions are considered for the seat assembly including structure. The next important dimension is to determine the X coordinate for the H-point. Initially it was decided to freeze the X coordinates to 1050 to take the advantage of frontal space for the assembly of steering mechanism and suspension system. During investigations it is proved that at X1050 it is difficult to place the rear seats and to accommodate the rear seat occupants keeping the wheel base at X1800. So it is decided to fix the H-point at X1010, Y0 and Z 350. The torso angle (A40) is assumed to 18 degrees, considering the vehicle to A class (see Table 9-2 for details).

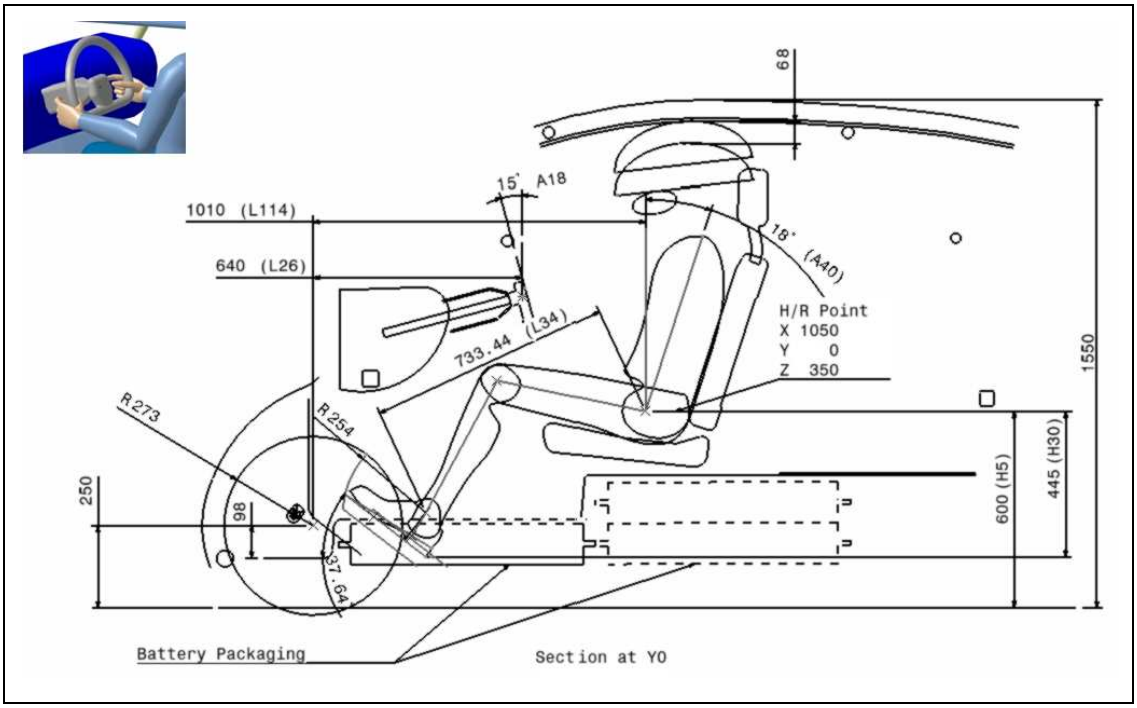


Figure 10-6: Driver Positioning Section at Y0 (First Scenario Results)

After freezing the coordinates for H-point, next is to determine the positioning of the steering wheel and pedals. The steering wheel diameter is assumed to

350 mm by benchmarking some of the M1 segments and to avoid the collision with driver thigh line it is considered to be flat on the bottom of steering wheel as shown in the inset of Figure 10-6 above. The coordinates for the centre of steering wheel is taken at X640, Y0 and Z 702 and steering wheel angle to the vertical A18 is taken as 15 degrees.

Pedal position determination: It is important to determine the dimensions of effective leg room to accelerator (L34), acceleration heal point (AHP), Acceleration Pedal Point (APP) , Shoe Plane Angle (SPA), BOF and Ball of Foot Reference Point (BOFRP) to determine the pedal position. The SgRPX is the dimension between SgRP and BOFRP, to have the X coordinates of the pedal at BOFPR. It can be determined by the following equation

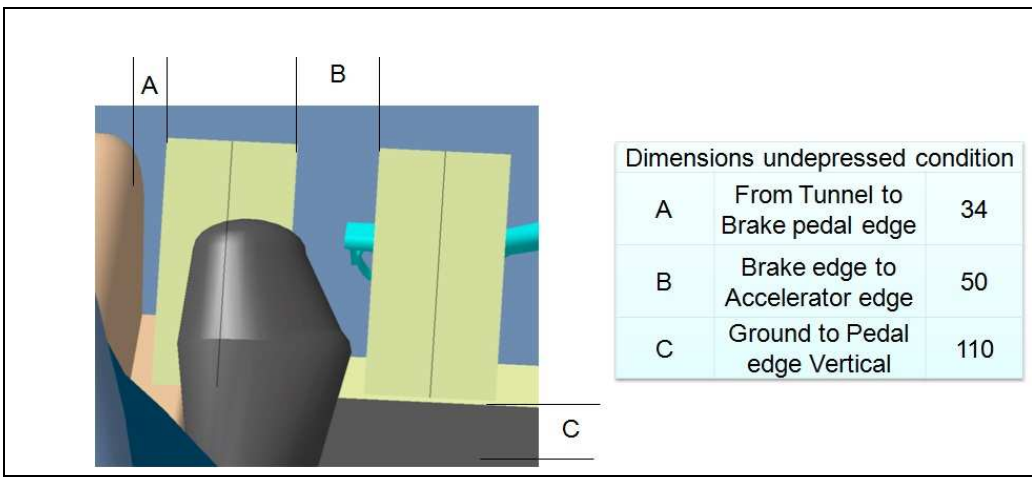
$SgRPX = 913.7 + 0.672316(H30) * 0.0019553(H30)^2$ = Distance (in mm) rearward of BOFRP [23] (Equation 2)

By subsisting the value of H30 which is 445 mm in above equation 2, the resultant value of SgRPX is 825.7 mm.

The SPA equation defines the side view orientation of the shoe (SPA) as a function of seat height (H30):

$SPA(A47) = 2.522(10^{-7})\ (H30^3) * 3.961(10^{-4})(H30^2) + 4.644(10^{-2})(H30) +$ 73.374 degrees from horizontal [23] (Equation 3)

= 37.8 mm.



Dimensions undepressed condition		
A	From Tunnel to Brake pedal edge	34
B	Brake edge to Accelerator edge	50
C	Ground to Pedal edge Vertical	110

Figure 10-7: Pedal Positioning dimensions (First Scenario Results)

The above figure shows the dimension values of

“A” Between the tunnel right edge to the brake pedal edge

“B” between the brake and the accelerator pedal edges and

“C” between the floor and the pedal edge in vertical

RAMSIS Analysis of First Scenario Results: The RAMSIS is the 3D CAD manikin highly accurate simulation software for the design and construction analyses. This software is used for ergonomics, comfort and safety at early stages of the project. Based on the results improvements can be achieved without the need of significant physical testing. After having some basic important dimensions for the driver position, the consolidated results and CAD data is handed over to Mr. Helmut Kemmler of EGI-Fahrerplatzauslegung department at Magna Steyr for RAMSIS analysis and recommendations for the improvement. The figure below shows the RAMSIS 3D manikins used for analysis of E-Mila Student.

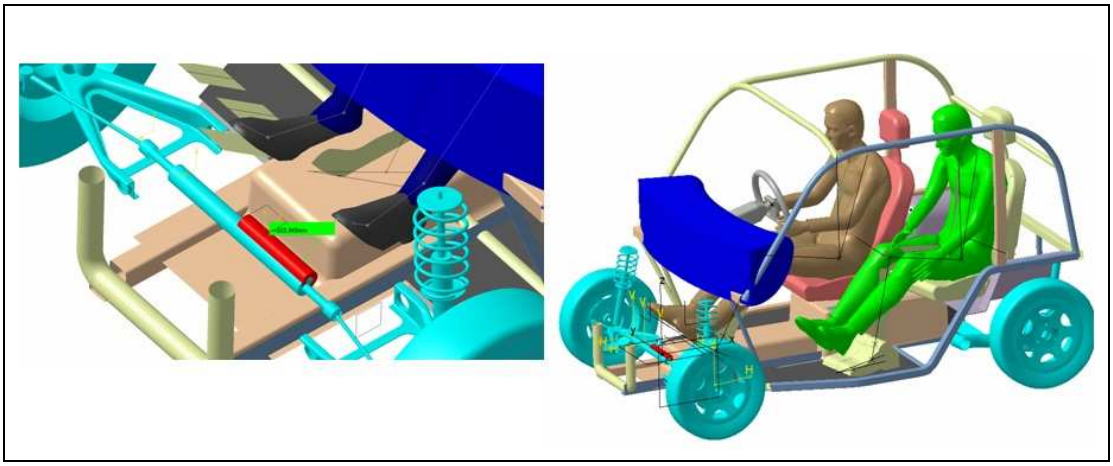


Figure 10-8: 3D Manikin RAMSIS Analysis on E-Mila Student

The outcomes of the analysis and recommendations are as follows:

- The pedal position is too high for the 5 percentile female manikin. It may not be possible to reach the pedal.
- The left edge of the first pedal must be at least greater than 120 mm. In case of fist scenario the A value is 34 mm from the central tunnel.
- The tunnel in between the legs is not comfortable position for the egress and ingress and the seating position while driving.

