



**CHALMERS**  
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## **Next Step for Storage in Car's Trunk**

A concept design proposal on solving the elicited needs to provide an optimal storage

IMSX30 - Master's thesis in Product Development

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Gothenburg, Sweden 2018



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## **Abstract**

This thesis was conducted at Semcon AB, Trollhättan within the department of Body and Trim, and it's a work also conducted for the department of Industrial and Material Science at Chalmers University of Technology, Gothenburg, Sweden. The project initially aimed to develop a multi-purpose trunk, but with the aid of user-centric method the focus changed towards finding the problems incurred in using a car's trunk and solving those. By performing an exploratory search and investigating the customer segments and their needs, a strong knowledge-base was formed and used it for the development work.

The project started with a wider scope and after a couple of cycles we were able to determine the actual problems and the needs. The concepts were generated by brainstorming, later carried by evaluating and eliminating using Pugh matrix and stakeholders feedback to further develop them into a final concept.

The final concept is a modular solution which offers unique space to access the cargo easily and secure it within less time. The solution provides space to store multiple cargo according to one's use, and a separate space for continuous storage. On the left trim, it integrates the tool kit and first-aid kit to keep it within visible and accessible position. Whereas on the right trim, features such as a kettle and custom-made umbrella is integrated to attract users. The concept on a higher-level aim to secure groceries and ensures that the user concentrates on the road rather than worrying about the groceries. It also solves a secondary need for providing more cargo space by utilizing the space beneath the load floor optimally.

Keywords: Car's trunk, Load floor, Product development cycle, Concept, Accessibility, Secure, Time, Customer needs, Testing, Semcon, Modular



## Preface

This report is meant to describe the process and results of the master thesis work which was performed until the period of Spring 2018. The work had been carried at Semcon's Body and Trim department at Trollhättan. Moreover, Semcon framed this thesis to create a platform to work along with a research institute for early stage development with the aid of cutting-edge research. Additionally, to provide an opportunity for students like us to stimulate distinct approach of developing a product and to showcase this collaboration with universities to their customers.

The project has been an interesting journey and we have met people with several helping hands along the way. A project that took a different path than expected to deliver fruitful results. Therefore, we would like to take this opportunity to thank one and all who provided with their valuable advice and assistance without which this project would not have been successful nor presented in this paper.

In respect, we have to thank many but some in particular have to be singled out since they have given us more than guidance.

Firstly, we want to thank Peter Skogh & Henrik Dahlén from Semcon AB for providing us the opportunity to perform this particular project and have along the way provided expertise knowledge regarding this area. It is our privilege to express to our deep sense of gratitude to our eminent supervisors for guiding us throughout the project.

We acknowledge our thanks with greatest sense to Lars-Ola Bligård, Researcher at the Division of Design & Human Factors, who helped a lot and guided during various phases of our project and suggesting best clues to outcome the various problems encountered during the work.

We also want to direct the thanks to all our friends & interviewees who contributed as our major stakeholders during the customer needs elicitation, without which it would have been impossible to deliver the presented output. Finally, we have our thanks for all those who in any manner directly or indirectly put a helping hand for completing this project.

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# 1

# Introduction

This chapter is meant to describe the underlying factors for this thesis work by introducing the company, the background of the project and purpose of why this work had been chosen. It further includes the delimitations by a specific scope to execute the work and a short overview of the report.

## **1.1 Company background**

Semcon AB is an international consulting firm with expertise in product development for engineering and product information services throughout the whole development chain. They have an active and diverse presence in fields mainly like automotive, energy, telecommunication and life sciences. As of today, Semcon has about 2000 employees and a wide geographical presence spreading more than 30 different localities, thus accounting to sales of approximately SEK 1.8 billion [1].

The Body and Trim department is involved in designing and developing the interiors and exteriors of automobiles for major OEM's. Since they carry extreme experience and knowledge within interior development including the car's trunk, they believe that trunk area has a potential for further development and hence want to explore this area.

## **1.2 Project background**

Car's trunk has particularly been a place for storage mainly located on the rear of the vehicle. Trunk is also called as boot, compartment and dickie (Rumble seat). Back in 19<sup>th</sup> century the trunk was an external rack as seen in Figure 1 which was mounted on rear of the vehicles for storage in a similar fashion of that on the coaches in 17<sup>th</sup> century. This external rack later in 1916 became an integral part of the car's body for storage and mainly for an aerodynamic design [2].



*Figure 1 1931 Ford Model A roadster [3]*

Since then the trunk has evolved with several developments made within and around it right from the manually operated tail gate until the latest hands-free tail gate operation to access the trunk. Moreover, the modern trunks mainly house people's cargo (mostly groceries), medical kit, tire pressure monitoring kit/system, warning triangle, the jack and spare tyre. However, the spare tyre is no more provided in the modern cars as it replaced by roadside assistance which is just a phone call away [4]. On day-to-day basis the trunk merely is treated as a regular space but those luxuries which are offered today are the product of innovation and change since centuries.

Most of the modern car's trunk look alike as depicted in the

Figure 2 (left). The same shows the different components in and around the trunk. However, another component which was considered for this thesis work was the space beneath the load floor and above the floor lid. This space is mainly dedicated to store the spare wheel and the tools as shown in

Figure 2 (right). However, as mentioned above, the new cars are shifting towards



imparting road assistance and thus creating an



empty space over there. Moreover, it is sometimes not so uncommon that this secondary space is often neglected and people at times don't realise its existence.

*Figure 2 Major parts/components within and around trunk*

Therefore, it is important to bring this space to light and optimize it according to the present use needs which could further create some value to the user. In addition, this space could address the problems faced in today's world especially relating to the secured way of storing common cargo (majorly groceries).

### **1.3 Purpose**

This thesis proposal is a conceptual design for a car's trunk majorly focusing upon the user. It mainly involves: understanding the user to establish their needs and deliver solution within the design space of the car. Moreover, to also ensure that the provided solution could be adapted to any car irrelevant of the brand, in simple term being modular. In addition, to also address and solve the other hidden needs which could improve the usability of the system/component.

### **1.4 Scope and limitations**

This thesis is focused on implementing the solutions on a general level by considering the average of several cars as listed in chapter 3.2 (benchmarking) and not sticking to a particular car model or brand. This is backed up by the reason that Semcon being an international consulting firm considers this as an in-house project and the solutions could further be shared/developed to any of their customers according to their interest.

Moreover, focus is narrowed down towards the mid- and the large-sized estate/station-wagons/combi cars in Sweden. This is because these car's offer more storage space by being functional and due the vast usage in Sweden. This is highlighted in chapter 3.1 (Market analysis).

The concept developed addresses to solve the important needs which contributes to a better usability of the trunk. The requirement specification chart defined by this project is seen in the appendix B.

### **1.5 Overview of the report**

The major objective of the report is to present the solutions of the developed work and at the same time to walk the reader through the whole process of the achieved output. This report also supplements the reader about the car's trunk, its usage and could be used for further development work. Moreover, the content in thesis is a detailed work involving the contributors from both academia and engineering wing. As the whole project is inclined towards a user-centric approach, this report strives to maintain complete transparency with the process and methods used.



# 2

## Methodology

To be able to approach at the above output, a process along with several methods/tools were incorporated. These mainly enabled in collecting data and taking decisions. Since every product is measured in terms of economic success, it is most likely to achieve it by identifying the customer needs and creating products which solve those needs. Therefore, a product development process which combines marketing, designing and manufacturing is preferably used to deliver that success [5].

This being an inspiration motivated us to use a process that solely concentrated on understanding the users and their needs to deliver a useful product. The process that was chosen for this thesis work is briefed below.

### 2.1 Engineering design process/methodology

As highlighted above about the importance of using a user-centric process, it was important to choose a methodology to carry out the work. Though there were several design methodologies presented by different authors and used differently in the industries, the choice of use for this project is restricted to a combination of 2 processes/methodologies. They are:

- Generic product development methodology [5]
- Design thinking [6]

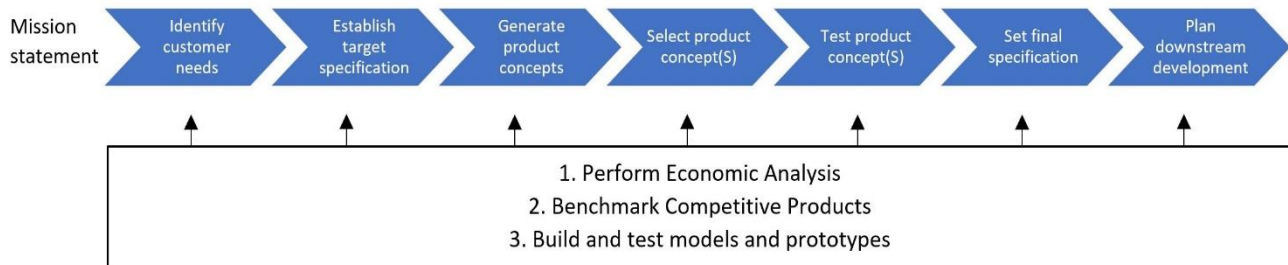
#### 2.1.1 Generic Product Development (GPD) methodology

Firstly, the methodology given out by Karl T. Ulrich (University of Pennsylvania) and Steven D. Eppinger (Massachusetts Institute of Technology) is a step-by-step user-centric process which acts as a perfect ground to deliver a market-push product. The methodology is described clearly in the Figure 3 which comprises of 6 major phases namely planning, concept development, system-level design, detail design, testing and refinement, as well as production ramp-up.



*Figure 3 Generic Product Development Methodology [5]*

As the project initially began with an open-ended problem/challenge, the use of this methodology helped contributing towards the front-end process. This front-end process as shown in Figure 4 is an expanded part of concept development phase in the GPD methodology.

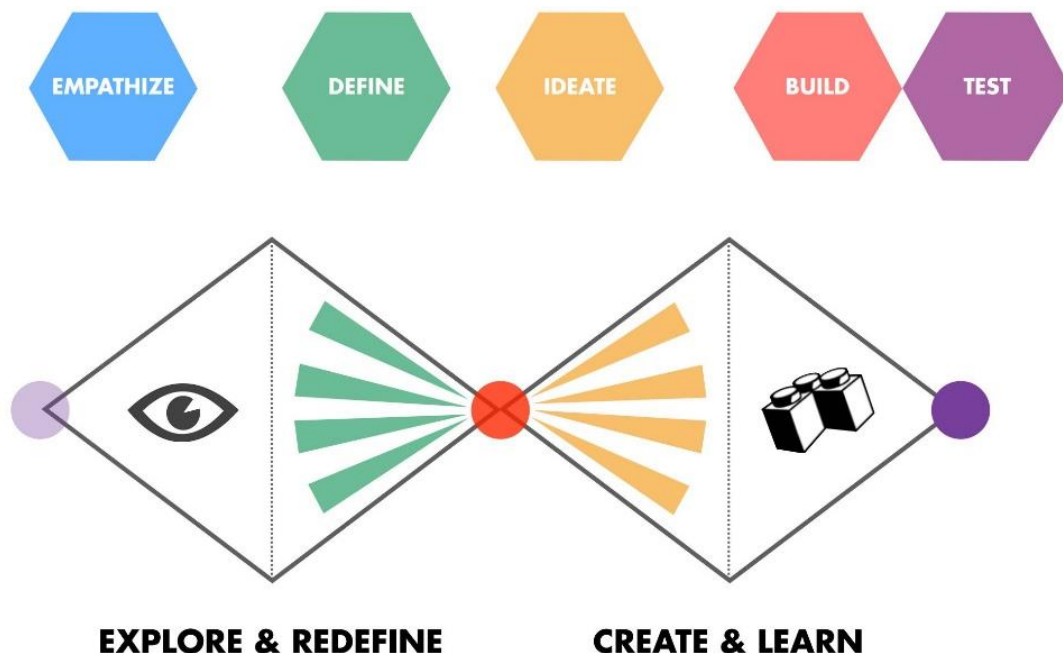


*Figure 4 The front-end activities within the concept development phase [5]*

Furthermore, the process stands to be a perfect fit for staying on technical ground rather than being radical. However, the methodology is altered according to the use scenario by considering the first 3 major phases namely: planning, concept development and system-level design. This is because the process should fit the project's time-frame, the scope and level of maturity.

### 2.1.2 Design Thinking

On the other hand, though Design Thinking (DT) as shown in Figure 5 as well focuses on understanding to whom the product and services are designed for, it stood to be another method providing a solution-based approach for the user.



*Figure 5 Design Thinking process [7]*

The best part of DT is empathising with the user to understand the root-cause for problems as well as its iterative nature which enables to look out-of-the-box. As

mentioned before about the open-ended problem/challenge, this approach as well suits best in identifying the problem/need of the user and solving them. [6]

### 2.1.3 Differences between the two methodologies

The differences of GPD and DT are mainly represented in the table below.

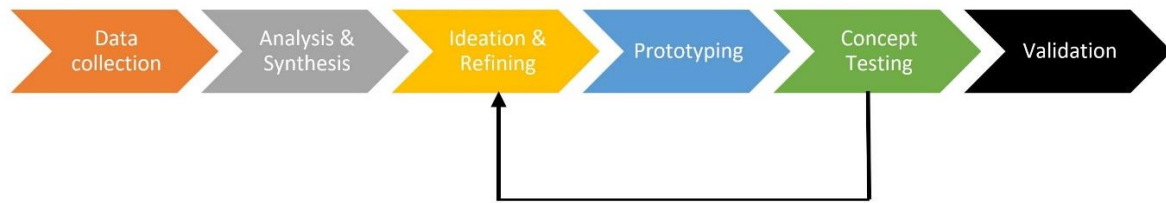
Phase/Stage	Design Thinking	Generic Product Development
1.Data Collection	More emphasis on user and lower importance on literature.	Equal importance on user and literature.
1.1 User Study	Empathy towards user and collects qualitative information.	Strives to collect information but misses out the root cause.
2. Requirement Specification	Tiresome due to use of clustering, and the presence of more data creates confusion.	Highly structured and use of different tools makes it look effective as well as efficient.
2.1 Problem Identification	Narrows down to a definite problem to be solved.	Considers almost every need by prioritizing.
3. Ideation	Extreme idea generation based on the framed problem.	Several ideas for several needs, hence, adds to confusion.
4. Prototyping	Rapid modelling or rough prototyping.	Concentrates more on quality.
5. Testing	Higher importance on testing to improve continuously.	Testing mainly at the last phase.

*Table 1 Differences between Design Thinking and Generic Product development*

Though both the processes are user-centric, they have some advantages and disadvantages over each other. However, combining them will somehow tone down the hurdles, thus leading to achieve the needed.

## 2.2 The re-designed methodology

As mentioned above, both the methodologies are combined and customized to suit our work. The re-designed version is showed in Figure 6.



*Figure 6 Customized/re-designed methodology*

The methodology looks like the GPD and DT; however the major change is to validate the concept soon after testing. That is mainly done by conducting literature study to cater a new solution to the stakeholders. In addition, to perform iterative loops if the tested concepts had to be altered to fulfil the needs. The tools used to perform these 6 phases are briefed below.

Before getting started with the actual work, a milestone timeline was created to organise the workflow and plan the deliveries as seen in the appendix B. As this master thesis is much inclined towards an innovative approach rather than a research, it is quite uncertain to deliver findings or results on a fixed date, hence it was beneficial to stick to a milestone timeline. The chart provides a schedule for duration of 23 planned working weeks.

Next, a set of research questions were framed to kick start with something and to ensure that the development work stays on track. These questions kept changing with the deeper understanding of the needs but ended with a set of 3 questions to arrive at the final solution. They were:

*Research Question 1: How could the trunk be optimized to be a next step for storage to attract the major crowd and eliminate the current problems?*

This question explains about how the solution can be beneficial to the users and make trunk a much better place to store cargo. The answer to this is the concept which understands the problems faced by the user and delivers an attractive as well as a functional design.

*Research Question 2: Who are the major users and how would it be possible to attract the other users?*

The answer is primarily the market and user study which highlights who the actual user is and what the lacking features are that the other users miss. Secondly, the final concept addresses those lacking features to attract the other users and add value.

*Research Question 3: Which customer needs must be evaluated to create value for the end user?*

The answer for this is the reframed problem statement that synthesises the relevant needs and enlightened the path for further development.

The work then kicked-off with understanding the market and the system. Later followed by collecting and analysing the data by the means of surveys, observations, interviews and benchmarking. Further the concepts were generated based on the synthesised data and then subjected to testing. This whole cycle was repeated in loops to deliver a final concept. The final phase comprised of system-level design and finalizing the report. All these phases and the methods integrated in them are explained below.

### **2.2.1 Data collection**

Since the process framed is inclined towards concentrating on the users, the initial phase being data collection adds to the purpose of gathering every bit of required information in several ways. This is mainly to understand and find the problems with respect to the interaction between users and the system (trunk and its options). The methods used to achieve this are:

#### **i. Benchmarking**

Performing benchmarking caters the understanding of technology maturity and developments in the relative area of the study. Performing this enacts as an inspiration from the technologies used on the present market and creates a pathway for creating new solutions.

