CHALMERS

Size classification of passenger cars

Pre-study on how to size classify passenger cars by inventorying the existing classification models.

Master's Thesis in the Master Degree Programme Civil Engineering

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Göteborg, Sweden 2007
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[Cover: Figure 3.7: Car Size Incomparability of VW Golf as timed goes by, thesis page 26.]

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The Master Thesis extent is 20 points and was initiated and conducted at Vägverket in Borlänge.

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Finally I like to thank all of you who I have not mentioned that helped and supported me during this time, without you this thesis would not have been possible to accomplish.

Göteborg 2007-05-17,

Linda Opland

Förord

Detta examensarbete är ett avslutande projekt i civilingenjörutbildningen Trafik & Samhälle vid Chalmers Tekniska Högskola. Examensarbetets omfattning är 20 högskolepoäng och har utförts på Vägverkets Huvudkontor i Borlänge på uppdrag av Vägverket.

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SUMMARY
Increasing competition in today's markets, resulting in high demands on good comfort for the driver and passengers, good cargo capacity, low environmental influence and low total costs for the car owner. Implying to the importance for a classification system that can define cars in relation to their actual sizes.
However, there are not many companies that have a well-defined system that are able to perform an independent assessment of the passenger car sizes. Some of the concepts existing in the systems today are dependent on the desires and wishes from the car manufactures regarding the car models ranking in each system, a ranking that mirrors the cars status and attributes.

On this basis, the objective of the report is following:
Analyze and validate the mathematical part and verification of the classification systems and models that is presently used. On basis of physical measurement data and efficiency measurements the external size and the actual usable compartment area inside the car are too reflected. The work is limited to study only present existing systems and models that are used by companies and organisations. Furthermore is only petrol cars studied, as they represent the significant larger part of the car fleet.

The main focus has been set on the first of the two aspects mentioned above. Known and presently used systems and models which describe how cars are classified has been thoroughly studied and on basis of this, data used in each and respective model. The conclusion from the evaluation shows several distinctive parameters.
Final evaluation also sheds light on the existing size classification systems and models from a validation point of view. The evaluation result of the validation shows that many of the models are strongly influenced by the car manufacturer.

The report concludes that only a few of the now existing classification systems and methods have the objectivity that is essential for analysing input and output data.

The report is written in English.

Keywords: Passenger Car, Classification, Car Size, Physical Measured Characteristics, Parameter Evaluation

Size classification of passenger cars
- Pre-study on how to size classify passenger cars by inventorying the existing classification models.

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SAMMANFATTNING
En allt hårdare konkurrens på marknaden medför krav på god förarkomfort, bra lastkapacitet, låg miljöpåvekan samt låga kostnader för bilägaren. Detta innebär att ett system för klassificering av bilar i förhållande till deras storlek får en allt större betydelse.
Det är däremot inte många företag som har en väl definierat system för att kunna utöva en oberoende bedömning av storleksklass på personbilar. En del av koncepten som finns i dagens system och modeller är beroende på biltillverkarna önskemål om bilens placering i sådana system där en bekräftelse om bilens status och egenskaper skall speglas.

På basis av detta är rapportens syfte:
Analys och validering av den matematiska bas samt verifikation av de klassificerings modeller och system som man idag använder sig av. Utifrån fysikaliska mätbara parameter och effektivitetsmått ska den yttre storleken och det verkliga användbara passagerarutrymmet inne i bilen speglas. Avgränsningarna har gjorts till att endast studera system och modeller som redan finns och används av företag och organisationer. Vidare studeras endast fordon som använder bensin som drivmedel, då dessa bilar utgör den signifikant största andelen i bilparken.

Arbetets tyngdpunkt har lagts på två punkter. Befintliga system och modeller som beskriver hur bilar klassificeras idag har studerats ingående och utifrån detta analyserades de data som används i respektive modell. Resultatet av genomgången urskiljde flertalet viktiga parametrar. Sist har undersökning av befintliga storlekars klassificeringssystem och -modeller validerats. Resultatet av valideringen har visat att många av modellerna har varit starkt beroende av biltillverkarna önskemål.

Slutligen konstateras att endast ett fåtal av idag existerande system och metoder har den objektivitet som krävs för att data skall kunna analyseras.

Rapporten är skriven på Engelska.

Nyckelord: Storleksklass, Klassificering, Personbil, Fysiskt mätbara egenskaper, Utvärdering av parametrar

Table of Content

1 Introduction

The introduction aims to give the reader some background information about the master thesis, which was carried out at the Swedish Road Administration (SRA), Environment Section in Borlänge.
Furthermore the issue and purpose of the study is presented.

1.1 Background

During the last decades there has been an increase in passenger vehicle sizes of the world. The implication is increasing global competition which forces car manufactures worldwide to improve and introduce larger car models in order to be competitive.
Increasing competition in today's global markets, combined with high demands on comfort, economy, fuel consumption as well as environment effects and – not to forget – the image, are all customer desired factors which contributes to the importance of a independent car classification model. As the car industry has become one of the most important employer in the industrial business, with over 8 million working in or in relation to it, the domestic issues of vehicles and transportation has now become global.
The environmental concerns have become an increasing factor to society (e.g. due to global worming), car manufactures are taking their responsibility by paying attention to CO_2 emissions and fuel consumption data. To monitor the development, the European Prailment established the directive 1753/2000/EC, a scheme to monitor the average specific CO_2 emission of new passenger cars.

As the homogenization of countries and cultures increases, due to media and Internet, it also creates new ways to communicate. Another is the forming of trade regions like EU, which also contribute to the globalization. History has shown that in a highly competitive environment many manufacturers begin to produce products that will give its owners a certain image or status. Whereas is a part of this.

In the automotive industry many companies have introduced so called family cars - based on the experience in family variety - to adapt to this new reality. This also includes cars like the SUV and crossovers.

However, there are not many magazines or car rentals – nor consumers – that have a clear definition on what i.e. an small family car is.
The reasons why this has happened are many, one is the lack of guidance from the producers and another is the individual assessment of i.e. "small". Another reason is the cultural differences where as "small" cars might not be seen as a good provider of safety and status in one part of the world, as in another it just might.

The process of classification definition, which is the focus of this master's thesis, is also crucial since the guidance of customers depends upon it. It should always give a good estimate of classification belonging. There are however many challenges which needs to be addressed. The passenger vehicle classification system has to be trust-worthy with a well tuned balance of vehicle classes that the overall users can agree upon. And yet, it should also have a low latency, and a high update frequency.

"All these tasks are together very complicated and there is doubt if it will be technically possible, to build a detection model that can succeed in covering all these tasks and be accepted by everyone. "[1]

Nonetheless there is much effort put into further assisting the consumers with an easy-to-handle system.
There is however other tasks that are less complicated in the creation of a size system, of which one is the external measurement tasks.

In order to develop a classification system based on measured characteristics, one needs to take a good look on available declared characteristics and make a balanced choice.
The type of parameters and vehicle will heavily influence the choice, which does not only concern the types of characteristics, as well as passenger area issues in order to achieve desired redundancy.
The vehicle classification systems infrastructure must be able to handle many different types of passenger cars in order to make it scalable and viable for the future. A common interface towards all measurements and comfort is therefore necessary.

With this background information at hand the SRA initiated a project in a form of a master thesis; a project the writer of this thesis now have finished.

1.2 Issue

With the aim of giving a valuable input regarding attempts of finding a suitable passenger car classification system, this master thesis will have external focus.
Consequently I will not just evaluate the other company's/agency's/magazines attempts but also study the bigger context in passenger vehicle development , i.e. what is the industry's evaluation grounds built on, how has the history affected the car development and what characterize the car industry culture.

Sweden and the Swedish industry have a good reputation which one could argue would simplify the creation. There are nevertheless few well known examples of systems that partly makes a successfully definition of classes.
I will therefore also try to investigate what kind of experience the magazines and car rentals really have of the vehicle size system and the creation of classes.
The learning's made from these studies can be applied to the SRA. I will try to give answers to questions such as; can an independent car size sorting attempt be initiated and how should it be carried out.

To sum up, the four questions I aim to answer in this thesis are:

- What characterize a passenger car as a "mini"; "small", "family" and "large"?
- How do the existing classification systems define an e.g. "small" passenger car?
- Which of the existing classification systems gives an assessment of independence?
- How can this knowledge be utilized in a passenger car classification model?

1.3 Purpose

The purpose of this master thesis is to find out whether there exists a clear definition on the classification of passenger cars, based on measured characteristics. Bring forth how a classification based on specific physical measured characteristics might be constructed.

1 Stated by: Mikael Stjärna, Teknikens Värld. (Free translation)

2 Mode of Procedure

In this chapter I report on how the thesis work was carried out. By doing this the reader can form is own opinion about the reliability of the study. I describe which methodological approach I have, but also how the study was carried out in practice. Finally I discuss the quality of my research including validity and reliability.

2.1 Method Used – an Overview

In order to answer the purpose of my thesis the study of The SRAs Policy for Renting and Hiring Cars has to be complemented with in-depth studies of other companies, magazines and car rentals. After discussions with my tutors in Chalmers and at the SRA we decided to carry out the thesis as a series of case studies. Companies from different sectors have been chosen to constitute a reference to The SRA and its classification attempts in the car industry. In addition to those an automotive company has been studied in order to understand of how companies work and how their car classification process are organised. These companies' experiences and procedures regarding Car Size Classification are analysed with the aim to formulate a so called white book on how to Size Classify Passenger Cars. This white book together with an analysis of the Restriction for Renting Cars context is used to formulate a strategy for conducting a classification system.

The research was divided into four phases as illustrated in figure 2.1.
The first phase, the pre-study, included project planning, method discussions, interviews with companies /magazines/car rentals and a first general study of the passenger cars size classification of today.
In the second phase - the internal scan - begun with a literature study, complemented by interviews with companies /magazines/car rentals and the study of the automotive producer. Testing managers at the companies were interviewed via telephone and complemented with interviews on e-mail.
The third phase - the external scan - a more thorough study of the classifying process was carried out together with a search for relevant theories connected to procurement. The case studies were also carried out in this phase.
The final phase – analysis – were initialized after a mid term seminar, where a reference thesis group as well as teachers gave us feed-back. This phase, and my thesis work, was completed with a presentation of our results at both the SRA and the concerned institutions at Chalmers University of Technology.

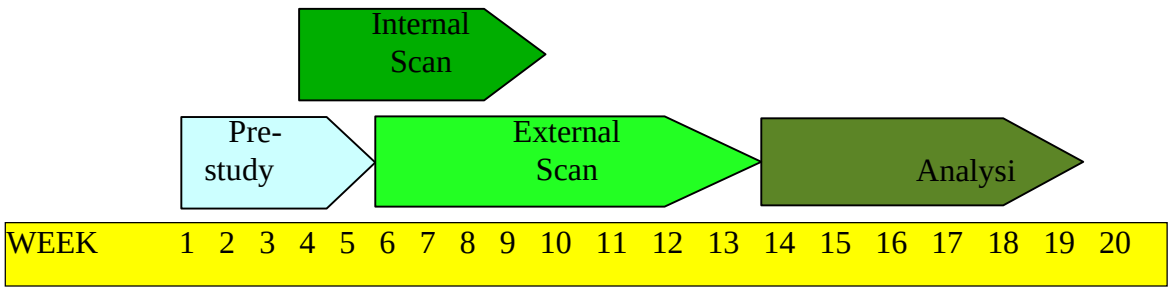


Figure 2.1: The four phases of the thesis work

2.2 Methodological Approach

There are basically two different ways on how to perceive the reality which you are studying, namely the positivistic and the interpretative approach. The positivistic approach is based on the thoughts of the philosopher Auguste Compte. He created and believed in a so called positive philosophy which implies that science should not study anything that is

not real and measurable and that facts should be separated from values. The purpose of a positivistic approach is to create a simplified model of reality since the reality itself is too complex to describe. In conformity with natural scientists the positivistic influenced social scientists believes in causal relations which involves an aim to find universal laws that are independent to the social context.[2]
The interpretative approach was formed as an alternative to the predominant positivistic orthodoxy. According to social scientists such as Max Weber and Alfred Schutz research in a social context should have a focus on understanding, rather than explaining, the human behaviour. The interpretative approach is a mixture between a numbers of different philosophies, which all asserts that the study object plays an important role for the applied method. The representatives for this approach argue that the study object in the social sciences - people and their institutions - differ a lot from the study object in the natural sciences, thus a special method is needed.
Since this thesis aims to increase the understanding of the car classification system context and relationship between people and corporations from different cultural contexts I found the interpretative approach most appropriate. In accordance with that philosophy I describe not just the experience of multi cultural business relations; but also put the result into a social science reference frame in order to better understand cultural differences that may influence business. The reference frame is based on both theoretical studies and on interviews with corporate representatives.

2.3 Research Strategy

The research strategy to use is dependent on the issue of the study. One of the most important decisions to make before carrying out the research is whether to use a quantitative or qualitative method. It is also important to decide which attitude towards hypothesis, or a pre-understanding of the study object, that is desirable.

2.3.1 Qualitative or Quantitative Approach?

The above presented scientific attitudes toward research are connected to the applied method, which can be either qualitative or quantitative. Which one to use is dependent on the issue of the research, but usually a quantitative study has a positivistic foundation while a qualitative study has an interpretative foundation.[3] There is no distinct difference between the two methods; they are both research tools that can be used separated or combined. Yet there are some principle differences between the two. In a quantitative approach the empirical information is transformed into figures that is processed and analysed using objective, often statistical, methods. When using a qualitative method the information is on the other hand processed by the researcher who influences the result with his interpretation of the problem.[4]
A qualitative study has a low formalization and the primary purpose is to understand what you study. You can use different ways to collect data to get a deeper understanding of the problem and describe the environment in which it exists. The method should reflect closeness to the source where you gather information.[5]
In this thesis I mainly use a qualitative approach. The external study is carried out as an in-depth study of a few companies and the companies are represented by only one or a couple of managers at preferably the purchasing/design/ ergonomic departments. Moreover I tried to find connections between parts that belong to a context instead of

2 Lundahl & Skärvad (1999) p 38-40
3 Holme & Solvang (1997) p 75
4 Holme & Solvang (1997) p 76
5 Holme & Solvang (1997) p 14

studying isolated events and their effects on businesses. The interviews were adjusted to the respondent in order to catch up individual experiences and deviations. Since this thesis is based on several cases that are compared to each other the approach can not be completely qualitative. The comparative aspects implies a procedure that is standardized to a certain extent. By doing this the legitimacy of a comparison is hopefully increasing, but it can also lead to questions that are based on prejudice. To prevent this I used an open questionnaire that was used more as a reference than a definite template.

2.3.2 Inductive or Deductive Method?

Also connected to the practical implementation of method in a research is whether to use an inductive or a deductive method. The differences between the two of them are illustrated in the figure below.

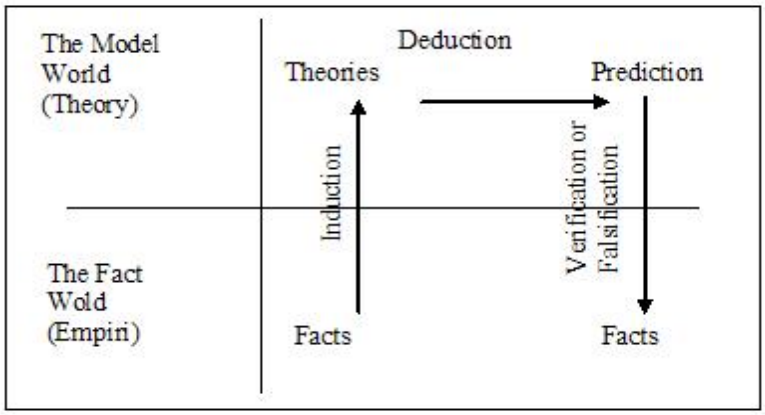


Figure 2.2: The research cycle according to the positivistic basic outlook.[6]

The inductive method is preferably used in the natural sciences or in positivistic influenced social research, often carried out in a quantitative study. This method implies that the researcher gather empirical information without prejudice and after that formulates a theory or a conclusion upon the findings. A method is nevertheless rarely completely inductive since research often is carried out in an iterative process where the theory formulation is complemented with more empirical findings. The deductive method implies that the researcher formulate hypothesizes upon his own knowledge and perception of the reality. When the researcher has abstracted the reality to hypotheses this, or these, are tested on the reality whereupon the predictions are verified or falsified in a consecutive order.[7]

In this study of size classification and how to manage customer relations with representations from manufacture and administrations, the empirical information is continuously interpreted with support from relevant theories. Since I used those theories together with the gathered empirical information my picture of what to study became clearer. This also affected the problem formulation that was a laborious process that went on during the whole research period.[8] Since I did not formulate hypotheses that were falsified or verified with a logical deduction nor made conclusions based upon solely empirical findings, my work method is to be considered as both deductive and inductive.

6 Lundahl & Skärvad (1999) p 41, figure 4.1, free translation
7 Bryman & Bell (2003) p 23-25
8 Holme & Solvang (1997) p 43

Hence, the method could be classified with an alternative approach developed by Glaser and Strauss (1967). This method - called grounded theory - is a mix between the deductive and the inductive method. The theory development, when using this method, is a process that goes on parallel with the empirical information gathering.[9] I find this classification the most appropriate for my thesis.

2.4 Practical Procedure

Besides the decision of which research strategy to use there are some decisions to make regarding the practical procedure of the study, e.g. which kind of case study is preferable, how should the information be collected and how should interviews be performed. In this section I report on the decisions made regarding those practical issues.

2.4.1 Is it a Benchmark or Multiple Case Studies?

Research can be carried out through experimental studies or non-experimental studies. In qualitative studies the researcher is obliged to the latter, since the possibility to perform an experiment is strictly limited. Among the non-experimental methods are surveys and case studies. In surveys a phenomenon is investigated by asking questions to a great number of respondents, while in case studies a fewer number of cases is investigated more thorough.[10]

A variant of the traditional case study is the multiple case studies where e.g. organisations are compared to each other considering different aspects. A comparative multiple study is to some extent a hybrid between the survey and the case study, but also the experimental study since it include the comparative dimension. The different cases can for example be chosen upon how successful they have been in a given situation. By doing this the similarities is as important as the differences seeing that they both contribute to the total outcome.[11] It is important to decide which analysis level that is relevant for the study, and if possible, study the cases upon the same level. The differences in analysis level are described in the so called SOGI model (Society, Organisation, Groups or Individuals).

This thesis is carried out as multiple case studies, where SRA's sourcing process and sourcing experiences is compared to that of five/nine other companies/magazines/car rentals. Since the purpose of this thesis is to formulate a so called handbook in car size definition the cases were chosen upon the following criteria, with the highest priority first:

- Is the company willing to be a part of our case study?
- What kind of passenger car size classification do they use?
- Does the company have a structured, standardized way of measuring/testing passenger cars?
- What kind of tests/standards/definitions do they use?
- Does the company have cooperation with other company's?
- Does the company have treated information from their cooperation company's?
- What kind of information does the company collect from these "suppliers"?

I contacted the Swedish Motoring Union that sent me a list of companies operating in Sweden. Among those companies/magazines/car rentals I selected 13 companies that I thought could fulfils the criteria mentioned above. Those, preferably big companies with representation offices here in Sweden, were contacted via mail or telephone. Finally

9 Holme & Solvang (1997) p 43
10 Lundahl & Skärvad (1999) p 50-51
11 Lundahl & Skärvad (1999) p 189

companies were chosen to be part of the multi cases study. The persons that represented the case companies were either test/product department managers or directors. The exact titles are presented in the list of reference. The selection of cases – and also the number of cases used - is often a compromise between what is theoretically desirable and what is practicable.[12]
I have intentionally chosen case companies that I believe are, or have been, successful in classification of passenger cars since the purpose of the study was to improve the possibility to find a unified classification model of independence. Hence, the study can be considered as a part of a benchmark process. One similarity between my study method and a benchmark is that both compare performance of one organization with others that are more successful in some aspects. However, my study process did not really conform to the definition of the conception benchmark that is "… the ongoing process of measure products, services and work methods in relation to those companies that can be considered as industry leaders."[13] The definition tells us that benchmarking is a continuous process that includes measuring the outcome of an operation, which not was the point of interest in this time limited research. This thesis can therefore not be classified as a benchmark study, even if it includes some elements that are similar to a benchmark study.

2.4.2 Information Gathering

In the qualitative research process information is gathered with a pre-understanding of the problem. Thus, the result will be affected by the researcher and his socially based prejudice.[14] I think that it is especially important to be aware of this fact when the study object concerns individual aspects such as my study does. The prejudice about car brands and perhaps passenger car sizes in particular, is formed since childhood and will probably affect the researchers approach to the problem. I have therefore carefully chosen my sources in the study of the thesis and also, if possible, gathered information "from both sides", i.e. read articles and interviewed people from both car manufactures and car magazine reporters.

Articles used in both the theoretical and empirical chapters have mostly been found on the electronic library of SRA, but also through Internet sites. The supervisor at the SRA has given me guidance in relevant literature that has been borrowed through the SRA's library service. When I searched information on Internet I carefully choose sites that are well known and well reputed.

Most empirical findings in this thesis are based on interviews with company representatives at the case companies (and material given by them), as well as with persons who have experience and knowledge about car manufacturing and industry. These interviews have been preceded by more or less extensive preparatory work e.g. studying of web pages, reading articles and other secondary information. The preparations were more extensive with the case interviews at hand since those interviews were more structured than the others. Furthermore I wanted to approach the interviews, concerning the use of measurement in definition of vehicle size, with a more open mind which included a restrictive use of manuals. Those interviews are to be classified as unstructured.

In the semi-structured interviews with the case companies I used the same manual for all interviews and also prepared the respondents by sending them the manual some days in

12 Lundahl & Skärvad (1999) p 192
13 Camp (1993) p 20; Free translation
14 Holme & Solvang (1997) p 97

advance. The case interviews that were carried out using telephones were later followed-up by personal interviews, when possible, and e-mail correspondence. This structured procedure is more often to be found in quantitative studies where the researcher have a clear view of what answers he is looking for. The reason for using it in my qualitative study is to ensure we get the right type of information and perhaps most important; when asking the same questions to all case companies it then allows one to compare the answers with each other.

After the first telephone interviews with the case companies I put together a survey about critical success factors for succeeding with defining car sizes based on the answers that were given.
The aggregated result from this small quantitative study are presented and analysed in the discussion chapter. The questionnaire that was used at the telephone and the on-site interviews is presented in appendix 1.

2.4.3 Observations

When making observations the researcher gets a picture of the reality by looking at, listening to and asking questions to the study object. This method implies that the researcher takes part in the group in an open or a hidden manner.[15] I have made observations at production sites, both in Borlänge and in Göteborg, which can be classified as open since the observed persons knew they were observed.
The case interviews have preferably been carried out on site which gave me a possibility to get a sense of the working environment. Since my thesis regards the designing and ergonomic aspects I highly prioritized meeting with design and marketing groups, not just to meet the case companies on site, but also to feel the atmosphere and the thought around the creation of a new car.

2.5 Quality of Research

In this final section an explanation of what validity and reliability is and what I have done to achieve this. In order to help the reader to make his own opinion about the validity and reliability of this study I also present some source criticism.

2.5.1 Validity and Reliability

To assure a high quality of the research it is important to pay attention to validity and reliability. The terms have a slightly different meaning depending on if you do a qualitative or a quantitative research. In a qualitative study validity means that there has to be conformity between the researcher's observations and the conclusions he draws. Often the validity of a qualitative study is high since the researcher spends so much time in the context he is trying to understand.[16] If a research has a high reliability it implies that the result of the study would be the same if the study was repeated in another time and another place. In other words; the study has no or few random systematic measuring faults. Reliability is harder to achieve in a qualitative study than in a quantitative one since it is impossible to "freeze" the social environment in which the study took place, and which affects the results of the study. In this thesis I have tried to reach a high validity by studying different types of companies from different sectors. I think that their aggregated knowledge about the study object can be summed up in general learning of how to manage definition of car sizes. However I am aware of the fact that all case companies are big

15 Holme & Solvang (1997) p 122
16 Holme & Solvang (1997) p 94

companies that have been chosen with SRA's situation in mind. This fact makes the results less general which therefore lowers the validity. A high reliability was important to achieve since my aim here were to compare the cases between each other. The procedure in the case studies was therefore standardized, which we described in section 2.4.2.

2.5.2 Source Criticism

The purpose of source criticism is to decide if the source is valid, reliable and if it is essential for the issues. This may be hard to determine for many sources but you should at least try to get a subjective opinion since this kind of analysis might give a clue on how certain the conclusions will become.

In this study I have mainly used internal documents, articles and interviews as secondary sources. The internal documents should give a good description of historical events (plans, former car negotiation documents), but they are however written by SRA employees and might therefore be to some extent subjective. The articles used in the theoretical framework are published in renowned papers and the books used are to a great extent prescribed books which both vouch for a high quality. The articles, books and brochures used in the empirical sections did not always have the same reliable source.

I have therefore had a critical attitude towards them and have tried to verify important fact with a supplementary source. The most difficult sources to criticize are the interviewees. I must guess the motives of the people I am interviewing and try to assess the information through that. One potential risk is that the people from the case companies might want to make their company sound more successful and innovative than it really is or was regarding e.g. their ability to conduct standardized and controlled measuring of internal car areas.
Finally, I like to comment the survey that was carried out at second interview occasion since its presentation in the discussion chapter may cause the reader to think it is a statistical survey. It is not to be seen as statistical survey but more as graphic illustration of important factors to consider when deciding upon passenger car size classification.

My aim is not to analyse the level of neither importance nor the difference among the factors but instead discuss those that most companies consider to be important and those that are needed to achieve an independent classification model.

3 Literature Study

The literature study covers the topics of interest in this study, namely definition of size, importance of standardized measuring methods and culture aspects of vehicles. The purpose of the chapter is to explain some of the trends and factors that affect international car manufacturing an also introduce the concepts used in the thesis. The three parts is finally brought together in a discussion based on a model about international size selection.

This framework is presented mainly to create a background for the reader about the factors that affects classification systems when it comes to definitions within their model. It is also a good description of the reality customers is facing today when it comes to car purchasing issues. Some of the topics described in the chapter will also be at help to discuss many of the empirical observations of the study which will be done in chapter 8.

3.1 General Theory

As companies struggle to increase customer value by improving performance, many car manufacture companies are turning their attention to passenger vehicles that are larger with more “sporty” attitude then previous passenger cars.

More recently, manufacturers have responded to buyer's complaints that e.g. SUVs "drive like trucks" and demands for "car like ride" with a new type of SUV. A new category, the crossover uses car design and components for lighter weight and better fuel efficiency, but is no longer designed or recommended by the manufacturer for off-road usage or towing.

Due to consumer trends, several companies now also produce *crossover* SUV models (also called CUV for Crossover Utility Vehicle) or XUV (not to be confused with GMC's Envoy XUV), based on a unibody which gives it a more economical construction. Typically, these models are lighter and more fuel efficient than traditional SUVs. Crossover models sacrifice off road features and load capacity for a performance/ride experience more closely matching that of a large model family car, while maintaining much of the appearance of a traditional SUV; these *crossovers* are not SUVs in the literal sense.

The CUV nomenclature was created by automotive marketing departments to move away from the station wagon, which has declined in popularity, and the SUV, which has been stigmatized in American and European culture as environmentally-unfriendly, over-sized, and wasteful with fuel. The word "CUV" or "Crossover" is not a ubiquitous term and is primarily used by people in the automotive industry.

The nomenclature's unpopularity may be due to the fact that some CUVs are compact- to mid-sized SUVs, built with car drive trains and suspensions (Subaru Forester, Volvo XC70 and Dodge Caliber etc.) while other CUVs are actually station wagons or 5-door hatchbacks with truck-like characteristics such as elevated suspensions and upright seating (Volvo XC90, Porsche Cayenne, BMW X5 etc.).

In some cases, marketing departments may sometimes blur the line between vehicle body types. Ford USA positions the Freestyle and the Edge as CUVs. Though these vehicles are actually station wagons where one resembles a compact-SUV and the other resembles a 5-door hatchback, respectively.

By one estimate between 50 percent and 70 percent of a manufacturing company’s potential in creating a new car model lays in over exceeding the competitors models; even for large manufactures like GM , Toyota, Ford and Daimler Chrysler, half of their design ideas and product development are in fact invented by other companies. Thus, an organisation’s profit is determined and defined by its customer’s purchases, and purchasing

has been considered one of the key drivers for a company's survival and growth among the development of new safety products. The car manufacturing company's has hence developed a cooperation during the years; from a situation where the only objectives were to obtain high car sales volume and services in response to internal needs, to a new one where the strategic aspects have become more important in creating more interesting cars. This development affects among other things the method of finding and selecting new marketing groups and also the relationship between companies.

Both primary and secondary data have been used, where, to a large extent, the primary data has been collected with interviews and the secondary data via literature studies.

3.2 National Car Culture

During the second part of the twentieth century there has been an rapid increase of private transports as well as lorry transports in the West Europe. A greater part of these transports is made by car. In accordance to Vilhelmsson [17] the movement of man has increased from 5 km/person and day in the 1950 to about 40 km/person and day in Sweden alone. The largest part is the household travelling, which indicates more households has access to a car. The possibility to quick and easy transportation to different locations is nowadays considered a crucial part of our culture. High movement possibilities increases the satisfaction aim of man's' wish to realize activities and needs.

The standard of living is higher than before indicates, not only an increase in travelling but also a grater awareness of quality and comfort. Some analysts believe that depending on the buyers education level results in more emotional needs, which implies that higher demands than what can be expected show in the statistics.

3.2.1 Differences in Car Culture

The culture within a country can help us understand how the cars originally were created, developed, changed and what aspects that lay behind the final design.
According to experts on cultures and organizations - every human has within them a pattern of thoughts, feelings and possible ways to react. This pattern is developed during our lives and is affected by our nationality, ethical affiliation, gender, generation, wealth and by the organizations we are a part of. People with similar experiences are said to have similar patterns inside and describe this phenomena as the culture from which the individual comes from and is affected by. Culture can be defined as "the collective mental programming that differ people from one category or group from others".[18]

Symbols are words, gestures or pictures that have special meaning for the people within a culture. All the expressions of a culture are visual practices of the culture; this means they are visual to people outside the culture. The core of the model is the values we have. These can not be observed by others but affect us a great deal. They decide e.g. what we find good or bad, clean or dirty, forbidden or acceptable and so on.
This can cause misunderstandings, confusion and creates a communication gap between companies. Especially since the separate classification systems to each car manufacture where initiated and conducted in different countries. Things to have in mind – and many other of which I will not be discussing further on in this thesis – when looking at different aspects of why different car manufactures has – usually – non direct comparative classification systems.

17 Vilhelmsson, B. 1(990) p 12
18 Geert Hofstede, Cultural scientist

3.3 Global Marketing

More and more companies choose to introduce their products to the global market at Car Exhibitions in Asia, and the reasons are many. It is often a question about economics; countries like China and India have much higher infrastructural development among the young population than the US and Sweden (and many other European countries) today. A contributing factor is seen e.g. in Japan when vehicles, often referred to in derogatory terms as "Kai"[19], due to their popularity among people living in central cities such as Tokyo, is given benefits such as free parking in the inner city and lower taxes. The upwards going marked for vehicles in this sector is to a larger extent concentrated in the younger population of buyers.
Although the development level is lower in these countries comparative with European countries the development gradient is much higher.

One of the main problems when analysing a car market is to identify which factors influence it. Selecting sales market is very important since a mistake might result in bad publicity. Customer age is one of the biggest barriers to international vehicle sale, and the understanding of culture and cultural differences is therefore a strength for any company that wishes to increase their sales marked among the younger population. There are however many factors that affect buyers decisions, most of which are presented in figure 3.1 and many of which have been discussed in this chapter.