- The steering wheel angle A18 is 15 degrees and it is too straight for the driver. Need benchmarking considerations for the steering angle.
- The seat travelling and access to different size drivers has to be checked further.
- Rear seat is too congested for the 95 percentile manikin.
- The H30 value 445mm is too high for the A class vehicles and can be reduced to 405 mm.

Based on the above results, it needs further investigations to improve the pedal, steering and driver seating position for different size occupants and rear seat occupant position. The improvements and analysis are further carried out in second scenario.

10.1.2 Driver Positioning Second Scenario

After considering the recommendations from the RAMSIS analysis and problems from the first scenario, the following changes have been done keeping the H-Point constant from first scenario.

- Tunnel in between the driver legs as been removed from previous proposal and pedals are placed in the centre of the vehicle.
- By moving the pedal to the centre, the collision of depressed pedal at wishbone suspension area is avoided. (New wishbone design is recommended to accommodate the suspension in compact space).
- The battery pack in-between the driver leg is placed below the rear seats horizontally and the central structure under the floor is maintained for the vehicle balancing. (Keeping weight distribution under control)
- The seat height H30 from the floor to the SgRP point is modified from 445 to 405 mm considering the pedal access to all kind of manikins and Class A vehicle recommendations.
- Outward Vision angle is considered as 30° for both eyes to find the field of vision of driver and vision points are taken according to directive 97/24/EC C12 homologation requirements.
- Outboard offset 23mm for head position as recommended in SAE J1052 is not considered as the driver location is in the centre, which is applicable to the outboard driver position.

- The steering angle A18 to the vertical is increased from 18 to 22 degrees. To provide the comfortable access to all kind of human sizes.

The Figure 10-2 below shows the flat area in front of driver without tunnel , new battery location from front of driver to the rear side in the shape of T and drivers field of vision without any abstraction from the A pillars and interiors. In addition to the above changes the secondary brake pedal moment of 130 mm in case of failure of primary brakes under normal depression condition of 50 to70 mm is also taken in to considerations. The secondary brake is mandatory as per the homologation requirements according to the directive 93/14/EC.

The firewall improvement for the accommodation of brake and acceleration pedals and the tire movement is different directions is recommended based on the investigations.

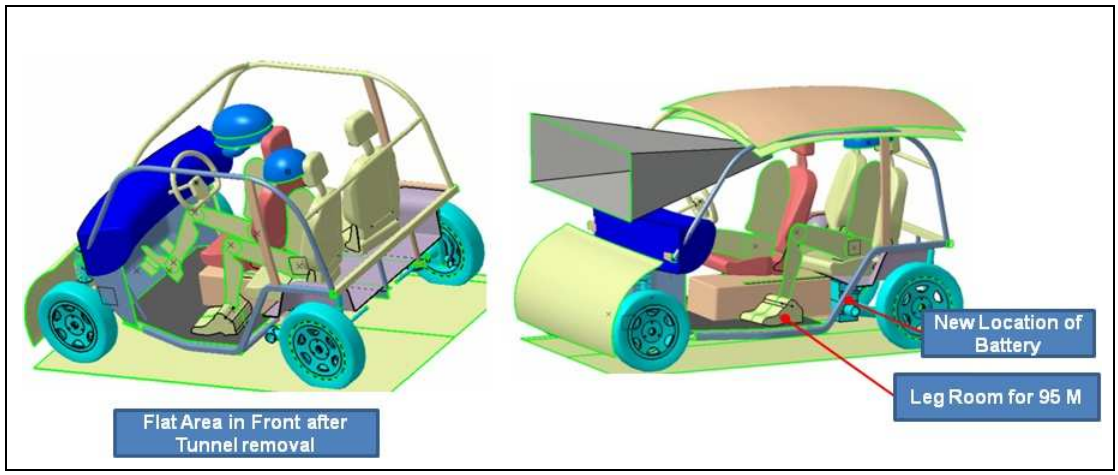


Figure 10-9: Floor Area and New battery packaging layout and Driver FOVs

The table below shows the some of the important dimensions evaluated from the second scenario. During further investigations and based on the bench mark results, some of the dimensions values are modified and are discussed in the third and final scenario of the driver positioning.

Code	Description	Dimension Value
L7	H-point to steering bottom	374
	H-point to steering bottom vertical dimension	193
H30	SgRP to AHP	405
H5	SgRP to Ground	600
W9	Steering Wheel Diameter	380
A18	Steering Wheel to Vertical	22°
A40	Torso Angle	18°
A47	SPA (Shoe Plane Angle)	43.9 °
L34	H/point to Ankle + 254	1011.6
Pedal Area		
B*	Brake pedal edge to the left	>120
A*	Brake edge to Accelerator edge	90
G*	Ground to Pedal edge Vertical	100
Note * Indicates the self defined codes		

Table 10-1: Dimensions Evolved from Second Scenario

The figure below shows the section passing through Y0 to determine the 95 percentile Manikin driver position.

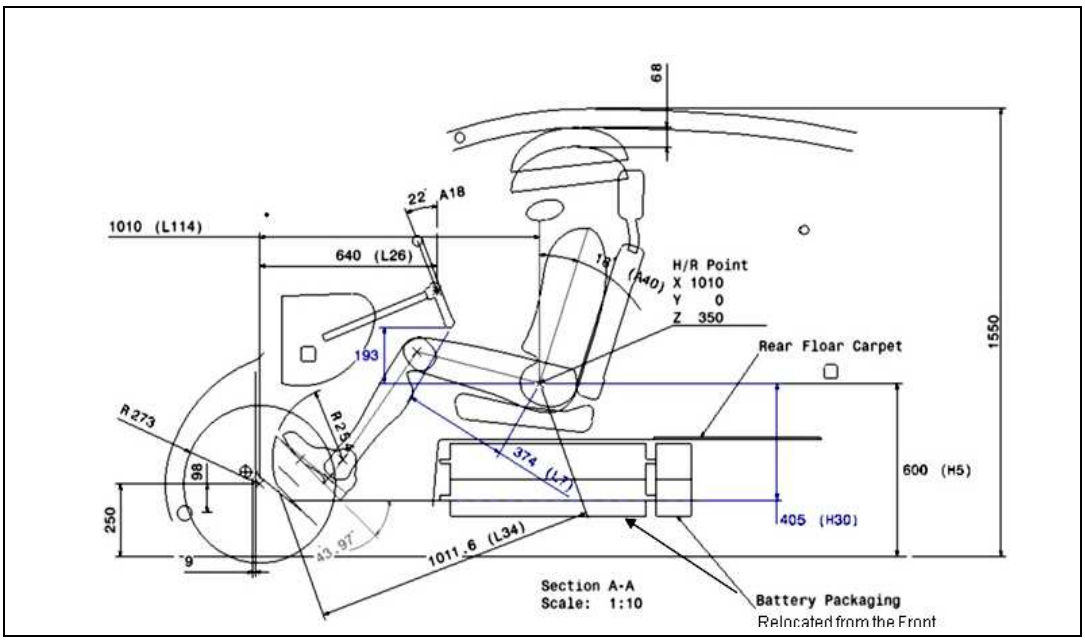


Figure 10-10: Driver Positioning Section at Y0 (Second Scenario Results)

The outcome of the second scenario and further recommendations after investigations are as follows:

- The H/R-Point is optimal for the 95 percentile manikin and H30 dimension of 405 mm is more adequate for different sizes of the manikin.
- The wheel base has to be increased from X1800 to the X1850 to accommodate the rear seats.
- The Steering wheel distance from H-point and Steering angle (A18) need to be checked for different sizes of people.
- Need to benchmark the CAD model for pedal to analyse the packaging of pedals under worst case.
- Need to redesign the firewall for central pedal area and at suspension area. Firewall clearance for the tire dynamics is necessary to investigate the driver compartment space.
- The rear battery packaging is having problems with central structure of the vehicle and the rear suspension.