#### **ii. User observations**

Conducting user observations is a strong tool for data collection to understand the usability of the product. Moreover, some unspoken needs and problems can be identified through observations. Another aspect is also that many people may not be comfortable to be interviewed due to their personal issues or lack of time, thereby, conducting observations enables to explore the problems and usability of the product at different scenarios.

#### **iii. Questionnaire surveys**

To also cover a major crowd, it is important to conduct quantitative study by sending out a questionnaire survey consisting of not many but not less than 15 to 20 questions comprising of majorly closed-ended questions (choosing between options) and a very few open-ended questions (expressing the views in sentences). This could be answered within 5 minutes as to not let the participants feel it as time-consuming else would result in half-filled surveys. The surveys were conducted by reaching out people electronically using social media; this is due to the vast and active presence of people on it these days. It is a cheap, quick and time-saving method to obtain large amounts of information from many people.

#### **iv. User interviews**

Conducting interviews is of paramount importance to empathise with users to elicit their needs as well as to understand the problems. User interviews are conducted on a scale especially by defining relevant parameters to explore (such as age, gender, employment etc.). This allows uncovering problem and provides an aid

towards narrowing down the area of focus. Semi-structured interviews are majorly considered to allow the interviewees the freedom to talk/express their thoughts. These interviews are conducted for about 1-2 hours. In addition to these, a few structured questions are preferred to obtain the yes/no answers.

By of this phase, all that one might have is a huge amount of data that needs to be converged to fewer or more needs to further proceed the development work.

### **2.2.2 Analysis & synthesis**

After collecting the data in the first phase, the next is to analyse those data to create needs and synthesize it into a problem statement. As it was important to know the major problems/needs that must be solved, this phase enacted to filter the most relevant needs from the gathered ones. Doing this enables to stay focused on the path of development. To do so, the data is analysed at the first place using methods such as:

#### **i. Clustering**

Here the collected quantitative data are analysed by grouping them in finding patterns, hence forming clusters pertaining to their criteria. The clusters which looked promising and in need to solve problems are further considered to form a problem statement or customer need list [8]. The major benefit of clustering is to group large amount of data in a simpler but effective manner. Moreover, it becomes easier to focus onto the root problem and choose what needs have to be proceeded further.

#### **ii. KANO model**

This is another way of clustering the qualitative data (customer requirements) according to a pre-defined criterion such as: basic, performance and delighters. The basic needs were the ones which must be solved or else results in customers being disappointed. Whereas the performance needs are an add-on to the basic, and hence craves attention for solving, this results in customer being satisfied. However, the delighters don't affect the users/customers if left unsolved, on contrary, it creates a wow-effect. This categorisation using KANO model suits best to prioritise on what must be solved the most [9] [10]. The model provides a clear distribution of needs into their respective criterion, thus making it simple to decide what needs must be processed further.

The end deliverable of this phase is to frame a functional and meaningful problem statement with the aid of a scenario that enables a goal-oriented approach.

### **2.2.3 Ideation and refining**

This phase is to generate ideas having a defined problem statement in mind, so that they solve the problem or fulfil the need. Taking the aid of brainstorming and biomimicry enables to stimulate free thinking and thereby adding valuable ideas. The best of these are an output of refining and elimination using Pugh matrices by



evaluating the ideas on selected parameters. The Pugh matrix is a simple method of evaluating concepts by having a reference concept and comparing it to score the rest other ideas. Here the signs used were ‘+’ which indicated “better than”, ‘0’ being “same as” and ‘-’ being “worse than”. A simple Pugh matrix looks like the one in Table 2.

	Concepts						
Selection Criteria	A Master Cylinder	B Rubber Brake	C Ratchet	D (Reference) Plunge Stop	E Swash Ring	F Lever Set	G Dial Screw
Ease of handling	0	0	–	0	0	–	–
Ease of use	0	–	–	0	0	+	0
Readability of settings	0	0	+	0	+	0	+
Dose metering accuracy	0	0	0	0	–	0	0
Durability	0	0	0	0	0	+	0
Ease of manufacture	+	–	–	0	0	–	0
Portability	+	+	0	0	+	0	0
Sum +’s	2	1	1	0	2	2	1
Sum 0’s	5	4	3	7	4	3	5
Sum –’s	0	2	3	0	1	2	1
Net Score	2	–1	–2	0	1	0	0
Rank	1	6	7	3	2	3	3
Continue?	Yes	No	No	Combine	Yes	Combine	Revise

Table 2 Pugh matrix for concept screening [5]

This phase starts with a divergent manner of bringing several ideas onto the paper and then converges to a point where one or more concepts are selected. The output from this phase would be a refined concept that decides to proceed further. The selected concept is then put to test with the presence of stakeholders to ensure if it matches the need.

### 2.2.4 Prototyping

The prototypes in this project are considered as presenting the refined concepts from the previous phase in terms of rough sketches. This enables to share the ideas in a pictorial and an understandable manner that makes it easier to describe during testing. This is specially chosen over detail or physical prototyping to stick within the time-frame and also with a perception that any demanded changes or feedback could be processed easily before moving into system-level design.

### 2.2.5 Concept testing

The whole idea of the main design process methodology in to improve continuously and hence testing was given a higher importance in this project. This not only enables to showcase the concepts but also intends to receive continuous feedback for achieving a polished output. This iterating phase involved the stakeholders from Chalmers and Semcon AB to improve the concepts. Being following a user-centric process, the demand to involve user is essential to achieve any product success and thus this phase assists to deliver the same.

### **2.2.6 Validation**

The primary goal of the project was to develop an optimized storage in cars trunk, it was utmost important to know about the researches done towards the development within the trunk, also the latest technologies, patents which doesn't hinder our solution from being published. The study included reading of necessary technical papers, surveys, articles and project reports and there was no restriction upon the limits. In addition to those, patent search was done using Google patents and other patent search tools.

The step-by-step process by including almost all the methods from the chapter 2.2.1 until 2.2.6 comprises to be one development cycle. In the further chapters 4 and 5 namely 'Product Development Cycle 1 & 2', it is a complete use of the re-defined methodology in a progressive manner with the use of fewer or almost all methods. The whole journey of this project is explained in terms of cycles.

### **2.3 System-level design (Final output)**

The final concept is designed using virtual prototyping tools such as CATIA V5 and Autodesk Fusion 360. The main purpose of the virtual prototype is to visualize the concept from rough sketches to 3D models. Additionally, to also show the functionality and the whole setup in a true car environment. Therefore, renderings are preferred to showcase the final concept to the stakeholders which gives a smooth and a picture close to reality.

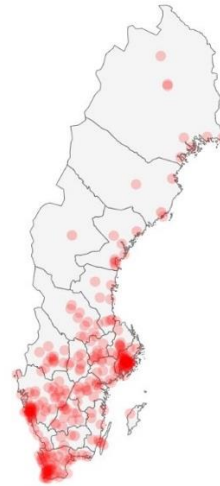
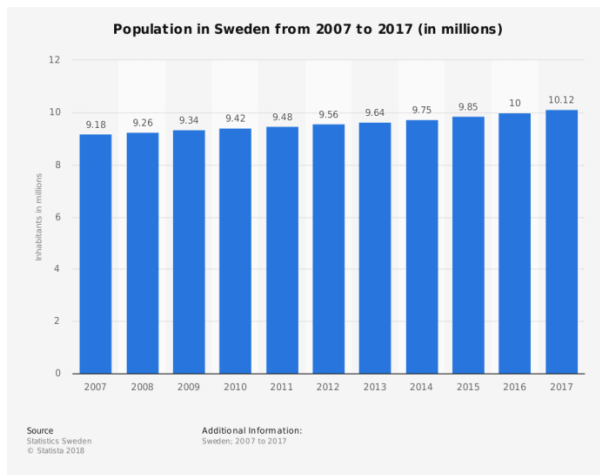
# 3

## Market Analysis on Swedish Automotive Industry

This chapter gives an overview of top automobile sellers, increase of cars in past years and the cars that were sold the most in Sweden. Moreover, it gives a better understanding of market and motivates in choosing the best segment of cars to carry the thesis work.

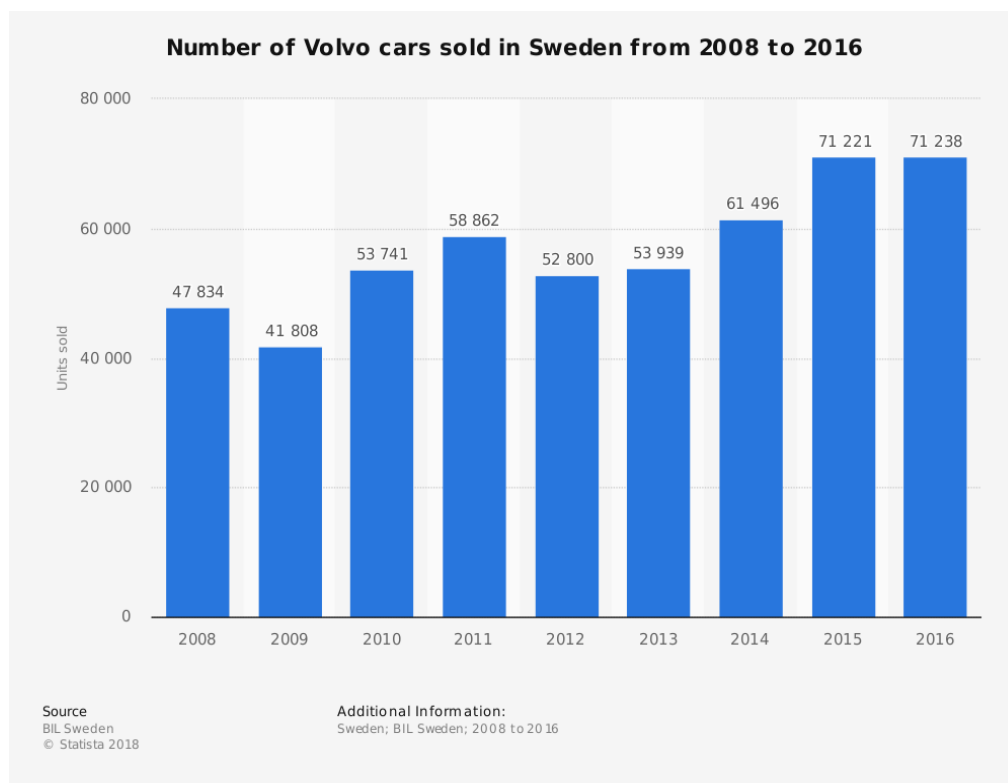
### **3.1 Demographics of the Swedish population**

Sweden is ranked as the 3<sup>rd</sup> largest country by land in the European Union [11]. It holds 16<sup>th</sup> position in population in European Union and 90<sup>th</sup> position in world's population according to United Nations Department of Economic and Social Affairs 2015. Most of the people live in the southern part of the country compared to north due to availability of employment and mainly due to the presence of the capital of the country, Stockholm which is the largest city in Sweden. The second largest city is Gothenburg and is in the west-coast of Sweden. This country is a land of several Multi-National Companies and top universities like Volvo, Scania, Assa Abloy, SCA, Södra, KTH, Chalmers, Uppsala etc... which is established in the Southern geographical area of Sweden. The population of Sweden is approximately 10.1 Million at end of the year 2017 [11]. Comparing it with population in 2010, the population was approximately 9.4 million, and the increase in population was observed to be 7.3% between the years 2010 to 2017 [11].

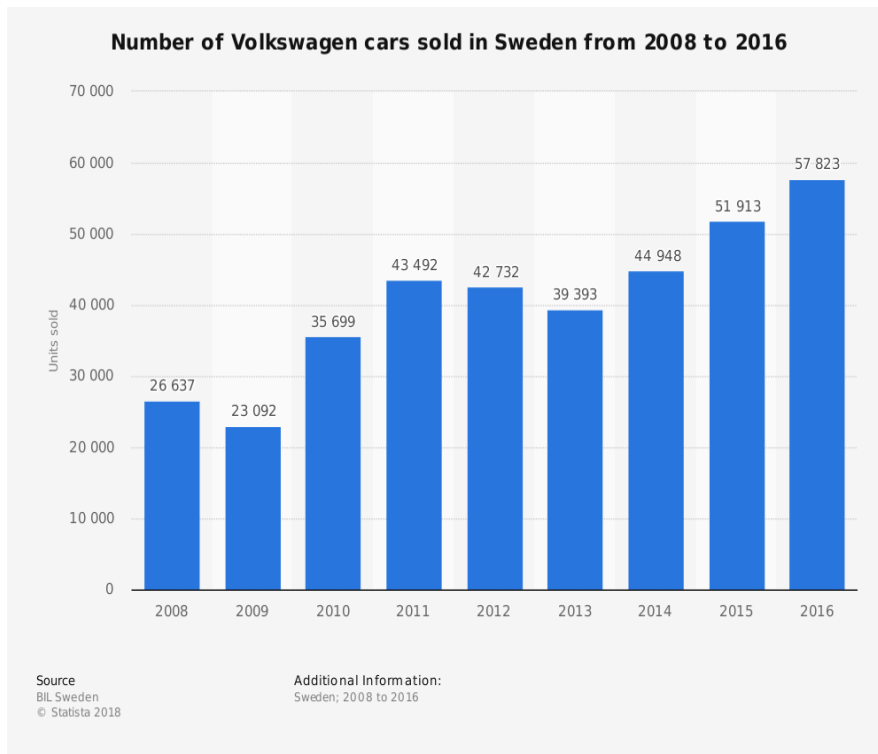


*Figure 7 Population in Sweden from 2007 to 2017 [11]*

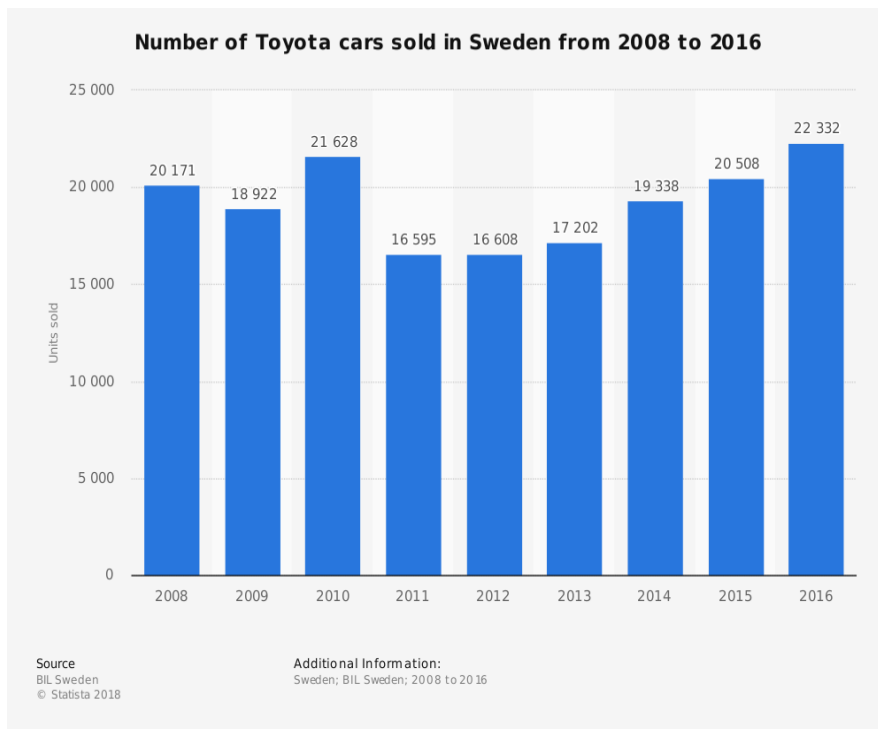
According to statistics there seems to be an increase in number of passenger cars on road which can be linked to the growing population. Volvo Cars is based in Gothenburg, Sweden who is well known for producing passenger safety cars. Volvo cars holds a market of around 19.6% in Sweden followed by Volkswagen which holds 15.2% and Toyota holding 6.3% of the total passenger car market in Sweden. Graphs below shows the sales of the above-mentioned passenger car manufactures in Sweden from 2008 to 2016 [12].