The culture, pre-decided judgements and ethics devices are all very important factors to analyse when defining purchasing behaviour. The buyer is always considering factors like cultural similarity, ethical standards when deciding upon car brand. Most research made on purchasing ethics concludes that a code of conduct helps define purchasing behaviour.

It is a cooperative effort between buyer and manufacturer to eliminate many of the manual steps that need to be taken when communicating.

The lack of understanding for foreign vehicle driving practice, cultural differences is some of the biggest barriers in international car manufacturing. The most common way to prepare for these things is through education and development of better guidelines. This can generate support for the process and create self confidence when making business in an international climate.

19 "Kai" = the Japanese character representing revolution

Exterior Affecting Decision Factors

Factors That Affects Decision Making
Economics
Environment
Comfort
Crash Safety
Needs & Demands (Justifying)
Status & Appearance

Figure 3.1: Decision Affecting Factors
Source: TRUM[20]

Human Background Factors

Factors That Affects the Assessment Factors
Age
Household Size
Sex
Driving Behaviour
Home Staying Children
Annual Income
Annual Driving Distance

Table 3.2 Affecting Human Factors
Source: TRUM [21]

3.3.1 Classification Process at the Vehicle Manufacture

The sorting function should determine the needs of the customers, their wishes of visual status and comfort. The company ought to follow up the obtained results with evaluations and improvements.

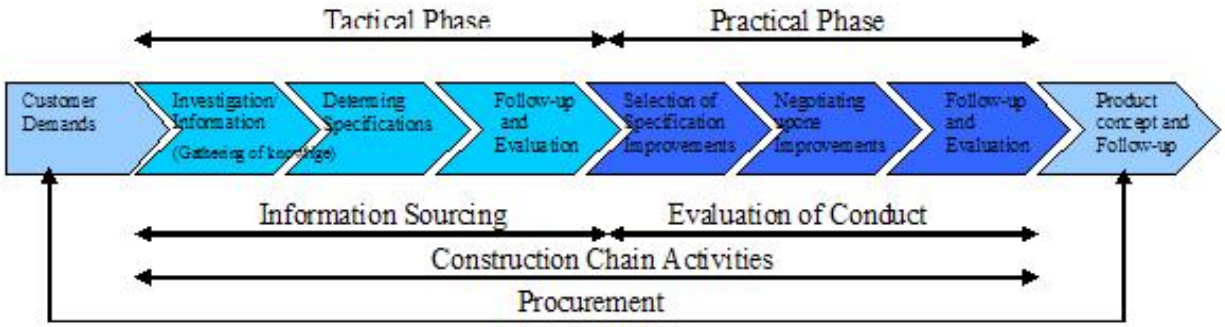


Figure 3.2: Illustration of the chain activities and also explains the terms used in car construction modelling.

According to this model the chain of passenger vehicle modelling begins with determining specifications. In this stage a need is observed and identified and the frequencies and

20 Report from TRUM, Umeå Universitet
21 Report fromTRUM, Umeå Universitet

quantity of the passenger car purchasing is determined. The next step is to identify possible improvements and then through evaluation eliminate the ones that do not reach the level of standards wanted or searched for.

This step also includes activities like finding and deciding upon the accurate car classification and gathering knowledge of the expected sales response. When it is decided upon which improvements that meet the requirements it is time for the negotiating in order to establish an agreement upon the cars development. Hopefully this agreement can be reached and the production phase can commence, this phase is also monitored and evaluated. During business-making between the companies the manufacturing car company will usually follow up and make product ratings and rankings which will then be used for further development and research.[22]

Both during the interviewing/information phase and the follow up phase the understanding of the cars impression of size has a big responsibility when assuring and determining the quality of the expected vehicle. This is usually done with assistance from a so called "marketing agency's". The marketing agency's main task is to prepare the specifications as detailed as possible, to make a preliminary qualifications potential customer's has. I will discuss the conception quality later in this chapter.

3.3.2 Classification Process for the Consumer

Besides the decision of what kind of model the customer wish to purchase, the decision is related to the discussion above concerning different types of products. The sale strategy from the manufacturer will also influence the customer's choice of model.

The choice of model in each specific situation reflects the vehicles strategically importance for the customer.

The first step in choosing car, often refereed to as confirmation sourcing, implying that the customer evaluates products or services within their conception of need (how large the family is, economy etc.) to define whether to look for a new or used vehicle.

The second step in choosing a car reflects the buyers' personal opinion of the manufactures origin and reputation.

With this information at hand the next step will be to categorize the manufactures vehicles into segments based upon their importance for the customers needs. A fundamental aspect when formulating a purchasing strategy and find out appropriate car model, is whether car manufactures has vehicle models equal or similar in sizes.

In premier studies, relation between car size, economy and environmental assessments shows significant effects on how vehicle are evaluated.[23]
One significant effect indicated that cars in the lower size spectrum are evaluated more positive in these cases then one in the upper size section. See table 4.6.

22 Van Weele (2002) p 14-17
23 Report from TRUM, Umeå Universitet

Assessments on Representative Passenger Car Size

Environmental Assessment on Car Size

CAR SIZE	AVERAGE VALUE	STANDARD DEVIATION	95% CONFIDENTIAL INTERVAL	
			Lower Control Limit (-2•)	Upper Control Limit (+2•)
SMALL	5.01	0.11	4.79	5.23
MID SIZE	4.39	0.10	4.20	4.58
LARGE	3.85	0.12	3.62	4.08

Economical Assessment on Car Size

SMALL	5.59	0.12	5.36	5.81
MID SIZE	4.44	0.10	4.24	4.36
LARGE	2.78	0.11	2.65	3.09

Table 3.3 Assessment made using a scale 1 to 7, where 1= In a very small extent and 7= In a very large extent.
Source: TRUM

Combined, all these factors relate to the further assessment, in which a selection of car models and equipment are determined.

The third step sums the outcome of the previous steps into car suggestions which fulfils the degree of need for its buyer. In this situation a vehicle that covers 5/6 of the desired quality elements is preferable.[24]

This strategy involves some sort of ruff standardization by the purchasing process and a reduction of the number of car models.

3.3.3 Professional and Company Vehicle Classification Process

Communities and authorities are looking in to their car fleet and transportation needs, and tries to correlate this by governing their transports. E.g. the actual transportation need for the upcoming travels and transportations. Private companies have also discovered the advantages with governing their transports.
Long term follow-ups can also display a win-win situation of the new strategy, since an active decision-making not only reduces their direct costs but also reduces the environmental impact of carbon dioxide pollution, higher traffic safety and simplified and improved administration.[25]

The environmental assessments for proposed actions, e.g. changing the entire car fleet of the company from gasoline to diesel, are often referred to as Environmental Impact Assessment (EIA). EIA is based on the notion that whenever an action is set, there will always be impacts on the environment.

With this information at hand a procure process can be initiated, which helps in specifying specific demands asked. A fundamental aspect when formulating a car fleet changing strategy and find out appropriate vehicles, is to evaluate the possibilities at hand in terms of covering existing needs based upon their importance.

24 Oral information from Gugge Hägström, SRA
25 Manual för upphanmdling av bilpool, September 2004 Pub.nr. 2004:126, p 7

The central aim and motive with the procure process is to formulate the organisations needs into demands, as in an economical efficiency manner helps to attain a functional car fleet.[26]

3.3.3.1 Evaluation of Needs

The strategy chosen for an analysis of the company car fleet has to have its initiation point, and in accordance with, the total need of transportation for the organisation. In these circumstances the evaluation shall aim at finding and determine to what extent the vehicles are to be used in transportation, and their exploitation grade but also the car fleets covering extent.

Further research could look for larger potential in using the vehicle capacity more correctly. As passenger cars often are a compromise of needs, the vehicles full capacity may not always be used. This confirms and suggests that the focus on the vehicles size ought to be considered, as its fully capacity might only be at use a few occasions.

3.4 The Strategic Importance of Passenger Car Size Definition

As mentioned in the previous sections the importance of size definition has increased during the last decades.

“Larger, bigger, more powerful and better comfort”. This sounds like a commercial sales advertisement for promoting the new cars improved features to the market. The truth is that it would almost fit every new passenger car model during the last 25 years, as the ongoing trend has been to build safer and bigger passenger cars.

The trend declares it self in every new generation of passenger cars as the addition of a few extra centimetres to it as well as some new extra kilograms. At the first look no dramatically changes is seen, but in a longer perspective a few centimetres has gown to decimetres and the weight from a couple of kilograms to a hundreds.

A part of the increasing of size has to do with the improvement of crash safety (e.g. more efficient deformation zones, safer occupant aria), ABS-breaks, 4-wheel drive etc. They all have a cost in weight and space. The same goes for the larger number of comfort equipments; air conditioning, GPS and electric heating in seats, which is almost seen as standard equipment in all new cars today.

Some of these weight issues have been reduced by the use of high performance steel and plastics, both in the interior and exterior design.

3.4.1 The Demanding Customer

Better car safety and more equipment inside them are not telling the full story regarding the passenger cars growing in length and weight. There are, in accordance to investigations made by both Elvingson and TRUM [27], statistics that strongly shows that a new car model will be chosen more frequently if they are larger, more ergonomic and comfortable than its predecessors. This is a demand from the customers that no manufacture dare to question. Who wants disappointed customers and reduced sales numbers?

26 Manual för upphanmdling av bilpool, September 2004 Pub.nr. 2004:126, p 13
27 Per Elvingson and TRUM Umeå Universitet

The drawback is the total increasing fuel consumption and carbon dioxide emissions. The “losers” in this case are two: Your wallet and the environment.

The most visual example on the growth of passenger car models during the past 25 years is made by Volkswagen. Due to the fact that their most important names on car models are still intact and still used since they were developed in the 70-tees. This makes it easier to follow the development of its size during the years.
Especially notify the VW Golf, which has since its début set the standard and pointed out the direction among its competitors in the same size.

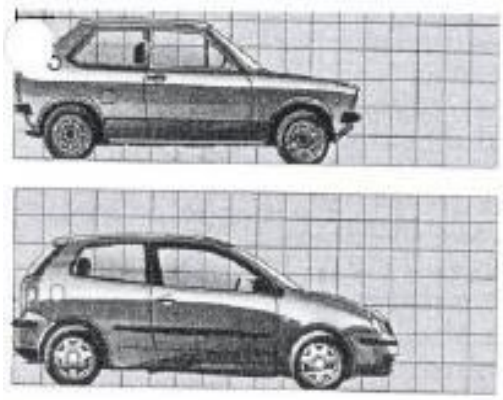


Figure 3.3:

- *First VW Polo: Length: 360 cm, width 157 cm, height 134 cm.*
- *Present VW Polo: Length: 390 cm, width 165 cm, height 147 cm.*

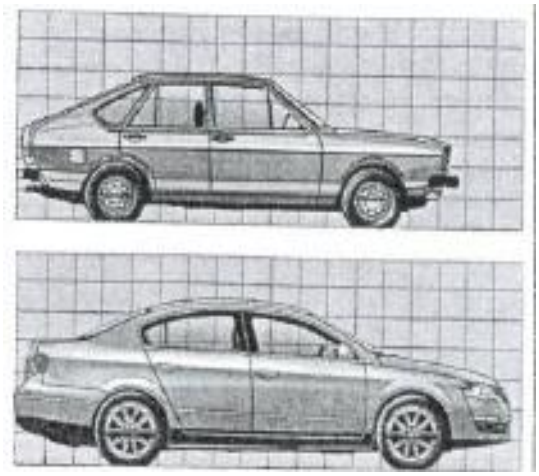


Figure 3.5:

- *First VW Passat: Length: 430cm, width 161 cm, height 141 cm.*
- *Present VW Passat: Length: 477 cm, width 182 cm, height 147 cm.*

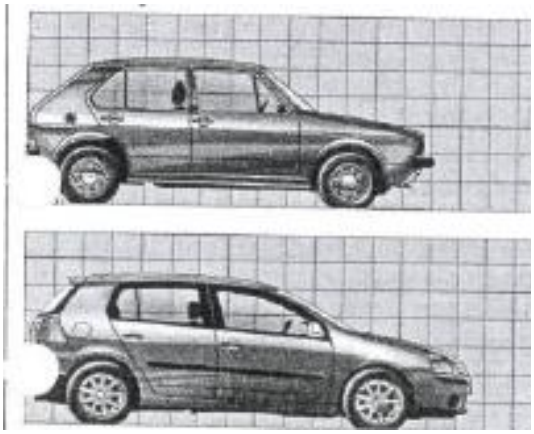


Figure 3.4:

- *First VW Golf: Length: 380 cm, width 162 cm, height 141 cm.*
- *Present VW Golf: Length: 420 cm, width 176 cm, height 149 cm.*

VW Passenger Car Growth

MEAURMENT		CAR MODEL*		DIFERANCE	
Characteristic	**SI-Unit**	**VW Polo I**	**VW Polo IV****	**cm**	**%**
Length	cm	360	390	+30	+8,3
Width	cm	157	165	+8	+5,1
Height	cm	134	147	+13	+9,7
Serving Weight	kg	780	1120	+340	+43,6
		VW Golf I	**VW Golf IV****		
Length	cm	380	420	+40	+10,5
Width	cm	162	176	+14	+8,6
Height	cm	141	149	+8	+5,7
Serving Weight	kg	910	1290	+380	+41,8

Table 3.4 Sample of VW Passenger Car Growth
** = comparing models from 1977 and 2005.*
*** = The fourth generation with the same name*

Car Model Growth

CAR MODEL*	MEAURMENT		DIFFERENCE + OR -	%
	Length, cm	Weight, kg	Length/Weight	Length/Weight
Audi 80/A4	430/459	990/1535	+29/+545	+6,9/+55,1
Audi 100/A6	470/492	1310/1690	+22/+380	+4,7/+29,0
BMW 320i/320i **	440/452	1180/1425	+12/245	+2,7/++20,1
BMW 728i/730i	490/503	1620/1880	+13/+260	+2,7/+16,0
Ford Fiesta/Fiesta**	365/392	830/1105	+27/+275	+7,4/+33,1
Ford Escort/Focus	405/434	960/1248	+29/+288	+7,2/+30,0
Mercedes 230/ E200K	475/482	1450/1580	+7/+130	+1,5/+9,0
Mercedes 280 SE/ S350	500/504	1750/1810	+4/+60	+0,8/+3,4
Opel Kadett/ Astra	395/425	920/1230	+30/+310	+7,6/+33,7
Opel Ascona/ Astra	435/460	1090/1455	+25/+365	+5,7/+33,5
Peugeot 305/ 307	425/420	1030/1300	-5/+270	-1,2/+26,5
Peugeot 504/ 407	450/468	1290/1530	+18/+240	+4/+18,6
Renault 5/ Clio	355/377	830/990	+22/+160	+6,2/19,3
Renault 14/ Mégane	405/421	980/1220	+16/+240	+3,9/+24,5
Saab 99Sedan/ 9-3	445/464	1250/1465	+19/+215	+4,3/+17,2
Toyota Corolla/ Corolla**	400/418	880/1270	+18/+390	+4,5/+44,3
Toyota Corona/ Avensis	430/463	1210/1460	+33/+250	+7,7/+20,1
Volvo 244/ S60	490/460	1340/1488	-30/+148	-6,1/+11,0
Volvo 245/ V70	490/472	1410/1556	-18/+146	-3,7/+10,4

Table 3.5 Sample of Passenger Car Growth
** = the predecessors name and new models name*
*** = passenger car models that has maintained its name sense 1977, the year of comparation.*
Source: Bilfakta 34/1977 and 116/2006

3.4.2 The Refill

As the journey continues with growing passenger cars, the distance between the former small cars and the middle sized is narrowing. To avoid that small cars are mistaken for larger models, in some extend upper sized car also has to undergo a change in size to maintain its distance towards the smaller car.

Sense the growth, cars that former belonged to the middle sized area, now tend to fit in the section of larger passenger cars.

The ability to offer customers small and cheep cars, however, it is necessary for the manufacture to fill the continuous enlarging gap that is been created.
This growing lack of smaller cars is filled up from beneath, when the former small cars passes on to larger sections.

Resulting in confusion when the selection of a car might end up in something less, or larger, than the initial thought was. Volkswagen is in this case perfect for the visualisation

of the problem. They who want a car, resembling to a Passat (from 1977) in size, now has to look for Golf. And they who wanted a Golf sized car now to find them self facing up to a Lupo.

3.4.3 Car Fleet range in relation to increasing weight, fuel consumption and environmental liability

Focusing on Sweden and the Swedish vehicle consumers, there is a significant large grope of new cars that has the highest fuel consumption in EU. Aspects of economy in forms of purchase, driving, taxes and insurance are one of the factors affected by this issue. Passenger cars in the upper size segment contribute to the environment liability with its higher fuel consumption.

The carbon dioxide emissions from new cars sold in Sweden 2006 are, in accordance to prognosis, to bee 189 g/km, which is about 11 percent over the EU-average (2004) on 170 g/km. Both Finland and UK, closest to Sweden in the list of carbon dioxide pollution, has a average emission below 180 g/km.[28]

3.4.3.1 The Environmental Disadvantages to Growing Car Sizes

For almost all passenger vehicles an increase of weight, accessories and the overall dimensions brings forth an increasing fuel consumption, which results in a higher particle pollution into the air.

Worth mentioning is the increasing volume of electronic equipments and gadgets inside cars e.g. GPS, ESC and cruise control. They all contribute to an extra fuel consumption, which is not shown in the statistics for new passenger cars, since the certification numbers are attained with e.g. ACC turned off.
This implies that the difference between the cheapest simplest car models and the largest most expensive ones is actually bigger then expected certification data.

For some car models, extra equipment can only be attained in combination with larger size of engine giving higher fuel consumption.

As a result to this, the car buyer has to choose a model with a larger engine and higher fuel consumption to obtain that little extra.

28 Oral information from Håkan Johansson, SRA Environment

Fuel Consumption in Correspondence to Car Size and Weight

CAR SIZE*	REFERENCE CAR MODEL**		CAR MODEL WEIGHT, kg		FUEL CONSUMPTION, l/100 km	
	1977	2006	1977	2006	1977	2006
Mini	Toyota Corolla	Toyota Yaris	944	1100	6,5	5,4
Small	Volkswagen Golf	Volkswagen Polo	780	1100	8,3	5,8
Small Mid size	Audi 100	Audi A3	1170	1410	10,5	7,1
Large Mid size	Ford Escort	Ford Focus 1.6	960	1248	6,4	6,7
Large	Peugeot 507	Peugeot 407 1.8	1290	1510	7,3	7,7

Table 3.6 Sample of Passenger Car Pollution
**Size Classification made by Gröna Bilister*
***Gasoline vehicles*

Several underlying factors lays behind the high carbon dioxide numbers. According to Håkan Johansson approximately 20% of the difference can be explained with a low cut of diesel cars in Sweden.[29]
As a consequent to this, the diesel driven passenger cars stands for a small part of the total annual sale in Sweden (approximately 20%)[30], I will not be able to use them furtherer on as reference in calculations or tables. Even though diesel vehicle models in general has the lowest contribution of the carbon dioxide pollution among the common existing vehicles on the marked. I will of this reason only evaluate car models running on gasoline.

Another factor influencing the consumer choice are low engine power (cheap) models which is only a question of ordering, but do not usually exist in car exhibition hall for test driving and/or has longer delivery time. Among cars that are found in the bottom of the sales list, are models with low fuel consumption which is not on sale in Sweden. E.g. Opel Corsa Eco Easytronic[31], the all over cheapest petrol car in the lower size segment, which Opel has decided upon not to bring on the Swedish market.

29 Klimatstrategi för vägtransportsektorn, p. 26-27
30 www.Bilswedwn.se, 2007-01-08
31 www.Opels.se and ACEA

Pollution in Correspondence to Car Size

CAR SIZE*	REFERENCE CAR MODEL**		FUEL CONSUMPTION, l/100 km		CARBON DIOXID, g/km	
	1977	2006	1977	2006	1977	2006
Mini	Toyota Corolla	Toyota Yaris	6,5	5,4	168	133
Small	Volkswagen Golf	Volkswagen Polo	8,3	5,8	173	151
Small Mid size	Audi 100	Audi A3	10,5	7,1	192	166
Large Mid size	Ford Escort	Ford Focus 1.6	6,4	6,7	188	165
Large	Peugeot 507	Peugeot 407 1.8	7,3	7,7	202	181

Table 3.7 Sample of Passenger Car Pollution
**Size Classification made by Gröna Bilister*
***Gasoline vehicles*

3.4.4 Incomparability Between Passenger Cars

Figure 3.6: Car Size Incomparability

Is this almost cartoon-image justified? To address the concerns, it's important to understand what car incomparability is.

When looking at two vehicles, their design characteristics affect the emotions for their occupants, and some of the same characteristics can effect differently for different people. Vehicle size and weight make a difference; with larger and heavier vehicles usually offering more visual comfort than smaller and lighter ones.

The other important aspects of comparability issue are the extent to which vehicle design characteristics increase the risks for people in traffic accidents. Vehicle weight is one such characteristic, but it's not the only one. SUVs have higher ground clearance than ordinary cars, and their front ends are often stiffer.

Figure 3.7: Car Size Incomparability as timed goes by

3.4.5 Evaluation of Test Dummy

Naked man is a fragile creature who must continually avoid harsh environments. When clothed, he can function in less favourable conditions, but he remains extremely vulnerable to blows, impacts, and accelerations. In early historic times, protective systems such as soldiers' shields were devised and later elaborated into full suits of medieval armour. The growing severity of environments rendered such protection primitive indeed, and even before the advent of the space age, the concept of human packaging within vehicles was introduced.

Anthropomorphic test devices commonly referred to as "dummies", have been the most widely used subjects for testing protective systems. The early, conventional dummies had only limited utility. While approximating human kinematics and providing acceleration and other data applicable to corresponding human body, such testing generally measures the stresses imposed upon the human body in the test situation. This can determine the potentials for severe or fatal injury associated with such stresses.

3.4.5.1 Meet the Drivers

Today the packaging of the human to minimize or avoid injury is a major undertaking. Automotive interiors are designed in conjunction with restraint systems to help safeguard the occupant, but also in achieving an ergonomic driving environment.

The dummies are classified according to their physical size. The mid-size adult male dummy, the most utilized in automotive restraint testing, approximates the median height and weight of the U.S. adult male population. The small female and large male dummies approximate the height and weight of the fifth-percentile female and 95th percentile adult male. Heights and weights of child dummies approximate median heights and weights of children of the specified age grouped, without regard to sex.[32]

32 www.ftss.com

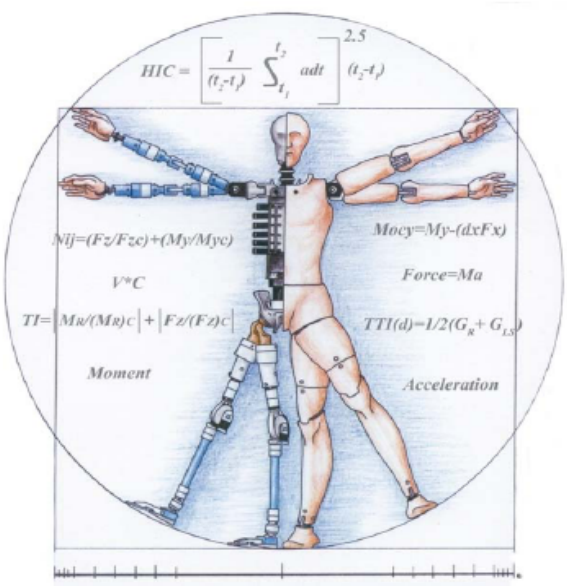


Figure 3.8: Dummy ál á Leonardo DaVinci

3.4.5.2 Dummies Used in Cars: What Dummies Know

The following contents in this chapter provides description of the present dummies most frequently used in vehicle manufacturing, their intended application, design specifications, physical characteristics and measurement dimensions.

See appendix 4E for further detailed information regarding the SAE Euro SID III Dummies.

Hybrid III 95th Percentile Male

The Hybrid III 95th Percentile Male Test Dummy are based on and represent the 95th -percentile of the European adult male population. The dummy is a larger scaled version of the Hybrid III 50th -percentile Male.

External Dimensions and Assembly Weight for Hybrid III 95th Percentile Male

Dimension *	**(in)**	**(cm)**	**Part**	**(Ib)**	**(kg)**
Dimension Length	(in)	(cm)	Body Segment Weight	(lb)	(Kg)
Head Circumference	23.7	59.7	Head	10.9	4.94
Head Width	6.3	16.0	Neck	3.7	1.68
Head Length	8.0	20.3	Upper Torso	49.2	22.32
Sitting Height	37.1	92.2	Lower Torso	66.8	30.3
Buttock to Knee Length	22.9	58.2	Upper Legs	18.1	8.21
Knee Pivot Height	23.9	60.7	Lower Legs and Feet	12.68	5.75
Total Body*	77.2	196.14	Total Body **	213.66	96.91

Table 3.8: Hybrid 95th -Percentile Male

* Other measurements, not included in Total Body Length, are; Hip Pivot From Backline and Hip Pivot Height.
** The Total Body Weight includes; Upper Arm and Lower Arm w/Hand.

Hybrid III 50th Percentile Male

The size and weight of the Hybrid III 50th Percentile Male Test Dummy are based on and represent the "average", a 50th percentile, of the European adult male population. The dummy was developed and constructed by a group of European research laboratories working under the auspices of the European Experimental Vehicle Committee (EEVC). The final specification for Hybrid III was established by EEVC in April 1996, after a 10-year period of extensive development and repeated evaluation tests.

External Dimensions and Assembly Weight for Hybrid III 50th Percentile Male

Dimension *	(in)	(cm)	Part	(Ib)	(kg)
Dimension Length	(in)	(cm)	Body Segment Weight	(lb)	(Kg)
Head circumference	22.5	59.7	Head	10.0	4.5
Head Width	6.1	15.5	Neck	3.4	1.5
Head Length	8.0	20.3	Upper Torso	56.5	25.6
Sitting Height	34.8	88.4	Lower Torso	46.7	21.2
Buttock to Knee Length	23.3	59.2	Upper Legs	26.4	12.0
Knee Pivot Height	19.4	49.3	Lower Legs and Feet	25.0	11.3
Total Body *	70.04	177.9	Total Body **	168.0	76.1

Table 3.9: Hybrid 50th -Percentile Male

Hybrid III 5th Percentile Female

The Hybrid III 5th Percentile Female ATD is a smaller scaled version of the Hybrid III 50th Percentile Male ATD. This ATD is used in test situations where the representation is needed for the minimum anthropomorphic dimensions for the adult female population. The Small Female design and test corridors were established by the Society of Automotive Engineers (SAE) for the 5th Percentile representation. In 2000, design revisions of the Small Female improved it's ability to evaluate airbag dynamics in Out Of Position (OOP) testing. The HIII-5F is provided completely tested and certified.

External Dimensions and Assembly Weight for Hybrid III 5th Percentile Female

Dimension*	(in)	(cm)	Part	(Ib)	(kg)
Dimension Length	(in)	(cm)	Body Segment Weight	(lb)	(Kg)
Head circumference	21.2	53.85	Head	8.23	3.73
Head Width	5.6	14.22	Neck	2.00	0.91
Head Length	7.8	19.81	Upper Torso	26.50	12.02
Sitting Height	29.5	78.74	Lower Torso	29.20	13.25
Buttock to Knee Length	20.5	53.34	Upper Legs	6.90	3.13
Knee Pivot Height	16.0	40.64	Lower Legs and Feet	8.95	4.06
Total Body *	62.0	157.48	Total Body **	108.03	49.05

Table 3.10: Hybrid 5th -Percentile Female

* Other measurements, not included in Total Body Length, are; Hip Pivot From Backline and Hip Pivot Height.

* * The Total Body Weight includes; Upper Arm and Lower Arm w/Hand.

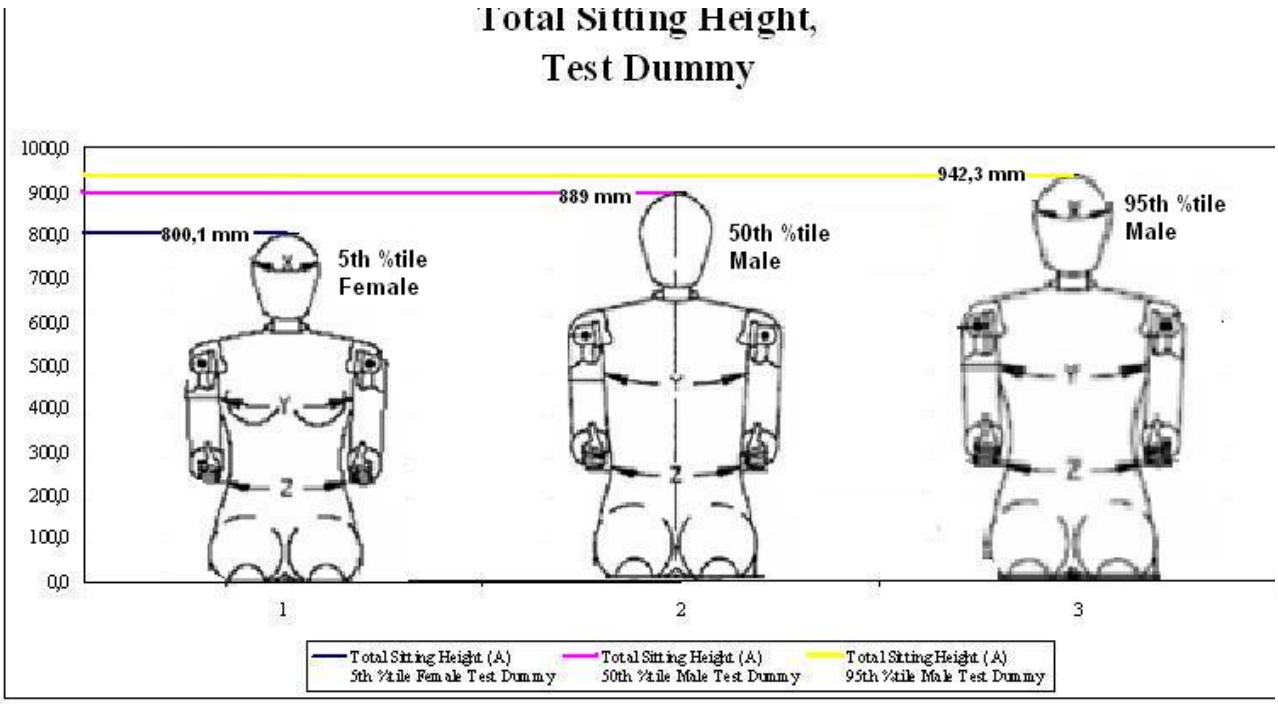


Figure 3.9: Compeer of SAE SID III Dummies

4 Regulations, Codes and Standards

4.1 Quality Systems and Norms

The most commonly used quality systems in the automotive industry are the ones mentioned above (ISO 9000 and SAE J1100), ISO/TS 16949 (where TS stands for technical specification) together with national standards such as VDA 6.1. There are also many other national standards such as AVSQ in Italy and EAQF in France. All of the mentioned standards are however very similar but I will only discuss the three most common used standards a bit more. (See Appendix 5 for further detailed information regarding the most important.)

4.1.1 International Organization for Standardization (ISO)

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from more than 145 countries, one from each country. ISO is a non-governmental organization established in 1947 and based in Geneva, Switzerland. Its mission is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity. ISO's work results in international agreements which are published as International Standards and other types of ISO documents.