10.1.3 Driver Positioning Third Scenario

Based on the results of the first and second scenarios, H-Point and Seating reference point (R) coordinates for the 95 M has been freeze to X1010, Y0 and Z350. The same is considered for the seating reference point as during investigations it has been absorbed that seat travel is only to accommodate the different size occupants. The following changes have been done to improve the overall packaging for different sizes driver position occupants.

- The H-Point for 95M is taken as the R-Point for seat designing and assembly and only forward travel in X direction of seat is consider. No vertical movement and no track angle.
- The steering angle A18 is modified from 22° to 29° after benchmarking with the similar size and type vehicles and to adjust the steering bottom to the vehicle properly.
- The flat bottom steering wheel is replaced with circular wheel and the steering wheel diameter W9 is modified from 380 to 360 mm.

- All the individual battery packaging has been relocated under front seat parallel to other batteries to accommodate more space and moved to front.
- The need of rough styling has been felt to determine the clearances for the head and to check the impact with top of counter. As well as the FOV can be analysed properly with it.
- The SPA (A47) is adjusted to suit the 50 percentile manikin from 43.9 to 40˚, so that the pedals can be accessible to all size of driving occupants. The cross sections taken at Y0 for different size manikins ranging from 95 percentile to 10 percentile, shows the pedal position is suitable to all the occupants and is optimal.
- Sections for seat travel line and the positioning of the different H-points have been studied to finalize the seat travel positions.
- The selected seat position curves are determined to check the different occupant positioning.
- Firewall is modified to suit the pedal well and to provide the clearance for suspension system and to accommodate the tire dynamics with clearance. It is also used to determine the driver cabin floor space.

The following figure shows the CAD image of component positioning for packaging analysis.

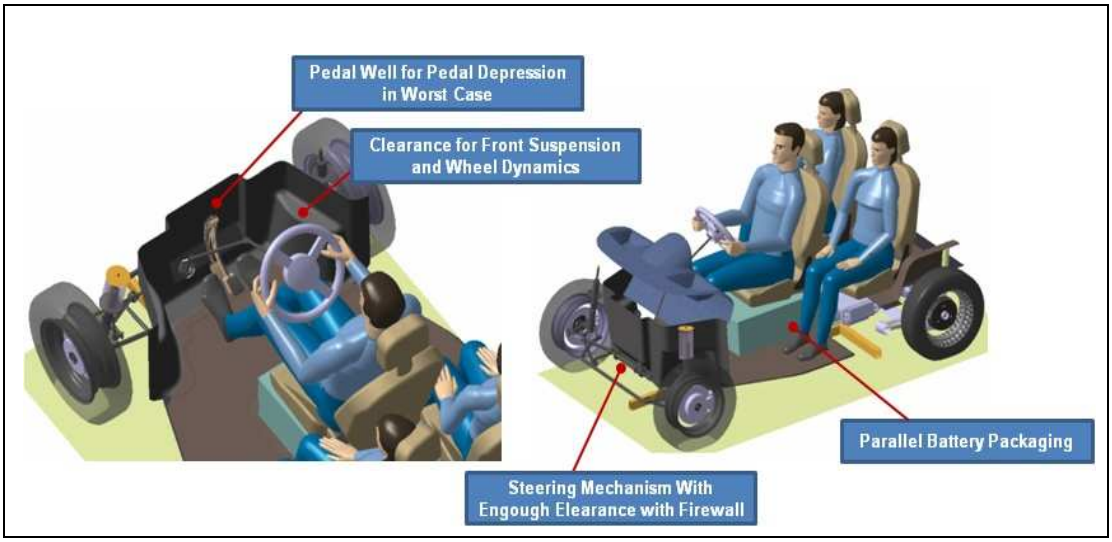


Figure 10-11: CAD Image Showing Firewall, Pedal and Battery Packaging

To accomplish the secondary brake requirements as described in the directive 93/14/EC, the hydraulic brakes with front disk with diameter 240mm

and rear drum 280 diameter are defined for this vehicle. As per the calculations achievable deceleration 0.5 with brake pedal travel of 100 mm is achievable. Usual travel of brake pedal in case of normal conditions is 80mm maximum and generally travel will be 50 mm.

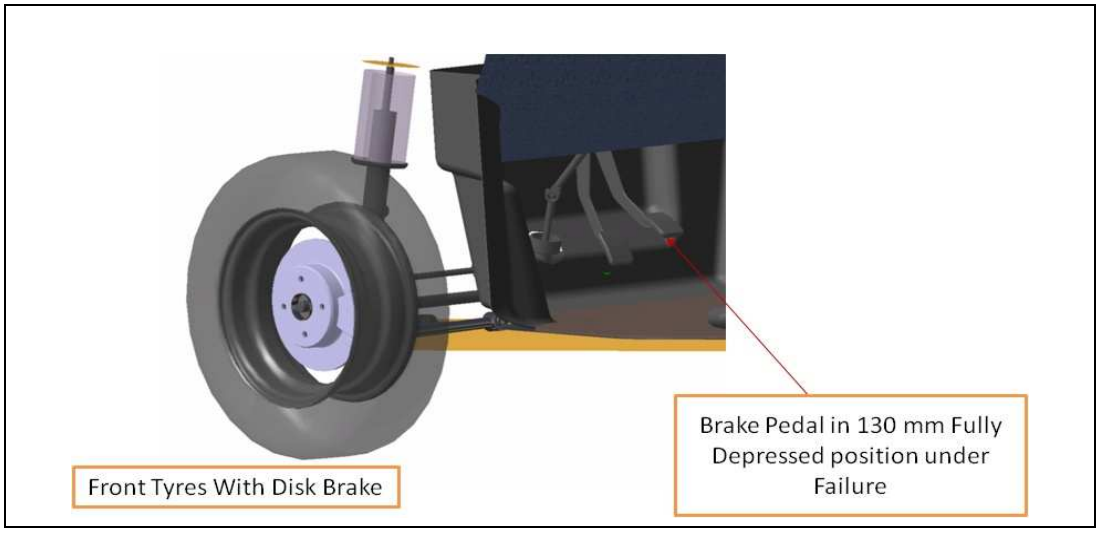


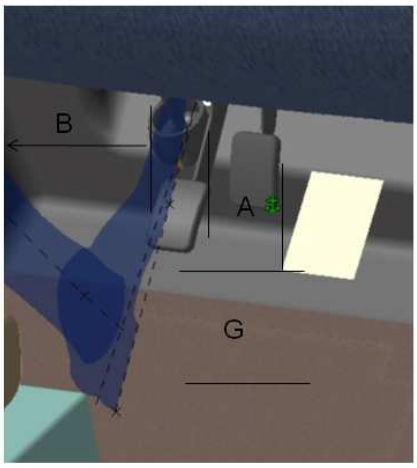
Figure 10-12: Front Tire and Depressed Brake Pedal in Worst Case

The following figure shows the dimension values of Pedal position

"B" Between the to the brake edge to the left side first object

"A" between the brake and the accelerator pedal edges and

"G" between the floor and the pedal edge in vertical



Dimensions undepressed condition		
B	Brake pedal edge	>120
A	Brake edge to Accelerator edge	90
G	Ground to Pedal edge Vertical	99.5

•Considering Seat travel 160mm in front only (X –ve only from design position)

Figure 10-13: Pedal Positioning dimensions (Third Scenario Results)

H-Point Traven Path: Defines the range of H-point locations provided by seat mechanism(s) for a given designated seating position. Only seat adjustments intended for driving and riding, or used by regulatory agencies are included. The following figure shows the H-Point travel path.