*Figure 8 Number of Volvo cars sold in Sweden [13]*



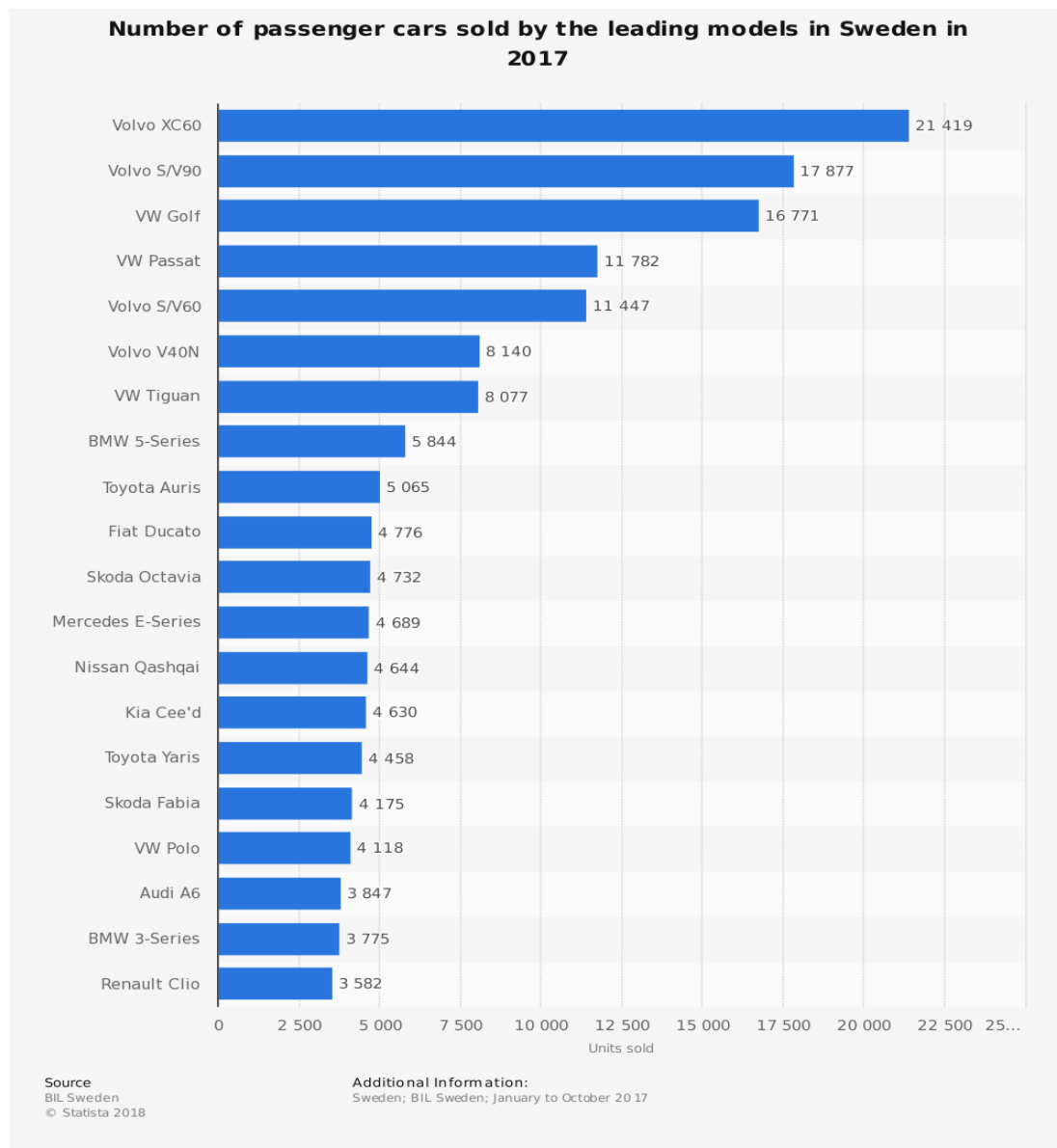
*Figure 9 Number of Volkswagen cars sold in Sweden from 2008 to 2016 [14]*



*Figure 10 Number of Toyota cars sold in Sweden 2008 to 2016 [15]*

From the graphs it can be seen there is an increase in the number of passenger cars every year. There are 4.9 Million cars in use according to the statistic report of 2017 [12]. This makes half of the population in the country to have access to a car. The highly sold segments in the market are Estate cars (Medium and Large)

compared to other segments. This segment of cars usually has large trunk space, and this explains that the people in Sweden opt to have large storage space for carrying different things. The graph below shows the sales of cars models in 2017.



*Figure 11 Number of passenger cars sold by the leading models in Sweden in 2017 [16]*

### 3.2 Benchmarking

Benchmarking was one of the key aspects in this master thesis. Since this project wasn't sticking to a specific car model or a brand, it was important to know the latest trends towards the development in car's trunk area till date. Therefore, performing benchmarking was one of the best ways to understand the trends and technological maturity towards development in car's trunk.

Benchmarking was done on twenty-one car models both mid-size and full-size estate cars from twelve leading passenger car manufacturers in the global market. The benchmarking was performed at various car showrooms/dealers located in

Gothenburg (Sweden). The main motive behind benchmarking these twenty-one cars was to not miss out any functionalities and implementations in all those different car's trunk area. Only Estate/Combi cars were benchmarked since the thesis scope was narrowed towards developing trunk area for Estate/Combi cars. Every detail in trunk was benchmarked, right from the capacity of the trunk to the different components present in it.

Benchmarking enabled to concentrate on developing new functionalities that do not exist in the current estate cars. It was a good learning from each passenger car manufacturers on how they took care of small details while designing and manufacturing to attract the customers by creating a wow effect. A comparison chart was made between all the cars benchmarked to know what the major differences were. This also gave the overview of commonalities in the trunk among all the cars. The chart can be found in the appendix B.

### **3.2.1 Results from benchmarking**

Each manufacturer had different options in the car's trunk area based on their brand value, origin of the car and the price segment. Benchmarking was done in two different segments mainly Premium and economy segment. Cars that were considered were on the premium scale were Audi, BMW, Jaguar, Mercedes, Porsche and Volvo cars. Cars considered on the economy scale were Ford, Kia, Skoda, Subaru, Toyota and Volkswagen. The major difference between the premium and economy segments are the touch and finish of the materials used for the interiors and added features in the trunk. Although both the segments have many things in common, the details are categorised and explained below.

#### **i. Storage capacity**

Of all the models that were benchmarked, the load floor was designed to be flat to provide easy access to the users. The mid-sized estate cars on an average had storage capacity of 515 litres and had an extended storage space (space when the rear seats are folded) of 1575 litres. The full-sized estate cars on an average had a storage capacity of 525 litres and had an extended storage of 1680 litres. Among all the models Skoda and Volkswagen had large storage space. Skoda Octavia and Volkswagen Golf in the mid-size segment had 610 and 605 litres of storage respectively. In the full-size segment Skoda Superb and Volkswagen Passat had 660 and 650 litres of storage respectively.

#### **ii. Tailgate and cargo secure cover**

Almost all the premium segment cars have electronically operated tailgate and the economy segments had a manually operated tailgate. All the models had the cargo secure cover in common but with few differences in the way they operate. There are three types of covers that are manually operated and one type which is automatic. In manually operated covers, first one is the standard cover which can be pulled in one direction and locked. The second one is like the first one, but it moves in a guided path to comfort the user. The third type is two-way adjustable

cover which has two guide rails, one on the side trims and other on the D-pillar. The advantage of having guided rails on the D-pillar is that the user doesn't need to operate the secure cover all the time and thus improving the accessibility by being hands-free. The automated cargo secure cover has the same functionality as the third type cover, but its automated using motors and sensors. The cover opens along with the tailgate and closes when the tailgate is closed.

### iii. Other options

- All the models have hooks for groceries, holders for cargo secure nets and lights in common.
- Few models have an accessory that can be mounted on the rails of the load floor, which acts as trunk separator for restricting the place to securing small and delicate things. Figure 12 Trunk splitter with guide rails



*Figure 12 Trunk splitter with guide rails*

- Few models have rails on the load floor Figure 13 Trunk load floor with guide rails for moving the holders for cargo secure nets. This solution is very helpful to the users because they don't need to stretch for the holder, the holders are in the four corners of the load floor. Where accessing to the rear two holders is very tough.



*Figure 13 Trunk load floor with guide rails*

- The Skoda models have a very smart solution in the trunk. Where one of the lights in the trunk can be detached and can be used as a torch.



- Almost 80% of the cars benchmarked have the warning triangles placed under the load floor. Only 20% of the cars have mounted it on the tailgate.
- In all the models there is a secondary storage under the load floor. Since there is no spare tire in the trunk any more. In the secondary storage there are spaces for warning triangle, pressure gauge, medical kit, towing tools, reflective waistcoat and few empty spaces for storing other things as shown in Figure 14 Tool storage space under the load floor.



*Figure 14 Tool storage space under the load floor*

- The Skoda and Volkswagen models had advanced load floor in all their models. Where the floor can be adjusted but lifting the floor and pulling it forwards the floor moves 100mm down providing more storage the space. By having this kind of technology, they have utilised the empty space under the load floor.
- The Volvo cars models had a foldable trunk splitter with hooks as shown in Figure 15 Integrated trunk splitter in Volvo V60, which is integrated on the load floor. This is used for placing the groceries bags or other small shopping bag. So, now the huge trunk space is split in to small spaces which improve accessibility to the users.



*Figure 15 Integrated trunk splitter in Volvo V60*

To conclude, the usage of cars will continue to grow, mostly due to the increase in population as reflected from the statistics where there was an increase in pollution and cars in the past ten years. Although there were new solutions available in the car's trunk area that fulfil the functionality of storing and securing luggage, there is always a room for development. Since most of the trunks look and function alike, there are some issues that are widely visible with respect to accessing the large trunks. The work moves further in exploring the problems within this area to deliver a beneficial solution to the user.

# 4

## Product Development Cycle-1

This chapter completely details about the work-flow process which began from mid-November. Firstly, it explains the initial work of the front-end process [5] on data collection and the obtained results. Further, it provides more details on how the data was synthesised to obtain a problem statement and then moving onto the ideas that were generated to solve the problem. Finally, the chapter motivates as why the concept was selected over the others.

### **4.1 Customer need analysis**

To understand customer use cases, their needs and requirements, three types of data collection tools were used to capture both qualitative and quantitative data.

#### **4.1.1 Data collection and analysis**

The results from the three data collection tools are presented in this chapter. This mainly includes the summary of the results from observations, semi-structured interviews and the online-survey.

##### **4.1.1.1 Observation results**

The observatory study was conducted at 4 different shopping stores in Gothenburg being IKEA Kållerød & Bäckebol, Systembolaget Bäckebol and Coop Kållerød. This was carried during a dry and a rainy day to understand the changes in using the car's trunk. The major take aways were:

Firstly, the usage varied between the age groups in terms of time consumed, where the aged users took some time to organise the trunk in a neat and secured way. Whereas the young and mid-aged users were in a hurry and barely spent time to organise cargo.

Secondly, none of the users were seen using the features provided in trunk such as the hooks and the safety nets (see Figure 16). This can be related to the above instance where time is identified as a major parameter. Moreover, the same are related in the semi-structured interviews which are discussed in the chapter 4.1.2.3 and Appendix A.



*Figure 16 Hooks on side trim (left), Net to secure cargo (right)*

Further the observations progressed in comparing the data which was collected through semi-structured interviews, and the interesting comparison was that when users carried fewer bags, they placed them on the rear seat. However, in the interviews most of the users mentioned that they placed the minimal cargo on the floor between rear and front seat.

Finally, the last observation at Systembolaget revealed interesting results. Irrespective age group people belonged, nor the climatic conditions, the users always spent extra time in securing the delicate bottles either by placing them at the corners or tying a knot on the hand cover.

Moving next, along with the surveys being sent electronically, semi-structured interviews were also conducted in parallel. The results are discussed in the next chapters.

#### **4.1.1.2 Online survey results**

The online survey which was posted on LinkedIn enabled the participants to choose between the categories on the type of trunk usage, namely rare use, often use and extreme (always) use. This yielded 69 responses (53 completed ones) in total and was able to allocate them in the above subjected categories. The numbers obtained consisted of 15.09% rare users, 60.38% often users and the rest 24.53% were extreme users. This provided an understanding about the trunk usage within people.

Moving next, the survey also intended to understand the users major purpose for using the trunk. The results are shown in the Figure 17.

### For what purpose do you use the car's trunk/boot?

Number of responses: 53

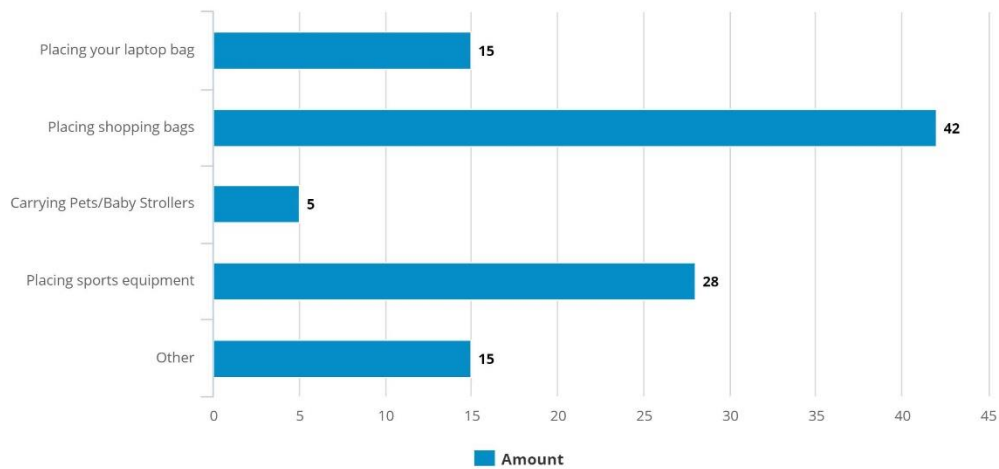


Figure 17 Results from the online survey to understand the purpose of use

The participants could choose multiple answers for the question ‘For what purpose do you use the car’s trunk/boot?’, and it was interesting to observe that majority uses the space to store groceries as well as sports equipment. Though the traditional use to store shopping bags is more, the survey revealed another interesting result that people are turning health conscious and it was important to consider these 2 factors for further development.

Finally, the survey as well revealed the criteria that user thinks it is important to be presented in the trunk. The Figure 18 below reveals the results.

### Grade on the scale ( 1 - 5 ) of how important do you think these criteria are while using the car's boot/trunk:

Number of responses: 53

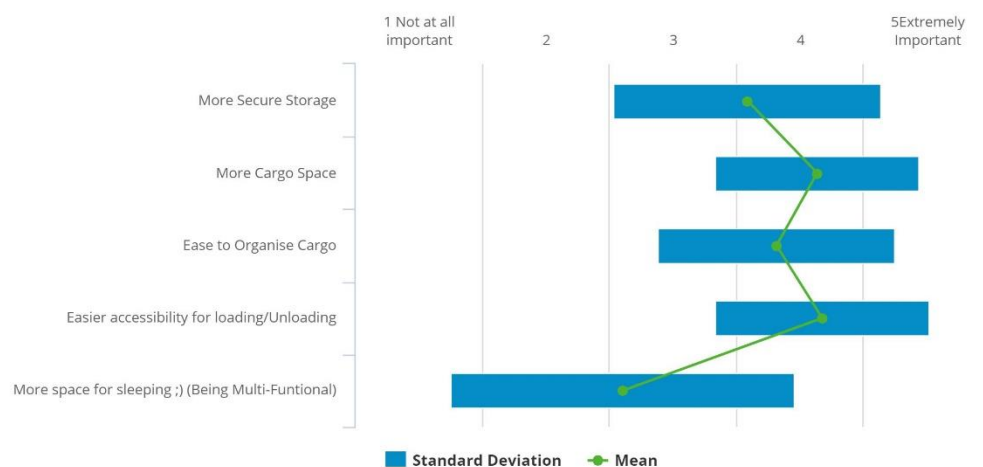


Figure 18 Survey results on the grading scale for the important criteria

The results were graded on the scale of 1-5, where 1 is read to be not at all important and 5 being extremely important. The results obtained were quite surprising, as most of them didn't really want to have a multi-functional trunk which was the primary aim of the project. Instead they preferred an easier access for loading/unloading cargo and more space. This grading scale gave a clear understanding on where the aim of the project had to be focused.

Having these as few inputs, the project progressed further in collecting more data in terms of semi-structured interview.

#### **4.1.1.3 Semi-structured interviews**

There was a total of 7 semi-structured interviews conducted of which one was a focus group (consisting of 3 interviewees at a time) for the product development cycle-1 and lasted for 1 hour each. The detailed version of each interview can be found in Appendix A.

The semi-structured interviews helped understand the users more and categorised them into 1 rare trunk user, 5 often users and 2 extreme users. The interviews revealed most of the important aspects and stories on how trunk was/would be used. However, the most common purpose still stands to be to carry groceries and sports equipment. Majority of them were concerned about securing their groceries as they tend to fall all over the trunk which made them to drive cautiously most of the times. Though they had few hooks (see Figure 16) on the trunk side trim to hang groceries, they hardly knew the presence of it and never used them. Moreover, these users never used the nets provided by the car manufactures to secure the cargo as they think its cumbersome process to use it. However, most of the interviewees told that they placed the bags on the floor between the rear and the front seat. This particular scenario takes place whenever there are minimal numbers of bags carried. Hence, this unveiled the importance of securing the groceries/any cargo as a major need and a problem to be solved.

Further, almost everyone interviewee mentioned that the shopping at mega stores and long-distance travelling were the only scenarios where the trunks were being completely used. That is when they mentioned about the need for more cargo space.

Moving next, one interesting area that interviewees gave their opinion was using the car and trunk as a service. The new on-going services like owning a car in terms of subscription and in-car delivery services were used as a base for the interviewees to express their view on it [17] [18] [19]. Many were positive towards having a service approach in future as they were concerned about congestions within the urban areas as well as the damage to the environment due to increase in cars. However, on contrast other set of interviewees were interested in this service but felt they might lose their personal space. This topic was included in the



All these needs are further processed and synthesized into a problem statement. The next chapter will discuss how the data was synthesized.