4.1.1.1 ISO/TS 16949: Quality management systems -- Particular requirements for the application of ISO 9001:2000 for automotive production and relevant service part organizations

This Technical Specification, in conjunction with ISO 9001:2000, defines the quality management system requirements for the design and development, production and, when relevant, installation and service of automotive-related products. This is published by AIAG on behalf of Ford, GM and Chrysler.

4.1.1.2 ISO 17025: Requirements for Accreditation of Testing Laboratories – Quality Management Control for Measurement Equipments and Methods

This standard sets out the general requirements in accordance with which a laboratory has to demonstrate that it operates, if it is to be recognized as competent to carry out specific calibrations or tests. It is used by calibration and testing laboratories in the development and implementation of their quality systems. It may also be used by accreditation bodies, certification bodies and others concerned with the competence of laboratories.

4.1.2 Verband der Automobilindustrie (VDA)

Verband der Automobilindustrie or VDA is the German Quality Management System (QMS) for the automobile industry. It was issued the 4th edition in December 1998 and it became mandatory for allGerman car makers on April 1, 1999.

4.1.2.1 VDA

With the VDA systems, surfaces are digitized non-invasive using the whitelight fringe projection method (triangulation with projected grid and camera). Thus, a fast (1.3 million points/view) and highly accurate measurement is achieved.

The patented technology guarantees highest data quality even on complex surface geometries (depressions, elevations, bridges, etc.) by using only one camera (no synchronization errors at two overlying images, no shading effects).

Using only one high-resolution camera - which captures 1.3 million points within one shot - minimizes shading effects on complex surface structures, and further contributes to high data quality.

4.1.3 The Society of Automotive Engineers (SAE)

SAE Technical Reports play a key role in market access, safety, reducing costs, increasing productivity, improving market position and advancing new technologies.

SAE Standards: These Technical Reports are a documentation of broadly accepted engineering practices or specifications for a material, product, process, procedure or test method.

4.1.3.1 SAE J1100: Motor Vehicle Dimensions

This SAE Recommended Practice defines a set of measurements and standard procedures for 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. In addition, if measurements are taken on physical properties, some differences in values should be expected.

Unless otherwise specified, all dimensions are measured normal to the three-dimensional reference system[33], 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. Although many terms and dimensions use human body parts in their name, they should not be construed as measures that indicate occupant accommodation, capabilities, or comfort.

4.1.3.2 SAE J4002: H-Point Machine (HPM-II) Specifications and Procedure for H-Point Determination--Auditing Vehicle Seats

This Standard provides the specifications and procedures for using the H-point machine (HPM) to audit vehicle seating positions. The HPM is a physical tool used to establish key reference points and measurements in a vehicle.

4.1.4 ACRISS

The Association of Car Rental Industry Systems Standards (or ACRISS) is an international industry organization developing standards for the rental car business.

ACRISS is set up as a European Economic Interest Grouping or EEIG. An EEIG is a form of association between companies or other legal bodies, firms or individuals from different EU countries who need to co-operate together across national frontiers. It is the ideal entity for a group like ACRISS which has members, currently from three different EU countries (France, Germany and the UK). An EEIG has full legal capacity. It cannot be formed with the aim of making profit but it must aim to facilitate or develop the economic activities of its members.

33 See SAE J182

4.1.4.1 The ACRISS Code

One of their main standards is the ACRISS codes (also known as SIPP codes, Standard Interline Passenger Procedure codes) for defining rental car specifications.
ACRISS car classification coding system has been adopted to ensure that all ACRISS members display the same coding for the same vehicle, enabling to make an informed decision when comparing rates. This is done from the head-office by a continuous updating their vehicle model list with new car models once every third month. The size classification in e.g. “mini”, “compact” and “full size” is made on the basis of the manufacturer's type designation, which differ from each brand. The variant of a car type, are not allowed to differ in the respect of body stile nor powered axles or steered axles.

4.2 EG Directives

A directive is a legislative act of the European Union which requires member states to achieve a particular result without dictating the means of achieving that result. It can be distinguished from European Union regulations which are self-executing and do not require any implementing measures. Directives normally leave member states with a certain amount of freedom as to the exact rules to be adopted. Directives can be adopted by means of a variety of legislative procedures depending on subject matter of the directive.

4.2.1 EG-Directive 70/156/EEC: Type-approval of motor vehicles and their trailers

For the purpose of this Directive, “type-approval” means the procedure whereby a Member State certifies that a type of vehicle, system, component or separate technical unit satisfies the relevant technical requirements of this Directive or a separate Directive contained in the exhaustive list set out in Annex IV or XI (from 70/156/EEC).

If a part has been type-approved[34] that part need not be described if reference is made to such approval. Similarly, a part need not be described if its construction is clearly apparent from the attached diagrams or sketches.

(b) Classified according to the following international category:

1. Category M1: Vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat.

Type Approval, also known as homologation, is the process of ratification by a third party that an article, or series of identical articles, meets the legal requirements to which it is subject prior to being placed on the market. The manufacturer, having obtained type approval, is committed to ensure that any further examples of the approved article are built in conformity with the approved type and generally has to attest to each article being in conformity by either applying a special marking to the articles and/or issuing a document, a certificate of conformity, with each individual article.
Another means of having a manufacturer declare that he is manufacturing articles to a particular set of requirements is “self-certification”. Here, the manufacturer again attests that the individual articles comply but without there being any prior ratification by a third party. “Self-certification” is the method used in the USA to show compliance with the Federal Motor Vehicle Safety Standards.

34 Type of vehicle means vehicles of one category which do not differ in at least the essential respects specified in Annex II.B. A type of vehicle may contain variants and versions (see Annex II.B), Directive 70/156/EEC.

4.2.2 EG-Directive 92/21/EEC: Masses and dimensions of motor vehicles of category M1

This Directive app to the masses and dimensions of motor vehicles in category M1as defined in Directive 70/156/EEC, Article 1.

For the purposes of this Directive, 'vehicle' means any motor vehicle in category M1 as defined in Annex I to Directive 70/156/EEC, being complete or incomplete, having at least four wheels and a maximum design speed exceeding 25 km/h, and its trailers, with the exception of vehicles which run on rails and of agricultural and forestry tractors and all mobile machinery.

It is accompanied by the following documents, in triplicate, and the following information: a description of the type of vehicle, specifying the characteristics listed in Annex II, together with the documents requested in accordance with Article 3 of Directive 70/156/EEC.

4.3 Measuring Methods and Equipment

The most commonly used measuring systems in the automotive industry/companies are; ACRISS (see former chapter), Autograph and VDA. The measuring systems and standards that are endorsed by these companies are frequently upgraded and can be generally seen as reliable methods.

There are also other types of measuring systems used that is not standardized, and are conducted on terms of what seems appropriate for the moment of measurement. These systems have low reliability and can not be used in a greater context in this thesis. Although it is important to mention them – in the context that they are frequently used – and since people in general understand and can comprehend them.

Examples of equipment used by non-standardized methods; laser Hilti HD30 (bought in iron stores), folding ruler and measuring tape.

4.3.1 Autograph

Autograph Diemensiond GmbH provides car manufacturers all over the world with package data for vehicles (*Autograph-program*); for the competitor analysis in design, research and development.

The measuring method uses approximately 6000 measuring points for 200 different dimensions which show the exterior, interior, and the SAE H-Point Template shown as 3-dimensional splines, lines and cross sections. The measuring process is carried out with the aid of 3D Coordinate Measuring Systems.

Autograph’s Data-sheets show the main splines and elements of side, front and rear elevation and it contains the main dimensional data.

4.4 Other Methods of Measurement

In comparison to calibrated and evaluated data sets, about 45 other reference methods - the use of rulers, measuring tape and laser measuring instruments that are used to check the accuracy of measurement - support the assessment of:

- length,
- width,

- thickness for materials such as steel, metals, glass and fabric.

Examples of specific non-calibrated equipment and methods used by test conductors, auto salesmen and other test performing companies are listed below.

- Folding ruler
- School ruler
- Measuring tape
- Laser measuring tool: Hilti HD30
- The thumb measurement from one in the test crew
- Fizzy drink boxes
- etc.

These measuring tools are designed to help us with physical measurements. Only when they are calibrated and standardized as well as described in a standardized method will they be reliable.

Since the goal of this was to evaluate and demonstrate the measurement and their accurately, folding rural and measuring tape do not fall into the section of reliable tools to use.

5 Passenger Car Classification

This chapter describes my findings from some of the case companies and compiles what they say about their system of classifying cars. The chapter also contains basic information about the generic conception of car test information reliability from a customer view. In the beginning a short discussion about how the interviews were conducted and why a quantitative survey was answered by the companies is presented. The most important features are visualised in this chapter, as for those who has more interest in a extended version of the companies can find it presented in Appendix 4A: Case Company Review.

This case study was, as said in the methodology chapter, conducted through interviews with mainly managers at the different companies. More detailed information about the respondents is found in the sources section. The qualitative questionnaire is mainly based on issues covered in the theoretical framework and is presented in Appendix 1A.

The quantitative survey was answered by the same people as the qualitative questionnaire and will function as graphical presentation to validate what is being said in the qualitative study, a compilation of the answers will be presented in Appendix 2.

5.1 The Generic Concept

In accordance to a study made by Marell, Davidsson and Gärling (1995)[35] the car buyers intentions is affected depending on the attained information.
In spite of the fact that they are not guaranteed an assessment of independence in all "Best Car Buy" tests, they tend to have a significant impact in the evaluation process. It lays in the nature of the test to be conducted in an independent and trustworthy manner, which is not always the truth.

5.1.1 "You are what you drive"

One of the social aspects is the visualization of status, comfort and wealth that comes with a certain car brand. Some other factors that affect the customers are the presentation of the car by the salesmen, car tests and finally the influence from friends and family.
Depending on these factors the need might be altered and new issues addressed, and change the original aim.

The most important factors besides car crash safety, is packable space and the overall comfort.
When it comes to comfort a significant effect depending on the car class size was attained ($p< ,001$)[36], in accordance to TRUM Study.[37] Post hoc test (Bonferroni) shows that a car in the larger size segment are assessed as more comfortable then a car in the lower size segments ($p< ,050$).

35 Marell, Davidsson and Gärling (1995)
36 p = probability
37 Transportation study by TRUM, Umeå Universitet

Comfort Evaluation in Passenger Cars*

CAR SIZE CLASS	AVRAGE	STANDARD DEVIATION	95% CONFIDENT INTERVAL	
			Lower Control Limit (-2•)	Upper Control Limit (-2•)
SMALL	3,11	0,10	2,91	3,31
MID SIZE	4,80	0,10	4,61	4,99
LARGE	6,37	0,08	6,22	6,52

Table 5.1: Average, Standard deviation value and Confident interval for the evaluation in the car size class.
*Evaluation based on a scaled of 1 to 7, where 1 means “In a very low extent” and 7 means “In a very large extent”
Source: TRUM

The result, visualized in table 5.2, brings forth that cars in the middle segment and in the upper are considered to have the ability to meet the requests and needs, in contrary to cars in the lower segment.

Quality Evaluation in Passenger Cars

ATTRIBUTE*	SMALL VEHICLE		MID SIZE VEHICLE		LARGE VEHICLE	
	Av.	Sd Dev.	Av.	Sd Dev.	Av.	Sd Dev.
ECONOMICAL	5,47	1,38	4,54	1,18	3,16	1,41
ENVIRONMENTAL	4,96	1,38	4,50	1,18	3,93	1,42
COMFORT	0,95	1,30	4,82	1,13	6,28	0,89
DEMANDS & NEEDS	2,83	1,83	4,69	1,70	5,47	1,78

Table 5.2: Quality evaluation of vehicles in the representative car size class. Average and Standard deviation values.
*Evaluation based on a scaled of 1 to 7, where 1 means “In a very low extent” and 7 means “In a very large extent”
Source: TRUM

5.1.1.1 Tests Final Evaluation

As a result, conclusions can bee drawn that the size of the car is significant and a decisive factor in the assessment to what extent the passenger car full fills the customers demands and needs. When it comes to crash worthiness and comfort larger cars in the upper size class region are considered as better then those in the lower region.

Due to human evolution we are more likely to select a car in a specific segment, when it has attributes that are desirable for many people. When it comes to environmental issues and actual needs, less is decided upon.

5.2 The Magazine Industry

Today magazines that are profiled on cars and specifies in car tests and evaluations, are many. As a potential car buyer it is a jungle to master, especially since you get different results, depending on the magazine.

As sad earlier; it lays in the nature of the test to be conducted in an independent and trustworthy manner, which is not presumed to prefer any brand. That a car becomes “Best Car Buy” in tests has a significant impact in the evaluation process and decision making. Therefore it is of importance to evaluate and identify how they attain their test results, conduction of methods and equipment used.

Magazines and company's specialized in performing car tests is generic seen as reliable and serious, in contrariety to the daily magazines/newspapers which tend to be less trustworthy.

5.2.1 Auto Motor und Sport

Auto Motor und Sport (AMS) has both a local and one global system. At the moment there is one German system that is used by all AMS magazines and one local for each country e.g. Sweden. Local test evaluations are used for supplying the car fleet in e.g. Sweden with raw material and less complicated test procedures, while the global one is intended to supply information to publication plants all over the world.

The German Auto Motor und Sport vehicle size classification is attained without special size definitions. To decide upon vehicle class, they only use external measured characteristics that are (by them) declared as sufficient enough.[38]

The parameters used in these car classes are defined by:

- Format (Length, width, height and size of internal area)
- Prize
- Name (The car classification expected depending on the history and wishes of the manufacture).
- How they stand comparative to VW models (All car manufacturers' compeer their cars in some extent with passenger vehicle models from VW).[39]

5.2.2 Teknikens Värld

A deeper integration of the test methods used by Teknikens Värld , displays that the test methods do not follow any official standardizations or norms, nor are the measurements done with any official standardized methods or equipment with certification.[40]
Measurement conduct protocol: See Appendix 3A.

The final car evaluation is made by the translation of different tests into a numeric scale, where the combined total sum measures the cars overall assessment. Through the years the tests has been improved several times as new parameters are evaluated and added to the systems accompanying the readers' interests.

Due to the method, the user can only compare models that are defined in similar classification classes by the manufactures. E.g. "Small"-cars at manufacture "A"'s classification system to "Small"-cars in manufacture "B"'s classification system. This does not allow a direct size comparison between the selected cars, mere a hint since the service is based upon manufacture definitions.

5.2.3 GT-Expressen

The Technical Motoring department at GT-Expressen is based on reporters with special interest in cars, motoring and technical devises.

GT-Expressen Motor has developed their own car size classification system in 7 different divisions, based on the idea to keep it simple for the reader to comprehend. These classes are founded on given size, measurements and class from the general importer.

38 Muntlig info från AMS
39 Information given from both Volvo, BMW VW and Renault.
40 Mikael Stjärna, Teknikens Värld

GT-Expressen tend to have a more or less floating classification system, discussions regarding in which category to put the car in question tend to act on a daily basis. However, this manually adjustable category undermines the professional aspects of the system. As the test methods do not follow any official standardizations or norms, or directives.

5.3 The Automotive Industry

Car manufacturing is a global industry and automotive companies operate world wide.

Assessing capacity and potentials within regions, Europe is a mature region and therefore slow-growing or stagnant market and has a significant overcapacity.[41] Estimation for this overcapacity in Europe is 20 – 25%, and suggests that the demand would have to increase by between 8% and 10% a year just to utilise existing manufacturing capacity.[42] Growth of 8 –10% in such mature markets tend to be unlikely, particularly bearing in mind increasing environmental concerns.

5.3.1 Cooperation between Car Manufactures

The risk for high development costs and unprofitable operations have forced car manufactures to join into big corporations (GM, Ford, Daimler Chrysler etc.). By using common strategies for development and manufacturing of cars within the corporation, large cost savings can be done.
Under this big corporations are cross-brand groups created; I.e. Premium Brand Group by Ford (VOLVO, Lincoln, Jaguar and Land Rover). In these groups common platforms are used to cost-optimize development- and manufacturing costs. This is a contributing reason to the fact that the differences in car size among the brands are smoothing out.

5.3.2 Bilfakta

Bilfakta Personbilar, is the most used car information books in the automotive sales industry today. Since it was established and systematically begun to test cars, the information is continuously updated each month to match the car industry.

Today the books consist of information regarding currant prices and technical performance, with to scale images over the car models. And it comprise the entire range of cars on the Swedish market, with approximately 1000 different car models and over 40 car brands.

41 Source: Centre for Automotive Research (Germany)
42 Source: ACEA and EU 15

Figure 5.1: Visualization of the Passenger car book and its contents.

The measurements used in Bilfakta includes 9 parameters, measured by the verification/authentication system *Autograph*, brings together forth an Internal Space Index of Passenger Cars (UTR-index in Swedish).

The IS- (or UTR-) Index does not classify or tell how cars stand up to each other, but gives a hint on how it can be possible to make an unified denomination system that will work for all passenger cars. Regrettably the IS-Index calculation is not connected to SAE or ISO nor to VDA standards.

Even though the recorded IS-index do not lend it to be compared with VDA, the use of Bilfaktas' Cargo Area Index is well known in the car industry.

5.3.3 Volvo Car Cooperation

In 2005, Volvo Cars sold a total of 443,947 passenger cars. The largest market is the USA, which accounted for 28% of the total sales volume in 2005. The US is followed by Sweden (12%: 52,696 cars), Britain (8.6%), Germany (7.9%) and Italy (4.6%).

Volvo has main responsibility within Ford (PGA) for new car models in the same size category as the Volvo S80 and V70. Volvo, with its tradition in the field of safety, also has main responsibility for engineering work relating to the body and interior, as well as electronics.

The car’s design is developed and enhanced in a continuous process. This includes the monitoring of new trends, design languages and customer preferences. (Increasing competition in today’s markets, combined with high demands.)[43]

Volvo as well as other car manufactures do not design their cars to fit into a specific classification group. They target customer groups, and of this reason do not use any classification models.

5.4 The Car Rental Company's

The Swedish Car Rental fleet had total revenue of around 1 413 millions in 2005, with 74% of the total cars rented were made at full service car rentals.
Due to the competitive environment in which these company acts, the information regarding their classification systems are difficult to receive. In spite of this fact the Swedish BURF (Biluthyrningsbranchens Riksförbund) has made a list of all Car Rentals in Sweden and information concerning company's in cooperation with them are able to attain e.g. Avis, Hertz and Sixt. By contacting the Swedish BURF, I was able to receive contact information to the larger car rental companies acting in Sweden.

43 www.volvocars.se

According to my responders, from the selected car rentals, there is a distinctive difference in the way which the company's operates.

5.4.1 AVIS

The AVIS Company Classification Code , AMS[44]; is based on the data given from the car manufactures and defines cars from the smallest as an “A” up to the fullest size, defined as “P” (premium van). Here the separate car manufactures concept definitions is valid due to lack of an independent size classification at AVIS.

Displayed below are samples of the car fleet in the AVIS system.

AVIS System Code

AMS Code	Car Model Examples
A	Hyundai Atos
B	Opel Corsa
C	Opel Astra 1.6
D	Nissan Primera 1.8
K	Opel Vectra 2.2
H	Nissan Primera Wagon
G	Opel Astra 1.6 Wagon
E	Opel Vectra 2.2
F	Saab 9-3 2.0
I	Opel Vectra 2.2 Wagon
O	Saab 9-5
J	Saab 9-5 Vector Wagon
N	Chevrolet Transport 3.6
M	Saab 9-5 Vector 2.3
P	Opel Vivaro 2.0

Table 5.3: Classification Samples

5.4.2 HERTZ

Hertz uses two separate classification systems when it comes to defining cars, ACRISS (see section 4.1.4) and their own Company Code.

The Hertz Company Classification Code is based on the data given from the car manufactures. Here the separate car manufactures concept definitions is valid.
The vehicles in each size of Hertz; *Small, Mid Size* and *Full size* is based entirety on the measure of classification outlined by the American National Standards Institute (ANSI D-16, 6th ed.). It is also used by NHTSA (National Highway Traffic Safety Administration) and adopted by the National Center for Statistics and Analysis (NCSA).

44 Avis Measuring System

Definition of Classification

Vehicle Class	Vehicle Criteria
Small car	Wheelbase: < 104 inches
Mid size car	Wheelbase: 105-109 inches
Full size car	Wheelbase: > 109 inches
Green Collection	Has a weighted CO_2 output level of less than 140g/km and between 40 to 65 MPG.
Prestige Collection	Includes the latest range of luxury models from an expanded fleet of sedans, coupés, convertibles and high-performance vehicles.
Fun Collection	Sport cars and vehicles with special popularity factors.

Table 5.4: Sample of Classification Definitions

5.5 Euro NCAP

Euro NCAP provides a system where the cars crash safety is evaluated. Crash testing cars is a way to get an early indication of the safety level of new cars as the test procedure visualise. Cars that perform well in this test should provide some sort of evaluation ground for the compeer of ability by given size f the vehicle.
Euro NCAP was originally developed by the Transport Research Laboratory for the UK Department of Transport (DFT). Subsequently the classification process used is basically the DFT system from 1996 (when Euro NCAP was initiated), and from 1998 the additional classification from vehicle manufactures up to present date.

Vehicle segments in Europe don't have formal characterization or regulations. Models are attributed a segment based on comparison to generalist brands models.

For safety ratings, the Euro NCAP uses nine car classification categories:

- Superminis (it includes city cars)
- Small family cars (also for stand-alone saloon superminis, like the Dacia Logan)
- Large family cars (includes compact executive cars)
- Executive cars (for expensive cars over 4.80m long)
- Roadsters
- Small off-roaders (similar to the North American crossover SUV category)
- Large off-roaders (similar to the North American SUV category)
- Small MPVs (both mini MPVs and compact MPVs)
- Large MPVs

6 Other Organisations and Administrations

6.1 Konsumentverket

The Swedish Consumer Agency (Konsumentverket) is a state agency whose task is to help the general public in Sweden with consumer affairs. The SCA represents consumer interests in relations to businesses, and pursues legal action in the consumer interest.

The car size classification is attained without special size definitions. Too decide upon vehicle class, they only use weight as characteristic that is (by them) declared as sufficient enough. No furtherer ranking is made.
The parameters used in these car classes are defined in table 6.1.

Car Classification by Weight

Classes	Parameters (Total Weight in kg)
Small	< 1101 kg
Small Mid-Size	1101 – 1250 kg
Larger Mid-Size	1250 – 1400 kg
Small Large	1401 – 1600 kg
Large	> 1600 kg

Table 6.1: Classification by Weight

6.2 Gröna Bilister

Gröna Bilister (The Swedish Association of Green Motorists, SAGM) was founded in 1994. It is a small non-governmental organisation (1 000 members) and based very much on voluntary work. The aim is to make road transport friendlier to the environment and to promote public transport and bicycling as alternatives, particularly in urban areas.[45]

The vehicle size classification are categorised by the passenger vehicles transportation capability, instead of external characteristic measurements (used up until spring 2006). The segmentation of classes (six in numbers) made by SAGM is based upon number of seats, maximum load capacity (passengers [á 70 kg] + luggage) and steered axle distance, which gives an indication of the inner volume and the number of adults [á 70 kg] that are declared to fit inside.

6.3 Centre for Automotive Industry Research (CAIR)

The complexity and diversity of cars means that conventional eco-ratings such as those used for white goods, present insurmountable difficulties. A number of environmental ratings systems for cars are currently in use, notably in Germany (VCD Auto Umweltliste; Auto Motor und Sport), Sweden (Rototest), but also in the UK (Environmental Transport Association Car Buyers Guide). These are all primarily aimed at private consumers. However, they miss out a number of key indicators. In addition, the European Commission has announced it was to introduce its own eco-rating for cars by 2000. This was likely to be based on CO_2 emissions, although a more comprehensive system where introduced in due course (AEA 42,1998, 13- 16).[46]

45 www.gronabilister.se
46 Developing an Environmental Rating System for Cars (2002), p 2

Dr Paul Nieuwenhuis and Dr Peter Wells from Centre for Automotive Industry Research, Cardiff University in Wales UK , were developing a system at the Centre for Automotive Industry Research (CAIR) in collaboration with a European car producer, that was aimed at corporate fleet buyers, who where facing the increasing pressure of their own company's environmental performance and image.

6.3.1 An Environmental Performance System

The system developed by CAIR and its partners are a first step in this eco-optimization direction. It is by no means straight-forward to rate the performance of a car.

In addition they where addressing some of the flaws of the existing systems by taking into account issues such as product durability, but also by incorporating a segmentation system allowing a more meaningful comparison of competing products to be made.

The formula is as follows and relates size and weight:

Vehicle length (metres) x width (metres) x weight (tonnes) = ESS*

As a proxy for the environmental impact of a vehicle it is a fair measure as it relates the vehicle's weight to its 'footprint' and thus relates literally to its impact on the earth. The system shows how light-weighting of larger cars can pay off, but also tackles Elise vs Discovery anomaly. In each case they used the lightest variant listed; i.e. with the lowest level of specification.

Although the ESS could be used as a stand-alone rating system, at present CAIR intends to use it as an input figure for a more comprehensive rating system, incorporating some of the elements reviewed thus far, which is still under development.

* ESS = Environment Segmentation System

7 Vehicle Classification by the English systems

There are many ways of classifying cars. The common North American parlance is word-based (e.g. compact car). While English-speaking European writers also use words to describe car sizes, rather than segment numbers or letters, the descriptions used are generally different from the North American terms. In parts of Asia, segment letters are sometimes used.

The passenger volume reported bellow is an estimate of the size of the passenger compartment. The luggage volume is the size of the trunk or, in station wagons and hatchbacks, the cargo space behind the second seat. In a few cases, the addition of passenger and cargo volume numbers indicates that a vehicle should be in the next higher classification. This is not the case as the data have been rounded to the nearest 0.1 cubic feet number.

7.1 North America: USA regulations (ACS)

The interior volume is measured using SAE Recommended Practice J1100 as American government defined class size under Code of Federal Regulations, Title 40--Protection of Environment, Section 600.315-82 Classes of comparable auto mobiles. Passenger car classes are defined based on interior volume index or seating capacity, except the ones classified as special vehicle. A two seater is classified as a car with no more than two designated seating positions.

The SAE procedure calculates interior volume from many height, width and length dimensions inside the vehicle, including head room, foot room, seat width, etc.

Others as follows:

American Car Classification

VEHICLE CLASS	MEAURMENT Interior Volume Index (Cu. Ft.)
SEDANS	
Mini-compact car	< 85
Sub-compact car	85 - 99.9
Compact car	100 - 109.9
Mid-size car	110 - 119.9
Large car	> 120
STATION WAGONS	
Small station wagon	< 130
Mid-size station wagon	130 - 160
Large Station wagon	> 160

Table 7.1 Sample of American Passenger Car Classification

Interior volume index is calculated differently for different vehicle classes:

- For passenger automobiles, it is calculated for each car line which is not a two seater. For car lines with more than one body style, the interior volume index for the car line is the arithmetic average of the interior volume indexes of each body style in the car line.
- For all body styles except station wagons and hatchbacks with more than one seat

(e.g., with a second or third seat) equipped with seatbelts as required by DOT safety regulations, interior volume index is the sum, rounded to the nearest 0.1 cubic feet, of the front seat volume, the rear seat volume, if applicable, and the luggage capacity.

- For all station wagons and hatchbacks with more than one seat (e.g., with a second or third seat) equipped with seatbelts as required by DOT safety regulations, interior volume index is the sum, rounded to the nearest 0.1 cubic feet, of the front seat volume, the rear seat volume, and the cargo volume index.

All dimensions and volumes shall be determined from the base vehicles of each body style in each car line, and do not include optional equipment.

Front seat volume is calculated as product of:

- Effective head room-front
- Average of shoulder and hip room-front, if hip room is more than 5 inches less than shoulder room; Shoulder room-front, if hip room is not more than 5 inches less than shoulder room
- Maximum effective leg room-accelerator

Rear seat volume is calculated for vehicles within a rear seat equipped with rear seat belts (as required by DOT), as product of:

- Effective head room-second
- Average of shoulder and hip room-second, if hip room is more than 5 inches less than shoulder room; Shoulder room-second, if hip room is not more than 5 inches less than shoulder room
- Minimum effective leg room-second

For passenger auto mobiles with no rear seat or with a rear seat but no rear three point safety belts, the area to the rear of the front seat shall be included in the determination of usable luggage capacity.

7.2 British: UK regulations (BCS)

English-speaking European writers also (like the American) use words to describe car sizes, rather than segment numbers or letters, the vehicle size descriptions used are generally different from the North American terms.

Vehicle segments in Europe don't have formal characterization or regulations, and as to that vehicle models are attributed a segment based on comparison to generalist brands models. For example, a car the size of a Volkswagen Golf would be its competitor. The Volkswagen Polo is smaller, so it belongs one segment below the Golf, while the bigger Passat is one segment above.
The classification system was initially developed by the Transport Research Laboratory for the UK Department of Transport (DFT). Subsequently as the classification process is also used by Euro NCAP, some of the car classes are similar to each other. Although the main difference between the two is the BCSs additional segmentation classification, which sets it in a similar position to ACS.

8 Summary of Case Study

In this chapter I analyse the findings from the case studies. Thereafter I will ascertain which implications these might have for the development of a classification model. The discussion how SRA should go on looking for a suitable classification model and what strategy to use if so is concluded in a scenario analysis. Finally I will give SRA my recommendations of what to do in chapter 12.

8.1 The Classification Context

The assessment of cross size sections and the actual usable passenger area inside a vehicle is a common request. Due to the integration of the methods and systems used in the car industry today, creating a new system that will assess a wide range of data without adding any uncertainty in measured characteristics is desired.

Demonstrating the suitability of a measurement process by means of measurement system capability studies is part of established and common practice in the car industry. However, there are no standards governing the activity of defining the (effective) size of a car. There are only requirements defined by various company standards. In the automotive industry, the procedures defined in chapter 4, have found widespread acceptance.

During the last few years several new vehicle types have appeared that require an own class, so called “crossovers”. They are often based on unibody architecture. Typically, these models are lighter and more fuel efficient than traditional SUVs. Crossover models sacrifice off road features and load capacity for a performance/ride experience more closely matching that of a large model family car, while maintaining much of the appearance of a traditional vehicle. The process for determining these vehicles into the system are in general done more or less in hope that they will have a own class later on. This might be on of the reason why the measurement in defining effective car size has so far not been a point of major interest in industry. But since some buyers now require a determination of the effective car size, it will only be a question of time before they ask for more detailed information about this.

8.2 Case Study Review

During my research I have collected a lot of information about how the studied companies/magazines/authority classifies passenger vehicles by size. A comparison of every aspect from every company in order to figure out the best way to determine the characteristics and parameters to use is thereby an essential part of this work. I will therefore analyse every company/magazines/authority and then use the characteristics which I believe to be the most important when defining a vehicle size classification, to compare the companies with each other. Those characteristics are obviously not the only factors which affect a company’s success in the classify task. I will therefore analyse every case shortly and highlight the qualities and experiences which have the biggest impact when attempting to size classify passenger vehicles.
A matrix that highlights the most important features of the companies is presented in Appendix 4.

8.2.1 Characteristics for the Passenger Vehicle Size Classification

Taking a closer look at the case studies, and disregarding the method for mathematical modelling of the measurements, a model that are independent, based on a few characteristics, is much easier to understand. If you make a further limitation or

assumption, i.e. that the factors that might be affecting the classification processes e.g. price, is not a correlated factor, the determination of characteristics for enabling a size classification of vehicles again becomes much easier. Following this approach, it is easy to define and apply a process for establishing the uncertainty of measurement by declared characteristics and thereby its definition of vehicle size, just as has been done in the case studies.

This approach is used to give a fairly straightforward description of how to establish the passenger vehicle size classification for various types of measurement processes.