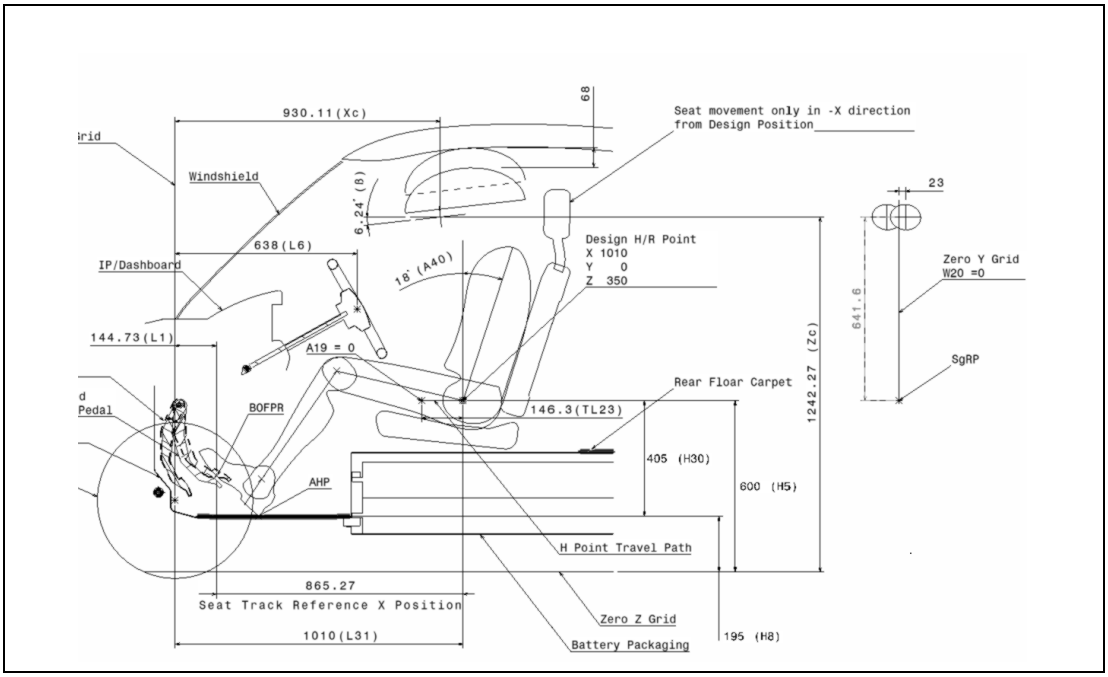


Figure 10-14: H-Point Travel Path Way in Forward Direction Only

Class A Vehicles Driver Selected Seat Position Lines: Is the series of curved two-dimensional side view lines which express driver selected seat position aft of the ball of foot reference for various accommodation levels as a function of vehicle H-point height (H30).

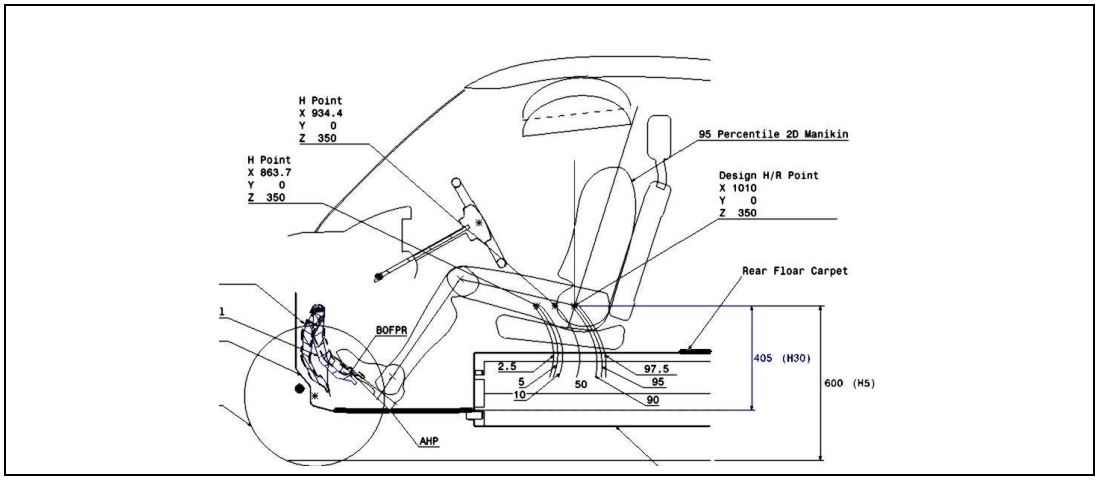


Figure 10-15: Driver Selected Seat Position Lines for Different Manikins

See SAE J1517 Mar 90 for more information related to construction of seat positioning lines.

The following figures shows the section at Y0 for the driver position of 95, 50 and 10 percentile manikins respectively to analyses the driver seating positions according to the seat travel in X forward direction.

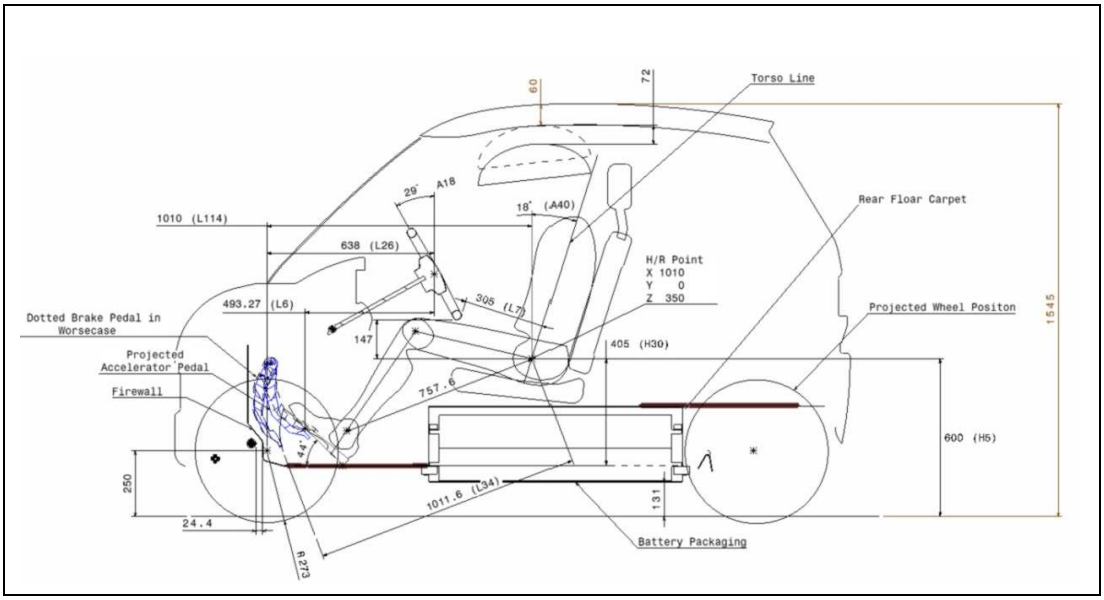


Figure 10-16: Section at Y0 for the 95 Percentile Manikins for Seat at Design Position.

In the above figure it can be seen that the driver SPA is 44° and the pedals or not in contact with the leg as the position of pedal is designed for 50 percentile manikin and in the figure 10-17 the pedal position can be seen in contact with the manikin leg at SPA 40° and respect ively it can be seen in figure 10-18 that pedal positioning is interfering with leg for the 10 percentile manikin. The pedal positioning is intended to provide access to all sizes of the people. The respective figures also show the comfortable positioning of steering wheel for all sizes of the manikins considering the dimension L7 and the vertical dimension from H-point to the bottom of steering. The dimension L34 for leg position in all the cases is taken considering the standards similar to M class vehicles, which is very comfortable positioning for the driver. The head clearance for 95 percentile manikin in figure 10-16 shows the comfortable positioning in seating design position. It is also having the acceptable range when the seat is in forward most position with the windscreen garnish.

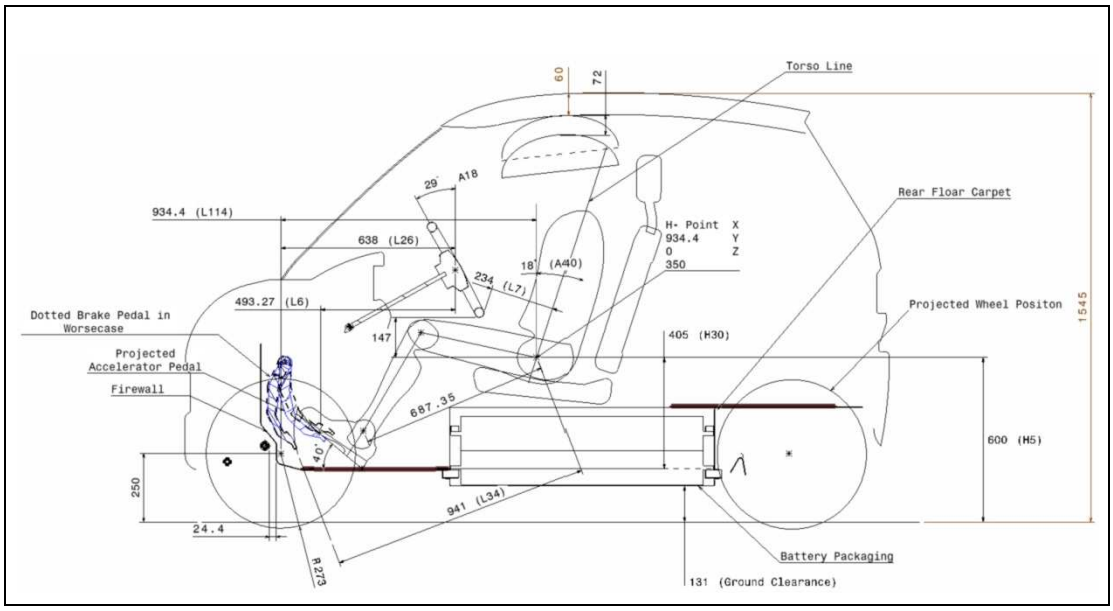


Figure 10-17: Section at Y0 for the 50 Percentile Manikins for Seat at X934.4.