After gathering huge data from different medium, it was important to find the users need. Therefore, the data was broken into small bits and written on post-its. Later, clusters were formed to find patterns as well as to get some insights out of it. These results are discussed below.

As mentioned above, the data was downloaded onto the post-its and stuck on the white board to frame a pattern. The common data were grouped into one category and thus resulted in 11 framed groups. The Figure 19 below shows the data categorised in different groups.



25

activities. In addition to this, the different ways people think about services was an interesting insight and that the people in Sweden consider shopping as a social event with family.

All these data put together catered some good information, but we had to dig further deep to understand the root problem. Hence another round of clustering was performed to find patterns which leads to find the problem.

#### 4.2.2 Clustering-2

During this clustering, the post-it's were moved around to find different patterns which would give a varied picture than the previous step. Surprisingly the new patterns were framed which resulted in 8 different clusters, this can be seen the Figure 20 below.

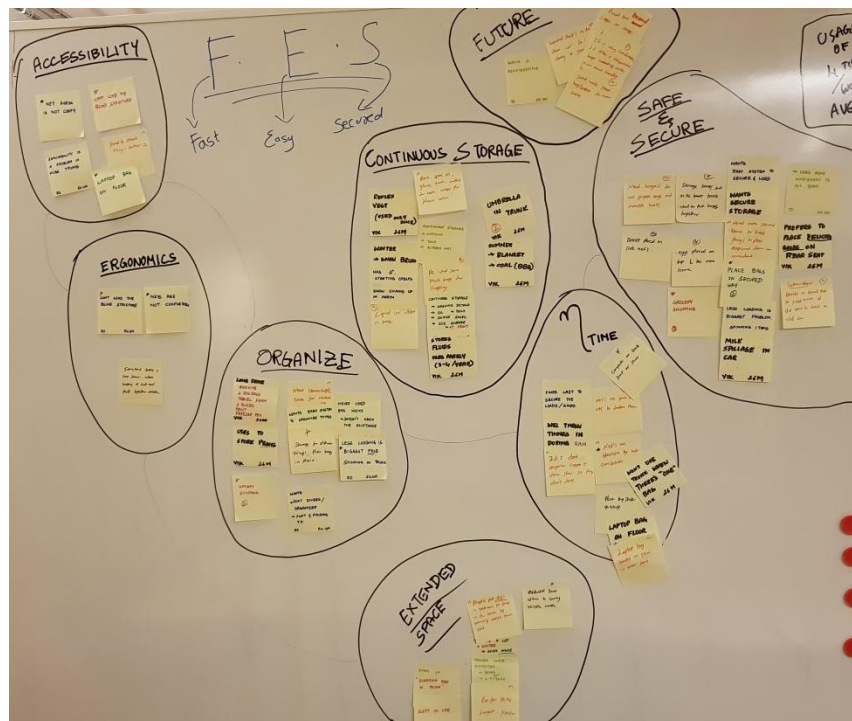


Figure 20 Results from the clustering-2 and the groups within it

The major insights led to the actual problem statement by considering 5 clusters namely: accessibility, ergonomics, organising, time-efficient and security. It clearly came to light that people wanted a faster and an easier way to secure cargo or mainly groceries. Therefore, the project progressed further to frame customer needs in terms of a Point of View (POV) and KANO model.

#### 4.3 Customer needs

To have a defined customer need, the problem statement was written in a format of a POV with respect to a particular scenario. The POV for this first product development cycle is:



*“Hashtag, 35 years old, after a stressful day at his office goes to shop groceries. He needs an organized and easy way to secure cargo fast, because absence of any one of those parameters would cost him resources as well as add more stress which isn't good for health.”*

To further make it much simpler and categorise the needs into some pattern, a KANO model was used. Here the most highlighted needs were represented in the model.

Basic attributes that must be present are:

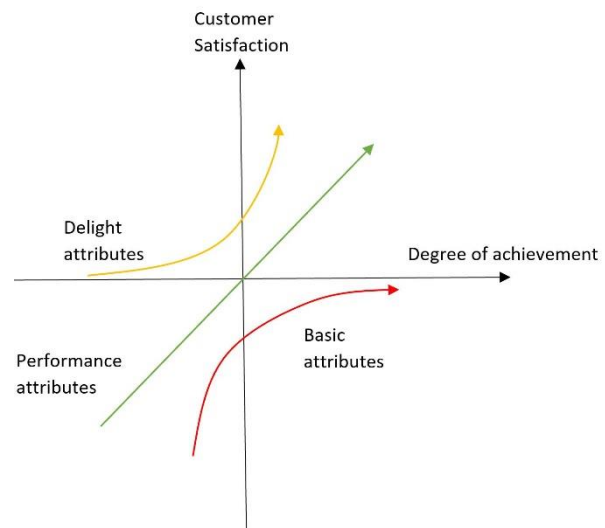
- The load floor must be flat.
- Trunk must accommodate basic luggage (at least 2 shopping bags).
- Visibility during dark.
- Simple trunk design.

Performance attributes are:

- To provide better accessibility.
- A secured storage.
- More space to store cargo.

The delighter attributes are:

- Smart platform to organise cargo.
- Eliminate the cargo secure cover product.
- Smart trunk that enables a service-oriented use.



*Figure 21 KANO model [10]*

Since the basic attributes were present in almost all the car trunks on the market, we moved onto solving the performance attributes which craved for some real solutions. To get started with solving those, a set of How Might We (HMW) questions were framed to be an aid to progress further. The different HMW questions are as follows:

HMW, help the person in organising his groceries and securing them?

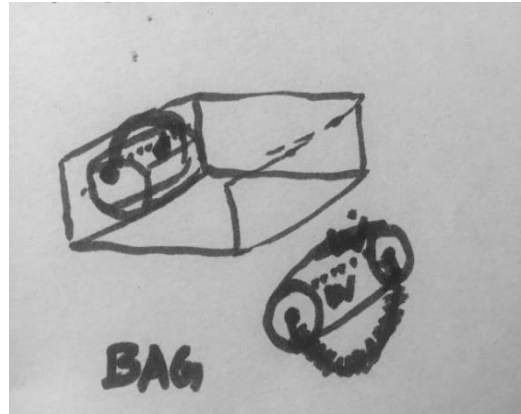
HMW, reduce the stress of a person by providing him with better accessibility in lesser time?

#### **4.4 Ideation**

Having HMW's as basis, several concepts were brainstormed and thus this chapter presents the concepts in terms of basic 2D sketches as well as explained in text.

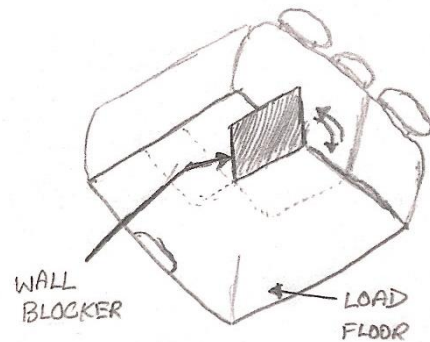
- The Luxury LV

This concept is basically a bag which can be used to carry to the grocery shop to have the goods placed in it. This bag has a zip to ensure that the things inside it remain safe, and acts as a regular bag. However, this is designed with hooks such that it fits at an allocated place inside the trunk, thus allowing the cargo to be secured. In addition, its reusability feature enables the user not to buy plastic bags which makes benefits the environment.



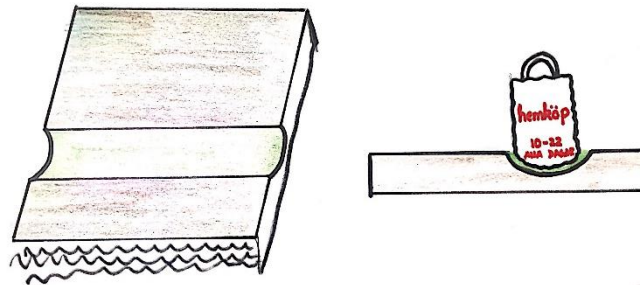
- Trump wall blocker

It is inspired from the walls that separate bodies, and this is a foldable wall which could be used to restrict the space within which the cargo is placed. Hence securing it from falling/spilling around. When the cargo is taken away, the wall can be folded in and the trunk looks the same as it today.



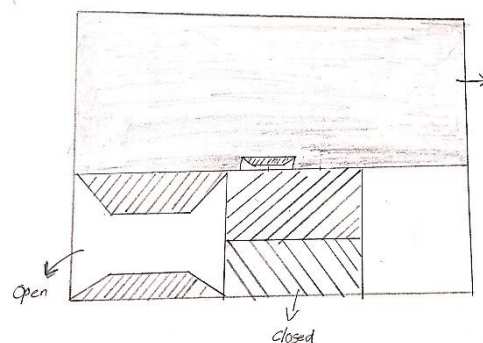
- U-shaped pouch storage (Reverse hump)

A simple concept that has a small pouch with rubber padding on the surface, this makes it hard for any cargo to slip. It hardly takes any time to place the bags on it.



- Easy bag drop

A concept inspired from trap doors which is used to catch something in it. This concept has two split doors on which the user can drop the bags, and that remains trapped inside it.



- The Amazing Spidey

This is an inspiration taken from the spiders which use nets to secure something. Similarly, this concept is to have nets below the rear windscreen where the user

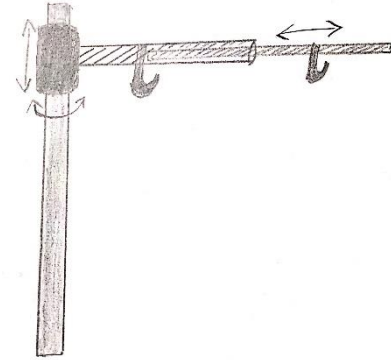
can drop the bags into it by opening just the windscreen rather than the whole tailgate.

- Custom bag holder

This is a concept totally similar to the luxury LV but the instead of hooks, this has a magnet below to secure the bag. In addition, it also has wheels to pull it as a trolley rather than carrying it by hand.

- Moving hook

This is a telescopic mechanism having arms with three degrees of freedom to lower/raise the main arm, rotate the secondary arm on the main arm and telescopically operate the secondary arm. This also has hooks to hook the bags on the telescopic arm.

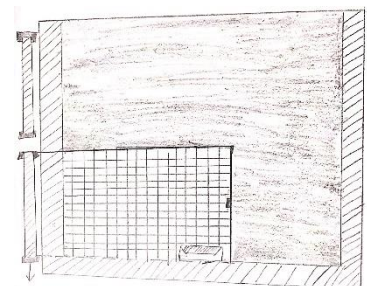


- The bottle stopper

This is a simple concept with a groove to hold many delicate bottles in a place and restricted them from falling and breaking.

- Belt on the floor

A concept where the cargo is secured using a belt that is like the 3-point seat belt. The belts are elastic in property which withholds the cargo securely.

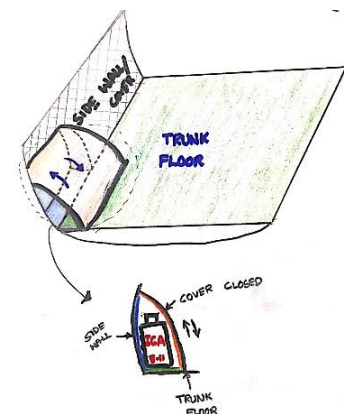


- Rolls on the floor

Integrating small roller balls onto the rear half of load floor to enable easier accessibility by sliding the heavy luggage is what the concept tends to be.

- The boxy

A concept where a foldable net on the side trim is folded down to turn into box and secure the cargo placed in it. The shape of it is look like a box and hence named if boxy.



Moving before scoring each concept, the amazing spidey was deleted as there was a similar solution out on the market. The next chapter will go through the method of comparing scoring each concept.

#### **4.5 Concept scoring and refining**

To evaluate and rank the concepts a Pugh matrix was used as an aid. The concepts were evaluated mainly using several parameters but mainly the customer needs. The parameters that were considered for evaluating the concepts are the ease of usage, cargo security, time to install the part, handling the cargo, feasibility and cost of the part. Feasibility and cost on the part were the added parameters apart from the listed needs, as it was important to have non-radical concepts which would fulfil the present need and fit within the project time plan. As the concepts had to be compared against one reference, the present net securing solution present on the market was considered. The result of the Pugh matrix can be seen in the Appendix B.

The concepts that successfully stood out were easy bag drop, moving hook and belt on floor. These concepts equally scored over the reference with a value 3 each. The concepts that didn't score well were mainly due to the non-feasibility and didn't meet the most important requirements. Having these many concepts, the next step was to test these with the stakeholders and to get some input even before further screening.

#### **4.6 Concept testing and elimination**

The testing took place with the stakeholders from Semcon at Trollhättan to evaluate the concepts and check if those meet their requirements. Several feedbacks were given on the concepts and they believed that the easy bag drop was simple as well as meeting the needs. The moving hook however, was an interesting concept due to its distinct mechanism. The stakeholders were quite worried if the belt on the floor could secure cargo and they felt it's a bit time consuming process when compared to the other two concepts. The project further progressed by selecting the easy bag drop concept and dropping moving hook and belt on the floor as it was important to keep the design space simple. Having moving hook and belt on floor would occupy visible space and thus not keeping the design space simple which was one of the basic attributes in the KANO model.

During the same meeting, the stakeholders from Semcon wanted us to explore how trunk might look in future and not only stick to the user needs. This led to take a short diversion which is further explained in the Product Development Cycle-2 chapter. However, the whole first cycle catered huge amount of data that could be easily analysed and extract the need. The concepts though looked simple provided a secured and easier access at a faster rate.

# 5

## Product development Cycle – 2

This chapter provides the details about the work-flow process post product development cycle-1. The flow remains quite alike the first cycle, however, there are few modifications wherein a very few methods were changed to fit the approach of development. The approach was a bit inclined towards looking into the futuristic solutions, thus calling it a technology-push. The process starts with collection data by only semi-structured interviews, followed by analysing and synthesising the data into a requirement specification table. Later, diverging the thinking by creating concepts and converging those at the testing phase contributed the last step of this cycle.

### **5.1 Data collection and analysis**

Although there were good outcomes from the first cycle of data collection, still there was a gap that needs to be filled. Only semi structured interviews was used as a tool for data collection in second cycle. Since the second cycle data collection is completely inclined towards user thoughts and user's opinions, it was decided that conducting semi-structure interview could suit best according to the need.

#### **5.1.1 Semi-structured interview results**

The results from the first cycle interview were inclined towards the basic requirements and problems in the trunk area. Moreover, people weren't expressive during the interviews and most of them gave short answers. The major issue encountered after the first cycle of interview was that the main scope of the thesis was missing. There was not enough data regarding what would the next step for storage in cars trunk be.

In the second cycle of interview, the interview questions of first cycle were reframed and few more questions were added. To get the maximum input from the interviews, there were few case scenarios added to the questions. For instance, instead of asking, "what you feel about autonomous cars in future?" there were a few scenarios created. For example, the interviewees were asked to imagine as though they were travelling in an autonomous car for 300km and what would they

probably want to do or have access to. This yielded a positive outcome in terms of data collection as it enabled people to be expressive and explained their views. The interviewees in the second cycle had a technical background as they were related to the automotive industry. The inputs from these people were towards development guidelines, current development process, and imagination versus reality in the final product and issues with using their own trunks. Main outputs from the second cycle interview compared to first cycle were about having a multipurpose utility trunk and that they wish to have access to the trunk when seated inside the car. Few more additional requirements which are briefed in detail can be found in appendix A2.

## **5.2 Synthesis**

After gathering huge data from the interviews, it was important to find the users need. Therefore, the data was analysed and extracted into a detailed requirements table.

### **5.2.1 Requirements specification**

The detail requirements table was made based upon the inputs from both the product development cycles. During the first cycle there was huge data from the interviews and observations. Using clustering in the first cycle resulted in a harder way of documenting the requirements. This is because the data was saved in the form of post-it. For easier and faster way of finding needs and requirements and to have proper documentation it was beneficial to document all the needs in terms of requirement specification table as seen in appendix B.

## **5.3 Second problem statement**

The major problem statement that was drawn in this cycle was to solve the delighter attributes from the KANO model and to investigate a futuristic concept. This is due to the reason that stakeholders (Semcon) wanted us to take a different route rather than being solely dependent on the user needs.

## **5.4 Ideation**

Brainstorming session was performed based on the problem statement and requirements by considering several factors, namely:

- The generated concepts should accommodate the selected concept from the first cycle or it should solve the problems encountered from first cycle.
- The concepts should be close to reality than being radical.
- Concepts should fit into all the estate cars that were benchmarked.

Hand sketching was used as a tool to sketch the concepts because it is the fastest way to visualized and test it. There were a total of six concepts that were sketched by hand in the second cycle. The details of each concept are explained below.