The one major problem that users currently have with the definition model is that there are several possible ways to interpret car size model. In other words, there is not just one method or standard, but users have to define 'their own' procedure. Hence, any company dealing with these matters would be well-advised to define a consistent procedure for its staff to follow. Otherwise the results will lack comparability, with disagreements between various company departments or between customers and suppliers being an inescapable consequence. Currently, no relevant commensurability exists between the measurement models of different companies.

8.3 An Analysis of Company/Organisation/Authority

It is clear that the size classification systems achieved in the scenario case analyses are not fully substantial. It is to some extent surprising that it is possible to separate cars built with the same design functions, and with differences that only be defined as luxury gadgets. While there are little to no difference between the car rentals size defining systems, car magazines seems to have some cooperation with accredited test labs and car producers. These magazines tend to have a definition system that is average or lesser compared to other and depending on the degree of the reporters interest and evaluation grounds. Authorities have a more intense cooperation with accredited test labs and car producers. This results in a high input of qualitative information data, enabling good grounding for a vehicle size definition system.

8.3.1 Comparing Passenger Vehicle Measurement System Studies and the Determination of Vehicle Size Classification

The statement can be formulated as "that there are at present no readily available methods for the assessment of car size classification, when the human interaction has a major influence on the system". With the results of this research, a solution is imminent. However, using numeric characteristics to assess and determine vehicle classification still requires more work further on.

The academic need, to detect methods and models and to use them to investigate the total systems behaviour against measured parameters, in order to obtain size determination system of independence has been satisfied. This work's research question can be formulated as "how to define a classification system, where the human influence is not an essential part for the performance of the total system". The associated hypothesis is that by extending the simulation models to not only cover the necessary regular car types and models e.g. sedan (Volvo S40) and station wagon (Volvo V50), but also include models of the more exotic versions e.g. extreme sport models (Ferrari F50), qualitatively better answers regarding above mentioned complex product properties can be found. There is no need to model the human influence involvement in detail; sufficiently good results can be obtained by implementing principal class operating decision models and strategies. This has clearly been demonstrated.

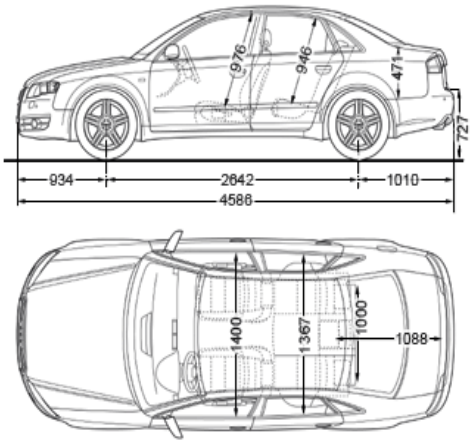


Figure 8.1: Vehicle Characteristics

8.3.2 Company Analysis

Companies of interest worth mentioning are reviewed in this chapter.
See appendix 4B for Case Company Matrix Comparisons, 4A: Case Company Review, and also 2: Case Company Questionnaire Answers.

Without going into the relative benefits and disadvantages of the given methods, this comparison shows that determine passenger vehicles by measurements ought to be just straightforward. Additional components can easily be taken into account. The widespread and proven study procedure can thus be transferred to the determination of necessary measurements, simplifying and formalising this process and ensuring that results will be comparable. Existing vehicle data from the general importers can even be used to calculate the relevant estimate of size.

EURO NCAP is an initiative to drive vehicle safety beyond current regulation, by offering the market more extensive information about adoption of best practice. Euro NCAP has never been intended to predict the size outcome on a car by car characteristic basis. It should not even theoretically be able to do that in the current form with no reflection on representative weights on different aspects of measurements, as e.g. Bilfakta does. However, it is still important to evaluate whether the general way of promoting vehicles with the system of today, actually fulfils the need of guidance.

Key Learning's from Euro NCAP:

- Structured way of obtaining crash safety data, large knowledge regarding vehicle crash compatibility.
- Reliable results and data with good monitoring of standards, regulations and methods.
- Is not strictly defining passenger vehicles by dimension characteristics into classes.

While Euro NCAP is in first case a process that should lead to car manufacturers aiming for best safety practice, SAGM (Swedish Association for Green Motorists) strives for a further development of environmental awareness in motoring and its importance to the outcome is constantly monitored.
Monitoring the vehicle size development is of importance also in finding any indications of

sub-optimisation or other negative consequences which have a large impact on environment, economy and safety.

Key Learning's from SAGM:

- Have strict demands on environmental pollution levels (particles, sound, vibrations and CO_2).
- Have ISO certification and EG Directives as required demands on pollution levels.
- Has made a simple and well working vehicle external size classification, which can be handled with ease. Although it gives nothing in terms of inner size nor the ergonomic aspects.

AMERICAN ENGLISH CLASSIFYING SYSTEM

American system defines class size under Code of Federal Regulations with the interior volume measured using SAE J1100. Passenger car classes are defined based on interior volume index or seating capacity, except the ones classified as special vehicle. A two seated is classified as a car with no more than two designated seating positions.

The procedure of calculating the interior volume is generated by the use of height, width and length dimensions inside the vehicle e.g. head room, legroom and shoulder room. This can be considered successful as for the determination of the inner area. Assessments of the vehicle size are obtained by the use of this index parameter. The reasons for their success are obviously many but perhaps most important is their visualisation of vehicle characteristics.

Key Learning's from the American English Classifying System (ACS):

- Two seated vehicle is not defined nor separated with a inner volume calculation.
- Do not measure trucks in the same manner as passenger cars.
- Has made a complex breakdown in vehicle class definition, and a well working inner volume size classification.
- Have strict boundaries on inner volume for each passenger vehicle class.
- The index parameter (inner volume) obtained by their calculation formula is a good provider of assessment for size denomination.

BILFAKTA is probably the company with most experience of obtaining accurate physical measurements in my study and, as I stated above, a company that can be in some extent considered successful with determination of the inner area. Although the index parameter obtained is not used for any assessment of size. They do not pinpoint car models in separate classes by their size, as they sort the vehicles by brand and vehicle name instead.

When I say that Bilfakta is successful in some regard, it is because they source a relatively big part – about 60 % of their total measurements - from the car manufacture head quarters. (OEM[47]) The reasons for their success are their visualisation of vehicle characteristics. The company also has a very well developed internal measurement denomination, since their primary activity is to visualise vehicle parameters.

Key Learning's from Bilfakta:

- Bilfakta do not pinpoint car models in separate classes by their size.
- The index parameter is obtained by their calculation formula and is not used for any assessment of size.
- They source their measurements from the car manufacture head quarters.

47 OEM = Original Equipment Manufacture

MAGAZINES like Teknikens Värld and Auto Motor & Sport, as well as almost every car magazine company, does not have its own very well developed vehicle classification in their organisation. The company purchase all technical data from other technical/motoring companies and it is the reporters that have the responsibility to create an efficient customer relationship. This is obviously not very surprising since they are typical magazine companies with a focus on the vehicles external design, driving capabilities, engine and safety gadgets.

Key Learning's from Car Magazines:

- Do not have ISO certification as a required demand, nor standardised measuring methods in their vehicle evaluations.
- Purchases all technical material and data from test institutes, which in some cases has ISO certification.

CAR RENTALS has a detailed and planned way of how to find the accurate classification for each vehicle. They have groups of experts and let them search the vehicle market and furthermore try to identify as many of the classes as possible to give a better picture of the overall status of the market. That is an issue car rentals generally is very good at; they are prepared to work closely with both dealers and car manufactures for its continuous improvement of their car denomination system.

Key Learning's from Car Rentals:

- Each company has their own classification model. This denies a fair comparison between companies.
- Continuously updates their classification list, to include the markets new car trends.

8.3.3 A Comparison of the Case Studies

From the empirical findings of my case study, the general thoughts about how to classify passenger vehicles by size are quite similar. All of the companies believe that you need; vehicle serving weight, interior volume, number of passenger seats etc. to some extend. Of the studied companies it is only Bilfakta that is successful in obtaining declared measured physical characteristics and the American English Systems in classifying passenger vehicles by declared characteristics into different sizes. Worth mentioning are also the Environmental Segmentation System (ESS) performed by CAIR. This is quite a simple basic index, strongly orientated to the 'popular' concerns over emissions. The only area where there is scope for improvement in the total score beyond a defined limit is fuel economy. This environmental performance rating has a number of advantages; chief among these strengths is its simplicity. Comparison with test results for larger cars also shows that these are not penalised unduly, each comparative test primarily scoring the cars tested relative to each other. Work which CAIR carried out recently for one of the leading UK leasing firms showed the importance of this.

What sets Bilfakta apart from the rest of the companies? First of all they have not developed a classification function. They are the only company in the case study which uses a finished measuring product from an well accredited supplier. Since Bilfakta is so dependent on their technological functions they have understood how important it is to actively develop the measuring systems further with the supplier, this is especially true as the IS-index is what the company known for. The measuring products they buy is mostly made by Autograph in Germany and are very complex to attain. Furthermore the supplier, Autograph, of the obtained measurement products are to be found to be reliable in order to

achieve good results. Bilfakta, compared with ACS, CAIR, Avis, Euro NCAP and SAGM (magazines can not really be compared in this regard since they lack the inner volume assess), does not have any basic demands on either size or inner volume criteria whereas their measurements are very flexible of use. I believe this is a conscious philosophy since the car industry is so rapidly changing.

ACS on the other hand has normally a lot of focus on the inner volume factors in order to minimise pollutions and economical disadvantages, as the system is used by the US DOE (Department of Energy) for the implementation of vehicle taxes. The aspects of vehicle size and the inner volume calculation system play a significant roll in the classification assessment. Also the beneficial impact with this all over vehicle evaluation is that it is simple to understand. It allows comparison to be made between models and manufacturers, regardless of vehicle prize, status etc.

The fact that most of the case studied companies actively participate in the development of new measuring techniques, probably explains their success to a large extent. This might also be the reason why, especially Car Magazines, have not been that successful in this regard. Companies operating in the car reviewing industry needs to understand the potential that lays in the standardised quantification of all measurable aspects.

8.4 Discussion

As earlier chapters describes it, a formal aim of this size classification is required as a basis and serves as an aid for, decision making with regards to internal space. Informal aims could be, according to Gugge Hägström and Petter Åsman48, to bring environmental, economical and actual need awareness into not only organisations but also to help private consumers evaluate the aspects of the vehicle parallel to the evaluation of economical aspects.

The vehicle definition can vary between countries depending on the requirements from the country's customers and their opinion on car size. Nevertheless, distinct stages that can be found in most systems in one form or another:

i. Vehicle type by the manufacturer's type designation;
ii. Clarification of vehicle class by weight, engine, powered axles, wheelbase etc.;
iii. Consideration of alternative classification (e.g. luxury);
iv. Auditing whether the vehicle meets its class objectives.

However these stages define the car in a class, there are seldom any assessments on passenger volume. If so, mostly as crash safety parameters for the interior safety equipments are mentioned.

8.4.1 Conclusion of Case Study

- There was a strong and consistent overall correlation between the passenger vehicle size classification model in Euro NCAP, and the size classification model by ACS, and information from Bilfakta and the BCS classification.
- The system developed by CAIR is a first step in a eco-optimization direction in which the environmental performance of a car is rated.
- No strong overall relationship between the classification models used by car rentals and those used at authorities and organisations could be detected.

48 Information given by Gugge Hägsrtröm and Petter Åsman, SRA Borlänge

- Overall, organizations are good in providing systems with well defined boundaries. Their systems provide a good assessment for the size denomination issue.

8.4.2 Final Summary of Case Study

Given the conclusions of the case study, the most important identified factor is the large variety of classification models existing within the car industry.

This discovery is important for a number of reasons. First of all it obviously contributes to the confusion when the systems can't be compared. The comparability is a vital function and it is not easy to compare the case companies' classification systems.
This can be explained by the fact that not all studied case companies tend to have a system based on measured dimensions made in accordance to standards. Another reason is the use of subjective "exclusive" classes in the classification model, where cars is separated depending on their price and luxury standard.

Furthermore, organizations like Euro NCAP; ACS, CAIR, has a direct relation and is familiar with the car culture industry which is an advantage in the classification model creation.

The second most important factor is very similar to the first, and treats how information is handled and used. The case company survey indicates that the large variety in handling e.g. measurements and its use in classification modelling is fatal for the classification model.

The second most important identified factor concerns the companies' set-up of classification definitions. In order to find suitable definitions, and be able to use them, a company must decide upon model boundaries and determining the measuring dimensions for each boundary level. This imps a certain amount of active decision-making and is an indispensable part of the classification assessment.

9 Experimental Set-up and Data Collection

The proper experimental set-up and field data collection is a significant part of my research project. The settings for data collection are described in this chapter.

As stated earlier the identification of measuring characteristics is of importance.
This leads me to believe that if an organisation wants to identify cars in a classification model they should focus on less complex classification, and use the measuring data available.
I also believe that a dynamic evaluation system is crucial for an organisation both through offering better car guides, and the ability to compare cars without the attribute of price and status.

9.1 Performance Evaluation

Whenever there are various possible ways to evaluate the same result, then you always evaluate the performance by using standardised methods. This can be done by using original methods or make some controlled amendments in those methods to get the optimal performance.

9.2 Evaluation of Methodology

The attempt has been made in researching the best methodology to detect and estimate the external size and interior volume and dimensions. The dimensions of the 5^{th}, 50^{th} and 95^{th} - percentile dummies are used as boundaries in the interior assessment, even though the dummies are not originally designed to be used in the assessment of interior dimensions.

Furthermore has the EPA Passenger Volume, CO_2 Mass Emission, ESS and vehicle weight as well as shadowed area been evaluated.

9.3 Modules and System

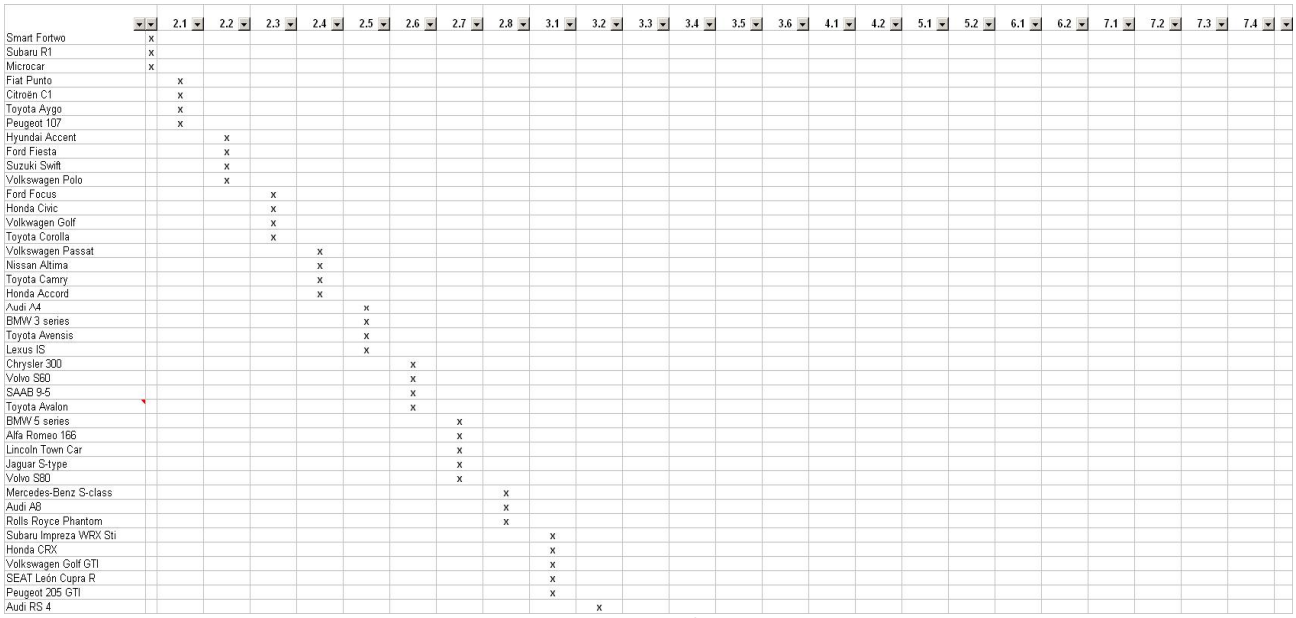
The size impact of a car, the vehicle's weight and its 'footprint', relates literally to its impact on the environment. In each case the most standard variant listed is used; i.e. with the lowest level of specification.
Combining the classification models by ACS, BCS, Euro NCAP and the common used Segments with a number of characteristics; it is possible to evaluate the methods independent of each other.

		American Classification	British Classification	EuroNCAP	Segment	Example
1	1.1	Microcar	Microcar, Bubble car	-	-	Smart Fortwo
2	2.1	-	City car	-	A class	Fiat Punto
	2.2	Subcompact	Supermini	Supermini	B class	Hyundai Accent
	2.3	Compact car	Small family car	Small family car	C class	Ford Focus
	2.4	Mid-size car	Large family car	-	-	Volkswagen Passat
	2.5	Entry-level luxury car	Compact executive car	Large family car	D class	Audi A4
	2.6	Full-size car	-	-	-	Chrysler 300
	2.7	Mid-size luxury car	Executive car	Executive car	E class	BMW 5 series
	2.8	Full-size luxury car	Luxury car	-	F class	Mercedes-Benz S-class
3	3.1	Sport compact	Hot hatch			Volkswagen Golf GTI
	3.2	Sport saloon	Sport sedan			Audi RS 4
	3.3	Sports car	Sports car	-	-	Porsche 911
	3.4	Grand tourer	Grand tourer	-	-	Jaguar XK 8
	3.5	Super car	Super car	-	-	Ferrari F50
	3.6	Muscle car				Pontiac GTO
4	4.1	Convertible	Cabriolet	-	-	BMW 3 Series Conv.
	4.2	Roadster	Roadster	Roadster	-	BMW Z4
5	5.1	-	Mini MPV	-	B class	Opel Meriva
	5.2	Compact minivan	Compact MPV	Small MPV	C class	Mazda5
6	6.1	Minivan	Large MPV	MPV	D class	Toyota Previa
	6.2	Van				Dodge Ram Van
7	7.1	Compact SUV	Compact 4x4	Small off-Roader	C/D class	Honda CR-V
	7.2	Mid-size crossover SUV	Large 4x4	-	E class	BMW X5
	7.3	Mid-size SUV	-	-	E class	Jeep Grand Cherokee
	7.4	Full-size SUV	Off-roader	Large Off-roader	-	Cadillac Escalade

Figure 9.1: Classification Model Matrix

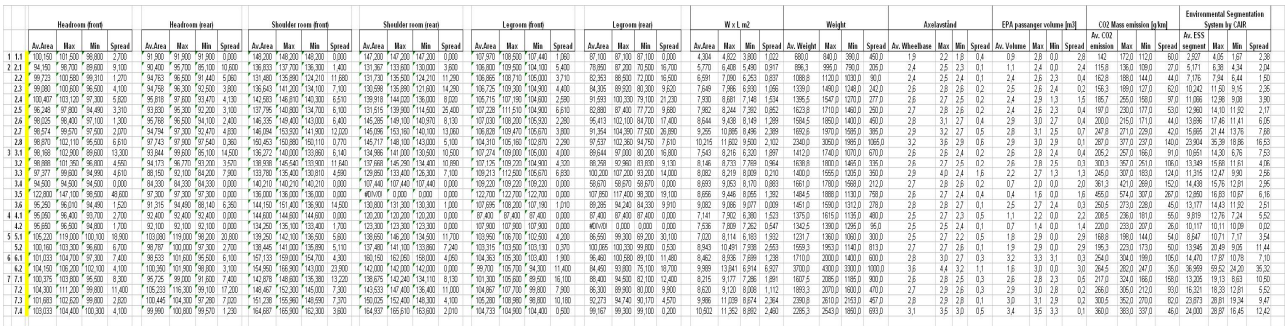
The sample size for each group is selected to be three to five vehicles, to obtain an average and spread. The following characteristics have been evaluated:

- Width (m)
- Length (m)
- Shadowed Area (m^2)
- Weight (kg)
- Wheelbase (m)
- Headroom front and rear (cm)
- Hip room front and rear (cm)
- Legroom front and rear (cm)
- Shoulder room front and rear (cm)
- EPA Passenger Volume (m^3)
- CO_2 Mass Emission (g/km)
- ESS (Environnemental Segmentation System) (m^2*tonnes)



	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	3.1	3.2	3.3	3.4	3.5	3.6	4.1	4.2	5.1	5.2	6.1	6.2	7.1	7.2	7.3	7.4
Smart Fortwo	x																							
Subaru R1	x																							
Microcar	x																							
Fiat Punto		x																						
Citroën C1		x																						
Toyota Aygo		x																						
Peugeot 107		x																						
Hyundai Accent			x																					
Ford Fiesta			x																					
Suzuki Swift			x																					
Volkswagen Polo			x																					
Ford Focus				x																				
Honda Civic				x																				
Volkwagen Golf				x																				
Toyota Corolla				x																				
Volkswagen Passat					x																			
Nissan Altima					x																			
Toyota Camry					x																			
Honda Accord					x																			
Audi A4						x																		
BMW 3 series						x																		
Toyota Avensis						x																		
Lexus IS						x																		
Chrysler 300							x																	
Volvo S60							x																	
SAAB 9-5							x																	
Toyota Avalon							x																	
BMW 5 series								x																
Alfa Romeo 166								x																
Lincoln Town Car								x																
Jaguar S-type								x																
Volvo S80								x																
Mercedes-Benz S-class									x															
Audi A8									x															
Rolls Royce Phantom									x															
Subaru Impreza WRX Sti											x													
Honda CRX											x													
Volkswagen Golf GTI											x													
SEAT León Cupra R											x													
Peugeot 205 GTI											x													
Audi RS 4												x												

Figure 9.2: Sample Size for each group



	Headroom (front)				Headroom (rear)				Shoulder room (front)				Shoulder room (rear)				Legroom (front)				Legroom (rear)				W x L m2				Weight				Axelcentand				EPA passenger volume [m3]				CO2 Mass emission [g/km]				Environmental Segmentation System by CAR			
	Av.Area	Max	Min	Spread	Av.Area	Max	Min	Spread	Av.Area	Max	Min	Spread	Av.Area	Max	Min	Spread	Av.Area	Max	Min	Spread	Av.Area	Max	Min	Spread	Av.Area	Max	Min	Spread	Av. Weight	Max	Min	Spread	Av. Wheelbase	Max	Min	Spread	Av. Volume	Max	Min	Spread	Av. CO2 emission	Max	Min	Spread	Av. ESS segment	Max	Min	Spread
1 1.1	100,160	101,500	98,800	2,700	91,900	91,900	91,900	0,000	148,200	148,200	148,200	0,000	147,200	147,200	147,200	0,000	107,970	108,500	107,440	1,060	87,100	87,100	87,100	0,000	4,304	4,822	3,800	1,022	660,0	940,0	590,0	450,0	1,9	2,2	1,8	0,4	0,9	2,8	0,0	2,8	142	172,0	112,0	60,0	2,927	4,05	1,67	2,38
2 2.1	94,165	99,700	89,600	9,100	90,400	95,700	85,100	10,600	136,833	137,200	136,300	1,400	131,367	133,600	130,000	3,600	106,800	109,500	104,100	5,400	79,860	87,200	70,500	16,700	5,770	6,400	5,490	0,917	896,3	995,0	790,0	205,0	2,4	2,5	2,3	0,1	1,1	2,4	0,0	2,4	116,9	136,0	109,0	27,0	5,171	6,38	4,34	2,04
2.2	99,723	100,580	99,310	1,270	94,783	96,500	91,440	5,060	139,480	139,890	124,210	11,680	131,730	135,500	124,210	11,290	106,895	108,710	105,000	3,710	82,353	88,500	72,000	16,500	6,591	7,090	6,253	0,837	1088,8	1120,0	1030,0	90,0	2,4	2,5	2,4	0,1	2,4	2,8	2,3	0,4	162,8	188,0	144,0	44,0	7,176	7,94	6,44	1,50
2.3	99,980	103,600	96,500	4,100	94,758	96,300	92,500	3,800	136,643	141,200	134,100	7,100	130,598	135,890	121,600	14,290	106,725	109,300	104,900	4,400	84,305	89,920	80,300	9,620	7,649	7,986	6,930	1,056	1339,0	1490,0	1240,0	242,0	2,6	2,8	2,6	0,2	2,5	2,6	2,4	0,2	156,3	189,0	127,0	62,0	10,242	11,50	9,15	2,35
2.4	100,467	103,120	97,300	5,820	95,818	97,800	93,470	4,330	142,583	146,810	140,300	6,510	139,918	144,000	136,000	8,020	105,715	107,190	104,600	2,590	91,593	100,330	79,100	21,230	7,930	8,681	7,145	1,534	1395,5	1547,0	1270,0	277,0	2,6	2,7	2,5	0,2	2,4	2,9	1,3	1,5	195,7	255,0	158,0	97,0	11,066	12,96	9,08	3,90
2.5	96,248	97,900	94,490	3,310	93,630	95,300	92,200	3,100	137,795	140,900	134,700	6,100	131,515	139,900	114,500	25,400	107,228	111,510	104,900	6,610	82,993	87,400	77,720	9,680	7,963	8,244	7,382	0,862	1623,9	1710,0	1460,0	250,0	2,7	2,8	2,6	0,2	2,4	2,6	2,3	0,4	197,0	230,0	177,0	53,0	12,960	14,10	11,92	2,17
2.6	99,025	99,400	97,100	1,300	95,700	96,500	94,100	2,400	146,335	149,400	143,000	6,400	145,295	149,100	140,970	8,130	107,030	108,400	105,920	2,280	95,413	102,100	84,700	17,400	8,644	9,438	8,149	1,289	1594,5	1850,0	1400,0	450,0	2,9	3,1	2,7	0,4	2,9	3,0	2,7	0,4	200,0	215,0	171,0	44,0	13,986	17,46	11,41	6,05
2.7	98,574	99,570	97,500	2,070	94,794	97,300	92,470	4,830	145,084	153,900	141,900	12,020	145,096	153,160	140,100	13,060	106,828	109,470	105,670	3,800	91,354	104,390	77,500	26,890	9,205	10,886	8,496	2,389	1692,6	1970,0	1595,0	395,0	2,9	3,2	2,7	0,5	2,8	3,1	2,5	0,7	247,8	271,0	229,0	42,0	15,995	21,44	13,76	7,68
2.8	99,870	102,110	95,500	6,610	97,743	97,900	97,540	0,360	150,453	153,880	150,110	0,770	145,717	148,100	143,000	5,100	104,310	105,160	102,870	2,290	97,537	102,360	94,750	7,610	10,215	11,802	9,500	2,302	2340,0	3050,0	1995,0	1055,0	3,2	3,6	2,9	0,6	2,9	3,0	2,9	0,1	267,0	377,0	237,0	140,0	23,904	35,39	18,86	16,53
3 3.1	99,168	102,900	89,600	13,300	93,844	99,600	85,100	14,500	136,272	140,000	133,860	6,140	134,966	141,000	130,500	10,500	107,274	109,000	105,000	4,000	89,644	97,000	80,200	16,800	7,543	9,216	6,200	1,897	1412,0	1740,0	1070,0	670,0	2,6	2,6	2,4	0,2	2,8	2,8	2,4	0,4	205,2	257,0	166,0	91,0	10,651	14,30	6,76	7,53
3.2	99,888	101,350	98,800	4,550	94,175	96,770	93,200	3,570	138,938	146,640	133,900	11,640	137,668	145,290	134,400	10,890	107,125	109,220	104,900	4,320	90,758	92,960	83,600	9,130	8,146	8,735	7,769	0,964	1639,8	1800,0	1495,0	305,0	2,6	2,7	2,5	0,2	2,8	2,5	0,3	300,3	357,0	251,0	106,0	13,349	15,66	11,61	4,06
3.3	97,377	99,600	94,990	4,610	88,150	92,100	84,200	7,900	133,780	135,400	130,810	4,590	129,660	133,400	126,300	7,100	109,213	112,500	105,670	6,830	100,200	107,200	93,200	14,000	8,082	8,219	8,009	0,210	1400,0	1555,0	1205,0	350,0	2,9	4,0	2,4	1,6	2,2	2,7	1,3	1,3	245,0	307,0	183,0	124,0	11,315	12,47	9,90	2,56
3.4	94,500	94,500	94,500	0,000	84,300	84,300	84,300	0,000	140,210	140,210	140,210	0,000	107,440	107,440	107,440	0,000	109,220	109,220	109,220	0,000	59,670	59,670	59,670	0,000	8,693	9,053	8,170	0,883	1661,0	1780,0	1559,0	212,0	2,7	2,8	2,6	0,2	0,7	2,0	0,0	2,0	361,3	421,0	269,0	152,0	14,438	15,76	12,81	2,95
3.5	122,800	147,100	98,500	48,600	97,300	97,300	97,300	0,000	136,000	136,000	136,000	0,000	#DIV/0!	0,000	0,000	0,000	122,700	122,700	122,700	0,000	107,950	117,400	98,300	19,100	8,666	9,446	8,055	1,392	1494,5	1699,0	1130,0	569,0	2,6	2,7	2,4	0,4	0,4	1,6	0,0	1,6	455,0	574,0	307,0	267,0	12,850	16,93	10,67	6,16
3.6	95,250	96,010	94,490	1,520	91,315	94,490	88,140	6,350	144,150	151,400	136,900	14,500	130,800	131,300	130,300	1,000	107,695	108,200	107,190	1,010	89,295	94,240	84,330	9,910	9,882	9,986	9,077	0,909	1451,0	1590,0	1312,0	278,0	2,9	2,9	2,7	0,1	2,5	2,7	2,4	0,3	250,5	270,0	230,0	40,0	13,177	14,45	11,92	2,51
4 4.1	99,059	99,400	93,700	2,700	92,400	92,400	92,400	0,000	144,600	144,600	144,600	0,000	120,200	120,200	120,200	0,000	87,400	87,400	87,400	0,000	87,400	87,400	87,400	0,000	7,141	7,902	6,380	1,523	1375,0	1615,0	1135,0	480,0	2,5	2,7	2,3	0,5	1,1	2,2	0,0	2,2	208,5	236,0	181,0	55,0	9,819	12,76	7,24	5,52
4.2	95,950	96,500	94,800	1,700	92,100	92,100	92,100	0,000	134,250	136,100	133,400	1,700	123,300	123,300	123,300	0,000	107,900	107,900	107,900	0,000	#DIV/0!	0,000	0,000	0,000	7,536	7,809	7,262	0,547	1342,5	1390,0	1295,0	95,0	2,5	2,5	2,4	0,1	0,7	1,4	0,0	1,4	220,0	230,0	207,0	23,0	10,117	10,11	10,09	0,02
5 5.1	105,220	119,000	100,100	18,900	103,080	119,000	89,200	29,800	139,250	142,100	136,500	5,600	138,650	146,200	134,500	11,700	103,950	106,700	102,500	4,200	86,550	99,300	69,200	30,100	7,020	8,114	6,165	1,932	1231,7	1360,0	1090,0	300,0	2,5	2,7	2,2	0,5	1,8	2,9	0,0	2,9	168,8	186,0	144,0	54,0	9,647	10,71	7,17	3,54
5.2	100,160	101,330	98,800	6,700	98,787	101,000	97,300	2,700	138,445	141,000	135,890	5,110	137,480	141,100	133,860	7,240	103,315	103,600	103,130	0,370	100,065	102,330	99,800	0,530	8,943	10,491	7,938	2,553	1599,3	1963,0	1440,0	813,0	2,7	2,7	2,6	0,1	1,9	2,9	0,0	2,9	195,3	223,0	173,0	50,0	13,945	20,49	9,05	11,44
6 6.1	101,033	104,700	97,300	7,400	98,533	101,600	95,500	6,100	157,133	159,000	154,700	4,300	160,150	162,050	158,000	4,050	104,363	105,300	103,400	1,900	96,460	100,580	89,100	11,480	8,462	8,936	7,899	1,036	1710,0	2000,0	1400,0	600,0	2,8	3,0	2,7	0,3	3,2	3,3	3,1	0,3	254,0	304,0	199,0	105,0	14,470	17,97	10,78	7,10
6.2	104,160	105,200	102,100	4,100	100,350	101,900	98,800	3,100	154,950	158,900	143,000	23,900	142,000	142,000	142,000	0,000	99,700	105,700	94,300	11,400	84,450	93,800	76,100	19,700	9,989	13,941	6,914	6,927	3700,0	4300,0	3300,0	1000,0	3,6	4,4	3,2	1,1	1,6	3,0	0,0	3,0	264,5	282,0	247,0	35,0	36,999	59,52	24,20	35,32
7 7.1	100,375	103,600	96,500	8,300	95,725	99,000	91,600	7,400	142,978	148,600	135,380	13,220	138,675	142,240	134,110	8,130	101,300	105,600	99,500	16,100	88,400	94,500	82,100	12,400	8,215	9,177	7,286	1,891	1607,5	2085,0	1165,0	920,0	2,6	2,8	2,5	0,3	2,6	2,8	2,3	0,5	217,0	324,0	166,0	158,0	13,205	19,13	8,63	10,50
7.2	104,300	111,200	99,800	11,400	105,233	116,300	99,100	17,200	148,467	152,300	145,000	7,300	143,533	147,400	136,400	11,000	104,867	107,700	99,800	7,900	96,300	99,900	80,000	9,900	8,630	9,120	8,008	1,112	1895,3	2070,0	1600,0	470,0	2,7	2,9	2,6	0,3	2,9	3,0	2,8	0,2	266,0	305,0	212,0	93,0	16,321	19,23	12,81	5,52
7.3	101,693	102,620	99,800	2,820	100,445	104,300	97,290	7,020	151,238	155,960	148,590	7,370	150,025	152,400	148,300	4,100	105,200	108,960	98,800	10,160	92,273	94,740	90,170	4,570	9,986	11,229	8,674	2,364	2390,8	2610,0	2163,0	457,0	2,8	2,9	2,8	0,1	3,0	3,1	2,9	0,2	300,5	352,0	270,0	82,0	23,873	28,81	19,34	9,47
7.4	103,033	104,400	100,300	4,100	99,990	100,800	99,570	1,230	164,687	165,900	162,300	3,600	164,937	165,610	163,600	2,010	104,733	104,900	104,400	0,500	99,167	99,300	99,100	0,200	10,922	11,352	8,892	2,460	2285,3	2543,0	1950,0	593,0	3,1	3,5	3,0	0,5	3,4	3,5	3,3	0,1	360,0	393,0	337,0	45,0	24,000	28,87	16,45	12,42

Figure 9.3: Characteristics Average and Spread

Figure 9.2 and 9.3 shows the extend of the total assembled parameters data file. Too large to handle, only small captures are shown from it for the illustration and understanding of its size and complexity.