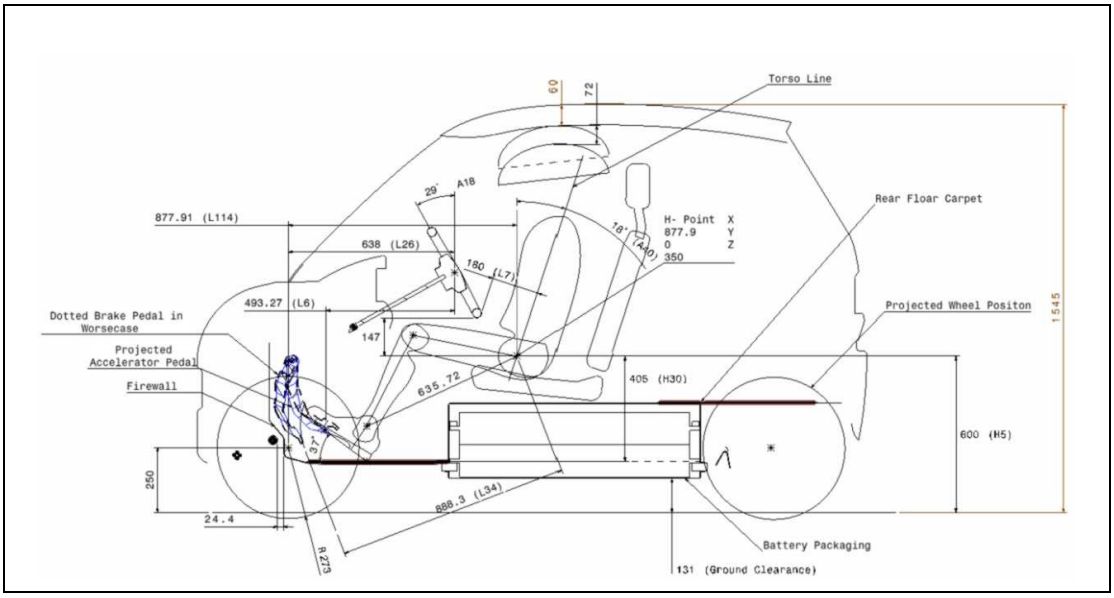


Figure 10-18: Section at Y0 for the 10Percentile Manikin for Seat at X877.9.

The above investigation shows that the achieved results are optimal at the concept phase and can be taken as output for further development. As a part of driver position it is also important to check the drivers FOV to fulfil the directive requirements of 97/24/EC. The outcome of the investigations is explained in the subsequent chapter.

10.1.4 Driver Field of Vision

The field of vision is required to check the visibility of the driver irrespective of the driver position and the wiper has to cover at least the 90 percent of the field of vision.

In case of E-Mila Student the driver is having the field of vision without any obstructions from the A-Pillar, roof and Steering wheel as shown in Figure 10-19. For all the construction details and angle of visibility see directive 97/24/EC. To fulfil the regulatory requirements E-Mila Student must be equipped with Windscreen, Wipers and Washer nozzles. Demist and defrost must be provided for the European version of the vehicle enabling any ice or frost covering the windscreen and any mist covering the inner surface of the windscreen to be removed. Inclusion of defrost/demist can be decided in other phases of the project for other target markets.

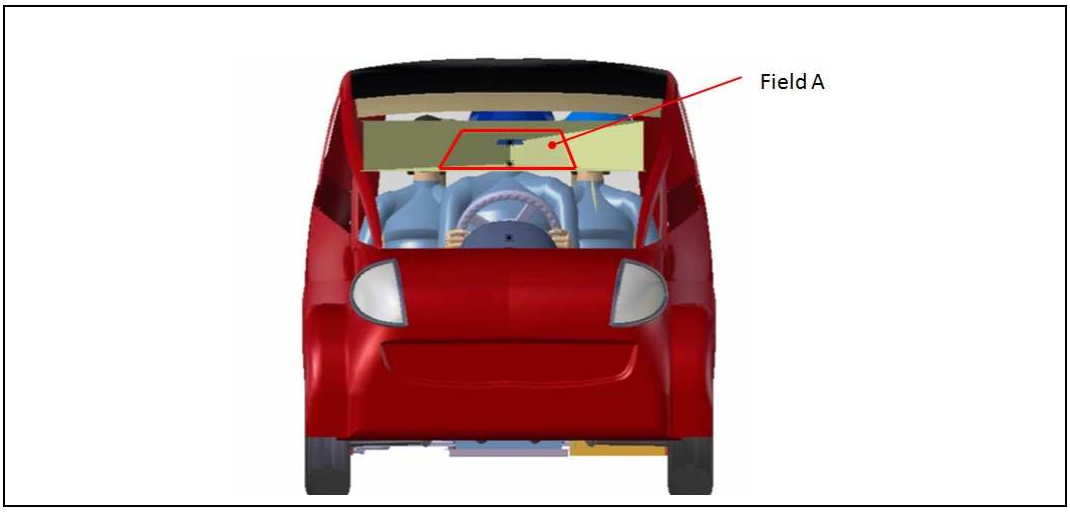


Figure 10-19: Field of Vision for E-Mila Student

10.2 Rear Seat Occupant Position

The results from the front seat driver position based on it s SgRP point and the available interior space and based on the further investigations, the following considerations are taken into account to position the rear seat and its occupants.

- The seating layout of E-Mila is unlike the regular M1 car and in the view of utilizing the front compartment space and to provide enough room for boot space the torso angle (A40) is set to 12° and the rear seat is tilted to 10° towards outboard to accommoda te the rear seat passenger comfortably and to avoid any collision with battery packaging and with the door trim when closed with the occupant leg.

- It is considered that the front seat is moving in the forward X direction only and front seat SgRP point is the starting point for the seat movement.

The results of the investigations shows very congested position for the 95 percentile manikin, but considering the city driving and short distances the size of occupant can be considered and comfortable position for the small than 95 percentile Manikin. The following procedure is adopted to position the 2D template in CAD as per SAE J826 standards.

The leg and shoe positioned considering the front seat in its SgRP position. Holding the torso portion of the template in position as placed the bottom of the shoe (heel and ball) on the depressed floor covering line. The shoe is to be placed on the Y-plane centreline of the occupant or up to 127 mm (5 in) on either side of the Y-plane centreline on the floor pan section to check the clearances with the leg as shown but it is tilted to 10° to Y plane as shown in the Figure 10-20 (is also useful for the locating the H-point machine. See standard for more information).

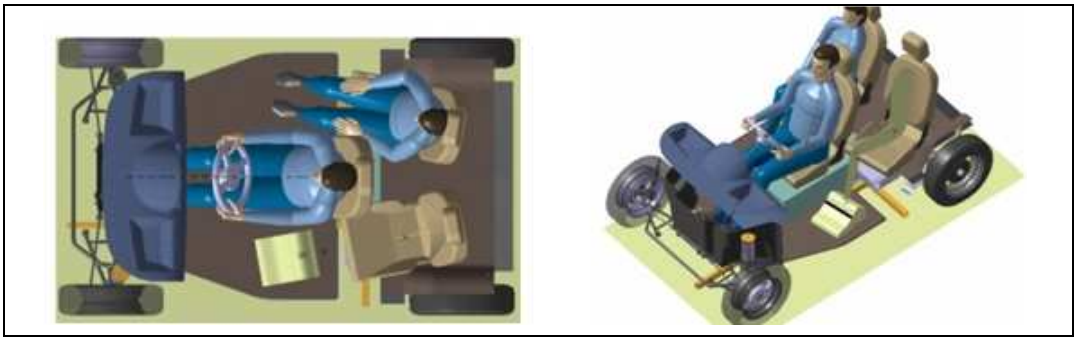


Figure 10-20: CAD Image Showing Shoe Clearance Study

Shoe is moved forward along the depressed floor covering line to the nearest interference of the toe, instep, lower leg, or knee with the front seat. The

ankle angle is to be restricted to a maximum of 130 degrees. The following figure shows the rear seat occupant positioning.