- Camping trunk

For this concept the load floor and the storage spaces on the side trims are modified. The concept consists of food warmer, chiller/freezer, a foldable table-chair assembly, kettle, Tools and shelves for plates, cups and other stuff. All there are integrated in the load floor and side trims by maintaining the load floor flat and by utilizing the empty space under the load floor. As it was known from benchmarking that there is huge empty space under the trunk, it was confirmed from the interviews that people rarely used that space. Therefore the space under the load floor can be utilized from the top by this concept. This concept will the attract the people between age group 55 to 75, because it was known from that interviews that people tend to switch to smaller cars since the number of people in a family reduces and estate cars weren't of much use. Implementing this concept could create value to the car, because the trunk here will not just be a place for storage. Rather people can go on a short-day trip, park their car near a lake or some good lookout point and relax.

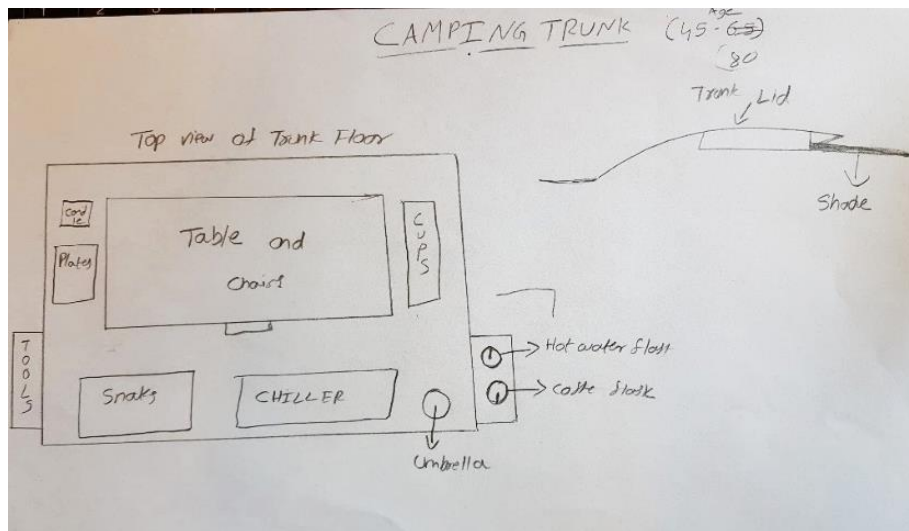


Figure 22 Concept - Camping Trunk

- Executive trunk

In this concept the load floor and the storage space in the side trims are modified. The concept consists of three boxes for toiletries accessories, foot ware and other storage that are integrated on the load floor. A hand steamer is also integrated on the right-side trim, the standard tool kit as well as tire puncture kit is moved on to the left side trim. This concept is generated for mainly executive purpose. Where people can store their different kind of shoes, ties and other toiletries stuff in their cars trunk and don't have to worry about anything if they need to attend a meeting. The steamer is integrated for steaming their suite and keeping them fresh and avoid from wrinkles. Even this concept utilizes the empty space under the trunk and maintains the trunk flat. This concept creates value to users of executive class, where they have many business meetings very frequently.



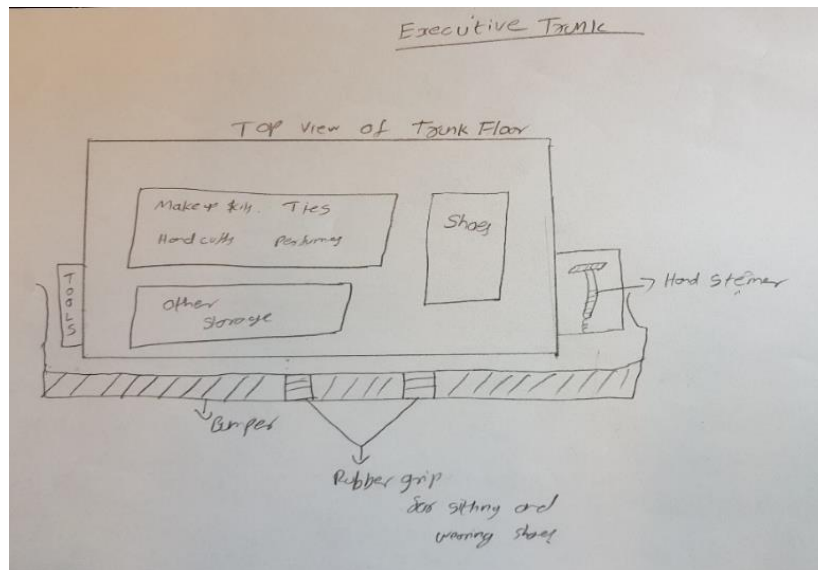


Figure 23 Concept - Executive trunk

- Movable trunk floor

For this concept the complete load floor needs to be modified. The concept consists of few electric motors, electronic circuits, load lifting mechanisms, rails and bearings. The function of the concept is to improve the accessibility in the trunk by moving heavy luggage and the luggage situated in the rear end of the load floor closer to the user. This process is done by constructing the load floor to move as shown in the Figure 24 with the aid of motors. The concept will solve the issues related towards lifting, bending and stress caused in moving the luggage in trunk.

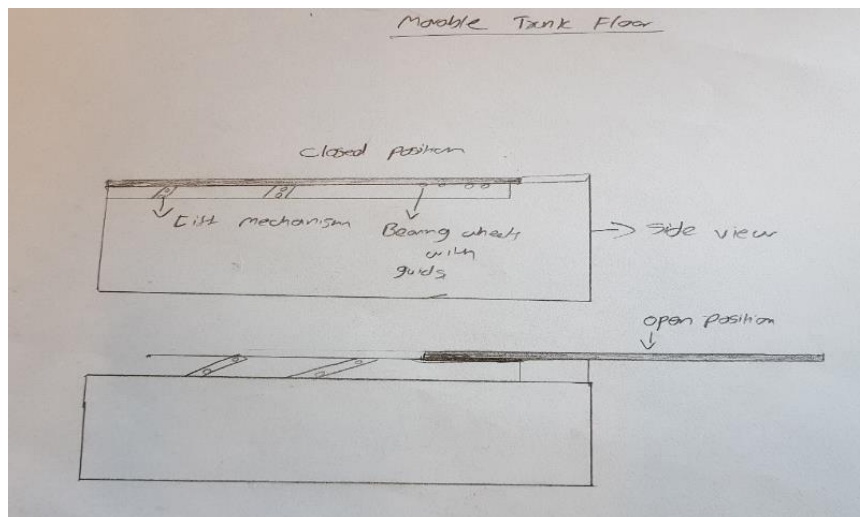


Figure 24 Concept - Movable trunk floor

- Smart glass

For this concept the rear windshield and quarter glass on both sides are replaced with smart glass. Smart glass is a new technology that already exists in the market [20]. It is a LED film that is attached to the glass which can turn the transparent glass into a dark glass and can also transmit images or designs to the glass. The



purpose behind using this technology is to eliminate the cargo secure cover which is very heavy and tough to unmount when users want to remove it. The smart glass turns dark when the car is parked in a parking lot, so that no one peaks through and see what's inside the trunk. Moreover, the rear windshield can be programmed to communicate with other road users in case of emergency by displaying warning symbols if needed.

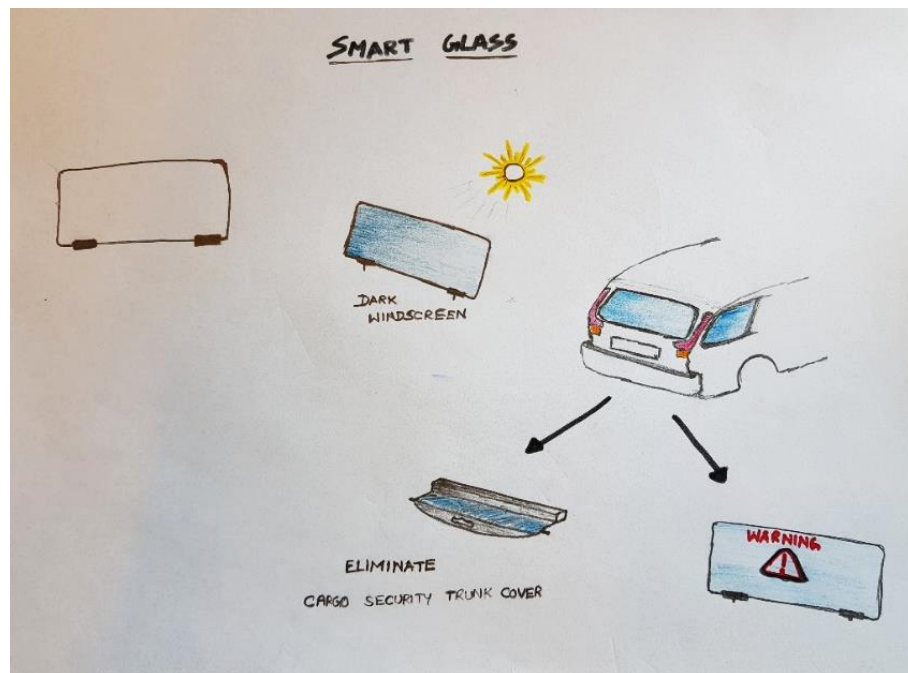


Figure 25 Concept - Smart glass

- Jump up

There's not much modification done to the car to implement this concept. A guided rail should be added on each C-pillar to accommodate the movement of the cargo secure cover. By doing this the cargo secure cover can be moved closer to the roof when it is huge luggage in the trunk as illustrated in the Figure 26. This will overcome the problems towards removing the heavy cargo secure cover when it is obstructing the storage of goods.

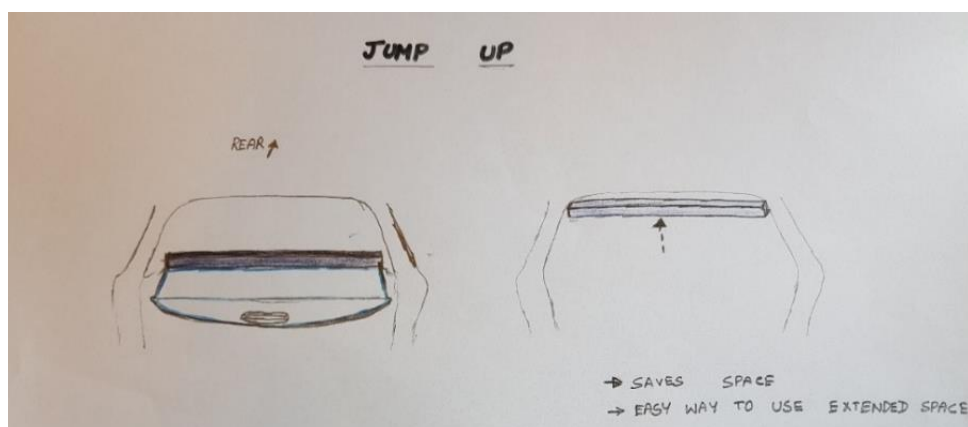


Figure 26 Concept - Jump up

- Smart trunk

The concept is like the trunk delivery system that is developed by Volvo cars [21] and used by some delivery services like Postnord, Mat.se, etc., where they can deliver your parcels, groceries, letters etc., when the car is parked at the user's office. This concept uses the same functionality but serves different purpose. It was known from the interviews that people live in small towns/villages and they travel every day to their workplace by car which is in a huge city. It was said that the postal service is very slow at the place they live. So, the smart trunk concept will help to improve the delivery service by implementing a mobile application. The application is about trunk delivery system, which includes delivering your own parcels and even parcels of the people living close to your house. Basically, the user of this application will be notified about the parcels to be carried to his town, if he accepts the offer the parcel will be delivered to his trunk and loyalty points with added to his account which can be used for shopping. On the parcels receiver end they will receive a notification based on the GPS system when the parcels are available to collect. This process will improve the delivery services in small places and creates value.

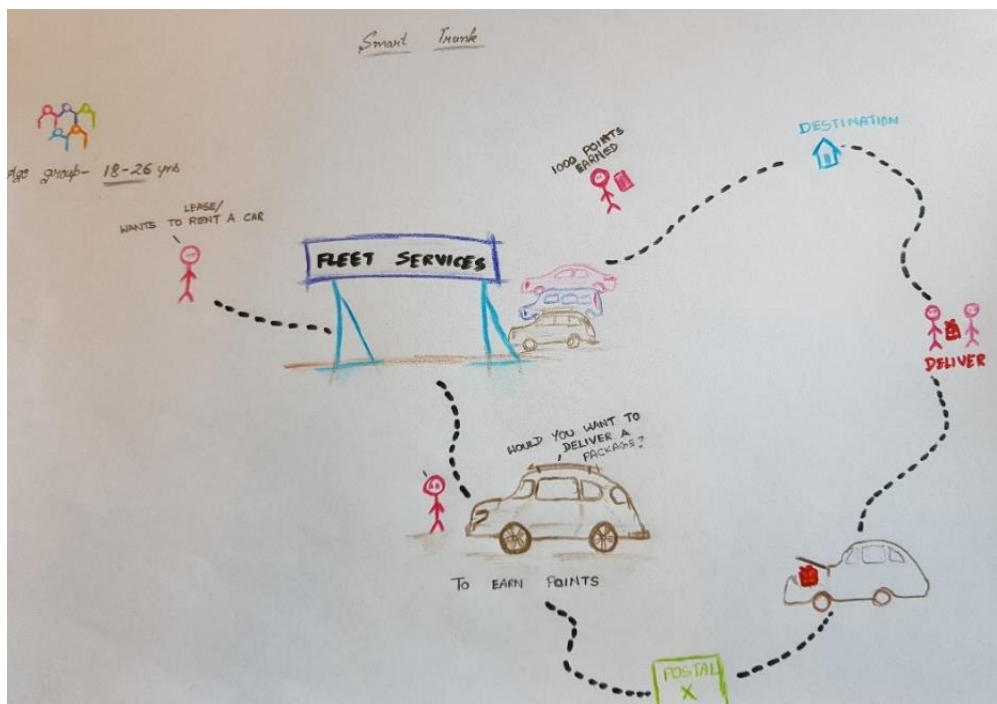


Figure 27 Concept - Smart trunk

## 5.5 Concept testing and elimination

Among the stated six concepts four concepts were eliminated and two concepts were grouped together with the selected concept from the first cycle. There was no concept elimination matrix used in the second cycle. The elimination was done according to discussion with stake holders.

- The concept Movable trunk floor was eliminated because there was one similar concept implemented by the stake holders from Semcon in one their previous development car project. They said they dint get good response regarding the sales and thus discontinued it.
- The concepts Smart glass, Jump up and Smart trunk were eliminated. Although those were pretty good ideas to implement, they fall out this thesis scope and will not really solve the issues reaching the storage and will not solve the title “Next step for storage in cars trunk”.
- The stakeholders recommended to further investigate on concept camping trunk and executive trunk to come out with some interesting concept that would also suit most of the users.

Having received these feedbacks, the work was brought back to the table to understand what could be further improved that suit most of the users. The work progressed in redefined the problem which is discussed in the next chapter. This cycle altogether provided a different view of looking into requirements and generating concepts for those. On the other hand, it wasn't a smooth approach as the whole project was meant to be user-driven and not a technology-push. Moreover, this approach rather limited the thinking which was reflected by the number of concepts generated along with the vagueness. After realising that the path leaded elsewhere, the work was brought back to redefine the problem.



# 6

## Redefining the problem to design the final concept

With the hurdle being placed in the path of study as mentioned in the previous chapter, it was now important to redefine the problem to proceed further. This first part of this chapter briefs out how the direction of the project was changed by redefining the problem statement.

The second part of this chapter is dedicated to present the final concept and the testing phase in a workshop.

### **6.1 Redefining the problem**

The process followed for redefining the problem was to pick the major learning outcomes from both the product development cycles to choose a focus area. Finally, to define the problem statement that needed to be solved.

#### **6.1.1 Learning outcome from both product development cycles**

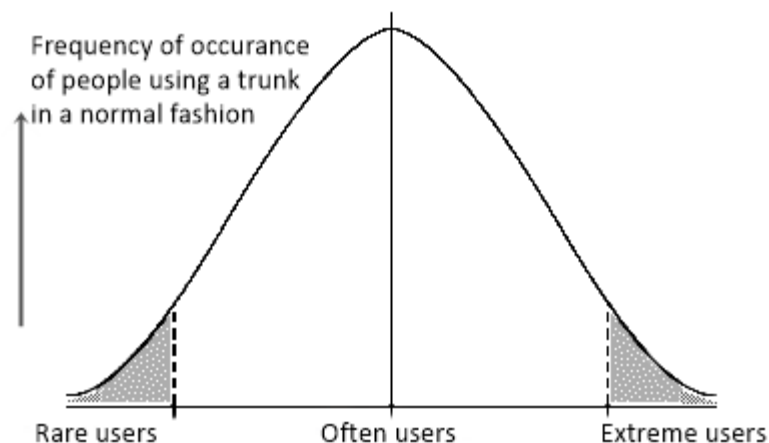
During the first cycle though several data was collected, the defined problem statement was inclined towards solving the present issues on the market. The major intension was to improve the user experience as majority problems were observed and mentioned by the users, hence being a market-pull approach. Concepts delivered were satisfying which mainly solved the needs.