9.4 Mathematical Definition of Size

As in the case of the studied project vehicle size classification, the size system boundaries do not differ much between some of the classes e.g. ACS and BCS. However, the size management model also includes a perspective in terms of the use of the passenger area resources.

This seeks to explain the different size classification models by relating the system boundaries to the volume and segmentation systems and to physical measurements within the studied classify processes. Even tough it might bring in important perspectives; the system boundaries applied by the public will not be further discussed here since the public often plays a minor role in practice for the classification process.

10 Findings

This chapter seeks to analyse the findings from the previous chapter 9. Thereafter I will ascertain which implications these might have for the development of a classification model. The discussion how SRA should go on looking for a suitable classification model and what strategy to use if so is concluded in a scenario analysis.

10.1 Pre-processing the Data

To achieve a compact representation of the characteristics involved in the classification they are converted into a sequence of figures. Using the 50^{th} and 95^{th} -percentile dummies for the internal ratings for the visualisation to better understand the impact of size.

10.2 Data Analysis

The following graphs illustrate the relations between weight, shadowed area, CO_2 mass emission and internal space parameters. This allows me to compare the results in the way in which they are related to the systems.
Unless otherwise noted, the Classes 1.1 to 7.4 are the same as those represented in figure 9.1. As for the figures, the upper line represents the maximum value and the lower the minimum value. The bars show the average value.

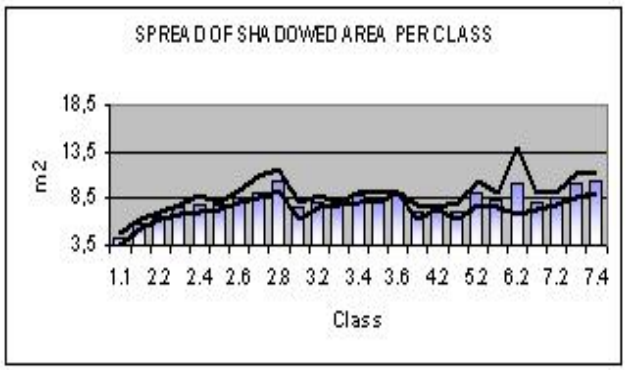


Figure 10.1: Shadowed Area

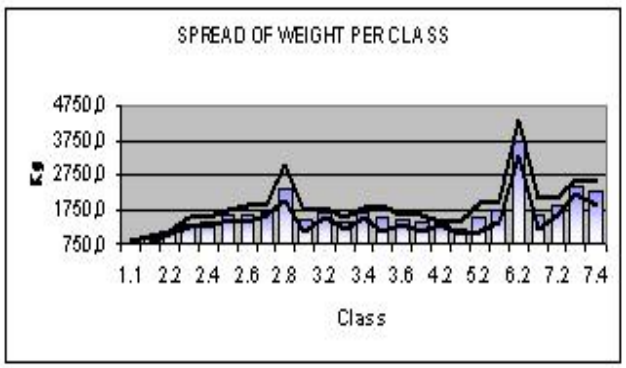


Figure 10.2: Weight per Class

Figure 10.1 and figure 10.2 shows respectively shadowed area and vehicle weight.

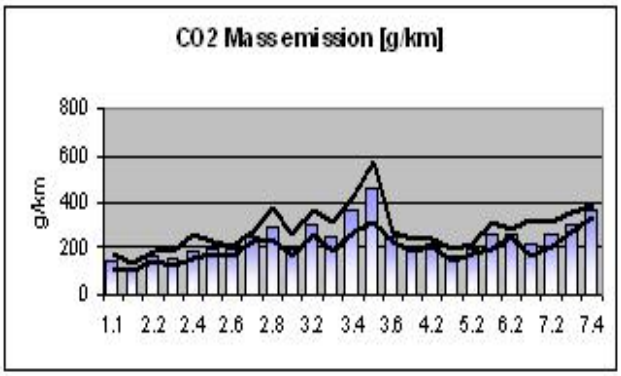


Figure 10.3: CO_2 Mass Emission

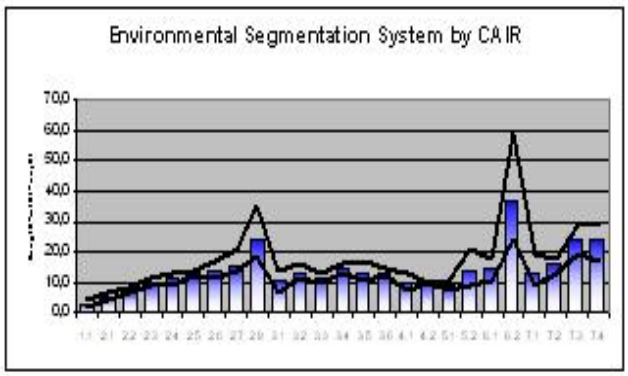


Figure 10.4: ESS Environment Segmentation System

Figure 10.3 and figure 10.4 shows the CO_2 mass emission respectively the ESS Environmental Segmentation System.

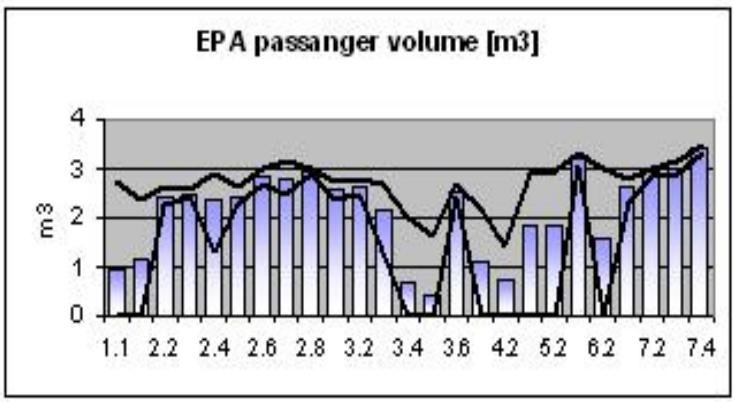


Figure 10.5: EPA Passenger Volume

Figure 10.5 shows the interior volume for all evaluated groups of cars.

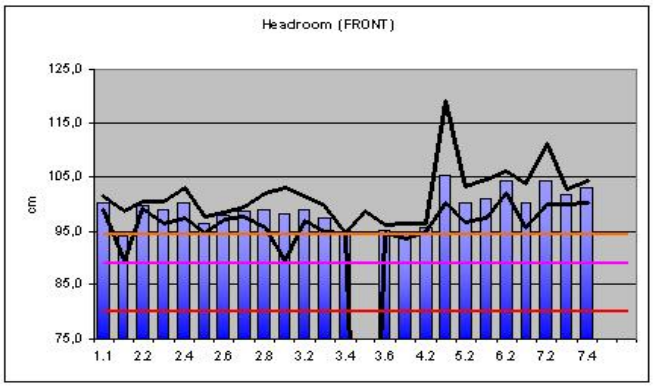


Figure 10.6: Headroom (Front Seat)

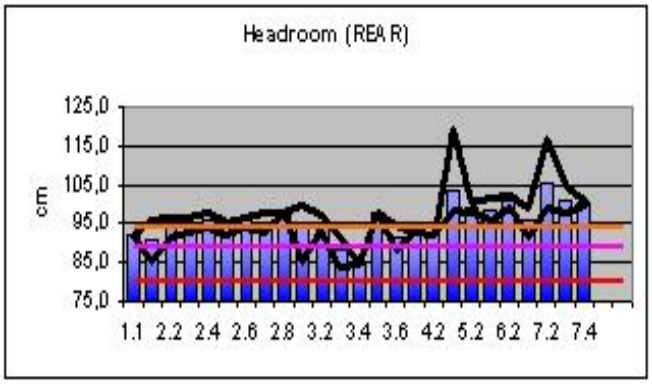


Figure 10.7: Headroom (Rear Seat)

Figure 10.6 and 10.7 shows the headroom spread in the front and rear.[49]

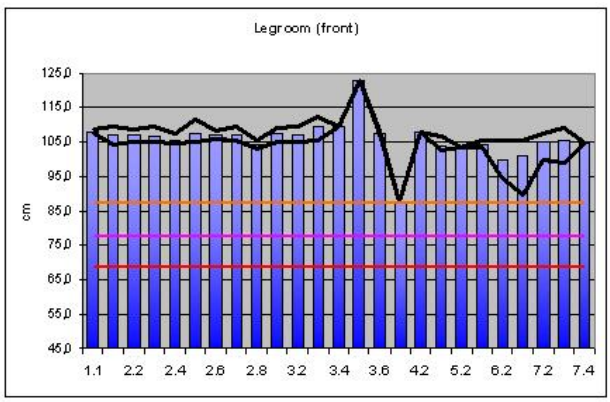


Figure 10.8: Legroom (Front Seat)

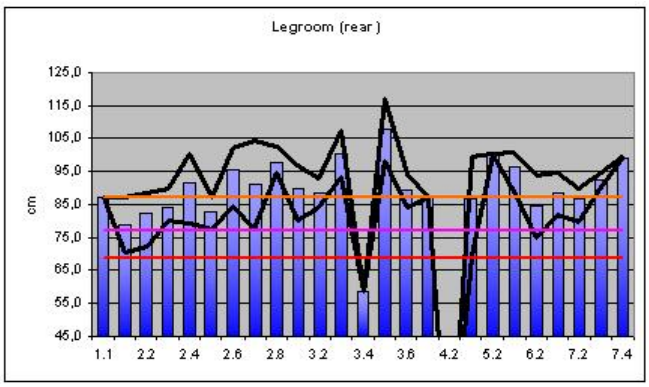


Figure 10.9: Legroom (Rear Seat)

Figure 10.8 and 10.9 shows the legroom spread in the front and rear.[50]

49 Read Line in graph = 5th-percentile Female, Lilac Line in graph = 50th -percentile and Orange Line in graph = 95th-percentile Male. See figure 3.9 for visually compeering the dummies by size.

50 Read Line in graph = 5th-percentile Female, Lilac Line in graph = 50th -percentile and Orange Line in graph = 95th-percentile Male. See figure 3.9 for visually compeering the dummies by size.

11 Conclusions and Further Research

In the conclusion I will sum up the most important findings that were discussed in the former chapters and let them constitute answers to the issues presented in the introduction chapter. I also give some advises regarding further research and discuss whether our finding can be used in another context, e.g. by other companies wishing to have a better understanding in the definition of car size.

11.1 Discussion of the Issues presented

In this study the car classification models by means of physical measurements, each defined by their classification constructor, have been analysed. Using available systems I have been able to evaluate and identify answers to the issues presented in the thesis introducing chapter.

In the beginning of this master thesis I introduced a few issues which were up for discussion. In the previous chapters answers to all these have been given but here I would like to highlight the most important findings.

11.1.1 What characterise a “small” passenger car?

Don't let the word "small" fool you. Today's new small vehicles can be big on value, flexibility and safety features, not to mention fuel savings. Cars may be small, but vehicles in this class typically don't need a lot of power to get them from place to place.

In previous chapters various methods in how to evaluate and determinate the actual size of a car were described. Visual performances are just as important for the characterisation of a e.g. small car.
There are several performances that are used for the characterisation of small car:

- Length and Width: It is generally seen as short and small due to the design
- Seats: < 4 or 5
- Small compartment areas
- Wheelbase: < 2,60 m
- Low fuel consumption: Generally < 6 l/100 km

11.1.2 How is “small” passenger car defined?

One of the key learning’s I have made during my thesis work has been the fact that the outcome of one single parameter/factor is not satisfactory in itself for the size classification issue.
I have in my study identified some important factors that I believe influence the overall assessment when defining e.g. a small car. These factors are separated into two attributes; external and internal physical measurements.

External

Shown in the previous chapters 9 and 10 the small car can be divided into three sub-classes. These classes can have a numeric spread up to 287% on weights and up to 169% on dimension. The spread of CO_2 values is 172%.

What Defines A Small Car: 1*

MEASURMENT		Micro car	City car	Super mini	Total
Characteristic	**SI-Unit**	**Max/Min**	**Max/Min**	**Max/Min**	**Max/Min**
Length	m	3.28/2.50	3.80/3.41	4.22/3.70	4.22/2.50
Width	m	1.50/1.47	1.66/1.61	1.69/1.65	1.69/1.47
Shadowed Area	m^2	4.82/3.80	6.41/5.49	7.09/6.25	7.09/3.80
Weight	kg	840/390	790/995	1120/1030	1120/390
CO_2 emissions	g/km	172/112	139/109	188/144	188/109

Table 11.1: Small Car Characteristics
*The spread in each class, with 3 to 5 cars in each class, makes it possible to find the maximum respectively the minimum characteristics in each class.

As the table 11.1 states; a small car can be represented by external measurements that vary within the given parameters.

Interior

The inner area performance of a car can not be reduced to a single factor such as head room or legroom, but they can provide as guidelines for the assessment.
With the physical parameters; head room, legroom and shoulder room an interior volume can be calculated. See table 11.2.

What Defines A Small Car: 2**

MEAURMENT		Micro car		City car		Super mini		Total	
Characteristic	**SI-Unit**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
Head Room F/R	cm	102/96	99/92	99/96	90/85	101/97	90/91	102/97	90/85
Legroom F/R	cm	109/87	*	110/87	104/71	109/89	105/72	110/89	104/71
Shoulder room F/R	cm	*	*	138/134	136/130	136/136	124/124	138/136	124/124
Interior Volume	m^3	*	*	2.352	2.240	2.614	2.261	2.614	2.240

Table 11.2: Small Car Characteristics
*Data is not available
**The spread in each class, with 3 to 5 cars in each class, makes it possible to find the maximum respectively the minimum characteristics in each class.

11.1.3 Which of the existing classification systems gives an independent assessment?

None of the existing classification systems gives a fully independent assessment of cars. Although, systems like ACS, CAIR, Euro NCAP and SAGM provides to some extend a reliable base for a classification. Additionally, they are all based on available existing physical measuring data.

11.1.4 How can this knowledge be utilized in a passenger car classification model?

There is much confusion and misunderstanding of the actual size “performance” of cars. Vehicle size issues are diverse, wide-ranging and often contradictory. Despite this, there have been a number of attempts to define an inner volume index and boundaries for passenger cars as we have seen in previous chapters.

A contentious measure is that which seeks to capture the relative efficiency of the vehicle in use.
By compeering the graph of shadowed area (figure 10.1) with the graph of weight (figure 10.2) it is possible see a correlation.
When comparing the ESS value (figure 10.4) with weight and shadowed area separately, you can see that the ESS value is enhancing the deviating effects in weight and shadowed area values.

As shown in figure 11.1, the CO_2 values (figure 10.3) do not fallow the pattern of ESS.

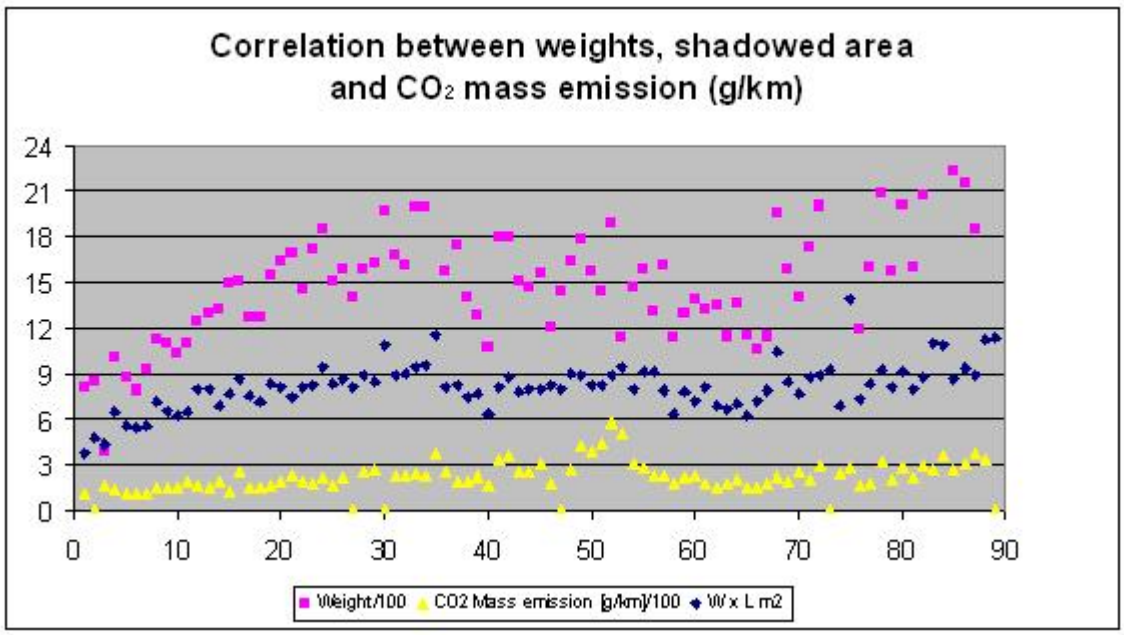


Figure 11.1: Correlation between weight, shadowed area and CO_2 mass emission.

In accordance to the measuring of passenger volume by EPA (figure 10.5), the volume performance of cars in classes 2.2 to 3.3 do not differ to a large extent considering the shown spread. In fact there are probably car that will fit in all this classes. Cars in classes 3.4 to 4.2 are mostly low production volume cars, and are to be considered as out layers in this work. In the larger class 6.1 to 7.4, the inner volume becomes significantly larger then in the previous car classes. The spread in each class makes it always possible for some cars to fit into more then one class.

The front headroom dimensions (figure 10.6) shows very small spread in classes 1.1 to 3.4. As for the remaining classes (3.6 to 7.4) the spread are larger and the level a bit higher. All front headroom measuring passes the headroom level for both the 5^{th} and 50^{th} -percentile dummies. And for the exception of a few cars, they also exceed the headroom level for the 95^{th} -percentile dummy.

Figure 10.7 shows the rear headroom dimensions where there are a larger amount of classes (then for the front headroom) that has problem with passing the 50^{th} -percentile headroom level.

As for the front legroom (figure 10.8) they all pass the legroom levels.
When looking at the rear legroom measurements in figure 10.9 it is interesting to observe that many of the cars do not obtain the 50^{th} -percentile level and even more cars do not obtain the 95^{th} -percentile level. When considering the spread.

To be a practical proposition, the volume and size indexes and their boundaries should:

- Be simple to understand in itself.
- Allow comparisons to be made between models and manufacturers.
- Use data which are already available, or could easily be made available.
- Allow size performance to be reflected in e.g. an index score.

These considerations suggest that the size and volume indexes should therefore use e.g. the following characteristics:

- Width (m)
- Length (m)
- Shadowed Area (m^2)
- Weight (kg)
- Headroom front and rear (cm)
- Legroom front and rear (cm)
- Shoulder room front and rear (cm)
- Inner Passenger Volume (m^3)

Other classification parameter should be CO_2 mass emission.

11.2 Future Research

As stated earlier, in previous chapters, the need for some sort of segment-based approach is great. Without these, problems with defining the accurate car size will be tremendous.

In this study I do not present any time-frame of when I believe that a functional car classification system will be developed.

The issues are complex, however it is important to make available some sort of independent car classification model for cars. Both private car users and fleet buyers are expecting such system to exist.
In truth, customers tend to choose not from the entire product offering available in the market, but from a small selection, although this does not always coincide with the segments as perceived by car makers or industry observers.

11.3 Generalisation

The conclusions presented in this master thesis are applicable mainly for companies/organisations, but as I have concluded, private car users have the same problem which makes my result applicable for them as well.

I have used a method in which I studied a few case companies which has constituted a reference to my “core case company”. Another way to do it could have been to study maybe just one or two companies but make the study more in-depth.
This alternative way would also have been hard to validate since there are so few companies which have succeeded with car classification.

I have considered tree attributes, which could be used to determine the car size; shadowed area, weight and interior volume. This in addition to CO_2 mass emission could create a classification system that is measurable and reliable.

To employ this type of classification system, the organisation would need first to determine the boundaries for the specified parameters.
Another conclusion is that the performance evaluation of vehicle classes is very complicated, due to the nature of the problem and need to be handled carefully in • nding simple and optimal classification technique.

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APPENDIX

Appendix 1: Questionnaire

- Vilken typ av fordonsklassificering används?
- Vilka attribut /definitioner grundar sig klassificeringen på?
- Vilka fordonsattribut grundar sig definitionerna på?(e.g. vikt, antal hjulaxlar, motoreffekt)
- Används (modellen) klassificeringen likvärdigt på alla bilar?
  a) Ja
  b) Nej
- Vilka mätmetoder andvänder ni?
- Hur har ni valt dessa metoder?
- Följer mätmetoderna någon officiell standard?
  a) Ja, de följer _____
  b) Nej.
- Används en officiellt standardiserad och certifierad mätutrustning?
  a) Ja, de följer _____
  b) Nej. *Gå till fråga 11*
- Viken typ av mätutrustning används?
- Vilken klassning, certifiering, standard har mätutrustningen? (SBSC SS3522 1:3, SS C97-268 A:F, ISO, SAE J1100 etc.)
  a) De följer _____
  b) Nej, de följer inga kända.
- Vilka parametrar har ni valt att använda?
- Hur har ni valt att använda dessa parametrar?
- Används andra externa källor?
  a) Ja, de är _____
  b) Nej.
- Om ja svarades på fråga 13: Finns det vetskap om varifrån de externa källorna tar sin information?
  a) Ja, de är _____
  b) Nej.

Appendix 2A: Answer from Auto Motor und Sport[51]

- **Vilken typ av fordonsklassificering används?**

  Svar:
  Inom motorjournalistikvärlden ändras detta från fall till fall. Som kommen från ingenjörshållet själv kan jag förstå om detta kan vara frustrerande. En ingenjör vill ha klara definitioner, men ibland är världen lite mjukare/flummigare än önskvärt.
  Märk: En fordonsingenjör jämför knappast en moped med en bil. Det kan däremot en journalist göra: ”Vilket färdsätt är kvickast i staden x”. Det kan vara nog med underlag till en bra artikel, tycker journalisten.
  Med detta vill jag säga att vi ständigt bryter mot de klassindelningar som vi själva satt upp eller följer (och nämns i nästa fråga). Grunden till det är att läsaren och kunden inte följer klassindelningen slaviskt. Man har ibland inte ens bestämt sig för om bilen ska vara ny eller begagnad. Då är det rätt meningslöst att dissekera upp exempelvis priserna på 20 bilar i småbilsklassen i tio jämnstora betyggssteg. Och han/hon väljer definitivt inte bil efter hur lång, bred eller hög den råkar vara. Däremot har han/hon en klar uppfattning om hur stor en ”Golf” är. Trots att klassen den går i egentligen gått från dagens Polo till gårdagens Passat beroende på vilka mått man tittar på.
  Vi använder alltså olika klassificeringar i olika tester. Två exempel:
  *I ett kommande nummer jämförs BMW 650i, Jaguar XK8 och Mercedes CL 500. Tre stycken lyxcoupéer. Man skulle kunna anmärka på att den stoleksmässigt mest jämförbara Mercan egentligen vore Mercedes CLS 500 istället. Den baseras tekniskt på E 500 som i sin tur är lika stor som BMW 550i som i sin tur gett den tekniska basen till BMW 650i. Den testade CL 500 kan med viss rätt anses för stor då den baseras på Mercedes S 500. Vars like hos BMW är BMW 750i.
  Men nu råkar dels CLS 500 vara en märklig och udda coupé med fyra dörrar. Kunden/läsaren kan därför mycket väl istället tänkas jämföra tvådörrarscoupén CL 500 med tvådörrarscoupén BMW 650i och tvådörrarscoupén Jaguar XK8, *trots* att de inte är exakt lika stora, eller dyra för den delen.
  *I nästa nummer jämför vi Ford S-Max (MPV), Peugeot 807 (MPV) och Hyundai Santa Fe (SUV). Hur i Hälsingland går detta när Santa Fe är en SUV? Jo, den är nämligen också 7-sitsig och kan fungera som en familjebil. Många väljer mellan dessa 7-sitsiga bilar trots att de inte går i samma klass. Vår chefredaktör var en av dem. Men visst, vi lät Santa Fe gå som en MPV i våra betygsmallar utan hänsyn till att exempelvis bagagerummet är mindre i denna klass (markfrigång tar plats). Och vi gör klart för läsarna att det handlar om en ”joker” i testet. Med det menar vi helt enkelt en bil från en annan klass i något avseende.

- **Vilka attribut /definitioner grundar sig klassificeringen på?**

  Svar:
  I vårt fall är ”personbilar” den enda definitionen som håller genomgående när det gäller tester i ams. Vi testar nämligen aldrig lastbilar eller riktiga bussar. Ej heller lätta lastbilar. Ej heller pickup-modeller, även om vi funderar på att göra ett undantag.
  Men vilka klasser använder vi då inom personbilarna? Jag är rädd att det varierar. Exempelvis har vi i ett kommande nummer en omröstning där läsarna ska välja en sin favorit i varje klass. Eftersom omröstningen är internationell är vi böjda att

51 Answers made by Mikael Johnsson, Auto Motor & Sport

använda tyska ams klassformulering utan undantag.
Den ser ut så här:

2. Minibilar
3. Småbilar
4. Kompaktklass
5. Mellanklass
6. Familjebilar
7. Lyxbilar
8. Sportbilar
9. Cabrioleter
10. Offroadbilar
11. MPV:er

Så ser klassindelningen ut i det fallet och det liknar något så när tankegången när vi väljer bilar till tester. Men många klasserna ovan är alldeles för omfångsrika för att det skulle fungera i test. Ta ”cabrioleter” exempelvis. Kan man jämföra en tvåsitsig Opel Tigra för 152 900 kr med en fyrsitsig Bentley Azure för 3 390 000 kronor? Ja, i vissa avseenden kanske. Men inte i alla.
Hur resonerar vi klassmässigt i testerna?
Ungefär den här indelningen:

- Småbilar
- Kompaktklassen
- Mellanklassen
- Storbilar (eller Övre mellanklassen)
- Lyxbilar
- MPV-lilla (baserade på kompaktklassen)
- MPV-stora (baserade på bilar som är större än kompaktklassen)
- SUV-lilla
- SUV-stora
- Sportbilar

Egentligen delar man nere i Europa in småbilar i ytterligare två storleksklasser. Dock säljs (och därmed testas) det så få småbilar i Sverige att vi får slår ihop dem för att få tillräckligt med underlag i våra mallar.

För övrigt talar man i branschen ibland om storleksklasserna A, B, C osv för personbilar. Där är A de minsta småbilarna (Smart Fortwo, Aygo/107/C1), B de lite större småbilarna (207, Yaris, Polo) osv.
Jag har dock aldrig sett någon riktig definition av denna klassindelning.

- **Vilka fordonsattribut grundar sig definitionerna på?(e.g. vikt, antal hjulaxlar, motoreffekt)**

Svar: I vår värld definieras en bils klass av:
*formatet (längd, bredd, höjd, innerutrymmen)
*motorstyrkan
*prisbilden
*namnet (Den förväntade klasstillhörigheten utifrån bilens historik)

- **Används (modellen) klassificeringen likvärdigt på alla bilar?**
  a) Ja
  b) Nej

  Svar: ”b”

- **Vilka mätmetoder andvänder ni?**

  Svar:
  För klassindelningen använder vi inga mätmetoder. Se fråga 3. Klassindelningen kan göras ändå. För bestämning av formatet räcker fabriksuppgifter.

  Sedan, under själva testet, då använder vi diverse egenutvecklade mätmetoder. Inget avancerat. Måttband från vissa förutbestämda ställen. Gällande kupéutrymmen mäter vi hur mycket plats en testförare har till vissa förutbestämda ”islagsytor”.

- **Hur har ni valt dessa metoder?**
  Svar:
  Metoderna har vuxit fram under åratal av upprepade biltester. Som allting annat är de en kompromiss/balans mellan behov i tidningens testartikel respektive tids- och utrustningsmässiga resurser.

- **Följer mätmetoderna någon officiell standard?**
  a) Ja, de följer _____
  b) Nej.

  Svar:
  Ja och nej. Vissa gör, Vissa gör inte.
  Vi tar många av våra mätvärden från det tyska ams-teamet. Deras mätningar är certifierade enligt ISO-standard. Detta gäller såväl måtten på banan för ”älgtestet” som att de har en blydocka att placera i bilens säten inför innerutrymmesmätningar. Svenska teamtes mätningar är inte certifierade.
  Gällande bagageutrymmen använder vi dock bara volymsiffror enligt VDA-metoden som kommit att bli standard i branchen.

- **Används en offisiellt standardiserad och certifierad mätutrustning?**
  a) Ja, de följer _____
  b) Nej.

  Svar:
  Ja och nej. Tyska ams lär göra. Inte vi.