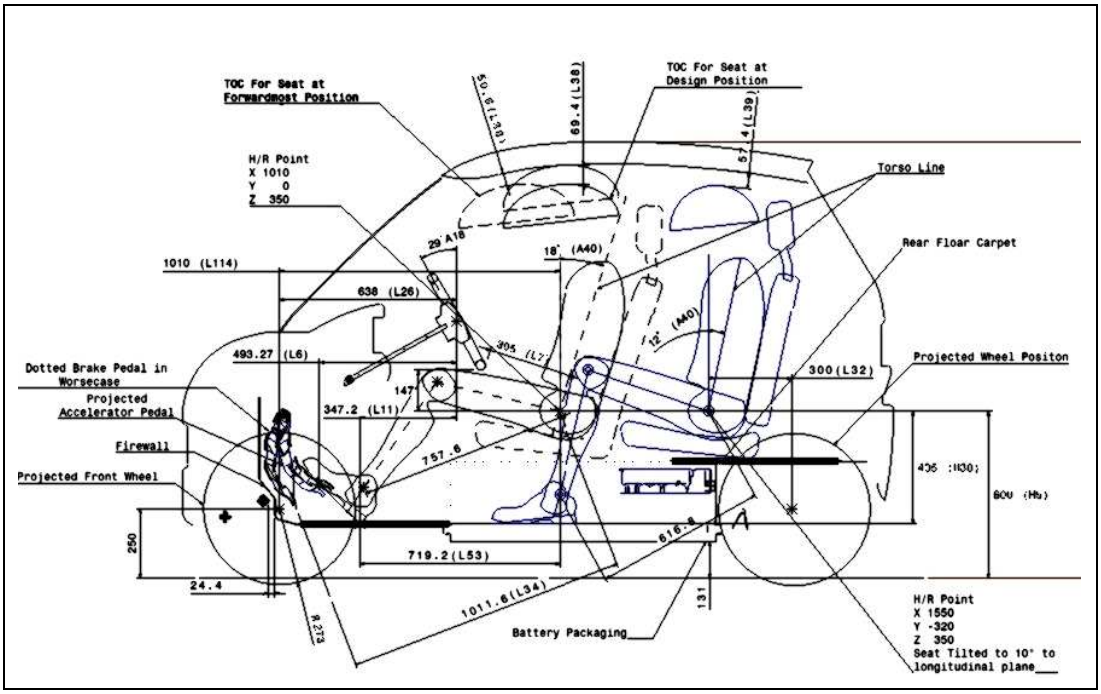


Figure 10-21: 95 Percentile Front and 50 Rear 2D Manikin at Seating Design Position (Rear Seat tilted 10° towards outboard)

10.3 Resulted Dimension List of Third Scenario

The following list of dimensions is evolved from the investigations of third scenario for front and rear seat occupants. The tables below shows the H-Point coordinates and important dimensions for front and rear seat occupants.

H-Point Coordinates for Occupants			
Driver Seat Position			
Manikin Size	X	Y	Z
95 Percentile	1010	0	350
50 Percentile	934.4	0	350
10Percentile	877.9	0	350
Rear Seat Position*			
For All Sizes	1550	±320	350
*** Note the seats are tilted 10° towards outboard**			

Table 10-2: H-Point Coordinates for Front and Rear Seat

Code	Description	Dimension Value
Driver Position		
H30-1	Seat Height	405
L114	Sgrp/R/H-point to centre	1010
W9	Steering heel Diameter	360
A40-1	Torso Angle	18 degrees
L34(1)	H/point to Ankle + 254 for 95M	1011.6
L34(2)	H/point to Ankle + 254 for 50M	941
L34 3)	H/point to Ankle + 254 for 10M	888.3
L7 (1)	Steering Wheel Torso Clearance for 95 M	305
L7 (2)	Steering Wheel Torso Clearance for 50 M	234
L7 (3)	Steering Wheel Torso Clearance for 10 M	180
	H-point to steering bottom (Vertical)	147
W9	Steering Wheel Diameter	360
A18	Steering Wheel to Vertical	29°
Pedal Position		
B*	Brake pedal edge	>120
A*	Brake edge to Accelerator edge	90
G*	Ground to Pedal edge Vertical	99.5
Leg Room and Head Clearance		
L34	The distance along a line from the ankle pivot centre to the SgRP –front, plus 254 mm, measured with the right foot on the undepressed accelerator pedal	1011.6
L38	Head Clearance to Windshield Garnish-Driver (95 M)	50.6 min (75)
L39	Head Clearance to Backlight garnish (95M)	62.4
L48	Minimum Knee Clearance(Passengers)	NA
L50	SgRP Couple Distance	540
L51	Effective Leg Room (Passengers)	870.8
L53	SgRP to Heel – Front	719.2
Other Important Dimension		
L3	Minimum Compartment Room	NA
L7	Steering Wheel Torso Clearance	305
L11	Accelerator Heel Point to Steering Wheel Centre	347.2
L32	SgRP–Second to Rear Wheel Centreline	300
L114	Front Wheel Centreline to SgRP-Front	1010
Note * Indicates the self defined codes		
(1)(2)(3) Indicates the values for 95, 50 and 10 percentile manikin positions		

Table 10-3: Consolidated Dimensions for E-Mila Student

11 Conclusion

Perhaps it’s too early to predict the future of electric vehicles but certainly the light weight compact electric vehicle can be one of the solutions to the green house emission and the urban traffic situation. The E-Mila Student can be significant as the city vehicle and to use in traffic situation and parking lots for urban commuters.

The design and developing a lightweight electric vehicle based on the different regional legislative laws and packaging the vehicle according to the standards and legislation is important for the successful development of the vehicle for different markets. This further requires the study of market legislation requirements and to develop a vehicle based on common platform which fulfil all the individual regional requirements. So that the knowhow of vehicle development can be used in different regions which ultimately leads to the overall cost saving.

The outcome of the study interprets that it is possible to build the E-Mila Student vehicle on common platform for more than one market regions based on the respective legislations such as L7e category for Europe, FMVSS and CMVSS 500 for US and Canadian markets under NEV‘s (Neighbourhood Electric Vehicles) . For US and Canada markets the speed limit can be controlled for same vehicle by providing multiple key systems for speed control according to regional regulatory requirements. Kei Jidousya for Japanese market has to be considered separately as the requirements of this car are in reach to the nearly of the category of general passenger cars. As a result E-Mila Student is suitable for Europe and penetrate to the US and Canadian markets. The vehicle needs additional necessities for Japanese market, which need to be investigated with local authorities.

E-Mila Student is packaged according to the legal requirements, wherever applicable and also to the ergonomic standards as per the recommendations of SAE J1100 is the added advantage for the compact design and penetration with or without minor modification in to different markets.

Comfortable access of the driver considering torso angle to 18 ° and narrow profile in front for driver for ingress and egress is the benefit for E-Mila Student as compare to other vehicles bench marked under same category. E-Mila Student ensures the comfort room space for the occupant within the compact design as the driver seat travel 160 mm in front to accommodate all kinds of human built from 95 percentile to 5 percentile. Although very tight position for rear seat occupants considering 95 percentile manikin (City travelling is considerable) but comfortable position for 50 and less percentile manikin as the rear seat occupant uses the portion of driver compartment of the vehicle and it provides enough knee room for all sizes of occupants in the rear seat.

This thesis work is the basis for the Concept development of E-Mila student and input for the further development phase of the vehicle. And also provide the solutions pertaining to the components requirement for the construction of vehicle. Though it is not confirmed by Magna about the future of the E-Mila Student project, but the current work can be used in many directions, such as it can be used for the engineering services backup for the similar kind of vehicles, can be used for the development of prototype and to check market penetration feasibilities for any new market. The project can be also used for the marketing of services for the similar kind of vehicles and advanced vehicle development investigation in such sectors.

List of references

1. **Laboratory, Transport Research.** *Electric vehicles: Review of Type-Approval Legislation and Potential Risks.* Berkshire (UK) : Transport Research Laboratory, 2010. CPR810.

2. **European Parliament, Council:** Access to European Union Law. *http://eur-lex.europa.eu.* [Online] 9 September 2007. [Sited: 12 October 2010]

3. **European Union parliament:** *Type-approval of two or three-wheel motor vehicles*. Directive 2002/24/EC .

4. **European Union parliament:** *Agreement concerning Uniform technical perception, Geneva 1958.* Geneva: European Union Parliament, 1995. E/ECE/324.

5. **European Union parliament:** *Masses and Dimensions of Two, Three - Wheel Motor Vehicle.* s.l. : THE COUNCIL OF THE EUROPEAN COMMUNITIES,, 1993. 93/93/EC.