Moving onto the second cycle, the suggestion from Semcon to look beyond the user needs motivated to think about “next generation” rather than “next step”. The approach considered was more of a technology-push but having no idea on what technology to test upon. Therefore, the only radical idea that stuck to mind was to investigate services and the delighter attributes listed on KANO model in chapter 4.3. This resulted in relatively good concepts; however, it involved several actors and was vague to proceed any further. Soon after the workshop activity, the inputs were brought back to the table to evaluate and scrutinize what exactly the next step could be.

Since this project was intended to provide design changes in trunk that benefits the users, it was important to investigate the focus area where the changes could be made.

### 6.1.2 Focus area

Firstly, considering the different categorised users namely the rare, often and the extreme users, it was basically important to stick to one focus group on which the design changes could be made. This was done by taking the anthropometry graph [22] as an inspiration and modifying it according to the project's need. Here the users were distributed in terms of trunk usage as shown below in the Figure 28.



*Figure 28 Distribution of users with respect to the trunk usage*

Since the often users were higher in number and dominate the category, the work proceeded in considering their needs to be prior over the other 2. Hence, the scope was narrowed down to concentrate on often use cases as like the product development cycle-1.

However, this doesn't mean that the other 2 user categories were completely neglected. They were considered too but the major priority was for the often users.

### 6.1.3 Redefined problem

After it was clear that the often category user needs were given priority, the needs listed down were to be solved. They were:

- Easier accessibility
- Securing the average number of grocery bags
- Time saving
- Improve concentration on road
- Attract rare and the extreme users

Easier accessibility refers to use scenarios mainly while placing the grocery bags, using the continuous stored items or the warning triangle; all these must be easily accessible for the user. When talking about securing as a need, it is estimated to

secure the average number of grocery bags as most of the users shopped an average of 2-3 bags during grocery shopping. And mainly to secure them in a fixed position which doesn't allow things to fall over. In addition, all these activities of accessing the cargo and securing must be done as quickly as possible, hence defining time saving as the next need.

Another need that was defined was to improve the user's concentration on the road. As most of the user's mentioned their driving used to be dependent on the bags placed in the trunk, because driving faster resulted in things fall/spill inside the trunk. This forced them drive carefully especially at the turnings or roundabouts. Moreover, this can be related to the Millers law which explains that a human has a capacity to process  $7 \pm 2$  things/operations at a time [23]. Therefore, it was important to ensure that the user stay focused on the road while driving rather than thinking about the cargo in the trunk.

The final need added to the list was to produce some design solutions which would attract the other users (rare and extreme users) to use the car furthermore. Additionally, as discussed in the market analysis regarding the trends with the estate cars, they were not popular with the older and younger generation. Therefore, this need is framed to attract every possible user by offering some functions in the trunk.

## **6.2 Combining concepts**

The concepts 'Camping trunk' and 'Executive trunk' from the second cycle were grouped together with the final concept 'Easy bag drop' from the first cycle. The new concept is named as "A Scandinavian Holiday" which is illustrated in the Figure 29. The concept provides a modular solution in the car's trunk area. To achieve this, the options in all the three concepts are converted into modules. The trap door idea from the concept Easy bag drop was considered as one module. The options from the concept Camping trunk regarding food warmer, chiller, kettle and camping table were considered as four modules. The features from the executive trunk regarding shoe box, steamer and other storage were considered as the modules. Therefore, the modularity concept was selected as final concept and was presented in a workshop activity to get a feedback. The rough arrangement of the modules can be seen in the Figure 29.



Figure 29 The Scandinavian holiday

### 6.3 Workshop Activity

A workshop activity was conducted at Semcon Trollhättan office, where the employees were invited to participate in the thesis concept workshop. The selected concept after concept grouping was presented with to the audience. They had the freedom to comment, criticize and give suggestions on the selected concept.



### 6.3.1 Learnings/Take away points

As the people who attended the work shop were experienced in working with automotive industry for ages, they gave some feedback on the selected concept. Firstly, they appreciated that the concept was impressive, and they haven't seen something like this before in cars trunk.

- A lady who is 50 years old, 160cm tall and drives an estate car had suggested having a sliding load floor, because it was very tough for her to access the luggage due to the presence of huge trunk space.
- A guy wanted this concept in his car because there was always a problem when he places the groceries in trunk. While driving they ended up falling all over the trunk and he needed to place them in the bag every time which was a cumbersome process. He feels this concept will solve his issue.
- Since it was said that the selected concept is modular, there was a suggestion to have a safe as one of the modules. So that people can store their valuable things when they park their car in the parking lot. There were few cases, when people store their valuables in the front glove box or in the storage space in the centre console. Since valuables have been stored here since ages, it is prone to theft at unfortunate scenarios. Therefore, this kind of modular system can solve the theft issues and keep the valuables safe.
- There was one suggestion towards appearance in trunk area. Since almost all the cars have the same kind of trunk being flat with one or two lights. It was suggested to have a premium appearance even in the trunk area by providing some ambient lights. This would add value to the car and attract many users.

All together this short iteration of going back to redefine the problem provided a better understanding on the focus area and took the study onto the right path. In addition to this, the workshop session ended up with a good feedback and gave a push to finalize the concept. Few of the suggestions were considered to integrate it in the concept which will be explained in the further chapter. Since, most of the needs had been partially solved in the first two development cycles, it was most likely to combine few concepts and alter the same to deliver the final design.



# 7

## Final Concept

This chapter presents the concept verification and the detailed version of the concept explaining about the functionality and its sub-functions. The details are presented in terms of renderings to help the reader to get a hold on the working mechanism and its functionality. The chapter ends with few suggestions on scope for future work which could be interesting to consider on further development.

### 7.1 Concept overview

The final concept is called “Model V (versatile)”, as the name says the concept is designed to fit estate cars that were benchmarked. This concept was further developed based on the feedback received from the workshop. The finalized concept will serve many purposes and solves issues related to trunk usage. In this final concept the total load floor area is redesigned.

The flat load floor is divided in to four modules as seen in the Figure 30 to accommodate different modules based on the usage. The tools were moved to the left side trim to improve the accessibility when the trunk is fully. A kettle and an umbrella were integrated on to the right-side trim which adds value to the user.

### 7.2 Concept validation

A concept validation check was performed on the final concept to verify and validate whether the concept can be accommodated in the estate cars and if there is any similar exiting technology to the final concept. To achieve this, a feasibility study and patent search was performed.

#### 7.2.1 Feasibility study

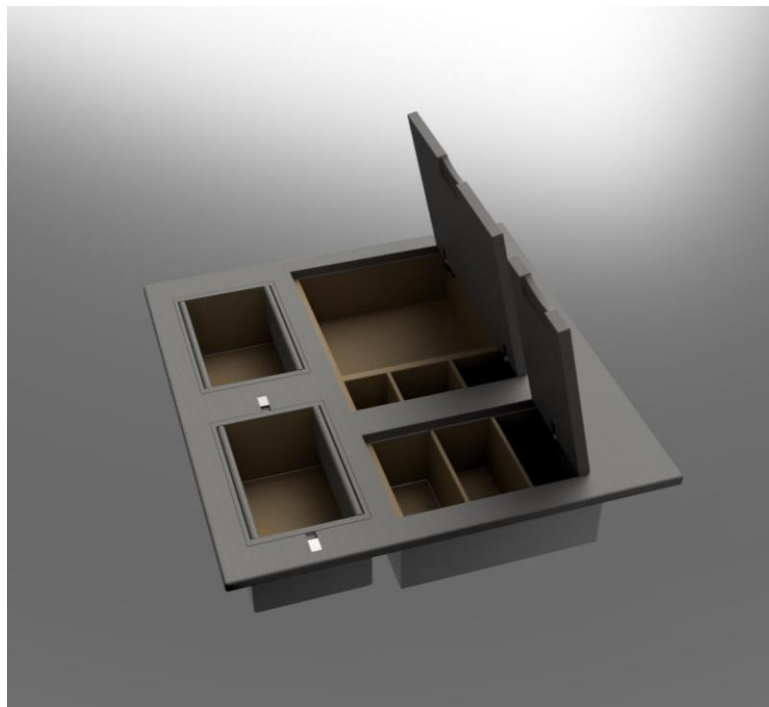
The feasibility study was done on eight top selling car models in Sweden to see if the final concept can be implemented. In this study, detail measurements of the trunk were taken regarding space on side trims, dimensions of the load floor, space under the trunk, height from ground to load floor and thickness of the load floor. The purpose behind conducting feasibility study on eight cars was to reverse engineer to ensure that the final concept must be designed for all and act as a platform.

### 7.2.2 Patent search

A patent search was performed for the final concept to check if there were similar technologies existing in the car's trunk area. The patents were searched between years 2008 and 2018. There were few interesting patents found regarding trunk development but there was only one patent regarding modularity. However, that was totally different from the final concept "Model V(versatile)". So, there were no patents that looked like the proposed concept. There were some patents that were interesting to go through and are presented in Table 6 that can be found in appendix B.

### 7.3 Final solution and detailed design

The final solution consists of four modules in the floor area and changes were made to the load floor, side trims and tail gate area. The final solution addresses the problem in to provide easy and better usage of the passenger car trunk area.



*Figure 30 Final Concept - Load Floor*

The major modification was done to load floor as this was the most used space in the trunk. The floor area was divided into four modules. Two of them are storages with trap doors which are ideal for securely storing grocery bags. Other two are general storage spaces with compartments and a door of which one is multi-storage compartment and the other one is meant for storing constant items such as jumper cables, car wind shield liquid and more.

The dimensions of the storage with trap doors are as follows: 370\*250 mm and the depth of the storage is 200mm. The trap doors are equal sized and put in place with spring loaded hinges which automatically open the door when loaded over it. The trap doors can be manufactured using glass fibre composites or hardwood

depending upon the material used for the load floor in the car. These trap doors can be locked when they are not in use with a help of a slide lock mechanism as shown in Figure 31.

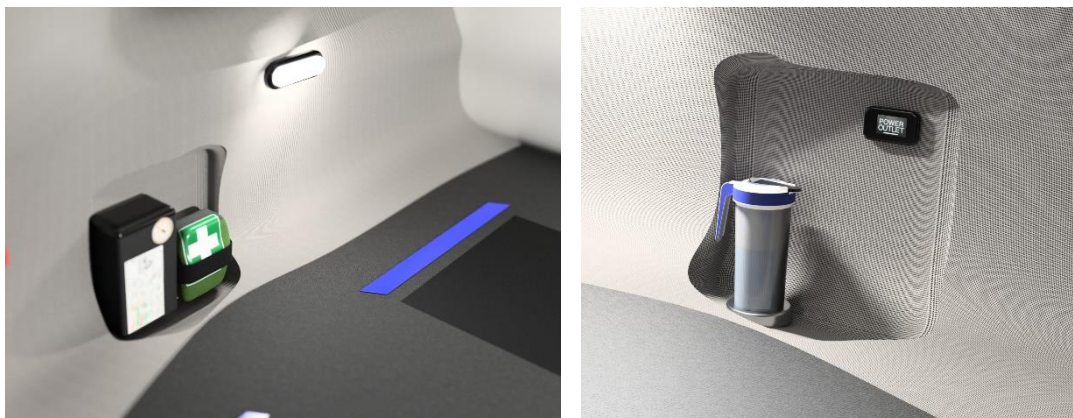


*Figure 31 Easy bag drop locking mechanism*

Dimensions of the multipurpose-storage compartments are 590\*440mm and 290\*440mm with a depth of 170mm. Spring loaded clamps are used for the door to cover these compartments. Similar to trap doors either glass fibre composites or hardwood can be used as the door material.

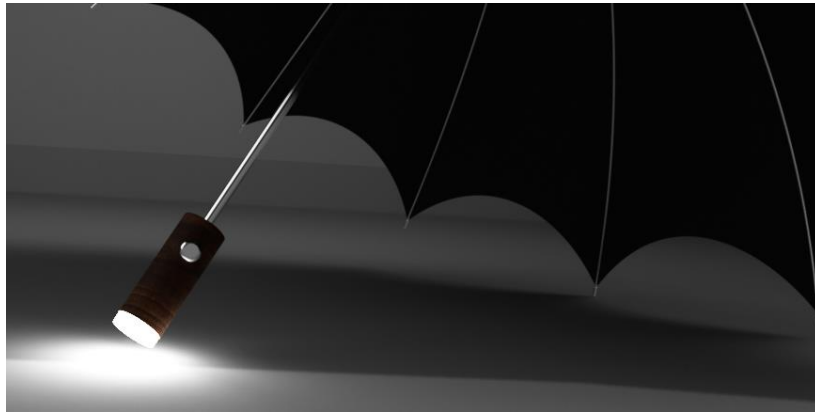
LED light strips are installed on the floor for better guidance of different storage areas on the load floor during low visibility conditions as shown in the Figure 32

A passenger car trunk has two side trims left and right-side trims. In this concept tire pressure pump, first aid kit and a towing tool are tucked into the left side trim. The reason for moving these to the side trim is that the space under the load floor is completely occupied because of the new design. Moreover, this improves the accessibility of the tools when the trunk is fully loaded. A kettle and an umbrella with a light are placed on the right-side trim as shown in the Figure 32.



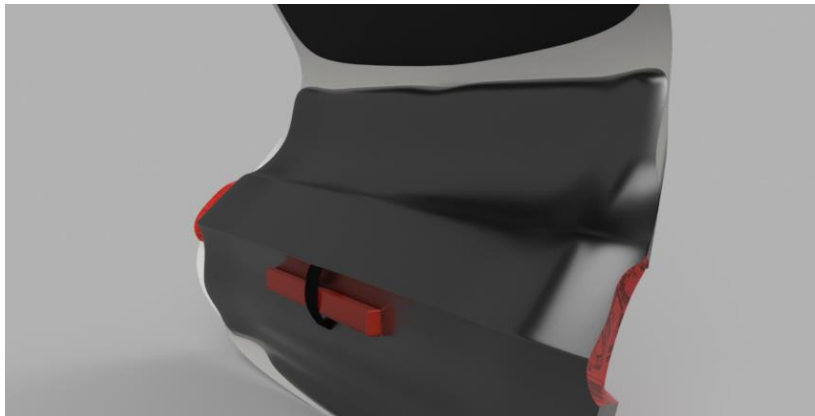
*Figure 32 Side trims*

A new umbrella was designed, which has an integrated light in the handle as shown in the Figure 33. By the using this the user doesn't need to use other hand for holding a torchlight in dark. This idea creates a value addition to the car.



*Figure 33 Umbrella with light*

Safety triangle and reflector jacket are placed on the tail gate for easy access as shown in the Figure 34.



*Figure 34 Warning Triangle*

#### **7.4 Scope for future work**

- Modular platform is created for the trunk which can be further developed for different applications. For example, replacing the trap door with a mini cooler or a safe for storing valuable things.
- Detailed material research to find out what type of materials to use for the load floor and doors.
- Trap doors can be automated using sensors for the luxury car segment.
- Further research on how to lock these modules to the load floor.
- Feasibility check for electronic tinted glasses for the whole car to replace the cargo secure cover.
- To enable this design in future, the Body-In-White (BIW) must be designed in accordance to fit this structure in place.

# 8

## Discussion

Initially the project began with a view to develop a multi-purpose trunk that could suit different use scenarios and to investigate how this space could be used more than just storage. As the project progressed by looking into user needs and the problems, the direction of the study changed. The crave to solve those needs were of paramount importance and resulted in delivering the concept-V. This chapter's purpose is to explain the challenges and the associated learning outcomes.

### *Learning outcomes concerning the methodology:*

The re-designed methodology was one of the major learning outcomes. We as product developers are always interested in learning new methodologies which enables us to develop a product. Of the two interesting methods being generic product development and design thinking, it was preferred to use anyone of them because it would had been time-consuming and lead to confusions. As there were few interesting things possessed by both methodologies, we managed to pick the positives from both the methodologies and frame a new one that suited our need.

As mentioned, it was mainly the process that must be complimented in achieving the solution. The iterative and testing approach towards understanding and solving a problem enabled to go lean by eliminating all the waste in the development cycles. At the end it helped framing solution within a minimal time-period of 3 weeks.

On the other hand, the whole process was time-consuming, and dealing with ambiguity for that long would be extremely stressful. Especially when working with industries, the management wouldn't be happy to wait long to see the results at every stage. It is also important to have managers possessing patience and believes in your work, like the managers from Semcon AB did with this project. Combining all these positives and negative aspects, the process helped in achieving the major purpose of identifying the hidden needs and delivering a modular solution that could suit almost every car with slight modifications. In addition, it also improved the usability aspect of being more functional for the estate cars.

*Learning outcomes concerning the tools used in the process:*

Interactions with end user to know their need plays a vital role in developing any kind of products. It's very hard to extract those needs from users in new development projects. The tools such as observation and qualitative interviews for understanding the user and their needs played a crucial role. Though most of the users weren't expressive, it was only possible to break the ice with a good interaction.

Throughout the project almost all the tools benefitted in solving the problems, but if something wasn't effective, it was the online survey. It didn't work to collect quantitative data as expected with a count of just 69 answers. This is mainly due to poor information flow, as it couldn't reach many people. The social media wasn't used to take major advantage with the fear that the contacts we have were originated from the country we come from and not Sweden, which would result in data that would lead elsewhere. If we had to redo the quantitative search, it would have been preferred to conduct structured interviews taking less than 2 minutes and passing printed forms to get answers. However, on the other hand, all the data collection methods worked well and enabled us to gather proper information.