- **Viken typ av mätutrustning används?**

  Svar:
  Jag begränsar mig till att svara för oss i Sverige här.
  För klassindelning? Det skulle vara måttband då.

- **Vilka parametrar har ni valt att använda?**

  Svar:
  Se fråga 3.

- **Hur har ni valt att använda dessa parametrar?**

  Svar:
  Helt godtyckligt från gång till gång. Situationen avgör.

- **Används andra externa källor?**
  a) Ja, de är _VDA-siffror_____
  b) Nej.

  Svar:
  Ja, VDA-siffror

- ***Om ja svardes på fråga 12:*** **Finns det vetskap om varifrån de externa källorna tar sin information?**
  a) Ja, de är _____
  b) Nej.

  Svar:
  b) Nej, men om jag fick tid skulle jag gärna gå till botten med hur VDA fått fram siffror på vissa bilar. Det finns en del som förbryllar.

Appendix 2B: Answer from HERTZ[52]

- **Vilken typ av fordonsklassificering används?**

  Svar: Det finns 2 typer:
  12. Acriss
  13. Nationellelt system eget, Bokstäver a-z och en siffra om det är en disel eller flexifuel.

- **Vilka attribut /definitioner grundar sig klassificeringen på?**

  Svar: A= minsta, Längre bal om de är automat =D och miljö =A,C skillnad på hergårdsvagn och sedan.

- **Vilka fordonsattribut grundar sig definitionerna på?(e.g. vikt, antal hjulaxlar, motoreffekt)**

  Svar: Det varierar, har ingen riktig koll.

- **Används (modellen) klassificeringen likvärdigt på alla bilar?**
  a) Ja
  b) Nej

  Svar: Ja

- **Vilka mätmetoder andvänder ni?**

  Svar: Nej, det är billeverantörens uppgifter som det går på.

- **Hur har ni valt dessa metoder?**

  Svar: Förlitarsig påleverantörens uppgifter.

- **Följer mätmetoderna någon officiell standard?**
  a) Ja, de följer _____, Volvos standardmetoder.
  b) Nej.

  Svar: Ja, de följer Volvos standardmetoder.

- **Används en offisiellt standardiserad och certifierad mätutrustning?**
  a) Ja, de följer _____
  b) Nej.

  Svar: Se ovan: Volvo

- **Viken typ av mätutrustning används?**

  Svar: Se ovan

52 Answers is made by Kalle Jacobson at Hertz Sweden.

- **Vilka parametrar har ni valt att använda?**

  Svar: Se ovan

- **Hur har ni valt att använda dessa parametrar?**

  Svar: Se ovan

- **Används andra externa källor?**
  a) Ja, de är _____
  b) Nej.

  Svar: Se ovan

- ***Om ja svardes på fråga 12:*** **Finns det vetskap om varifrån de externa källorna tar sin information?**
  a) Ja, de är _____
  b) Nej.

  Svar: Se ovan

Appendix 2C: Answer by Teknikens Värld[53]

- **Vilken typ av fordonsklassificering används?**

  Svar: Efter behov. Testar vi mellanklassbilar skriver vi "mellanklasstest". Testar vi premiummodeller i mellanklassen skriver vi något annat, "lyxbilstest" eller dylikt.

- **Vilka attribut /definitioner grundar sig klassificeringen på?**

  Svar: Det är en kombination av pris, bilstorlek, tillverkarens ambitioner samt motor och övrig utrustning.

- **Vilka fordonsattribut grundar sig definitionerna på?(e.g. vikt, antal hjulaxlar, motoreffekt)**

  Svar: Se ovan.

- **Används (modellen) klassificeringen likvärdigt på alla bilar?**

  Svar: Se ovan.

- **Vilka mätmetoder andvänder ni?**

  Svar: Vi mäter själva.

- **Hur har ni valt dessa metoder?**

  Svar: Efter omfattande interna diskussioner och test av hur olika mått varierar.

- **Följer mätmetoderna någon officiell standard?**

  Svar: Nej.

- **Används en offisiellt standardiserad och certifierad mätutrustning?**

  Svar: Nej.

- **Viken typ av mätutrustning används?**

  Svar: Vi mäter för närvarande med en lasermätare som heter Hilti HD30. Tysktillverkad sak, men Hilti är baserat i Lichtenstein.

- **Vilka parametrar har ni valt att använda?**

  Svar: Vi mäter kupébredd i framsäte och baksäte, höjd i framsäte och baksäte, benutrymme fram och bak samt skjutmån på förarstolen. I bagageutrymmet mäter vi bredd, längd med fällt och uppfällt säte, höjd i bagageutrymme till tak respektive insynsskydd, lasthöjd, ståhöjd under baklucka.

53 Answer madeby Mikael Stjärna, Teknikens Värld

- **Hur har ni valt att använda dessa parametrar?**

  Svar: För att de säger något om bilens utrymmen.

- **Används andra externa källor?**
  Svar: Nej.

- **Om ja svardes på fråga 12: Finns det vetskap om varifrån de externa källorna tar sin information?**

  Svar: Nej.

Appendix 3A: Measuring procedure by Teknikens Värld

Mätning

Allt mäts med lasermätaren, Hilti HD 30, och alltid utan passagerare/förare.

Kupéutrymmen

Längsta benutrymme fram:

Stolen i sitt lägsta och bakersta läge. Om dynan är justerbar i längsled ska den vara max utdragen. Svankstöd i sitt innersta läge.
Börja med att mäta dynans längd från dess framkant med lasermätaren. Använd vattenpasset för att få en lodlinje att utgå från (mät från stålplattan på vattenpasset) och mät till ryggstödet.
Mät därefter avståndet dynans framkant till mitten på pedalen. Avrunda först efter att måtten lagts samman.

Ställbara pedaler:
I botten.

Svankstöd:
I botten.

Skjutmån:
Skjut stolen i sitt främsta läge, mät från dynans framkant till mitten på pedalen med lasermätaren. Addera måttet på dynans längd.

Bredd axelhöjd fram:
Mät mellan B-stolparna med lasern i höjd med dörrkarmen (kromade armbågens naturliga placering).

Takhöjd fram:
Stolen i lägsta och bakersta läge. Lasermätaren stående i lod, ställ mätaren från lägsta dynplaceringen (oftast ca fem centimeter från ryggstödet) och mät rakt uppåt. INTE VINKLAT!

Om bilen har sollucka:
Mät på lägsta stället i stället.

Kortaste knäutrymme bak:

Lägg vattenpasset i ”sittriktningen” och lägg sedan lasermätaren på vattenpasset. Mät med utgångspunkt i ryggstödet. Om ryggstödet är skålformat, mät där det är djupast. Om stolen framför har urgröpningar för benen, mät där det är djupast. Om bilen skulle dra nytta av båda dessa komforthöjande faktorer, gör så här:
Lägg vattenpasset över urgröpningen i ryggstödet framför och mät hur djup den är med tumstock. Mät sedan resterande benutrymme på ovan nämnda sätt. Addera sedan.

Takhöjd bak:
Samma metod som fram, oavsett om taket lutar.

Bredd axelhöjd bak:
Mät i höjd med dörrkarmen vid axelns naturliga placering.

Effektiv kupelängd:

Dynor fram och bak adderat plus skjutmånen.

Externa utrymmen och lastmått

Bredd mellan hjulhus:
Mät smalaste stället.

Lastytans längd uppfällt läge:
Kombikupé och kombi mäts med bakluckan stängd inifrån kupén. Lasermätaren läggs på golvet och mäter till kortaste punkten, oftast där luckans låsmekanism sitter monterad.

Lastytans längd fällt säte:
Mätt med bakluckan stängd inifrån. Om dynan är uppfällbar – mät från den. Om dynan inte är uppfällbar, mät från förarstolens ryggstöd med förarstolen i mittläge.

Normal lasthöjd:
Mätt från golvet upp till taket, se till att mätaren står i våg. I kombi mäter vi upp till lastskyddet.

Höjd i bakluckans öppning:
Mätt från bakluckeöppningens högsta punkt i lod ner till golvet.

Lasthöjd utvändigt:
Mätt i lod från mitten på bakluckan. Lägg vattenpasset över öppningskanten och utgå från det när det ligger i våg.

Tröskelhöjd invändigt:
Mät mitt på bilen med tumstock. Om kanten är kraftigt rundad, använd vattenpasset (i våg) som mätpunkt uppåt.

Höjd under bakluckan:
Eventuell ställbar fjädring i normalläge. Utgå från mitten av bakluckan och mät i lod rakt nedåt. Se till att bilen står plant – alltså inte på lyften. Obs: ställbar fjädring i lägsta och högsta läge. redovisa båda måtten.

Bakluckans största bredd:
Lika enkelt som det låter. Öppningens bredaste punkt, under förutsättning att denna finns i den aktiva delen av lastöppningen. Mät i våg till listkanten på andra sidan.

Bakluckans minsta bredd:
Lika enkelt som det låter.

Läskbackar fällt säte:
Stapla alla backar i varandra, alla backar upprätta. Detta är enda sättet att lasta backar och samtidigt ha någon form av repeterbarhet. När backlastningen är klar ska du göra en skiss över hur du har lastat. Inget avancerat, utgå från en rektangel som får föreställa lastutrymmet och rita sedan i om staplarna står på längden eller tvären. Skriv i varje stapel hur många backar den innehåller. Framstolarna i det bakerst möjliga läget.

Appendix 4A: Case Company Review

New car models do not always find itself in a certain car class and sometimes through its design it can be adjusted to fit two o three car classes, although that is not desirable since it increases the amount of uncertain classifications. The companies obviously also use their own assessment model, which can result in a large variety sense each land has their own test groups.

Auto Motor und Sport

The Company

Auto Motor und Sport (AMS) helps their readers to find best buy regarding new or used cars, private importation, car price guides and car tests such as driving experience, how the car relates to the road, crash safety and service costs. Auto Motor und Sport is organized in several supporting divisions; the operations division that includes purchasing and logistics and the sales and marketing division, as well as two major test divisions; the process technology division and the equipment division. Auto Motor und Sport has readers in approximately 36 countries around the world. They cover about 39% of the car magazine market, where 87% is sold in Europe, 13% in the rest of the world. The most important sale markets are still Europe, but other countries are becoming more important since global competition increases.

Auto Motor und Sport is considered an important car market evaluator, and sold for 9 million Euros in 2006. Everything that is produced in the car manufacturing business including custom made cars is tested and assessed. When they test new cars they mainly use information from the head office and general importers. The company has recently started to look for possible global measurements system, to improve their vast collection of information.

Car Size Classification Experience

New car models do not always find itself in a certain car class and sometimes through its design it can be adjusted to fit two o three car classes, although that is not desirable since it increases the amount of uncertain classifications. The company obviously also use their own assessment model, which can result in a large variety sense each land has their own test groups.

The continuous evaluation of passenger cars is based on test reliability, quality reliability and bought information. Passenger vehicle sizes can be defined by standardized ways of detecting and evaluate sizes in a classification models of the vehicle. However, the company does not have a measure of classification outlined for them self. Instead they use the Euro NCAP's deviation of classes combined with information from both general importers and test laboratories.

Test Department/Technical Division

As mentioned above the Test Department is part of the Technical division. The company has a global test department in Germany. They also have local test department in each reviewing country they distribute magazines in, which is about 20 around the world.

Depending on when the local departments where initiated a large variety of solutions in measuring the internal dimensions. The most common assessment is based on the size of the test driver of the vehicle, whether he/she finds the driver/passenger seat appropriate for

their length. This indicates only the need for representatives in the same percentile (50^{th} in most cases) as the test driver is a member to.

A Global System with Local Assessments

Auto Motor und Sport (AMS) has both a local and one global system. For the moment there is one German system that is used by all AMS magazines and one local for each country e.g. Sweden. Local test evaluations are used for supplying the car park in e.g. Sweden with raw material and less complicated test procedures, while the global one is intended to supply information to publication plants all over the world.

Auto Motor und Sport offer their readers help in finding used cars, private importation, car price guides and car tests such as driving experience, how the car relates to the road, crash safety and service costs.

The constant development of the test and its evaluation methods, AMS has moved from an exclusive use of stars (scaled of 1 to 5, where 1 means “OK” and 5 means “Excellent”) as an assessment on vehicle performance to percent (1-100). The advantage with using a larger scale (like 1to 50, with 50 as the top rating) is the more precise declaration of the vehicles advantages and disadvantages. Details of how the scores are arrived at are not available.

The German Auto Motor und Sport classification sizes:

- Mini
- Small
- Compact class
- Middle class
- Family
- Luxury
- Sport
- Cabriolet
- Off-road

The classification can be attained without special size definitions. Too decide upon vehicle class external measured characteristics is sufficient enough.

The parameters used in these car classes are defined by:

14. Format (Length, width, height and size of internal area)
15. Effect (engine)
16. Prize
17. Name (The car classification expected depending on the history and wishes of the manufacture)
18. How they stand comparative to VW models (All car manufacturer's compeer their cars in some extent with passenger vehicle models from VW)

The components in the definition consist of blended information, often treated with somewhat poor made translations. Due to this some direct misunderstandings and errors regarding the products also occur. For the Swedish edition of Auto Motor und Sport, Auto Motor & Sport, the measurement equipment has a lot of uncertainty due to translation from German test result documents.

Auto Motor und Sport put a great effort in finding new testing methods since the requirements regarding those are of great importance for their customer's: The readers.

To the disadvantages of using a supplier is the sometimes very poor quality of the delivered goods. They have therefore an interest in establishing long term relationships with the most dedicated and well established test plants, especially those who are or intended to be ISO certified or with similar quality assurance certifications. In those cases Auto Motor und Sport work actively and close with the plant which sometimes also include financial support to the supplier of test laboratory measurement. AMS strives for a balanced relation to the supplier where neither party is dominant; a situation that at times is unavoidable since AMS often is a very important customer for the supplier of tests. Comparison with test results for larger cars also shows that these are not penalised unduly, each comparative test primarily scoring the cars tested relative to each other. A comparative test of the Mercedes E 55 AMG against the Jaguar XJR from the same issue, for example came up with ratings for these two cars of 77 and 67 points respectively. However in this case perhaps not enough attention is paid to the relative environmental impact of different sizes of car. Similarly, neither of the German systems takes durability into account.

Cooperation with Other Company's

As a company producing magazines with a technical data and information, in a comprehensive format, they work in close relation to car manufactures and producers. The car manufacturing industry's general agents is the primer source of information, while other magazines like M3 and E-magin are more frequently used with custom made cars.

Some of the company's Auto Motor & Sport (Swedish edition) are in co-operation with:

- E-magin
- M3
- Car manufacture general agents
- Euro NCAP

A Car Culture

Auto Motor und Sport believes that doing magazines in the country's in question own language is a way to satisfy a larger part of those interested in vehicles. One of them is the importance of a personal relation to the readers which are facilitated since the tests are specific for each country's car park e.g. Sweden.

The company also believe that the technical competence is sufficient but that the competence regarding standardisation and norms is less developed. One big obstacle in addition to translation of language in domestic tests which among other things affects quality and reliability in delivering accurate test results. This fact makes selection of proper classification of the car more important than in e.g. the actual car brand. Even if the way of conducting and assess tests and information is somewhat different is not that different from that in other magazine tests because “at the end of the day everybody wants to make money without spending any”.

Teknikens Värld

The Company

The magazine was established 1948 in Sweden and begun to systematically test cars within a large range of models, everything from new and old standard cars to custom made cars. Today the company consists of six divisions; information and sale, reporters/test team, Special unit: co-workers with special knowledge, Webb/ Internet support, reporters and marketing/advertising. Reporters and people of the special unit is the largest division with 19 people last year followed by Webb/Internet support with 3 employees.

The company Teknikens Värld, with total revenue of around 1 millions Euros, is owned by a huge investment company called Bonnier Tidskrifter AB, by which all managers in the group are employed. Bonnier Tidskrifter AB invests in a great variety of industries, i.e. banking, health magazines and fact literature, investment and economy.

Teknikens Värld is famous for the Moose-Test, it is the most important trademark and the most used car tests in the automotive industry. The test procedure made large headlines 1997 when Mercedes A-Class flipped over during the execution of the test. The test drives is usually done at Björkvik Ring, former military airfield.

Car Size Classification Experience

Teknikens Värld offer its readers test information based on measured characteristics e.g. acceleration, engine output, CO_2 -emission and fuel consumption.

The company primarily perform driving test on vehicles new to the market, but occasionally older vehicles to contribute to the diversity of cars. The focal point of test strategies and the methods developed from them is always the customer, who expects a fully functioning, reliable evaluation which will assist them in their car selection.

The assessment of cross sections and body types is a common application frequently demanded in practice. The Internet system user can easily control the measuring for the objected model with cars similar to the one selected by using the “Compare to Other Cars”-function. A comparison of the measured data with this function represents an automatized tool for comparability control between cars based on class, body type, engine effect and price. Deviations between the measured data can be visualized quickly and displayed numerically on-site.
Thus, owing to the variety of car classification systems, for each specific model description an application for the optimal size definition is offered. The system user can then control the measuring between car objects; in e.g. car manufacture defined “Mid size”-cars, using the crossed reference measurement database.

Due to the integration of the system method, the user can only compare models that are defined in similar classification classes by the manufactures. E.g. “Small”-cars at manufacture “A's” classification system to “Small”-cars in manufacture “B's” classification system. This does not allow a direct size comparison between the selected cars, mere a hint since the service is based upon manufacture definitions.

Test Department and Technical Division: A Local System with Global Techniques

The co-working company, Lundblads Motor & Service Center, have developed test procedures which affords a systematic understanding of the cars abilities with a ISO 9000/9001; 14000/14001, VDA, SAE J1100, 17025 and SP standardised laboratory equipment from Sun Maskin & Service.

A deeper integration of the test methods used at the test driving scene however, displays the test methods do not follow any official standardizations or norms. Nor are the measurements done without any official standardized methods or equipment with certification.
Equipment used are folding rural and a laser measuring tool, Hilti HD 30, which the user can apply without additional expensive software packages from other suppliers. [54]

Deviations between the measured data attained and data from the general importer among with those from the co-working company can be visualized quickly and displayed numerically on-site. Thus, an inspection of the measurement procedure involved in the on-site tests displays that a comparison with the controlled parameters attained is not always possible.

As against this, the company (in accordance to the reporter, at the Swedish version, Mikael Stjärna) insist upon using non-certified measuring tools as they see no obstacle for the comparison of the measured data in terms of reliability.[55]

Measurement conduct protocol: See Appendix 5A.

Description of Measurements of Interest

COUPE AREA		CARGO AREA	
A	Leg Space, Maximum in Front Seat	1	Length of Cargo Area
B	Leg Space, Minimum in Front Seat	2	Length of Cargo Area, Lowered Rear Seat
A-B	Movable Leg Space	3	Height in Cargo Area
C	Roof Height, Front Seat		
D	Shoulder Width, Front Seat		
E	Leg Space, Minimum in Rear Seat		
F	Roof Height, Rear Seat		
G	Shoulder Width, Rear Seat		
A+E	Length of Internal Coupe Area.		

Table 2.1: Measurements of Conduct

Additionally, an important part of the evaluation of the cars is the tests final summoning in a numbering total. Through the years the tests has been improved several times as new parameters are evaluated and added to the systems due to change in interests of the readers.

In recent years, a great deal has been achieved in combating the evaluation of passenger vehicle by translation of different tests into a numeric scale with a final sum, which measures the cars overall assessment.

As some of the test reporters will be replaced due to retirements and a change in the design of the organization, the assessment and evaluations too, is expected in a near future

54 Mikael Stjärna
55 Mikael Stjärna

Car Assessment Codes

NUMERIC		STARS		EURO NCAP STARS	
1	Lousy	1	Failure	1	
2	Very Bad	2	Approvable	2	
3	Bad	3	Good	3	
4	Hardly Approvable	4	Very Good	4	
5	Approvable	5	Excellent	5	
6	Average				
7	Good				
8	Very Good				
9	Almost Perfect				
10	Perfect				

Table 2.2: Assessment points and grading

Cooperation with Other Company's

In recent years, a great deal has been achieved in co-operation with company's that provides reliable information, even at difficult conditions with custom made cars is high data quality is achieved.

Of these, two (Lundblads Motor & Service Center and Sun Maskin & Serviceare) in a closer relationship then the rest whereas they, has played, and continues to play, a important role.

- Lundblads Motor & Service Center
- Sun Maskin & Service
- Euro NCAP
- General impostures: e.g. Audi, Volks Wagn, Volvo and Saab
- Close relationship with the car manufacture industry

GT/Expressen

The Company

GT-Expressen Motor is its own magazine within the daily newspaper of GT-Expressen, and is one of their 6 departments specialized. It has as a goal to be the customers' best friend in buying or selling of a car, talk about horsepower and gears but also the handyman consultant in repealing and pimping of cars.

Aiming to be the quickest and most accurate when it comes to car news and tests, they are intending to provide the readers with extensive tests. Focus is set on driving experience, technical data and and the overall design. With this information at hand they are in charge od Sweden's most well known car ranking, ranking 25 cars in six classes.

The Motor magazine is found in GT-Expressen every Saturday in the newspaper and all over the year on the Internet, which had over 166 071 visitations in November 2006.

Quick History

Some important years to understand the development of the magazine;

- 1813 GP is established for the first time.
- 1822 The magazine is lade down to reappear in 1850-51
- 1858 The GP known today is founded.
- Expressen was established in 1944, by Lars Johan Hierta.
- In 1987 is the Mariebergskoncernen resulting in that DN and Expressen becomes systerbolag company's.
- 1995 GP is now on Internet.
- 1997 GP is sold to Expressen.

Car Size Classification Experience

Technical Department/ Technical Division

The Technical Motoring department at GT-Expressen is based on reporters with special interest in cars, motoring and technical devises.

Reporters at this division are all educated journalists and several have made further studies in other fields to widen their knowledge, which are frequently demanded in practice.

Due to the inspection of their knowledge into the aspect of car classification and test methods, without additional integration, any negative effects or flaws made, which normally weight light to what they have created, is dramatical visualised as they tend to have a close co-operations with their customers.

In the near future GT-Expressen expects a big increase of the annual sale volume and hence a significant higher production volume than today. Therefore, this area becomes even more interesting for the magazine to analyse. Additionally, in a couple of years an important part of the personnel will be replaced due to retirements and a change in the organization is expected.

Classification Process: A Local System

GT-Expressen Motor has developed their own car size classification system in 7 different divisions;

- *Mini*

- *Small*
- *Medium*
- *Family*
- *SUV*
- *Sport* and
- *Luxury*

The number of classes is based on the idea to keep it simple for the reader to comprehend.

These classes are founded on given size, measurements and class from the general importer but also advertising field. The “ordinary” passenger cars (mini, small, medium and family) are all categorized in suitable classes after how they are presented by the manufacture. SUV and Sport is more categorized depending on their area of use and the manufactures own definition and design ideas for the car.
Luxury cars are more or less classified depending on price and prestige. These cars do not fall into the same category as sport cars, as their design tend to have more in comment with the “ordinary” passenger cars.

GT-Expressen tend to have a more or less floating classification system, discussions regarding in which category to put the car in question tend to act on a daily basis. However, this manually adjustable categories undermines the professional aspects of the system. As the test methods do not follow any official standardizations or norms, nor directives.

However, in the near future the system now used at GT-Expressen is going to undergo a change. The systematic classification of today tends to collect a vast number of cars into one and the same category, a result of the manually sorting process.

Therefore, as for both private and profession related consumers, the development of a new system that will allow comparability between a larger number of passenger cars with similar functions.

Cooperation with Other Company's

As a company producing daily newspapers and with a technical data and information, in a comprehensive format, they work in close relation to car manufactures and producers. The car manufacturing industry's general agents is the primer source of information, while other companies are more frequently used with custom made cars.

Bilfakta

The Company

Bilfakta was established in 1966 with their first book; Bilfakta Personbilar. The book contained figure data, standard vehicle equipment, technical facts and images over the cars. A complementary division came in 1987 with a book regarding facts of transport cars, Bilfakta Transportbilar. Sense that year 116 Passenger car books and 25 Transportation car books has been published.

In September 2004 Bilfakta Sverige AB was bought by Content Company which is the solitary owner and thereby is the directory boards of Content Company also the same for Bilfakta Sverige AB.

They are providing people with facts, knowledge and inspiration regarding passenger and transportation cars as well in private as in profession.

Car Size Classification Experience

Bilfakta Personbilar, is the most used car information books in the automotive sales industry today. Sense it was established and systematically begun to test cars, the information is continuously updated each month to match the car industry.

The ability to compare up-to-date information is a powerful tool and support for the work of profession in the car industry.

Today the books consists of information regarding currant prices and technical performance, with to scale images over the car models. And it comprise the entire range of cars on the Swedish market, with approximately 1000 different car models and over 40 car brands.

The company primarily collects information data on vehicles from the general importer of the car brand in question.

Technical Department

Quality is reached by continuously updating the data collection each month, manly these data is received by the general importers for each specific car brand and model. Some of their latest improvements have been to develop the measuring model and technique used in the *Autograph* system. This mainly to have the ability to follow the diversity of new car models vast design and advantages in ergonomic features.

By systematically improvements of the product Bilfakta wants to create creditability and offer quality facts. Assessment of test executions improvement is not only evaluated by Bilfakta themselves, but also by their customers in order to attain significant information. The four quality issues they work by are;

- Quality is when the customers expectations is reached.
- Quality is reached by using well known and functional test procedures.
- Quality is reached by using standardized measuring equipments and techniques.
- Quality is reached by education of staff and thorough follow-up's on results.

Figure 4.1: Visualization of the Passenger car book and its contents.

Classification Process: A Local System with Global Capacity

In recent years, a great deal has been achieved in combating vehicle classification by body type and a IS-Index. Of these, the body type, has played, and continues to play, a decisive role. Whereas in the size of vehicles were less successful, the introduction of the Internal Space Index (ISI) and other systems that is bases upon measurement characteristics are therefore a important step i the right direction to develop a classification system.

These attributes are used to classify different types of passenger cars. These types of light vehicles, referred to as automobiles, are designed primarily to transport passengers. The denomination displayed are determined by the model of vehicle selected. For example, if the model selected is a Coupe, the body type is in similar design and construction as displayed. The screen description for the body types displayed are beginning showed below;

- *Sedan*, refers to a passenger car equipped with four doors for ingress/egress and a separate trunk area for cargo (i.e., trunk lid hinged below the backlight). Folding rear seats do not necessarily violate the separate "trunk area" concept.
- *Coupe*, refers to a passenger car equipped with two/three doors for ingress/egress in which 2 of the doors are located on the driver's side and a separate trunk area for cargo(i.e., trunk lid hinged below the backlight).
- *Station Wagon*, refers to a passenger car with an enlarged cargo area. The entire roof covering the cargo area is generally equal in height from front to rear and full height side glass is installed between the C and D-pillars. The rearmost area is not permanently partitioned from the forward passenger compartment area. (e.g., "horizontal window shades" to hide cargo do not constitute partitions). Folding rear seats do not necessarily violate the separate "trunk area" concept.
- *Station Wagon-Sedan and Station Wagon-Coupe*, refers to a passenger car with an limited enlarged cargo area. The rearmost area is not permanently partitioned from the forward passenger compartment area. (e.g., "horizontal window shades" to hide cargo do not constitute partitions). Folding rear seats do violate the separate "trunk area" concept. The cargo area is not permanently partitioned from the passenger compartment area.
- *Convertible and Coupe-Convertible*, (excludes sun-roof and t-bar) refers to a passenger car equipped with a removable or retractable roof. To qualify for this code, the entire roof must open. Convertible roofs are generally fabric; however, removable hardtops are also included.[56]

56 Free translation from Bilfakta Personbilar Nr. 116. pp.412

Internal Space Index of Passenger Cars

The Swedish automotive producers are some of the companies that have adopted the Bilfakta books advantages to visualize measurements with an description of the car. This has in fact resulted in a need for closer cooperation between company's since the value chain of information has to be well coordinated to work sufficiently and correct data given.

The company have therefore developed a information system which affords a systematic understanding of the information gathering and treatment processes.
In this way, it proved possible to isolate single measurements which are needed to make a comparability measure. In conjunction with a manufacturer of sensors, a dew laser measuring sensors was being developed which permitted the measurement of actual space within the coupé area to be evaluated. By means of this system, any car manufacturer will be in a position to conduct investigations at different locations in the vehicle and under varying car body types. Once the measurement characteristics have been recorded, it will be possible to reproduce comparable realistically conditions in the computer simulation. All further measurements are provided when a SAE-Dummy, called Oscar with a special weight of 76,5 kg, embedded within the passenger seats.

This measurement verification/authentication process and system, called *Autograph*, includes having a representative of an authentication system provider witness an individual autographing an item and generate a unique label for each signed item. The unique information may be accessed through the database.

The measurement used in Bilfakta includes 9 parameters, taken in the mentioned process, that all together makes a Internal Space Index of Passenger Cars (UTR-index). Measured in SI-unit: mm.
Having a representative data of an authentication system provides witness to a unique label for each individual car:

Internal Space Index Measurements

MEASUREMENT	INTERNAL CAR POSSISION		DESCRIPTION
Legroom	Front	Back/ 3:rd	
Height seating position	Front	Back/ 3:rd	
Hip rom	Front	Back/ 3:rd	
Shoulder room	Front	Back/ 3:rd	
Length of internal coupe area.			

Table 4.1: Internal Space Index Measurements

The IS-Index, or UTR-Index in Swedish, does not tell where /how cars stand up to each other but gives a hint on how it can be possible to make a unified denomination system that will work for all passenger cars.

In the 38th edition of “Bilfakta Personbilar” a new generation of the Autograph measuring method was proposed that divorces the earlier measurements from the newer recordings.

Cargo Area in Passenger Cars

The determination of the cargo area involves investigating possible measures, such as variations of width, height and depth within the cargo area. With an effective method, it will be possible to determine the abilities of the packable area with simple measures to rely on.

The focal point of test strategies and the solutions developed from them is always the customer, who expects a fully functioning, reliable product which will display actually functioning cargo area.

Regrettably the measuring method is not connected to SAE or ISO 3832 and VDA standards. The cargo area measuring method has become a permanent feature whereas, at one time, simple measures were adequate; they are now becoming increasingly complex in order to meet the demanding requirements. Requirements that in specific cases need accurate measurements in order to be reliable. The use of references boxes is well known among the SAE-norms in terms of measuring cargo areas. Although the reference boxes at Bilfakta are smaller in size compared to those in the SAE-norm, a great deal has been achieved.

Even though the actual figures of VDA do not lend themselves to being compared with the measuring recorded by Bilfakta, the use of their Cargo Area Index is well known and the results has a significantly shorter time for the object to be measured.

In contrast to other norm and standardization systems, the measuring area is only done in sedan, coupe and convertible cars. Station wagon cargo areas are not measured by Bilfakta.

Once the volumes of the cargo area have been recorded, it will be possible to compare similar car model areas. By means of this system, any car manufacturer/salesman/buyer will be in a position to conduct investigations regarding the cargo capacity in cars.

Cooperation with Other Company's

The Swedish automotive producers are some of the companies that have a close work relationship with Bilfakta.
Among other thing this has affected the company’s way of working with other car manufactures. This has in fact resulted in a need for closer cooperation with general importunes since the information chain has to be well coordinated to work sufficiently.

They demonstrate this by continuous upgrade their methods in order to provide recognition to outstanding contributors in the profession.

Some of the company's that are in cooperation with Bilfakta are as follows;

- Dagens Nyheter: Bilfakta
- Pilkinton
- Wasa Kredit
- Bilprovningen

Whereas DN (Dagens Nyheter) bases their services on both content and function of the system provided by Bilfakta.