6. **European Union parliament:** *The braking of two or three-wheel motor vehicles.* s.l. : THE COUNCIL OF THE EUROPEAN COMMUNITIES,, 5 April 1993. 93/14/EEC.

7. **European Union parliament:** *Installation of lighting and light-signalling devices.* s.l. : THE COUNCIL OF THE EUROPEAN COMMUNITIES, 05.December.2008. 93/92/EEC .

8. **European Union parliament:** *Audible warning Devices.* Luxemburg: The Counsel of European Communities, 14 June 1993. 93/30/EEC.

9. **European Union parliament:** *The space for mounting the rear registration Plate.* s.l. : THE COUNCIL OF THE EUROPEAN COMMUNITIES,, 30 June 1992. 93/94/EEC.

10. **European Union parliament:** *ELECTROMAGNETIC COMPATIBILITY.* Oct 2002. Directive 97/24/EC - CH8.

11. **European Union parliament:** *Rear View Mirrors. Directive* 97/24/EC.

12. **European Union parliament:** *External Projections From Two or Three Wheel Motor Vehicles. Directive* 97/24/EC C3.

13. **European Union parliament:** *Glazing, Windscreen Wipers, Washers, de-icers and de-misters.* Directive 97/24/EC Chapter 12 .

14. **European Union parliament:** *Safety Belt Anchorages and Safety Belts.* Directive 97/24/EC C11.

15. **US Department of Transport:** *LABORATORY TEST PROCEDURE FOR FMVSS 500.*

16. **US Department of Transport:** Standard. Neighbourhood Electric Vehicle. FMVSS 500.
17. **US Department of Transport:** *FMVSS 205 - Glazing Materials.* Washington DC : NHTSA, 2006. FMVSS 205.
18. **Transport Canada:** *Technical Standard Document 500.*
19. **Nobumasa Saeki, Norio Yamada and Rokue Kojima:** *Japanese and Their Minicars (Kei* Jidousaya*) Technical Characteristics.* s.l. : SAE, 1983. Paper No. SAE 830942.
20. **Society of Automotive Engineers:** *Surface Vehicle Recommended Practice.* Warrendale : SAE International, 2009. SAE J1100.
21. **Society of Automotive Engineers:** *Motor Vehicle Fiducial Marks and Three-dimensional Reference System.* SAE J182.
22. **Society of Automotive Engineers:** *Defining and Measuring Vehicle Seating Accommodation.* SAE J826.
23. **Society of Automotive Engineers:** *Positioning the H-Point Design Tool—Seating Reference Point and Seat Track Length.*. SAE J4004.

Weblinks

About the Magna Group (2010)
http://www.magna.com/magna/en/about/ , 23.09.2010

About the Magna Steyr (2010)
http://www.magnasteyr.com/xchg/complete_vehicle/XSL/standard.xsl/-/content/148_906.htm?rdeLocaleAttr=en 24.09.2010

Road map on Electric cars
http://ec.europa.eu/enterprise/sectors/automotive/files/pagesbackground/competitiveness/roadmap-electric-cars_en.pdf accessed on 10.12. 2010

Electromagnetic Compatibility Test equipment
http://delphi.com/manufacturers/testing-services/luxembourg-technical-center/electromagnetic-compatibility/ dated 22nd Nov 2010.

FMVSS Regulations
http://www.nhtsa.gov/cars/rules/rulings/lsv/lsv.html 27.09.2010

FMVSS 209 Seat Belt Assembly
http://www.fmcsa.dot.gov/rules-regulations/administration/fmcsr/fmcsrruletext.aspx?section=571.209
29.09.2010

Homologation in Europe
http://europa.eu/legislation_summaries/institutional_affairs/treaties/treaties_eec_en.htm 12.10.2010

Exterior Projections
http://www.a2mac1.com/support/shareddocuments/download.asp?fid=28-10-2010_15-20-45.highlights_renault_grand_scenic_uk.pdf

Kei – Jidousya (Japanese light motor Vehicle)
http://www.nhtsa.gov/cars/rules/rulings/lsv/lsv.htm

List of Figures

List of Tables

Appendix

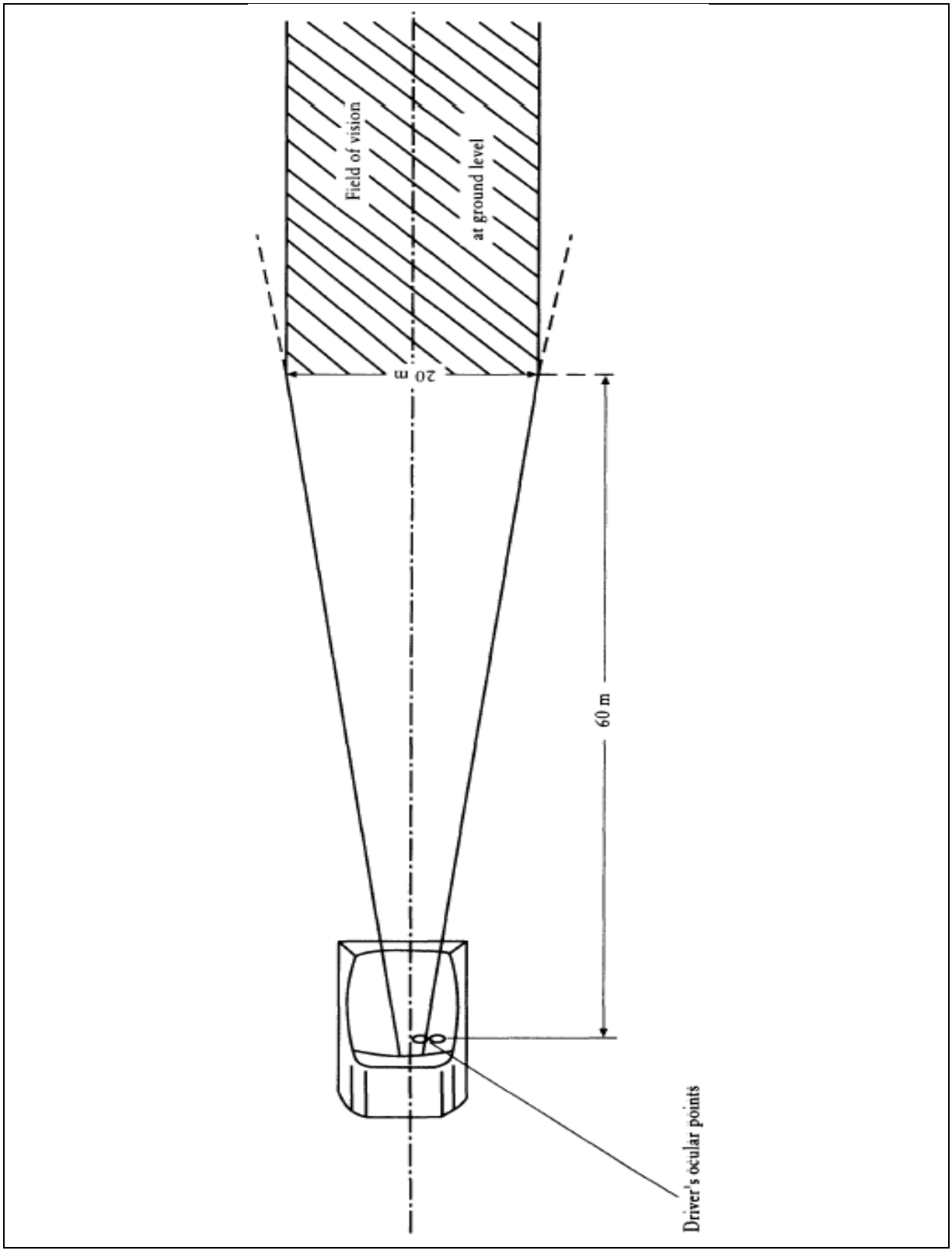
Appendix I: General Specification of E-Mila Student

E-Mila Student General Specifications	
Drive	Electric
Type of drive	Rear Wheel Drive
Chassis type	Space Frame (Al, Steel)
Outer Panels	Through-Colored, recyclable, natural fibres
Recycling Rate [%]	85
Recycling Rate and Recovery [%]	95
Number of Seats	3
Number of Wheels	4
Number of doors	3
Driver Position	Central
Motor	3 Phase Brush less
Cooling	Air
Gearbox	Single Speed