If something more had to be criticised, it would be the tool clustering. Though it was beneficial in serving the major purpose of identifying the root problem, it was hard to keep track and document the needs. Thus, it resulted in spending much time on creating requirement specification list in the second development cycle.

*Learning outcomes concerning the project itself:*

Considering the project, it was an open-ended project without any explicit project targets that made it interesting to explore but was equally a risk to deal with uncertainty within the given time. On a positive-note it enabled us to explore multiple problems and understand the users in much better way, thus resulted in choosing what must be delivered. At the end, we managed to add value to the solution by not only solving the problem but also attract user by adding features that improves the user experience. To look into a deeper level, the project fulfils the major purpose of providing a modular solution that fits majority of the cars by slight changes in designs. On the other hand, if a defined problem was provided, it might have provided an opportunity in diving deep in generating several solutions and resulted in a research project.

*Learning outcomes concerning team work:*

The only concern was that dealing with lean process would be hard to divide tasks at the end if there is minimal amount of time as we had. Especially with large team it would be tedious to plan among whom the work shall be distributed which might result in uneven contribution. However, as the team knew the strengths and weakness of each other, it was easy to distribute tasks which enabled to deliver the design solution as quick as possible. Moreover, it is also the trust and the



bravery within the team that must be present in working with these ambiguity projects.

At the end, what is to be understood is that no matter what process one might use, it is important to design products that suits the user and make it a successful one.

Considering the thought if the project had to be redone, the team would certainly have an eye on 2 main aspects, they are:

- The type of project and
- Conducting structured interviews

Firstly, to wisely choose between a technological-pull or a technological-push approach. It is important to choose between these as the mixture of both would result in extreme time-consumption which may not lead anywhere. A technological-push approach would have narrowed down the work to a definite point and maintained a structured flow towards the project. At the end of the day the team would have achieved to produce a physical-working product and showcase it rather than having a virtual concept.

Secondly, if stuck to technological-pull approach, the next major importance other than conducting semi-structured interviews would be to conduct structured interviews with the users instead of sending out surveys to cover a huge crowd. To support this, it is also preferable to chose proper weather conditions other than rainy or a winter season which would enable to conduct structured-interviews. People wouldn't rush into their cars soon after shopping if it would have been a summer season, and this would have allowed us to conduct these interviews. Moreover, this would have not kept us waited long to collect data and thus resulting in gaining much time at the end stage for prototyping.

### **Ethical consideration**

There are three main ethical considerations that the solution is focused towards. Firstly, the car user's concentration on the cargo influences the driving style, thus creates more stress which results in health problems on long term. Secondly, if considering storage as a parameter, it was observed that the users preferred to change cars once when their kids move out of their home as they think estate cars are huge for 2 people. But providing them with these attractive solutions would make them stick to the same car, thus enabling to use the complete life-cycle of the car. This as well adds to the sustainability aspect of reducing the cars which results in less harm to the environment. Final consideration was to use recyclable materials which doesn't cause any harm to the environment thus creating an ecological balance.



# 9

## Conclusion

We have proposed a new solution which makes a next step for storage in car's trunk which is an optimized space under the load floor. This offers a modularity platform featuring an easy luggage drop space which secures the cargo and enables a better accessibility within no time. In addition to that, the solution also offers a storage spaces for a multi-purpose use making it much versatile by improving accessibility. Also, few values added features like moving warning triangle to access it better, umbrella integrated with lights and kettle attracts the users. Altogether, this new pack of solution is an improved step which solves the encountered problems and stands to be the next step.

The solution was mainly achieved by eliciting the user needs and converting them into proper requirements. It all began with understanding the market and the users who are relevant to this development work. The data was categorised according to the use cases drawn from the data collected from a wide spectrum. The project further progressed in solving the needs in two development cycles. The solution was also tested to receive feedback and successfully designed as a platform that could be developed in future.

The solution fulfils the need of providing a better accessibility, secured storage, time saving, and attractiveness for all user categories and important ensures the user stays focused while driving rather than concentrating on the cargo in trunk. All these promising results would be beneficial to Semcon AB if they are willing to present this solution to their customer and further develop it according to the need.



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# A1

## Appendix

### **Interview 1:**

X1 (48 Years old, Male)

#### General Information

X1 is married and has 3 kids. He is 175cm tall and has 30 years of driving experience. He uses his car almost every day to transport between cities, drive to office and visit places nearby during weekends.

Finding out how the trunk is used?

He uses the trunk frequently during the weekends to store groceries and carry luggage on short picnics. However, during weekdays there isn't much use with the trunk. Apart from that, several things are stored continuously throughout the year, such as:

- Snow shovel.
- An umbrella.
- Towing rope.

Weather contributes towards the trunk usage, especially during summer his trunk is loaded with fishing rods and its accessories. In addition to this, his mountain hiking activities also results in carrying tents and the things necessary for that instance. Hence, he feels climatic conditions do influence the way of using trunk.

Looking into other scenarios

He felt surprised and not to complain about the trunk space on his old car when he had loaded a dishwasher with the presence of 4 passengers. On the other hand, there were also scenarios where the space wasn't enough to store luggage with the presence of pet cages. While transporting groceries, he ensures that he packs the bags in secure way and restrict them from moving around. In case of delicate goods, he uses the nets/pouches on the side trim which hold 2 small bags tight.

Finding out the other needs!

He feels that he misses out the provision to lock the load floor at a position to have a hands-free way to access things underneath it, as his present car doesn't allow that. He also prefers to have a quicker and secured access. Moreover, he also wants the trunk to be flexible which could be adaptable to the different use scenarios.

Looking into the different things carried in the trunk!

He mentions that loading the pram/baby stroller was a hectic work, and that it occupies half of the space in the trunk during any circumstances. Looking into another scenario, he uses the extended trunk space (folding the rear seats) only when he's out for a huge shopping at IKEA and other mega stores.

In contrast to just storing, he once slept in the car during the summer which was a whole different experience for him.

Service-oriented

He related services in terms of renting car and he was not pleased with the cars within this fleet as it was not maintained well. He also points out that he would want to have a value for money and like to own something that he is paying for. However, if a car caters flexible solutions with respect to use scenario, he would consider it as an option.

## **Interview 2:**

X2 (26 Years old, Male)

General Information

X2 is married and has a kid who's 2 years old. He is 182 cm tall and not much into sports, however, he participates in marathon once a year. Has 8 years of driving experience and owned a car from 2011. At present he drives a Volvo V50 which is being used since 2015.

He mainly uses his car to visit his family twice a month on weekends, and sometimes, for grocery shopping.

Finding out how the trunk is used?

Mostly to store pram/baby stroller, and shopping bags when out for a grocery shopping. Apart from that, several things are stored continuously throughout the year, such as:

- Fluids like windscreen cleaner.
- A blanket for winter.



- An umbrella.
- Reflex vests.

However, the usage also differs with the change in the weather. During winter, he places the blanket under the trunk floor and a snow scrapper/brush throughout the season. Whereas in the summer, coal for barbecuing and camping stuff are commonly stored.

#### Looking into other scenarios

Apart from the above mentioned, he likes travelling and had been on a trip which covered almost 6000Kms. During the trip, the trunk was filled with 2 big bags, travelling prams for his child, a tent along with small bed for the baby, a freezer box and 2 bikes mounted behind the tailgate. He chose to go travel in the car as caravan would have costed him more. The food was however placed on the rear seats to avail a constant and an easy access. Due to the presence of mounted bikes, he pre-organised the luggage accordingly (packed left to right depending on the need to access things) in the trunk to ease things. The presence on curved walls and pockets in the trunk was a hinder for him to fit luggage as it was uneven as well as non-functional.

#### Finding out the other needs!

He feels that he misses out space with the presence of curved walls, whereas the flat side walls would have made organising the luggage easier and gained extra space. In addition, he highlights on the view about the securing of grocery bags, and how it ends up falling around inside the trunk.

#### Considering the different things carried in the trunk!

He mentions that loading the pram/baby stroller is a hectic work, and that it occupies half of the space in the trunk during any circumstances. Considering another scenario, he uses the extended trunk space (folding the rear seats) only when he's out for a huge shopping at IKEA and other mega stores.

In contrast to just storing, he once slept in the car during the summer which was a whole different experience for him.

#### Service-oriented

Considering service point of view, he mentions that would surely be a nice change when he doesn't require 2 cars in future, however, he will miss out his personal space. His major concern is also towards the child seats which puts him in a dilemma if he wants to use one. Further, he was positive while discussing about the stationary cars at the parking lot and using them as delivery points. However, not as a delivery point for groceries to save time but for the online delivery goods

from DHL as such. He finally justified his point by mentioning that, “Shopping in Sweden is a social event”.

### Interview 3:

Names Questions	X3	X4	X5
Basic	-39 Years old, Male, 170cm. -Single and lives by himself. -Into swimming, running and mountain biking. -Has a BMW 3 series touring.	-54 Years old, Male, 175cm. -Single. -Active sailor and into running. -Has a Mazda Miyotta and Mazda 3.	-22 Years old, Male, 180cm. -Single. -Cycling. Chrysler 1991.
Car's usage	Uses it every day to travel to work.	Uses only during summer for going out to his yacht dock and not winter. He finds it inconvenient to use it rest other time.	Uses his car twice a week during summer as it's a convertible and best suited particularly for summer.
Trunk usage	Uses it every day to store groceries, delicacies like bottles.	Rarely uses it.	Never uses the trunk and has no need. However, he adjusts with the scenario.
Continuous storage	Washing details, oils, tools, soccer shoes, starting cables.	Warning triangle and starting cables.	None
Needs and Problems	-Finds lazy to secure the loads and wants an easy way to do it. -Extremely difficult to load the blind cover structure in his old car. -Easy system to organise goods.	-Less loading is the biggest problem and results in spinning. -Reachability is a problem in huge trunks.	-A way to easily load and unload the heavier goods. -Protect the spoiler from being scratched while loading/unloading.

	<ul style="list-style-type: none"> <li>-Proper room for tools.</li> <li>-Straight access in and out of the trunk.</li> </ul>	<ul style="list-style-type: none"> <li>-Tools below trunk floor is hard to access.</li> <li>Example: the starting cables.</li> <li>-Soft divider to organise goods.</li> <li>- A flat trunk floor.</li> </ul>	
Looking into different scenarios	<ul style="list-style-type: none"> <li>-More of a traveller and hence had travelled long distances during summer and winter.</li> <li>-Uses the extended space, carries a cooler, bags and groceries.</li> <li>-Transported his pet however not in the trunk as his pet feels insecure and wants someone to pamper it.</li> <li>-Placed his skis inside the car by using the extended trunk space.</li> </ul>	<ul style="list-style-type: none"> <li>-Uses trunk as a dumping place for bags while on a long trip.</li> </ul>	<ul style="list-style-type: none"> <li>-Uses his rear seat for everything.</li> </ul>

#### Interview 4:

X6 (29 Years Old, Male)

##### Basic Questions

He is single and lives with his girlfriend. He is 187 cm tall and plays football as well as handball. X6 has almost 12 years of driving experience and owned at least 9 cars till now. At present he drives a Saab 9-3 and a Honda Civic (Hatchback).

He uses his car every day to travel to work and gym during weekdays. However, during weekends, he indulges in shopping as well as meeting his friends.

Finding out how the trunk is used?

He uses the trunk to store groceries which he shops at least twice a week. Moreover, under continuous storage he also stores stuff such as:

- Spare oil.
- Wrench.
- Power Cables and ropes.

Most of the time he places his laptop bag in the trunk and sometime on the floor at the rear seat. This is due to the safety reasons to not let goods damage him during crash.

Considering other scenarios

He uses his trunk a lot during long distance travel to Stockholm, skiing and camping. The maximum usage of trunk is during summer as he likes camping. He ensures the warning triangle and lights are easily accessible. However, during winter he carries a de-icing spray rather than ice scraper.

Finding out the other needs!

He misses a lot of cargo securing options and organising walls. Also, he would want to have a portable solution that allows him to carry his cargo. In addition to these, he would like to use the space to transport people in the trunk, but he's afraid that the legislation hinders to do so.

Service-oriented

He was positive with respect to service approach of using trunk. He especially would consider this place to get food delivered whenever possible.

### **Interview 5:**

X7 (28 Years old, Male)

Basic Questions

He is in a Sambo relationship. He is 180 cm tall and goes to gym rarely. X7 has almost 10 years of driving experience and owned at least 7 cars till now. At present he drives a BMW 330.

He uses his car 4 times a week to travel to work and grocery shopping. He also travels to Småland whenever possible.

Finding out how the trunk is used?

He uses the trunk to store groceries which he shops at least twice a week. He feels very happy with the accessibility to the trunk from the rear windscreen of his car

and that he doesn't need to operate the tailgate every time. Moreover, under continuous storage he also stores stuff such as:

- Napkins.
- Special tool kit.
- Rubber mat.

Most interesting fact is that he is an extreme trunk user and has built a foldable bed which fits exactly to the dimensions of his car. He parks his car during the long trips and sleeps with this custom kit.

Looking into other scenarios

He uses his trunk a lot during the long-distance travel for sking and hardware shopping from the mega stores as he loves building furniture. He uses the extended trunk space by folding down the rear seats which helps him carry his sleeping kit during long travel. In addition to this, he has an external battery that powers the heater/cooler needed regarding the weather he's travelling.

Finding out the other needs!

He feels his custom trunk is complete. Before he used to miss electrically operated tailgate, but now with that being integrated in most of the cars makes him happier. If something's missing for him that would be a small refrigerator to keep his beverages cool.

Service-oriented

He was very positive towards the service approach and was curious to see future developments in this field, at the same time he was in a dilemma if he really wanted one. When looked deep into it, he is worried if the services would be accessible at rural areas and older people wouldn't prefer it. He feels that people can get lazy as they get older.

## **Interview 6:**

X8 (26 Years old, Male)

Basic Questions

He is single and an international working in Gothenburg. He is 181 cm tall and hardly indulges in sports. X8 has almost 8 years of driving experience and but drove rarely in Sweden as he doesn't own a car.

He used his car almost every day back in his country to travel to work and store cargo. Apart from that he travels a lot in Europe by renting cars. This puts him into the category of extreme users.

Finding out how the trunk is used?

Most of the times he uses the trunk to pack bags in an organised way to fit in many luggage's. He makes sure he places food above the luggage's which enables the passenger in the rear seat to access it during the trips. Back in his country where he comes from, the trunks are very basic, and he uses the space to dump cargo. He isn't very keen on securing them. Moreover, under continuous storage he also stores stuff such as:

- Vacuum cleaner.
- Pressure pump.
- Extra bulb.

Finding out the other needs!

He feels that there is always lack of lighting within the trunk and this could be improved. In addition, he wants an organised way to place his bags rather than stuffing luggage.

Service-oriented

He had not much clue about how services work here as it seemed to be new for him, however, he was interested to know more regarding it. Since he was single and didn't own a car, he felt this could be something that suits him. He strongly feels that these services are feasible in developed countries like Sweden.

# A2

## Appendix

### **Interview 7:**

X9 (54 Years old, Male)

#### Basic Questions

He is a married and has 3 children. He is 180 cm tall and doesn't exercise much. X8 has almost 36 years of driving experience. He uses his car almost every day to travel to work and grocery shopping.

Finding out how the trunk is used?

He uses the trunk to place his laptop bag and uses one of the hook feature to hang the grocery bags. Moreover, under continuous storage he stores stuff such as:

- Snow chains.
- Washer fluids.
- Battery start cables.
- Towing rows.

Looking into other scenarios

He used the trunk before to store prams when his children were newly born. When he had 2 kids he switched to a bigger car with more trunk space. Looking into another scenario, he expressed his thoughts about the accessibility under the load floor when there a flat tire. Back then he had to unload the cargo to access the tools to fix the problem. Nowadays he uses the trunk mainly to carry groceries, laptop bag and recycling bags.

Finding out the other needs!

He misses some good grocery storage solutions rather than the present hooks, as they aren't designed to fit different types of grocery bags. He strongly feels that the security triangle shouldn't be stored under the floor as he once had an ill experience as narrated above. In addition to these, he also needs an easier access

to cargo not only while unloading it from tailgate but also to access it from the rear seat.

### Autonomous driving

His views on the activities that could be done when car is autonomous were interesting and he gave some good inputs. If he had an option to use that service, he would prefer to take some extra sleep to work or wanted to have some information search to be productive. During long trips he would need some refreshments, power supply units to charge his electronics, comfortable beds and an ambient environment that would disconnect him from the outer environment.

### **Interview 8:**

X10 (52 Years old, Male)

#### Basic Questions

He is a married and has 2 children. He is 178 cm tall and doesn't exercise much. X10 has almost 35 years of driving experience and he uses his car almost every day to drop his kids to school, travel to work and grocery shopping.

Finding out how the trunk is used?