A Car Culture

As a company producing books with technical data and information, in a comprehensive format, they work in close relation to car manufactures and producers.

However, in the near future car industry's expects a big increase of the annual sale volume and hence a significant higher production volume than today. Therefore, this area is becoming even more interesting for both private and profession related consumers.

Volvo Car

The Company

The Volvo Group is one of the world's leading manufacturers of trucks, buses and construction equipment, drive systems for marine and industrial applications, aerospace components and services.

The Group also provides complete solutions for financing and service. The Volvo Group, which employs about 82,000 people, has production facilities in 25 countries and sells their products in more than 185 markets. Annual sales of the Volvo Group amount to about 23 billion Euro.

The Volvo Group is a publicly-held company headquartered in Göteborg, Sweden. Volvo shares are listed on the stock exchanges in Stockholm and on NASDAQ in the US.

Volvo now sells cars in over 100 countries. Globally, a relatively small manufacturer with a market share of about 1-2% on the main markets. One exception, however, is Sweden, where roughly one in every five cars sold is a Volvo.

In 2005, Volvo Cars sold a total of 443,947 passenger cars. The largest market is the USA, which accounted for 28% of the total sales volume in 2005. The US is followed by Sweden (12% : 52,696 cars), Britain (8.6%), Germany (7.9%) and Italy (4.6%).

Car Size Classification Experience

Product Development and Technical Department

What differentiates a Volvo from other cars is its properties. Naturally within the areas that are core values at Volvo Cars—safety, environment and quality—but also the car's comfort, driving properties and usability have clear Volvo genes. The company was founded on the basis of safety. "Cars are driven by people. Therefore the guiding principle behind everything at Volvo is and must remain safety".[57] Developing and ensuring these properties is an important task for the product developers. Their work is based on the expertise of the 4000 or so employees of the Product Development department in Göteborg, which has been built up over decades of car development. Volvo Cars also has access to the combined competence of Ford Motor Company and the many suppliers who actively contribute to the development of new Volvo cars.

The design of Volvo's cars is strongly flavoured by Scandinavian origins. This is also reflected in the design of the passenger cars—outside and in. Based on the customer's needs and lifestyle along with the values that are represented by the Volvo brand.

Production is largely customer order-driven, imposing major demands on flexibility; among other things, several models are built on the same production line.

Classification Process

In this joint approach, Volvo has main responsibility for new car models in the same size category as the Volvo S80 and V70. Volvo, with its tradition in the field of safety, also has main responsibility for engineering work relating to the body and interior, as well as electronics. Electronics is without doubt the most dynamic area within car development and a key to success within both active safety and environmental care.

57 Assar Gabrielsson and Gustav Larson 1927

The car's design is developed and enhanced in a continuous process. This includes the monitoring of new trends, design languages and customer preferences. (Increasing competition in today's markets, combined with high demands.)[58]

Volvo as well as other car manufactures do not design their cars to fit into a specific classification group. They target customer groups, and of this reason do not use any classification models.

Models with current denomination

Today, the company uses a system of letters denoting body style followed by the series number. S stands for saloon (BE) or sedan (AE), C for coupé or convertible and V for versatile. XC stands for cross country originally added to a more rugged V70 model as the V70XC and indicates with a raised suspension to give it a mock SUV look.

Originally, Volvo was planning a different naming scheme. S and C were to be the same, but "F", standing for flexibility, was to be used on station wagons. When Volvo introduced the first generation S40 and V40 at Frankfurt in 1994, they were announced as the S4 and F4. However, Audi complained that it had inherent rights to the S4 name, since it names its sporty vehicles "S", and the yet-introduced sport version of the Audi A4 would have the S4 name. Volvo agreed to add a second digit, so the vehicles became the S40 and F40. However, that lead to a complaint from Ferrari, who used the Ferrari F40 name on their legendary sports car. This lead to Volvo switching the "F" to "V", for versatile.

The Car Rental Company's

The Swedish Car Rental Park had a total revenue of around 1 413 millions in 2005, with 74% of the total cars rented were made at full service car rentals.

Due to the competitive environment in which these company acts, the information regarding their classification systems are difficult to receive. In spite of this fact the Swedish BURF (Biluthyrningsbranchens Riksförbund) has made a list of all Car Rentals in Sweden and information concerning company's in cooperation with them are able to attain e.g. Avis, Hertz and Sixt. By contacting the Swedish BURF, I was able to receive contact information to the larger car rental companies acting in Sweden.

According to my responders, from the selected car rentals, there is a distinctive difference in the way which the company's operates.

Cooperation with Other Company's

In recent years, Volvo Cars has intensified its cooperation primarily with other European companies within Ford to initiate introduction of a new approach for shared product development. The aim is to harness specialist competence in each company and to make product development as efficient as possible. This in turn creates new opportunities for innovation and fresh approaches.

58 www.volvocars.se

Avis

The Company Overview

The company is part of Avis Budget Group, Inc., (NYSE: CAR) formerly Cendant Corporation. Avis Rent A Car System, LLC and its subsidiaries operates one of the worlds largest car rental brands, providing customers with a wide range of services at more than 2,000 locations through a network spanning 112 countries in Europe. In Europe the Avis rental car fleet averages 700 000 vehicles and features a wide variety of licensees whereas 31 % Airport and 69 % Off Airport.

Quick History

Founded in 1946 by Warren Avis - "Avis Airlines Rent A Car Systems" at Willow Run Airport, Detroit - (who sold his interest in 1954), Avis was the first company to rent cars from airport locations. The company grew rapidly during the 1950's through franchised and corporate-owned expansion. In 1963, Avis introduced the award-winning "We try harder®" campaign and the tag line remains the company's rallying cry even today.

Car Size Classification

The AVIS Company Classification Code , AMS; is based on the data given from the car manufactures and defines cars from the smallest as an "A" up to the fullest size, defined as "P" (premium van). Here the separate car manufactures concept definitions is valid due to lack of an independent size classification at AVIS. Displayed below are samples of the car fleet in the Avis system.

AVIS System Code

AMS Code	Car Model Examples
A	Hyundai Atos
B	Opel Corsa
C	Opel Astra 1.6
D	Nissan Primera 1.8
K	Opel Vectra 2.2
H	Nissan Primera Wagon
G	Opel Astra 1.6 Wagon
E	Opel Vectra 2.2
F	Saab 9-3 2.0
I	Opel Vectra 2.2 Wagon
O	Saab 9-5
J	Saab 9-5 Vector Wagon
N	Chevrolet Transport 3.6
M	Saab 9-5 Vector 2.3
P	Opel Vivaro 2.0

Table 6.1: Classification Samples

As a company producing books with technical data and information, in a comprehensive format, they work in close relation to car manufactures and producers.

However, in the near future car industry's expects a big increase of the annual sale volume and hence a significant higher production volume than today. Therefore, this area is becoming even more interesting for both private and profession related consumers.

Hertz

The Company

The Car rental, the largest and best known of Hertz' activities, is conducted from approximately 4,600 international locations in more than 150 foreign countries and deliver approximately 30 million reservations annually. Hertz offers a wide variety of current-model cars on a short-term rental basis – daily, weekly or monthly – at airports, in down town and suburban business centres, and in residential areas and resort locales.

Quick History

In September of 1918, the pioneer of auto renting, Walter L. Jacobs, at the age of 22, opened a car-rental operation in Chicago. Starting with a dozen Model T Fords, which he repaired and repainted himself, Jacobs expanded his operation to the point where, within five years, the business generated annual revenues of about $1 million. In 1923, Jacobs sold his car-rental concern to John Hertz, President of Yellow Cab and Yellow Truck and Coach Manufacturing Company.

Car Size Classification Experience

Classification Process: A Global System

Hertz uses two separate classification systems when it comes to defining cars, ACRISS and their own Company Code.

The Hertz Company Classification Code is based on the data given from the car manufactures and defines cars from the smallest as an “A” up to the fullest size, defined as “Q”. (See Appendix ACRISS for example). Here the separate car manufactures concept definitions is valid due to lack of an independent size classification.

When it comes to the Classification Code there is a wide range of vehicles that in addition to the experience of classification lands in-between two classes; the Crossovers. Passenger cars with a little more off-road characteristics, but lesser than a SUV. These cars are often classified as SUV, in order to maintain their idea off a off-road adapted city car.

Classification and Vehicle Type

Vehicle Class		Vehicle Type
A	Small car	Fiat Panda 1.3D MJT, Fiesta 1.4 TDCI
-	Mid size car	Focus 1.6D ZESIV
Q	Full size car	Laguna 1.9DCI SW, FIAT Croma 1.9JTD
D	Automatic car	Mercedes C200CDi A
E	Hybrid	Toyota Prius
A, C *	Green Collection	Volvo S60 Bifuel
X	Prestige Collection	Jaguar XJ8, HUMMER H2,Volvo V70 Cross Country XC
Z	Fun Collection	Mustang Shelby GT-H, Ford Escape XLT Sport

Table 7.1 Sample of Classification and Vehicle Type

*A = sedan och C= station-wagon + number that defines Diesel or Flexifuel.

Vehicle Class Specification

Passenger vehicle sizes can be defined by length, width, wheelbase, or the weight of the vehicle. The vehicles in each size of Hertz; *Small*, *Mid Size* and *Full size* is based entirety on the measure of classification outlined by the American National Standards Institute (ANSI D-16, 6th ed.). The passenger vehicles have been classified by size as depicted in Table 4.4. It is also used by NHTSA (National Highway Traffic Safety Administration) – which data is being based on the car classification size outlined in Table 4.4. – and adopted by the National Center for Statistics and Analysis (NCSA).

However, for the other vehicle classes as *Green Collection; Prestige* and *Fun Collection* there are no direct size indicators. The separate collection has their own brake down in specification (whereas shown in Table 4.4).

Definition of Classification

Vehicle Class	Vehicle Criteria
Small car	Wheelbase: < 104 inches
Mid size car	Wheelbase: 105-109 inches
Full size car	Wheelbase: > 109 inches
Green Collection	Has a weighted CO_2 output level of less than 140g/km and between 40 to 65 MPG.
Prestige Collection	Includes the latest range of luxury models from an expanded fleet of sedans, coupés, convertibles and high-performance vehicles.
Fun Collection	Sport cars and vehicles with special “bling” factors.

Table 7.2 Sample of Classification Definitions

Examples on the Prestige Collection

Figure 7.1 Prestige Collection Models

Examples on the Fun Collection

Figure 7.2 Fun Collection Models

Cooperation with Other Company's

As a company providing customers with rental cars all over the world, they work in close relation to car manufactures and producers.

Among other thing the continuous development of new cars, named *crossovers*, has affected the company’s way of working with other car manufactures. This has in fact resulted in a need for closer cooperation with general importunes since the information chain has to be well coordinated to work sufficiently.

Some of the company's that are in cooperation with Hertz are as follows;

- American National Standards Institute
- Euro NCAP
- American NCAP

Euro N CAP

Today, more than ever before, safety sells cars. For car buyers it is a key element of their purchasing decision.
It's essential that motoring consumers can obtain reliable and accurate comparative information regarding the safety performance of individual car models.
By law, all new car models must pass certain safety tests before they are sold. But legislation provides a minimum statutory standard of safety for new cars; it is the aim of Euro NCAP to encourage manufacturers to exceed these minimum requirements.

The Company

Euro NCAP is a crash test program, which was established in 1996. Since that time and up until springtime 2000, 64 different car models have been tested and the results have been published. The cars are tested in a frontal collision and in a side collision.

The aim of the Euro NCAP crash test program is two fold. There is a need for objective consumer information, but there is also a need to promote industry when an effort is made to improve their vehicles beyond the demands of legislation. Crash testing is a way to get an early indication of the safety level of new cars. When cars have been on the market for some time, ratings obtained from real life accidents give important and more valid information about the real life protection level of cars.

Euro NCAP uses stars to indicate the safety level of a vehicle. A combined star rating shows the protection level in the front collision and side collision together. The star scoring is based on point scores for the front and side. Maximum 34 points can be achieved by adding 16 front and 18 side points. The intention of the scores is to give an indication to what extent best practice or benchmarking has been applied to an individual car model, and not to predict the real-life outcome. Neither the test set-up nor the scoring system would be theoretically able to predict the outcome in all types of crashes. On the other hand, there should be a good correlation between promoting higher scoring in the Euro NCAP and overall safety benefits in road accidents.

Technical Division

The main aim of Euro NCAP is to provide accurate information that will enable the consumer to compare the safety properties of vehicles available on the European market. Euro NCAP has specific working procedures in place to ensure the effective implementation of this task.

The **'Euro NCAP Process Map'** illustrates succinctly the role of the three stakeholders: Euro NCAP, car manufacturers and the consumer in this overall process.

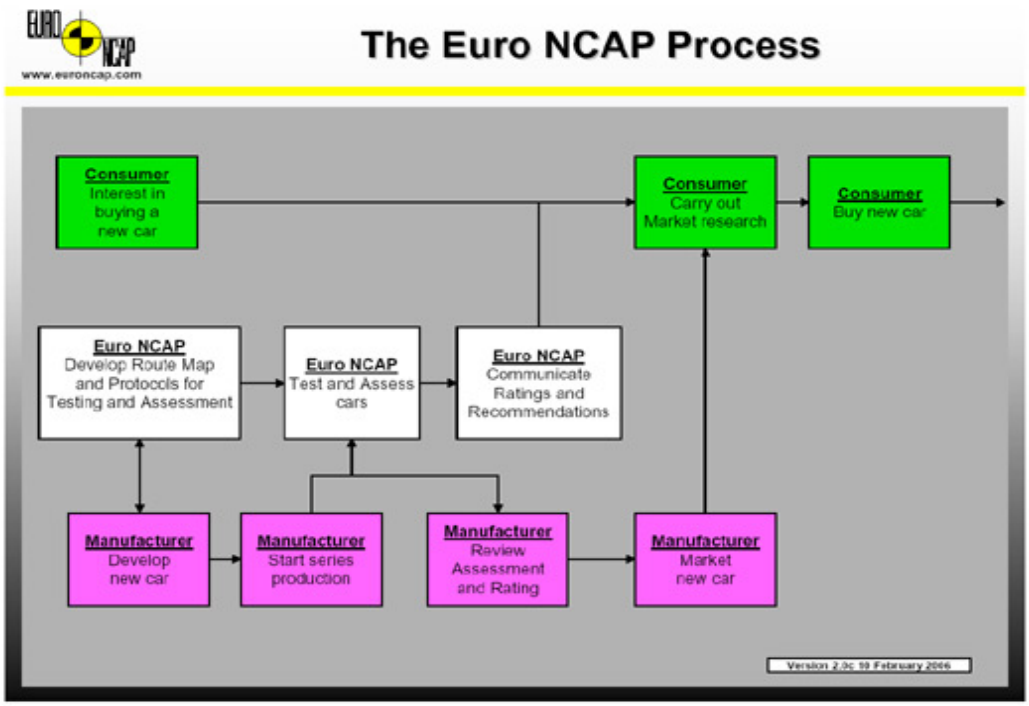

Figure 8.1 The 'Euro NCAP Process Map'

Test Procedures Explained

The Euro NCAP programme is designed to provide a fair, meaningful assessment of the impact performance of cars. It is intended to inform consumers, so providing an incentive to manufacturers as well as giving credit to those who excel at occupant or pedestrian protection.

The tests used are based on those developed for legislation by the European Enhanced Vehicle safety Committee (EEVC), for frontal and side impact protection of car occupants and for the protection of pedestrians hit by the front of cars.

No stylised test procedure fully reflects the protection provided by a car in the wide variety of accidents which occur on the roads. However, cars that perform well in these tests should provide better protection in accidents than cars which perform less well. No anthropometric dummies are available which can measure all the potential risks of injury to humans or assess protection for different sizes of occupant in different seating positions. To compensate for this, the assessment procedure takes account of other information related to occupant kinematics, interior contact points and vehicle structure.

The **'Testing Phase'** describes the various roles and interactions involved in Euro NCAP's testing process.

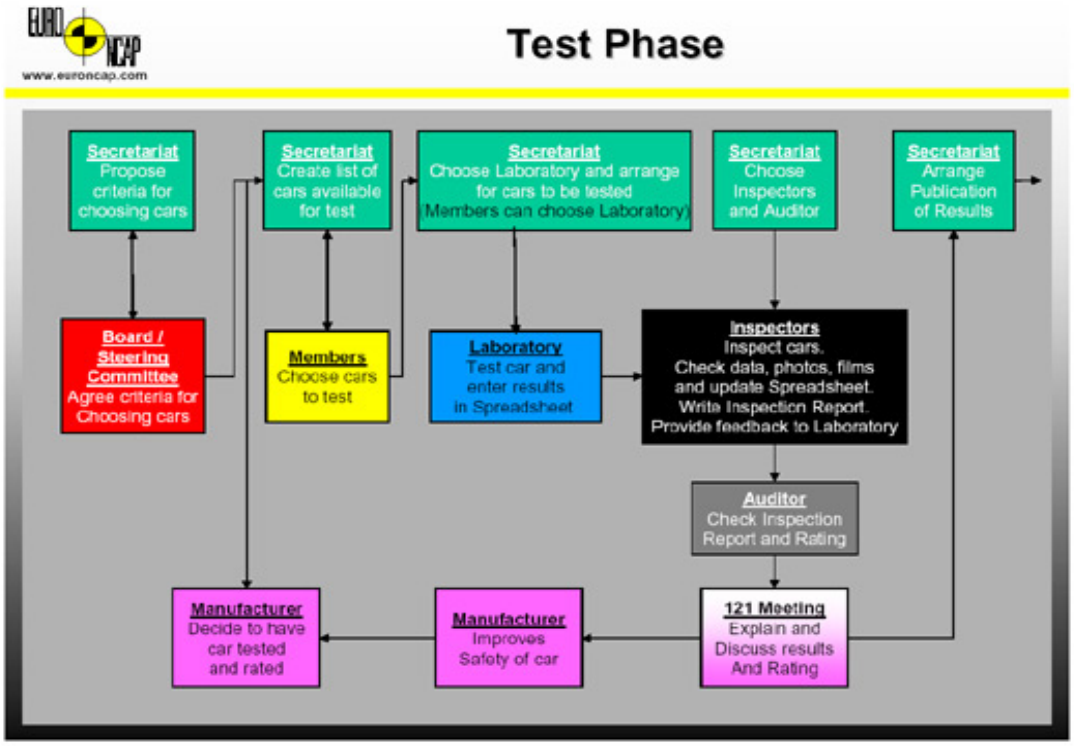

Figure 8.2 The 'Testing Phase'

The repeatability of the tests procedure is fully investigated in research by the EEVC.

After each test, an expert inspector examines the cars and test data. From their inspection, the assessment is expanded to cover different sizes of occupant in different seating positions and slightly different impact severities and directions. Each inspection report is audited to check for accuracy and consistency between inspectors when finished.

After each car model is tested, a meeting – called 121 meeting – is held with the manufacturer to discuss the results and obtain further information.

Euro NCAP Principles

The Euro NCAP test results are not specifically sent to any organisation (Insurance Companies/Car Hire firms/fleet buyers) as they are now easily accessible on Euro NCAP's.

Car Size Classification Experience

Euro NCAP was originally developed by the Transport Research Laboratory for the UK Department of Transport (DFT). Subsequently the classification process used is basically the DFT system from 1996 (when Euro NCAP was initiated), and from 1998 the additional classification from vehicle manufactures up to present date.

Many other interested parties have joined Euro NCAP later on. The European Commission is an observing member of Euro NCAP's board and provides additional support. This wide consortium of members ensures our independence.

Euro NCAP itself is an International Association under Belgian law. Euro NCAP is independent of the automotive industry and political control. No individual member can bias Euro NCAP towards their individual interests.

Classification Process

No stylised classification test procedure fully reflects the comfort provided by a car in the wide variety of size, mistakes which often occur on the market. However, cars that perform well in these tests should provide some sort of evaluation ground for the compeer of ability by given size f the vehicle. Demonstrating larger vehicles allows better protection in accidents than smaller which ought to perform less well.

So to take account of vehicle and test variations, a number of actions have been taken e.g. : The overall assessments are based on the combination of multiple results. Variations in any one of these will only have a limited effect on the overall rating.

The least demanding performance boundaries for the frontal and side impact parameters have been set to be equivalent to the ninety-five percentile male population. Limits that are proposed in the EEVC test procedures. The EEVC limits were set to provide a basic minimum level of protection and only protect in a moderate proportion of accidents. For car occupants, these limits are too lenient to adequately identify best practice in current production cars and to provide a goal for further improvement. Additional, more demanding, boundaries have been set, to identify aspects of a car's performance which offer significantly greater protection.

For safety ratings, the EuroNCAP uses nine categories:

- Superminis (it includes city cars)
- Small family cars (also for stand-alone saloon superminis, like the Dacia Logan)
- Large family cars (includes compact executive cars)
- Executive cars (for expensive cars over 4.80m long)
- Roadsters
- Small off-roaders (similar to the North American crossover SUV category)
- Large off-roaders (similar to the North American SUV category)
- Small MPVs (both mini MPVs and compact MPVs)
- Large MPVs

Classification Categories

Euro NCAP	Car Model Examples
-	Smart ForTwo
Super mini	Fiat Panda
	Hyundai Accent
Small family car	Ford Focus
Large family car	Volkswagen Passat
	Audi A4
Executive car	Chrysler 300C
	BMW 5 Seriec
-	Mercedes-Benz S-Class
-	Porsche 911
-	Jaguar XK
-	Ferrari F50
-	BMW 3 Series
Roadster	BMW Z4
Mini MPV	Peugeot Partner
	Opel Meriva
	Mazda5
MPV	Toyota Previa
Small Off-Roader	Suzuki SX4
	Honda CR-V
Large Off-Roader	BMW X5
	Jeep Grand Cherokee
	Cadillac Escalade

Figure 8.3: Classification with Examples

Cooperation with Other Company's

Current members include the Catalonian region of Spain, France, Germany, the Netherlands, Sweden and the UK. Consumer groups in Europe are represented by International Consumer Research and Testing. Motoring Clubs are represented by members of the FIA Foundation and ADAC, the German Motor Club. British Insurers are represented by Thatcham.

Euro NCAP tests are performed by six laboratories around Europe. These include one based in France (UTAC in Montlhery), two based in Germany (ADAC in Munich and BAST in Bergisch Gladback), one in the Netherlands (TNO in Delft), one in Spain (IDIADA in Tarragona) and finally one in the UK (TRL in Berkshire).

Six organisations have been approved by Euro NCAP to be responsible for its test programme. In each case, they have had a close relationship with one or more of the members and most are experienced in vehicle safety research. They are commissioned by Euro NCAP to carry out the tests on individual car models.

The laboratories approved to be responsible for testing are:

- ADAC Germany
- BASt Germany
- IDIADA Spain
- TNO The Netherlands
- TRL United Kingdom
- UTAC France

The car manufacturers are involved in the tests, each manufacturer is told of the choice of car, variant and options. Preferably vehicles for the tests are acquired anonymously, but if this is not possible they are randomly selected. Manufacturers are asked to provide test set up information, to recommend child seats and to make any general comments. They are invited to witness the tests and to say whether they are satisfied with the way the test is run. After the test, they are given the test results and invited to comment on any anomalies when compared with their own data.

A Car Culture

The Euro NCAP tests have been designed to guide car design to provide good protection over a wide range of crash types. The test reports indicate the areas where improvements would provide safety benefits. However, it is not for Euro NCAP to tell manufacturers how to design their cars. If manufacturers wish to take action on the basis of the results made, they are the ones who fully understand the design of their products and are best placed to decide how any improvements could be made.

The Swedish Consumer Agency (Konsumentverket)

The Company

The Swedish Consumer Agency (Konsumentverket) is a state agency whose task is to help the general public in Sweden with consumer affairs. The SCA represents consumer interests in relations to businesses, and pursues legal action in the consumer interest.

Car Size Classification

The car size classification is attained without special size definitions. Too decide upon vehicle class, they only use weight as characteristic that is (by them) declared as sufficient enough.
The parameters used in these car classes are defined in table 9.1.

Car Classification by Weight

Classes	Parameters (Total Weight in kg)
Small	< 1101 kg
Small Mid-Size	1101 – 1250 kg
Larger Mid-Size	1250 – 1400 kg
Small Large	1401 – 1600 kg
Large	> 1600 kg

Table 9.1: Classification by Weight

As the SCA classification is believed to full fill its mission, no furtherer ranking is made.

The information presented by SCA is mainly received from the manufactures head quarters and general importers. From the beginning of this year (2007) a survey, in accordance to directive 1999/94/EG, is done over the Swedish car marked. This directive provision regards the awareness to the consumer regarding; fuel economy, fuel consumption and CO2 mass emission of new cars.
It also states that information regarding fuel economy, fuel consumption and CO2 emissions are to be available at the sale promotion of new cars.

The Swedish Association of Green Motorists

The Company

Gröna Bilister (The Swedish Association of Green Motorists, SAGM) was founded in 1994. It is a small non-governmental organisation (1000 members) and based very much on voluntary work. The aim is to make road transport more friendly to the environment and to promote public transport and bicycling as alternatives, particularly in urban areas.[59]

They work closely together with the European Federation for Transport and Environment, T&E, trying to influence the European Union´s policies on exhaust emissions, fuel quality, alternative fuels and the taxation of road transport (internalising external costs).

Car Size Classification Method

The vehicle size classification are categorised by the passenger vehicles transportation capability, instead of external characteristic measurements (used up until spring 2006). The segmentation of classes made by SAGM is based upon number of seats, maximum load capacity (passengers + luggage) and steered axles, which gives an indication of compartment capacity.

There are however difficult to draw strict categoric boundaries between passenger vehicles.

Presentation of the vehicle size classification is done in the table 10.1 below with an car model example.

Definition of Classification

Definition	Preferences							Car Model Examples
	Seats	or/and	Axel Distance	or/and	Maximum Load	Adults á 70 kg	Luggage	
	Number		cm		Kg	Number	kg	
MINI	< 4	or	< 240	or	< 280	4	-	Toyota Yaris 1.0 16V
SMALL	> 4	and	> 240	and	> 280	4	-	Wolksvagen Polo 1.2
SMALL MIDSIZE	> 4	and	> 250	and	> 320	4	40	Audi A3 SB 1.4 TPI DPF
LAGRGE MIDSIZE	> 5	and	> 260	and	> 350	5	-	Ford Focus 1.6 TDI DP
LARGE	> 5	and	> 270	and	> 400	5	50	Peugeot 370 SW 1.6 HDI FAP
FAMILY BUS	> 6	and	-	and	> 420	6	-	Renault Grand Scénic 1.6 16V

Table 10.1 Classification Definitions[60]

59 www.gronabilister.se
60 From www.gronabilister.se

Centre for Automotive Industry Research (CAIR)

The complexity and diversity of cars means that conventional eco-ratings such as those used for white goods, present insurmountable difficulties. A number of environmental ratings systems for cars are currently in use, notably in Germany (VCD Auto Umweltliste; Auto Motor und Sport), Sweden (Rototest), but also in the UK (Environmental Transport Association Car Buyers Guide). These are all primarily aimed at private consumers. However, they miss out a number of key indicators. In addition, the European Commission has announced it was to introduce its own eco-rating for cars by 2000. This was likely to be based on CO emissions, although a more comprehensive system where introduced in due course (AEA 42,1998, 13- 16).[61]

Dr Paul Nieuwenhuis and Dr Peter Wells from Centre for Automotive Industry Research, Cardiff University in Wales UK , were developing a system at the Centre for Automotive Industry Research (CAIR) in collaboration with a European car producer, that was aimed at corporate fleet buyers, who where facing the increasing pressure of their own company's environmental performance and image.

An Environmental Performance System

The system developed by CAIR and its partners are a first step in this eco-optimization direction. It is by no means straight-forward to rate the performance of a car.

In addition they where addressing some of the flaws of the existing systems by taking into account issues such as product durability, but also by incorporating a segmentation system allowing a more meaningful comparison of competing products to be made.

The formula is as follows and relates size and weight:

Vehicle length (metres) x width (metres) x weight (tonnes) = ESS

As a proxy for the environmental impact of a vehicle it is a fair measure as it relates the vehicle's weight to its 'footprint' and thus relates literally to its impact on the earth. The system shows how light-weighting of larger cars can pay off, but also tackles Elise vs Discovery anomaly. In each case they used the lightest variant listed; i.e. with the lowest level of specification.

It must be remembered that optional extras can add significantly to the weight of a car. Some examples of how the rating works are outlined in Table 11; some non-cars have been added for comparison.
The system shows by the fact that the Elise appears in ESS segment 1, while the light-weighting strategy followed by Audi for its A8 - not otherwise apparent in any absolute rating system - is clearly illustrated by its environmental segment rating, especially when compared with the S-class, with which it competes. It also shows that the Saab 900/9-3, with which its maker competes against the BMW 3-series and its ilk actually belongs one segment higher than its perceived competitors. It comes in fact very close to its stablemate the 9000CS, soon to be phased out, which does remarkably well for its segment, together with Volvo's V/S70.

Although the ESS could be used as a stand-alone rating system, at present CAIR intends to use it as an input figure for a more comprehensive rating system, incorporating some of the elements reviewed thus far, which is still under development.

61 Developing an Environmental Rating System for Cars (2002), p 2

The CAIR Environmental Segmentation System (ESS): Examples

SEGMENT	*VEHICLE LENGTH x WIDTH x WEIGHT (m x m x tonnes)*	ESS
ESS Segment 0 (0-2)		
ProFlex 656 MTB*	1.72 x 0.58 x 0.01236	0.012
Flevobike AllewederHPV**	2.50 x 0.75 x 0.030	0.056
ESS Segment 1 (2-5)		
Daihatsu Mira	3.31 x 1.395 x 0.63	2.91
Lotus Elise	3.73 x 1.70 x 0.67	4.25
Peugeot 106	3.565 x 1.61 x 0.78	4.47
ESS Segment 2 (5-10)		
Ford Fiesta	3.83 x 1.635 x 0.93	5.82
Nissan Primera	4.40 x 1.70 x 1.075	8.04
Volvo S40	4.48 x 1.72 x 1.20	9.24
ESS Segment 3 (10-15)		
Saab 900	4.635 x 1.71 x 1.295	10.26
Volvo V70	4.71 x 1.76 x 1.42	11.75
Audi A8	5.03 x 1.88 x 1.46	13.8
Lamborghini Diablo	4.46 x 2.04 x 1.57	14.27
ESS Segment 4 (15-20)		
Lexus LS 400	4.995 x 1.83 x 1.68	15.35
Land Rover Discovery	4.52 x 1.81 x 1.92	15.70
Lincoln Town Car	5.56 x 1.945 x 1.83	19.79
ESS Segment 5 (20+)		
Rolls-Royce Silver Spirit	5.295 x 1.915 x 2.43	24.64

Table 11.1: Examples of the ESS

* This is an aluminium-framed full-suspension mountain bike.

** This is an aluminium monocoque full-suspension three-wheeler human-powered vehicle.

Vehicle Classification by North America

There are many ways of classifying cars. The common North American parlance is word-based (e.g. compact car). While English-speaking European writers also use words to describe car sizes, rather than segment numbers or letters, the descriptions used are generally different from the North American terms. In parts of Asia, segment letters are sometimes used.