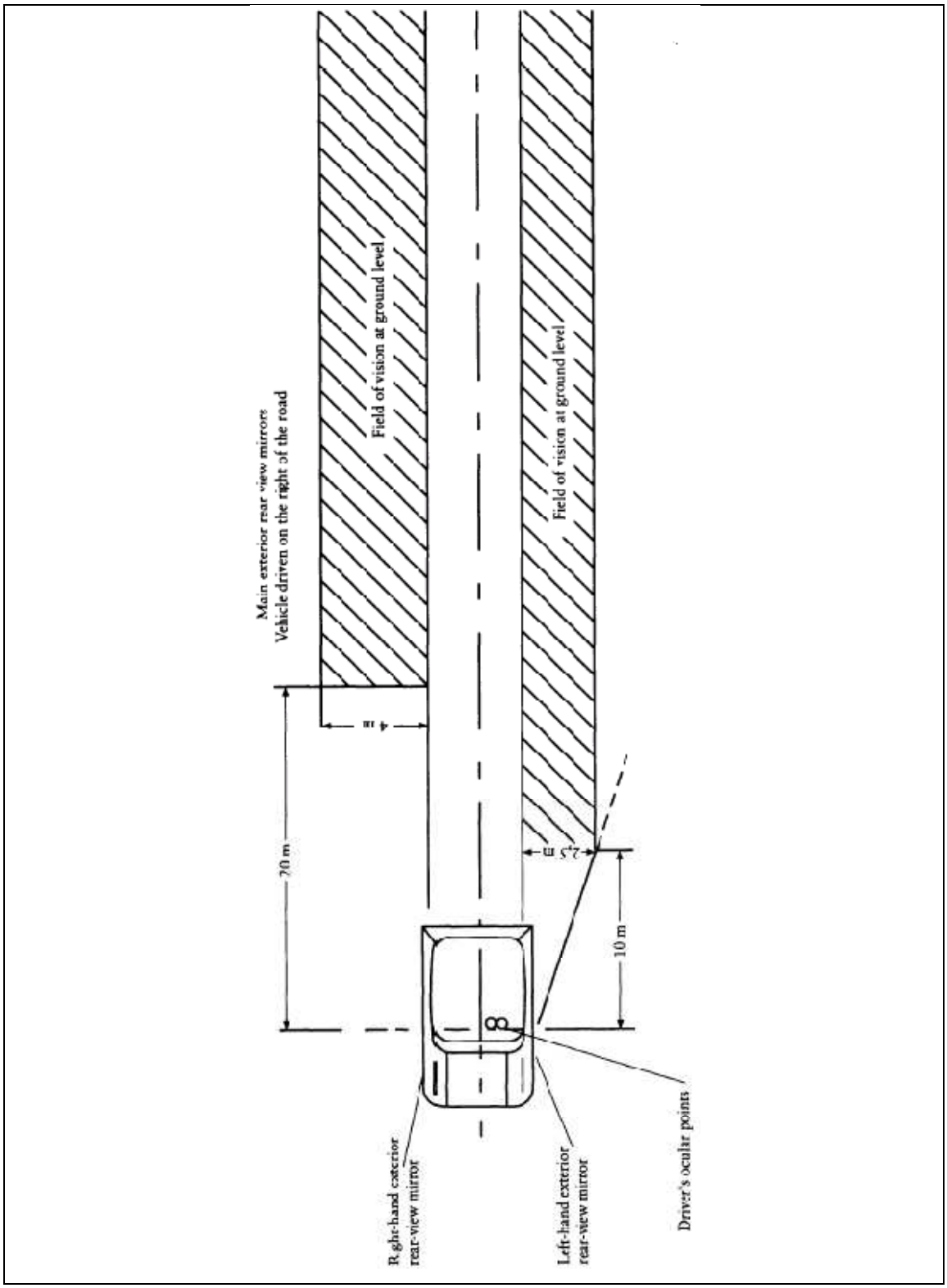
Appendix II: Technical Specification of E-Mila Student

E-Mila Student Technical Specifications	
Dimensions	
Height [mm]	1560
Length [mm]	2550
Width [mm]	1475
Wheel base [mm]	1850
Wheel Track front [mm]	1300
Wheel track rear [mm]	1300
Ground clearance [mm]	130
Overhang rear/front [mm]	50/50
Turing cycle left [m]	8
Turing cycle right [m]	8
Trunk Volume [l]	180
Interior with front/rear	1100/1350
Weight	
Vehicle weight without battery [kg]	400
Battery Weight [kg]	250
Curb Weight [kg]	650
Max. Weight kg inc. Bat+ Person + Freight [kg]	950
Weight distribution front/rear [%]	40/50
Tires	145/70 R13
Driving Performance	
Power [kW]	15
Torque [Nm]	TBD
Top Speed [kph]	85
Top Speed limited USA [kph]	56
Acceleration 0-50 km/h [s]	6
Range (including all electric auxiliaries) [km]	90
Battery	
Battery type	Lithium Ion
Battery Capacity [kWh]	15
Battery Supplier	Magna E-Car Systems
Battery warranty [years]	3
Battery warranty [km]	70000
Battery life cycle [km]	150000
Recharge time full [h]	6
Recharge time 80% fast charge [h]	0,75
Charging methods on board	normal + fast 3 phase

Appendix III: Figure showing Field of Vision for Interior Rear View Mirror (Class I)



Appendix IV: Figure showing Field of Vision for Exterior Rear View Mirror for LHD Position (Class L)



Appendix V: Complete marketing Survey

Specifications	From Priess	From Wechselberger	Europe UNECE/EEC	US/CANADA	Japan	E-Mila Student	Remarks
Vehicle Category/Standards							
Vehicle Class	L7e	L7e	L7e /L5e	FMVSS 500/TSD 500	Kei-Jidosha	L7e	
Maximum Overall Dimensions (mm)							
Height	1600-2000	1560	2500	-	2000	1545	
Length	~3000	2550	4000	-	3400	2550	
Width	max 1480	1475	2000	1828	1480	1475	* SAE Standard J2258 Recomandations
Front	No info	1238	-	-	-	1300	
Wheel Track Rear	No info	TBD	-	-	-	1300	
Wheelbase	TBD	TBD	-	-	-	1850	
Vehicle Weight(Kg)							
Unladen Mass (Without battery)	400	400	400	-	-	400	
Battery weight	~250	250	-	-	-	150	
Curb weight	~650	650	-	-	-	650	
weight	950	950	1000	1361	-	950	
Seats	3-4	3	Seat belts with 3 anchorage points	Seat Belts	Seat Belts	3	3 Seater
Powertrain							
Power (KW)	15	15	15	-	44		60 Hp in Japan
top Speed km/h	80	85	-	40	-	85	
Acceleration 0-50 km/h (s)	6	6	-	-	-		
Range km	100	90	-	-	-		100km praposed
Battery							
Battery type	LION or LMP	LION or LMP	-	-	-	LION	
Battery Power	TBD		-	-	-		
Battery Supplier	Magna E-Car System	Magna E-Car System	-	-	-	Magna E-Car System	
Battery warranty	10yrs or 100.000km	70.000 Km	-	-	-		
Battery life cycle	150000km	150000km	-	-	-		
wheel	Rear	Rear	-	-	-	Rear	
Recharge time (h)	6h full/ 45 min for 80% with fast charge	80 % fast Charge	-	-	-	80 % fast Charge	
Chassis tech	TBD spaceframe	Spaceframe	-	-	-	Spaceframe	
Outer Panels	Through-Color recyclable high natural fiber portion	-	-	-	-		
Specialities	2 charging methods on board : normal + fast 3 phase	normal + fast 3 phase	-	-	-		
Sales numbers							
base Price €	10000 wo battery						
partners	???						
Markets	Starting EU, later ROW						
Availability date	2012						
manufacturer link							
Tyres	Unloaded 519mm/T/2		Up to P category only				Superior than Standards
* SAE Standard J2258 Recomandations							
(1) Need to clarify with local authorities for details							
(2) 60 Hp in Japan							

Appendix VI: List of Regulations Cannot be used as Alternatives to Directives.

Regulation		Rev	Series	Supp	Corr
9*	Noise: 3-Wheelers	2	6	1	
15*	Emissions	3	4	1	1
29*	Protection of Occupants (cat N)	1	2	1	
32*	Rear End Collision	1		1	
33*	Head On Collision	1		2	
35*	Foot Controls	1		1	
36*	Bus Construction	3	3	12	
40*	Motorcycle Emissions		1	1	
41*	Motorcycle Noise	1	3	1	1
42*	Bumpers			1	
47*	Moped Emissions			1	
52*	Small Bus Construction	3	1	9	
55*	Mechanical Couplings	1	1		1
61*	Exterior Projections (Category N)			1	
63*	Moped Noise		1	1	
65*	Special Warning Lights	1		6	1
68*	Maximum Speed			1	
76*	Headlamps: Moped (2 Beams)		1		
84*	Fuel Consumption (OLD)				
88*	Reflective tires (category L)			1	
92*	Replacement Silencers			3	