The English Car Classes

American English	British English	Car Model Examples
Microcar	Microcar Bubble car	Smart ForTwo
-	City car	Fiat Panda
Sub-compact car	Super mini	Hyundai Accent
Compact car	Small family car	Ford Focus
Mid-size car	Large family car	Volkswagen Passat
Entry-level luxury car	Compacvt executive car	Audi A4
Full-size car	Executive car	Chrysler 300C
Midsize luxury car		BMW 5 Seriec
Full-size luxury car	Luxury car	Mercedes-Benz S-Class
Sports car	Sports car	Porsche 911
Grand tourer	Grand tourer	Jaguar XK
Super car	Super car	Ferrari F50
Convertible	Cabriolet	BMW 3 Series
Roadster	Roadster	BMW Z4
-	Leisure activity vehicle	Peugeot Partner
-	Mini MPV	Opel Meriva
Compact minivan	Compact MPV	Mazda5
Minivan	Large MPV	Toyota Previa
Mini SUV	Mini 4x4	Suzuki SX4
Compact SUV	Compact 4x4	Honda CR-V
Mid-size crossover SUV	Large 4x4	BMW X5
Mid-size SUV	Off-Roader	Jeep Grand Cherokee
Full-size SUV		Cadillac Escalade

Table 12.1: Examples of the English Classes

Vehicle Classification by North America and USA regulations

The passenger volume reported on this site is an estimate of the size of the passenger compartment. The luggage volume is the size of the trunk or, in station wagons and hatchbacks, the cargo space behind the second seat. In a few cases, the addition of passenger and cargo volume numbers indicate that a vehicle should be in the next higher classification. This is not the case as the data have been rounded to the nearest whole number.

The interior volume is measured using SAE Recommended Practice J1100 as per EPA Fuel economy regulations, reg. 40 CFR 600.315-82 "Classes of Comparable Automobiles." Automobile manufacturers calculate the interior volume of their vehicles and submit this information to EPA.

The SAE procedure calculates interior volume from many height, width and length dimensions inside the vehicle, including head room, foot room, seat width, etc. The trunk volume is typically determined by putting many suitcase sized boxes in the trunk and adding up the volume of each box.

American government defined class size under Code of Federal Regulations, Title 40--Protection of Environment, Section 600.315-82 Classes of comparable automobiles. Passenger car classes are defined based on interior volume index or seating capacity, except the ones classified as special vehicle. A two seater is classified as a car with no more than two designated seating positions.

Others as follows:

The American Classes

Vehicle Class	Interior volume index (cubic feet)
SEDAN	
Mini-compact car	under 85
Sub-compact car	85-99.9
Compact car	100-109.9
Mid-size car	110-119.9
Large car	120 or over
STATION WAGON	
Small station wagon	under 130
Mid-size station wagon	130-160
Large station wagon	over 160

Table 12.2: Examples of the Classes

Non-passenger automobiles are defined as small pickup trucks, standard pickup trucks, vans, and special purpose vehicles. Pickup trucks is separated from car line based on gross vehicle weight rating (GVWR). For pickup truck car lines with more than one GVWR, the GVWR of the pickup truck car line is the arithmetic average of all distinct GVWR's less than or equal to 8,500 pounds available for that car line.

The Non-passenger Classes

Vehicle Class	GVWR *(pound)
Small pickup truck	under 4500
Standard pickup truck	4500-8500
Van	undefined

*Gross Vehicle Weight Rating (GVWR) = truck weight plus carrying capacity.

Table 12.3: Examples of the Non-passenger Classes

Special purpose vehicle is defined as automobile with GVWR less than or equal to 8,500 pounds which possess special features that are more appropriately classified separately from typical automobiles or which do not meet the definitions of above mentioned classes.

Interior volume index is calculated differently for different vehicle classes:

- For passenger automobiles, it is calculated for each car line which is not a two seater. For car lines with more than one body style, the interior volume index for the car line is the arithmetic average of the interior volume indexes of each body style in the car line.

- For all body styles except station wagons and hatchbacks with more than one seat (e.g., with a second or third seat) equipped with seatbelts as required by DOT safety regulations, interior volume index is the sum, rounded to the nearest 0.1 cubic feet, of the front seat volume, the rear seat volume, if applicable, and the luggage capacity.
- For all station wagons and hatchbacks with more than one seat (e.g., with a second or third seat) equipped with seatbelts as required by DOT safety regulations, interior volume index is the sum, rounded to the nearest 0.1 cubic feet, of the front seat volume, the rear seat volume, and the cargo volume index.

All dimensions and volumes shall be determined from the base vehicles of each body style in each car line, and do not include optional equipment.

Front seat volume is calculated as product of:

- Effective head room-front
- Average of shoulder and hip room-front, if hip room is more than 5 inches less than shoulder room; Shoulder room-front, if hip room is not more than 5 inches less than shoulder room
- Maximum effective leg room-accelerator

Rear seat volume is calculated for vehicles within a rear seat equipped with rear seat belts (as required by DOT), as product of:

- Effective head room-second
- Average of shoulder and hip room-second, if hip room is more than 5 inches less than shoulder room; Shoulder room-second, if hip room is not more than 5 inches less than shoulder room
- Minimum effective leg room-second

For passenger automobiles with no rear seat or with a rear seat but no rear seat belts, the area to the rear of the front seat shall be included in the determination of usable luggage capacity.

Cargo volume index is calculated as follows:

v. For station wagon, it is the product of Shoulder room-second, Cargo height, Cargo length at belt-second.
vi. For hatchback, it is the product of:
    1. Average cargo length, the arithmetic average of Cargo length at second seatback height-hatchback and Cargo length at floor-second-hatchback
vii. Shoulder room-second
viii. Second seatback to load floor height.

British: UK regulations (BCS)

English-speaking European writers also (like the American) use words to describe car sizes, rather than segment numbers or letters, the vehicle size descriptions used are generally different from the North American terms.

Vehicle segments in Europe don't have formal characterization or regulations, and as to that vehicle models are attributed a segment based on comparison to generalist brands models. For example, a car the size of a Volkswagen Golf would be its competitor. The Volkswagen Polo is smaller, so it belongs one segment below the Golf, while the bigger Passat is one segment above.

The classification system was initially developed by the Transport Research Laboratory for the UK Department of Transport (DFT). Subsequently as the classification process is also used by Euro NCAP, some of the car classes are similar to each other. Although the main difference between the two is the BCSs additional segmentation classification, which sets it in a similar position to ACS.

Appendix 4B: Case Company Matrix

	Preferences						
Company	**Number of Car Classes**	**Defined Car Sizes by Measurement**	**Classifying System Developed by the Company**	**Defined Measuring Characteristics**	**Use of Standardised SAE Dummies**	**Use of Standardised Equipments**	**Use of Regulations, Codes or standards in Car Size Classification**
	Amount	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**
Auto Motor & Sport	9	N	N	Y	N	N	N
Avis	15	Y	Y	N	N	N	N
Bilfakta	0	N	N	Y	Y	Y	Y
Centre for Automotive Industry Research (CAIR)	5	Y	Y	Y	N	Y	Y
Euro NCAP	12	N	N	Y	Y	Y	Y
Swedish Association for Green Motorists	6	Y	Y	Y	Y	Y	Y
GT/Expressen	7	N	Y	Y	N	N	N
Hertz	8	Y	Y	Y	N	Y	Y and N
Swedish Consumer Agency	5	Y	Y	Y	N	Y	N
Teknikens Värld	7	N	N	Y	N	Y	N
Volvo Car	7	Y and N	Y	Y	Y	Y	Y

Preferences for Regulation, Codes and Standards Used

Company	ACRISS	AUTOGRAPH	EG-Drirectives	ISO	SAE	VDA
	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
Auto Motor & Sport	N	Y and N	N	N	N	Y
Avis	Y	-*	N	N	-	-
Bilfakta	N	Y	N	N	N	Y
Centre for Automotive Industry Research (CAIR)	N	N	N	N	Y	N
Euro NCAP	N	Y	Y	Y	Y	Y
Swedish Association for Green Motorists	N	N	Y	N	Y	N
GT/Expressen	N	N	N	N	N	N
Hertz	Y	N	N	N	-	-
Swedish Consumer Agency	N	N	Y	Y	Y	N
Teknikens Värld	N	N	N	N	N	N
Volvo Car	Y	Y	Y	Y	Y	Y

* Note: Intentionally left blank, as non information was attained on the question in regard.

Appendix 4C: Case Company Comparisons

Company	GLOBAL COMPANY	INFLUENCED BY LAW AND GOVERNMENTAL DISISIONS	DOMESTIC INFORMATION SOURCING	NON DOMESTIC INFORMATION SOURCING
	Y/N	Y/N	Y/N	Y/N
Auto Motor & Sport	Y	N	Y	Y
Avis	Y	N	Y	Y
Bilfakta	N	N	Y	N
Centre for Automotive Industry Research (CAIR)	Y	Y	Y	Y
Euro NCAP	Y	Y	Y	Y
Swedish Association for Green Motorists	N	Y	Y	N
GT/Expressen	N	N	Y	N
Hertz	Y	N	Y	Y
Swedish Consumer Agency	N	Y and N	Y	N
Teknikens Värld	N	N	Y	N
Volvo Car	Y	Y and N	Y	Y

Appendix 4D: Case Company Matrix, SAE Dummy

Company	SAE DUMMY USED IN MEASUREMENT Preferences		
	5th Percentile	50th Percentile	95th Percentile
	Y/N	Y/N	Y/N
Auto Motor & Sport	N	N	N
Avis	N	N	N
Bilfakta	N	Y	N
Centre for Automotive Industry Research (CAIR)	N	N	N
Euro NCAP	Y	Y	Y
Swedish Association for Green Motorists	N	N	N
GT/Expressen	N	N	N
Hertz	N	N	N
Swedish Consumer Agency	**N**	N	N
Teknikens Värld	N	N	N
Volvo Car	Y	Y	Y

Appendix 4E: SAE Dummy

Hybrid III 50th Percentile Male

This is a 50th percentile adult male dummy specified by Part 572 of the Code of Federal Regulation to be used for compliance testing cars. The basis for the Hybrid III is the ATD 502, an advanced test dummy developed by General Motors in 1973 under a contract with the National Highway Traffic Safety Administration. The ATD 502 featured a head with humanlike impact response characteristics for the hard surface forehead impacts. The European Side Impact Dummy, EuroSID – II, was developed for use as a test dummy in vehicles subjected to lateral impacts. EuroSID – II is included as a test device in the European Regulation for Side Impacts: Directive 96/27/EC and ECE-Regulations '95. A curved lumbar spine was used to achieve a more humanlike automotive seating posture. Constant torque joints were incorporated in the knee, elbow, and shoulder joints to improve repeatability and minimize the time required to set joint torques. The shoulder structure was designed to improve belt-to-shoulder interfacing, which was a problem with the Hybrid II shoulder design. The Hybrid III dummy retained these ATD 502 features, while design changes were made to improve the impact response biofidelity of its neck, chest, and knees. Transducers were incorporated into the Hybrid III design to measure the orthogonal linear acceleration components of the head and chest, the sagittal plane reactions (axial and shear forces and bending moment) between the head and the neck at the occipital condyles, the displacement of the sternum relative to the thoracic spine1 the axial femoral shaft loads.

The mean total body weight of the fully instrumented Hybrid III dummy exceeds the 50th percentile adult male median weight of 164lbs by 7.3 lbs. or 3.3 kg. The excess weight is due primarily to the provision of fully instrumented lower legs with ball joint ankles on the dummy. These modifications strengthen the lower legs and ankles to prevent them from breaking in crash tests resulting in extreme rearward displacements of the floor or firewall of the vehicle.

Hybrid III's use is Federally mandated for certifying the crashworthiness in frontal impact of all passenger cars sold in the United States and in some other countries. It is extensively used by General Motors and other vehicle manufacturers to assess the occupant protection potential of their new car designs.

The size and weight of the Hybrid III 50th Percentile Male Test Dummy represent the "average" of the European adult male population. The design incorporates the range of motions, centres of gravity and segment masses determined by anthropometric studies to simulate those of human subjects. While the Hybrid III dummy provides excellent assessments of the effectiveness of automotive restraint systems for the midsize adult male occupant, it provides no information concerning restraint effectiveness for large- or small-size adult occupants.

The dummy was developed and constructed by a group of European research laboratories working under the auspices of the European Experimental Vehicle Committee (EEVC). The final specification for Hybrid III was established by EEVC in April 1996, after a 10-year period of extensive development and repeated evaluation tests.

The calibration tests performed prior to shipment include:

- Head Drop
- Neck Flexion and Extension

- Thorax Impact
- Knee Impact and Knee Slider
- Hip Joint Range of Motion
- Foot Compression

Standard equipment included in the base price of this device:

19. Chest Deflection Potentiometer
20. Knee Slider Potentiometers
21. Accelerometer mounts for head, chest and pelvis*
22. Structural replacements for all load cells.

*User must specify the accelerometer manufacturer and type at the time of order placement

External Dimensions and Assembly Weight for Hybrid III 50th Percentile Male

Dimension *	**(in)**	**(cm)**	**Part**	**(Ib)**	**(kg)**
Dimension Length	(in)	(cm)	Body Segment Weight	(lb)	(Kg)
Head circumference	22.5	59.7	Head	10.0	4.5
Head Width	6.1	15.5	Neck	3.4	1.5
Head Length	8.0	20.3	Upper Torso	56.5	25.6
Sitting Height	34.8	88.4	Lower Torso	46.7	21.2
Buttock to Knee Length	23.3	59.2	Upper Legs	26.4	12.0
Knee Pivot Height	19.4	49.3	Lower Legs and Feet	25.0	11.3
Total Body*	70.04	177.9	Total Body **	168.0	76.1

Table 3.9: Hybrid 50th -Percentile Male

Hybrid III 5th Percentile Female

The Hybrid III 5th Percentile Female ATD is a smaller scaled version of the Hybrid III 50th Percentile Male ATD. This ATD is used in test situations where the representation is needed for the minimum anthropomorphic dimensions for the adult female population. The Small Female design and test corridors were established by the Society of Automotive Engineers (SAE) for the 5th Percentile representation. In 2000, design revisions of the Small Female improved it's ability to evaluate airbag dynamics in Out Of Position (OOP) testing. The HIII-5F is provided completely tested and certified.

New design features incorporated into the 2000 revision of the Small Female include:

- Modified chest jacket design.
- Upper and lower rib stops.
- Additional accelerometer mounts in the Thoracic Spine and Sternum for V*C measurement capabilities.
- Cable bushings added to the lumbar spine and neck.
- 45 degree feet with ankle bumpers and heel pads.
- Modified femurs with bumpers.

* Other measurements, not included in Total Body Length, are; Hip Pivot From Backline and Hip Pivot Height.

* * The Total Body Weight includes; Upper Arm and Lower Arm w/Hand.

External Dimensions and Assembly Weight for Hybrid III 5th Percentile Female

Dimension*	(in)	(cm)	Part	(Ib)	(kg)
Dimension Length	(in)	(cm)	Body Segment Weight	(lb)	(Kg)
Head circumference	21.2	53.85	Head	8.23	3.73
Head Width	5.6	14.22	Neck	2.00	0.91
Head Length	7.8	19.81	Upper Torso	26.50	12.02
Sitting Height	29.5	78.74	Lower Torso	29.20	13.25
Buttock to Knee Length	20.5	53.34	Upper Legs	6.90	3.13
Knee Pivot Height	16.0	40.64	Lower Legs and Feet	8.95	4.06
Total Body *	62.0	157.48	Total Body **	108.03	49.05

Table 3.10: Hybrid 5th -Percentile Female

Hybrid III 95th Percentile Male

The Hybrid III 95th Percentile Male Test Dummy are based on and represent the 95th -percentile of the European adult male population. The dummy is a larger scaled version of the Hybrid III 50th -percentile Male.

External Dimensions and Assembly Weight for Hybrid III 95th Percentile Male

Dimension *	(in)	(cm)	Part	(Ib)	(kg)
Dimension Length	(in)	(cm)	Body Segment Weight	(lb)	(Kg)
Head Circumference	23.7	59.7	Head	10.9	4.94
Head Width	6.3	16.0	Neck	3.7	1.68
Head Length	8.0	20.3	Upper Torso	49.2	22.32
Sitting Height	37.1	92.2	Lower Torso	66.8	30.3
Buttock to Knee Length	22.9	58.2	Upper Legs	18.1	8.21
Knee Pivot Height	23.9	60.7	Lower Legs and Feet	12.68	5.75
Total Body*	77.2	196.14	Total Body **	213.66	96.91

Table 3.8: Hybrid 95th -Percentile Male

* Other measurements, not included in Total Body Length, are; Hip Pivot From Backline and Hip Pivot Height.

* * The Total Body Weight includes; Upper Arm and Lower Arm w/Hand.

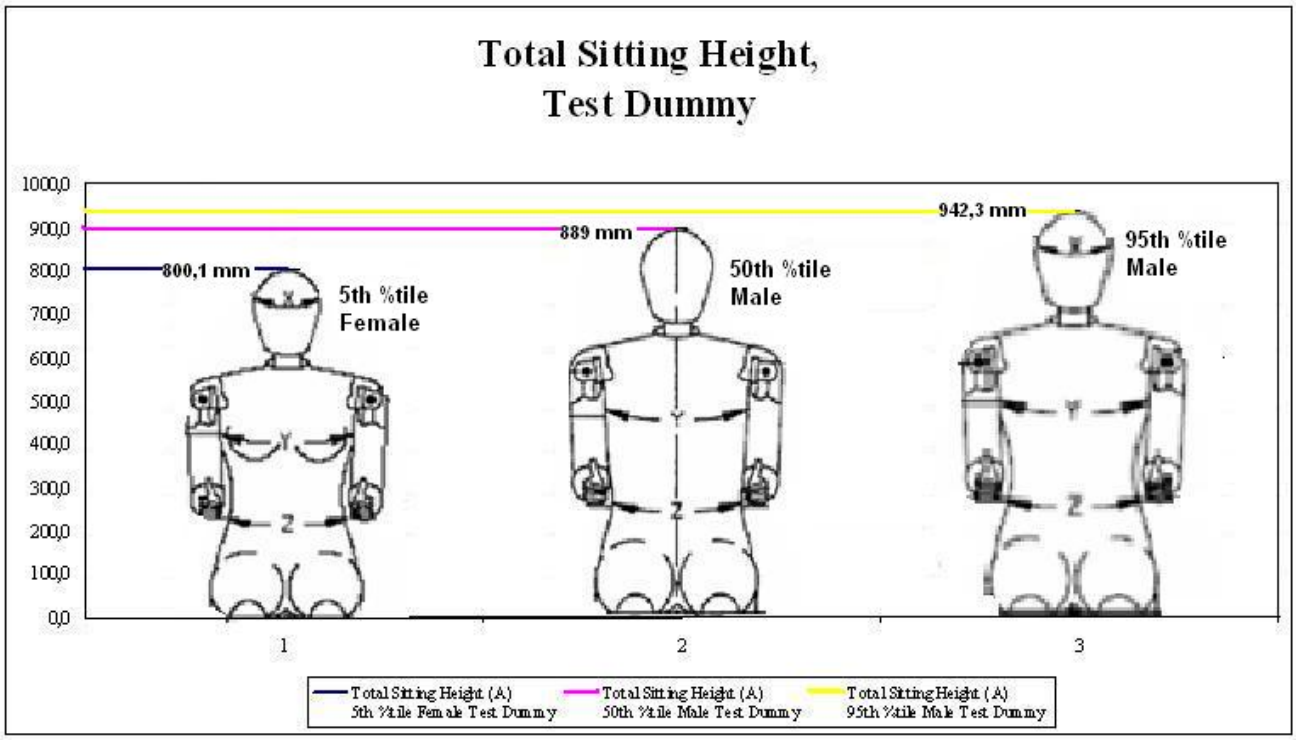

Figure 4D: 1. Compeer of SAE SID III Dummies

Appendix 5A: ACRISS

The Association of Car Rental Industry Systems Standards (or ACRISS) is an international industry organization developing standards for the rental car business.

ACRISS is set up as a European Economic Interest Grouping or EEIG. An EEIG is a form of association between companies or other legal bodies, firms or individuals from different EU countries who need to co-operate together across national frontiers. It is the ideal entity for a group like ACRISS which has members, currently from three different EU countries (France, Germany and the UK). An EEIG has full legal capacity. It cannot be formed with the aim of making profit but it must aim to facilitate or develop the economic activities of its members.

The ACRISS Code

One of their main standards are the ACRISS codes (also known as SIPP codes, Standard Interline Passenger Procedure codes) for defining rental car specifications.
ACRISS Members utilise this industry standard vehicle matrix to define car groups ensuring a like to like comparison of standards across countries. This easy-to-use matrix consists of four categories. Each position in the four character vehicle code represents a definable characteristic of the vehicle.

The expanded vehicle matrix makes it possible to have 400 vehicle types. GDS car codes are created by selecting one character of each column and combining them into a four-character car code:

Car Code Listing

CLASS		TYPE		TRANSMISSION/ DRIVE		FUEL/ AIR CONI	
M	Mini	B	2-3 Door	M	Manual Unspecified Drive	R	Unspecified Fuel/Power With Air
N	Mini Elite	C	2/4 Door	N	Manual 4WD	N	Unspecified Fuel/Power Without Air
E	Economy	D	4-5 Door	M	Manual AWD	D	Diesel Air
H	Economy Elite	W	Wagon/Estate	A	Auto Unspecified Drive	Q	Diesel No Air
C	Compact	V	Passenger Van	B	Auto 4WD	H	Hybrid Air
D	Compact Elite	L	Limousine	D	Auto AWD	I	Hybrid No Air
I	Intermediate	S	Sport			E	Electric Air
J	Intermediate Elite	T	Convertible			C	Electric No Air
S	Standard	F	SUV			L	LPG/Compressed Gas Air
R	Standard Elite	J	Open Air All Terrain			S	LPG/Compressed Gas No Air
F	Full size	X	Special			A	Hydrogen Air
G	Full size Elite	P	Pick up Regular Cab			B	Hydrogen No Air
P	Premium	Q	Pick up Extended Cab			M	Multi Fuel/Power Air
U	Premium Elite	Z	Special Offer Car			F	Multi fuel/power No Air
L	Luxury	E	Coupe			V	Petrol Air
W	Luxury Elite	M	Monospace			Z	Petrol No Air
O	Oversize	R	Recreational Vehicle			U	Ethanol Air
X	Special	H	Motor Home			X	Ethanol No Air
		Y	2 Wheel Vehicle				
		N	Roadster				
		G	Crossover				
		K	Commercial Van/Truck				

Table1: The Industry Standard Car Classification Code

ACRISS car classification coding system has been adopted to ensure that all ACRISS members display the same coding for the same vehicle, enabling to make an informed decision when comparing rates. This is done from the head-office by a continuous updating their vehicle model list with new car models once every third month. The size classification in e.g. “mini”, “compact” and “full size” is made on the basis of the

manufacturer's type designation, which differ from each brand. The variant of a car type, are not allowed to differ in the respect of body stile nor powered axles and steered axles.

E.g. : CCMN = Compact Car - 2/4 Door - Manual Transmission - Non air-conditioned

Car Code Display

CAR MAKE AND MODEL	CODE			
Alfa Romeo 145 1.4	C	B	M	N
Alfa Romeo 145 2.0 Twin Spark 16v	I	S	M	N
Alfa Romeo Sport Wagon 2.5 V6 Q-System (provisional)	S	W	M	R
Asia Rocsta	I	F	M	N
Audi S8	X	S	M	R
Audi TT Coupe 1.8	P	S	M	N
Audi 100 2.8E Quattro	P	D	M	N
Audi 80 2.0	S	D	M	N
Audi A2 1.4i	I	D	M	N
Audi AllRoad 2.7 Quattro	L	F	M	R

Table 2: Sample of vehicle classification listings

Appendix 5B: Autograph

Autograph Diemensiond GmbH provides car manufacturers all over the world with package data for vehicles (*Autograph-program*); for the competitor analysis in design, research and development.
They do not use manufacturer's construction data – to achieve absolute unprejudiced package data from the measuring's carried out, Autograph does not prefer certain car brands and there are no financial partnerships or other influences by any car manufacturers.

The measuring method is according to standard SAE J 1100, ISO 3832 and ISO 17025, i.e. approximately 6000 measuring points for 200 different dimensions which show the exterior, interior, and the SAE H-Point Template shown as 3-dimensional splines, lines and cross sections. The measuring process is carried out with the aid of 3D Coordinate Measuring Systems and the international standardized 3D H Point Machine. Luggage capacity is measured according to ISO 3832 as V210, V211, V213, and V220. Formerly capacity was measured according to special Autograph standard.

Next to 2- and 3-dimensional CAD Drawings, the standard products are the Autograph Database and the Data-sheets. The Package Data are made in a well prepared form.
For example, the CAD drawings are divided into various useful layers, which can be shown separately or in a whole. It's also possible e.g. to combine the CAD data of different vehicles in one drawing.

The following measuring data integrated into the standard products:
3D-H-Point Machine (manikin) at rear seat: Additional centre line of right foot – shown as red dashed line. If great differences between rear floor under right and left foot occur, the centre line of left foot is included, too.
(Formerly luggage capacity was measured according to special Autograph standard).
Measuring of reclining point (REC point) of driver's seat-back, if possible – shown as measuring point in the interior.

Autograph's Data-sheets show the main splines and elements of side, front and rear elevation and it contains the main dimensional data.

- *Side Elevation:*
  Exterior and simplified interior drawing in side elevation, scale 1:20.
- *Front + Rear Elevation:*
  Exterior and simplified interior drawing in scale 1:10.
- *Visibility Sheet:*
  Visibility data and visibility diagram.

The CAD Package Drawings are in form of:

23. Industry Standard Package Drawings in 3D with SAE Dimensions.
24. Industry Standard Package Drawings in 2D: front, rear, side and top elevation, with SAE Dimensions.
25. Industry Standard Package Drawings in 2D, without SAE Dimensions.

The CAD drawings are visualized in IGES format, scale 1:1. All dimensioning is made in accordance to SAE standard.

CAD Drawings Includes:

- Elements and Cross Sections of the Exterior & Interior.
- Driver Centre Lines.

- Rear Passenger Centre Lines
- Car Centre Line.
- Elements and Cross Sections of the Luggage Compartment.
- Eye Ellipse Template.
- Head Template Front and Rear.

Today you will find a list of models since 1975 – that equals more than 1000 different cars! And will continuously be upgradeing the car model list with the data of up to 40 new models each year.

Appendix 5C: Directive 70/156/ EG

B. DEFENITION OF VEHICLE TYPE

- For the purpose of category M_1:

A “type” shall consist of vehicles which do not differ in at least the following essential respects:

26. the manufacturer,
27. the manufacturer's type designation,
28. essential aspects of construction and design:
    29. chassis/floor plan (obvious and fundamental differences),
    30. power plant (internal combustion/electric/hybrid).

“Variant” of a type means vehicles within a type which do not differ in at least the following essential respects:

- body style (e.g. saloon, hatchback, coupé, convertible, station-wagon, MPV),
- Power plant:
    - working principle (as in point 3.2.1.1 of Annex III in the directive),
    - number and arrangement of cylinders,
    - power differences of more than 30% (the highest is more than 1,3 times the lowest),
    - capacity differences of more than 20% (the highest is more than 1,2 times the lowest),
- powered axles (number, position, interconnection),
- Steered axles (number and position).

“Version” of a variant means vehicles, which consists of a combination of items shown in the information package subject to the requirements in Annex VIII in the directive.

Multiple entries of the following parameters may not be combined within one version:

- technically permissible maximum laden mass,
- engine capacity,
- maximum net power,
- type of gearbox and number of gears,
- maximum number of seating positions as defined in Annex IIC in the directive.

5. For all categories:

Full identification of the vehicle just from the designations of type, variant and version must be consistent with a single accurate detention of all the technical characteristics required for the vehicle to be put into service.

B. DEFENITION OF TYPE OF BODYWORK
(Only for complete/completed vehicles)

The type of bodywork in Annex I, Annex II, Part 1, point 9.1 and Annex IX, point 37 of the directive shall be indicated by the following codification:

- Passenger cars (M_1)

AA Saloon	ISO Standard 3833 – 1977, term No 3.1.1.1, but including also vehicles with more than four side windows.
AB Hatchback	Saloon (AA) with a hatch at the rear end of the vehicle.
AC Station-wagon	ISO Standard 3833 – 1977, term No 3.1.1.4 (estate car)
AD Coupé	ISO Standard 3833 – 1977, term No 3.1.1.5
AE Convertible	ISO Standard 3833 – 1977, term No 3.1.1.6
AF MPV	Motor vehicle other than those mentioned in *AA* to *AE* intended for carrying passengers and their luggage or goods, in a single compartment. However, if such a vehicle meets both of the following conditions: a). The number of seating positions, excluding the driver is not more than six. A “seating position” shall be regarding as existing if the vehicle is provided with “accessible” seat anchorages. “Accessible” shall mean those anchorages, which can be used. In order to prevent anchorages being “accessible”, the manufacturer shall physically obstruct their use, for example by welding over cover plates or b fitting similar permanent fixtures which can not be removed by use of normally available tools; and b). P – (M+N *68) > N*68 Where:

P = technically permissible maximum laden mass in kg
M = mass in running order in kg
N = number of seating positions excluding the driver

This vehicle is not considered to be a vehicle of category M_1 if the formulas answer is false.

Appendix 5D: SAE J1100

This SAE Recommended Practice defines a set of measurements and standard procedures for 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. In addition, some dimensions can be taken in an actual vehicle. If measurements are taken on physical properties, some differences in values should be expected. Also, care should be taken to not confuse design intent measurements with those taken on a physical property .Unless otherwise specified, all dimensions are measured normal to the three-dimensional reference system (see 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. Although many terms and dimensions use human body parts in their name, they should not be construed as measures that indicate occupant accommodation, capabilities, or comfort.

Appendix 5E: VDA

The contact less, three-dimensional capture of freeform surfaces with optical systems has become an important tool for the following industry areas in the last few years: product development, Reverse Engineering, and quality control. The high measuring speed obtained with a simple measuring procedure, as well as the high data accuracy and the high point density are the main advantages in comparison to tactile systems.

With the VDA systems, surfaces are digitized contactlessly using the whitelight fringe projection method (triangulation with projected grid and camera). Thus, a fast (1.3 million points/view) and highly accurate measurement is achieved.
The patented technology guarantees highest data quality even on complex surface geometries (depressions, elevations, bridges, etc.) by using only one camera (no synchronization errors at two overlying images, no shading effects).

The following measuring data is integrated in the standard product:

- 3D-H-Point Machine (manikin) at rear seat: Additional centre line of right foot – shown as red dashed line. If great differences between rear floor under right and left foot occur, the centre line of left foot is included, too.
- Luggage capacity is measured according to ISO 3832 as V210, V211, V213, and V220. (Formerly luggage capacity was measured according to Autograph standard).
- Additional cross section of interior and exterior at 635 mm above H-point.

PHYSICAL MEASURING PRINCIPLE OF VDA

The physical basis of the technology is the phase measurement triangulation. Here, a fringe pattern (grid) is projected onto the object to be measured using a whitelight illumination source. The pattern on the object surface generated in this way is captured from the imaging direction by a CCD camera. By moving the grid mechanically, the projected fringe pattern is shifted. Thus, for every pixel on the CCD chip a definite code can be allocated. The 3D position for every single object point is then calculated from the distance between the objective lenses K1 and K2, and the angles • and • with the triangulation method.

Using only one high-resolution camera - which captures 1.3 million points within one shot - minimizes shading effects on complex surface structures, and further contributes to high data quality. Further on, synchronization errors which occur when using common systems working with two cameras are eliminated. The high quality of the obtained 3D data proves these facts for every measurement. With the patented measuring method, a verifiable accuracy of up to +/- 20 µm is achieved.

Owing to the software-controlled zoom functions, the user of the VDA can easily vary the resolution. Thus, important details can be measured with the high resolution mode. For larger, homogeneous surface areas the standard mode is ideally suited, so the user can easily apply the best measuring strategy to the specific application.
By using the software-controlled zoom function, no complicated and error-prone hardware changes are necessary.