He rarely uses the trunk and hence places himself in rare trunk user category. Moreover, under continuous storage he stores stuff such as:

- Pair of gloves.
- Reflex jacket.

Looking into other scenarios

He uses his trunk to place luggage while he travels long distances. His major concern is only towards securing the crates of wine and beer, he achieves this by using the securing nets provided by the manufacturer.

Finding out the other needs!

Since he is a rare trunk user, he is happy with what he has now and didn't mention any needs nor problems. He only mentioned he would prefer an easier access when he is much older.

### Autonomous driving and service-oriented approach

He totally has no interest in either of the options as he thinks it's more of a business strategy by the automakers. Whereas, he loves to fix his cars and prefer the old-school way.



### **Interview 9:**

X11 (41 Years old, Male)

#### **Basic Questions**

He is single and owns a car. He is 178 cm tall and indulges in cardio training and gym. X11 has almost 18 years of driving experience and he uses his car only during weekends.

Finding out how the trunk is used?

He rarely uses the trunk for placing his groceries by using the hook feature provided by the car manufacturer. He comes under the rare trunk user category. Moreover, under continuous storage he stores stuff such as:

- Umbrella.
- Starting cables.

Finding out the other needs!

Since he is a rare trunk user, he is happy with what he has now, but wanted a bigger trunk for shopping at mega stores. He further added to have an access using the rear door rather than the tailgate.

#### **Autonomous driving and service-oriented approach**

He totally has no interest in either of the options as he thinks it's more of a business strategy by the automakers. Whereas, he loves to fix his cars and prefer the old-school way.

### **Interview 10:**

X12 (29 Years old, Male)

#### **Basic Questions**

He is single and an extreme road traveller in Europe. He is 170 cm tall and practices dance. X12 has almost 11 years of driving experience and he rents car to travel around Europe. He goes to work in his colleague's car and they take turns driving to and fro.

Finding out how the trunk is used?

He uses the trunk for placing the suitcase trolley containing laptop and office papers. Since he doesn't own a car here in Sweden he refers the below mentioned things he stores continuously back in his country, they are:

- Pressure kit.
- Bulb.
- Jacket

Looking into other scenarios

He uses the trunk most of the time to dump the luggage while travelling, and also used the space many a time to sleep. He mentions that the trunk occupancy is directly proportional to the number of people travelling, but he ensures that they use the extended space to sleep while they take breaks during long distance travel.

Finding out the other needs!

Since he is a extreme trunk user, majorly to fill the trunk with luggage he feel that the stacked luggage restricts the driver from viewing the vehicles coming behind using the interior mirror. He also mentions that he needs an easier way to access few things from rear seat. Finally, he highlights the problem with turning the engine on while sleeping inside car to operate the air-conditioning/heater system.

Autonomous driving and service-oriented approach

He is quite positive towards using the car services like delivery to trunk or fleet services as it would be a nice feature to use when he's not owning a car. But he didn't want to use the autonomous driving as he thinks it would steal the adventure he experiences while driving.

### **Interview 11:**

X13 (54 Years old, Male)

Basic Questions

He is married and has 2 kids. He is 184cm tall and practices running twice a week. X13 has almost 36 years of driving experience and he uses his car only during winter to work. He owns a Mini clubman 2008 which has a unique trunk tailgate or mostly two split doors.

Finding out how the trunk is used?

He rarely uses the trunk for stuffing building materials and for placing grocery bags. He sometimes carries a pet cage to transport his cat. Moreover, under continuous storage he stores stuff such as:

- Bike hook.
- Roof rails.
- Ropes.

- Power cables.
- Limited tools.
- Washing fluid.
- Cooling water.

Considering other scenarios

He always brings his own bags to shop grocery and places it securely in the trunk as he's cautious and doesn't want to allow the cargo to cause harm during any crash. He mentions about keeping his cargo secure and hidden from the outsiders by using cargo securing cover provided by manufacturers. In addition to all these, he also used the trunk as a place to sleep but it wasn't much comfortable.

Finding out the other needs!

The only important problem he faced is the rear cargo security cover which he feels heavy to remove it to access the extended trunk space.

Autonomous driving and service-oriented approach

He however isn't super positive towards the fleet services as he wants to spend to own something rather than not having anything. Moreover, during any breakdown he finds it fun to fix things rather than hiring services.

When investigated in the autonomous car usage scenario he would love to take extra sleep while travelling to work and use the cars to transport much goods to his summer house. While seated inside the car he would also want to have access to food.

## **Interview 12:**

X14 (46 Years old, Male)

Basic Questions

He is married and has 2 children. He is 185 cm tall and owns 2 cars. X14 has almost 28 years of driving experience and he drives 100kms every day to his office.

Finding out how the trunk is used?

He rarely uses the trunk for placing his groceries while returning home and sometimes uses it to dump waste. Moreover, under continuous storage he stores stuff such as:

- Battery cables.
- Reflex vests.

### Considering other scenarios

During trips he carries portable refrigerator/cooling box to store food and beverages. He never places his laptop bag in the trunk but keep it on the floor between the rear and front seat. When discussing about the rear cargo security cover, he never wanted to use it as he thinks it's an indication of valuables being stored.

### Finding out the other needs!

He badly wants some solution that replaces the rear cargo security cover due to the valuable cargo indication to the outer world. He also wants to eliminate the rubber mat on the load floor which makes it harder to unload heavier luggage. In addition to these, he also wants a better solution that replaces the hooks to hang bags as he strongly feels it isn't customer friendly and one of the hook in his car was damaged.

### Autonomous driving and service-oriented approach

He has no views regarding the services but would want to experience the digital key sharing solution. When speaking about autonomous cars, he badly wish to have a work station and some accessibility to food/coffee.

# B

## Appendix

### Milestone time plan:

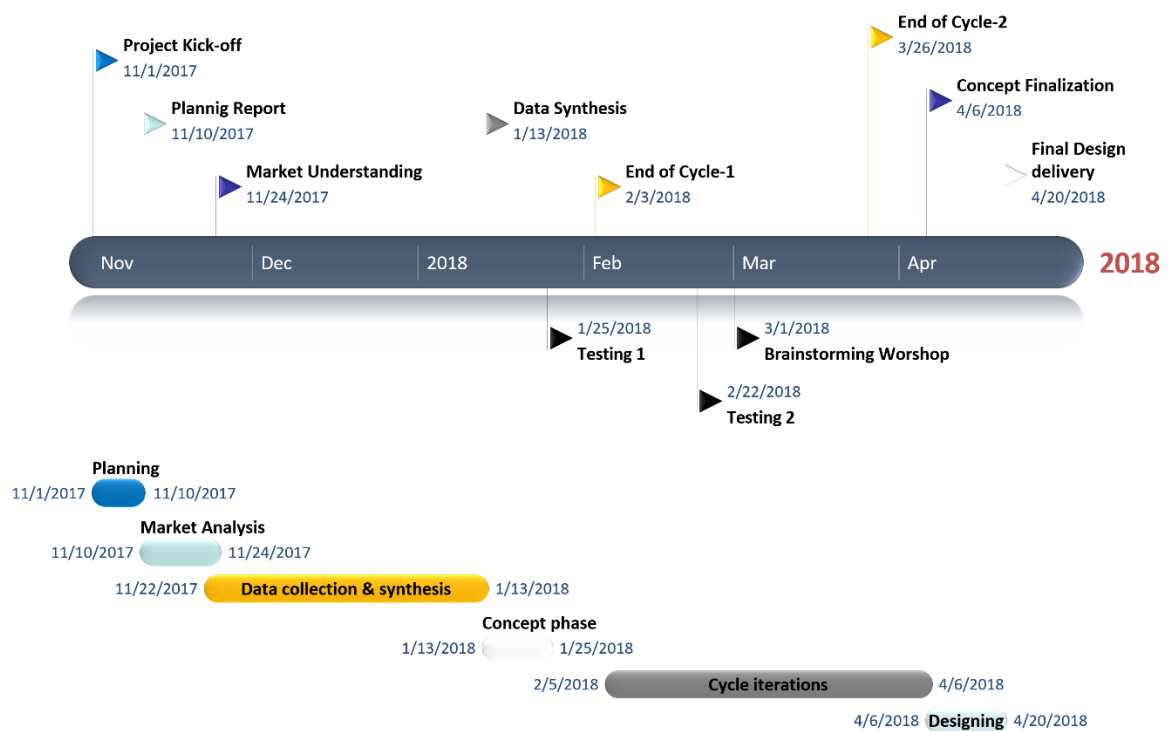


Figure 35 Milestone timeline for the master thesis

## Benchmarking

Car Brand	Boot Capacity in liters	powered tail gate	Hooks for holding Bags	Lights	Additional Storage on side trims	Warning Triangle	Security Cargo Covers	Under the Trunk Load Floor	Others
Audi A4	505/1510	Yes	2	2 LED	Yes	Intigrated in tailgate	Two directional with guids	Big battery , puncture kit and some tools.	Electronic cargo cover
Audi A6	565/1680	Yes	2	2 LED	Yes	Intigrated in tailgate	Two directional with motor	Empty sapce in the shape of a tyre, puncture kit.	Electronic cargo cover, four moveables hooks with rails close to side walls and foldabel floor with stopper.
BMW 3	495/1500	Yes	2	2 LED	Yes	Intigrated in tailgate	One directional with guids	Space for tools, splitter and two pockets for storage	Samll compartment to the left for first aid kit. Adjustable removable Trunk splitter with luggage fasteners which can be placed in two positions. floor is splitted into two parts under first one the splitter is placed second has two pockets used for storing some things.
BMW 5	570/1700	Yes	2	2 LED	No	Intigrated in tailgate	One directional with guids	Some small space which is split into two and is in a shape of rectangle	Electronic cargo cover. A compartment in the tail gate for triangle and first aid gas spring for holding floor.
Ford Focus	476/1502	No	4	2 LED	Yes	Below the load floor	One directional with guids	Wheel shaped empty space, some tools are ploed at eh centre.	
Ford Mondeo	525/1630	Yes	2	2 LED	Yes	Below the load floor	One directionl without guids	Tools for towing and tyre pressure and some empty space	Under the floor is split into two leve is the forest level has tools and samll paces the second level has semicricled space with 200 to 250mm of depth.
Jaguar XF	565/1700	Yes	2	2 LED	Yes	unknown	Two directional with guids	Tools for towing, trailer holder and tyre pressure, two empty partitions for placing some things.	Electronic carge secure cover, good lighting rectangular sahpe trunk, foldable floor and stopper holding the folded floor.
Kia Ceed	528/1642	No	2	1 LED	Yes	Below the load floor	One directional with guids	Floor has two openings, one in the front has a rectangular section with rough depth of 9 inches, and second opening has three compartments for placing different things. the compats can be lifted up, under the compartments there are tools for towing and puncture kit	Nicely designed under trunk space
Kia Optima	552/1686	Yes	2	1 LED	No	Below the load floor	One directionl with guids	Space for storage and tools	
Mercedes C	490/1510	Yes	2	2 LED	No	Below the load floor	Two directional with guids	Space for tool and foldable box and huge eampy space	Electronic cargo secure cover, and foldable box
Mercedes E	640/1820	Yes	2	2 LED	Yes	Below the load floor	Two directional with guids	Two slots for foldable baskets and tools for puncture and towing, a warning triangle, huge emptyspace.	
Porsche Panamera	495/1304	Yes	0	1 LED	No	Below the load floor	One directional	Only tools and battery	The foldable box is very interesting.
Skoda Octavia	610/1740	No	4	3 LED	Yes	In the right side trim	One directional with guids	Has two levels, one level is just flat, second level have three box spaces, where one filled with tools and other two can be used for storage	Nothing special
Skoda Superb	660/1950	Yes	4	3 LED	Yes	In the right side trim	One directional with guids	Has two levels, one level is just flat, second level have three box spaces, where one filled with tools and other two can be used for storage	Inter way of folding the floor to increase the height for storing large things. one removable led which can be used as torch
Subaru	512/1848	Yes	2	1 LED	Yes	Below the load floor	One directional without guids	Two huge sapce boxes for storage, tools close to side walls under the floor.	Inter way of folding the floor to increase the height for storing large things. one removable led which can be used as torch, smart way of storing the secure screen under the floor
Toyota Auris	530/1658	No	2	1 LED	Yes	Below the load floor	Two directional with guids	Floor is split into two, first half has two levels where the first level is flat and seconds level had space for tools and for storage, the second half has three partitions for storing different things	Nice position for storing the tools.
Toyota Avenis	509/1320	No	2	1 LED	No	Below the load floor	One directional without guids	Floor is split into two, first half has two levels where the first level is flat and seconds level had space for tools and for storage, the second half has three partitions for storing different things	Small storage space on the side walls for placing small things easy to access
Volkswagen Golf	605/1620	No	2	1 LED	Yes	Intigrated in tailgate	One directional with guids	Huge empty space and sapce for storing luggage secure blinds	Foldable floor
Volkswagen Passat	650/1780	Yes	4	1 LED	Yes	Intigrated in tailgate	One directional with guids	Huge empty space and sapce for storing luggage secure blinds	Foldable floor
Volkvo V60	430/1246	Yes	4	2 LED	No	Below the load floor	One directional without guids	No much space under the floor, only few slots to hold first aid kit, triangle and a secure net	Simple hook to hold the floor, a smart trunk splitter and a net to split rear seat and trunk with some pockets for storage
Volkvo90	560/1526	Yes	4	2 LED	Yes	Below the load floor	One directional without guids	Two layers under the floor, first one has just empty space and second one has tools.	Gas cylinder for holding the floor, multiple trunk accesories, have cage for dogs, a rear seat and trunk splitter grill that can be floed towards the roof.

Table 3 Benchmarking

Parameters	Holder nets (reference)	Easy bag drop	The Luxury LV			U shaped pouch storage	Trump wall blocker	Custom bag holder	Moving hook	The bottle stopper	Hold me	Belt on floor	The boxy
Ease of usage	0	1	1	1	1	1	1	1	0	0	1	1	1
Cargo security	0	1	0	1	1	1	0	1	1	1	1	1	1
Time to install the part	0	1	1	1	1	1	1	1	0	-1	0	0	0
Handling the cargo	0	0	0	1	1	0	0	0	1	0	0	0	1
Feasibility	0	0	0	-1	0	0	0	0	0	1	0	1	0
Cost of the part	0	0	-1	-1	0	0	0	-1	1	-1	0	0	0
Net Score	0	3	1	2	2	2	2	2	3	0	2	3	3

Table 5 Pugh matrix for product development

Requirements	Parameters						Justification	Verification
	Accessibility	Storage	Secure and safety	Capacity	Ergonomics	Miscellaneous		
Need shelter to access cargo during rainy weather	x						Observations & Interviews Observations & Interviews, Survey	More use crisis Mechanical CAD
Wants to store in an easier way		x					Observations & Interviews Observation & Interviews	CAD Time measurement CAD
Take less time to store badly need a secure way to store common cargo	x	x						
Wants more cargo space			x				Observation and survey	CAD
Avoid spill				x			Interviews	CAD and Material selection
Easier way to access tools/objects under Trunk floor	x					x	Interviews	CAD and Ergonomics
More comfort in rear seat while not using trunk						x	Interviews	
Needs to mount bike but yet access trunk	x						Interviews	Use crisis
Wants to hide or cover the cargo in much better way					x		Interviews	CAD
Wants to eliminate the retractable slide cargo cover					x		Self-experience	CAD
Wants a flat trunk floor when extended					x		Interviews	
Access things from rear seat	x				x		Interviews	CAD
To store skie equipment in trunk		x					Interviews	CAD
Emergency Indicator							Interview	Optimization
Easier loading/unloading of cargo (reduce physical effort)	x						Interviews and observation	CAD
Dedicated place for continuous storage		x					Observation	CAD
Ease of use and understandibility					x		Cognitive study	Cognitive science

Table 4 Requirement specification table

# Requirement Specification Table and Pugh matrix

## Interesting Patents

Table 6 Patent search table

Patent Owner	Patent Number	Description	Status
Diemar FingerRainer Jung	DE102010011111A1	The retention device has a wall with a recess for retaining objects in the recess. A tape is provided for holding the object in the recess, where a fastening device is also provided for the tape. The wall with the recess has a panel for the imitation of inner space of the motor vehicle.	Pending
Park Byung-heeByung YoonPark Young-ae	KR20130096591A	PIRPOSE: A mesh for a vehicle trunk is provided to prevent a product from being separated from an install location, and to be assembled. CONSTITUTION: A mesh for a vehicle trunk includes a main body, a plurality of extension members which are connected to the edge of the main body by being spaced and are bendable by penetrating the inner surface of the trunk, and a fixing member that is coupled to the extension member and is hooked on the outer surface of the trunk. The fixing member is cut along a length direction, and includes a first portion and a second portion. The first portion is fixed to the extension member, and the second portion is contacted with the extension member. When the extension member is bent, the extension member and the second portion are mutually separated, and the cut portion of the separated second portion contacts with the outer surface of the trunk.	Granted (2014-10-27)
Stephane Berth	FR2985697A1	The car has a rear shelf extending between a rear window and an upper part of a backrest of a rear seat. Two opposite lateral edges of the shelf are pressed on respective cross-pieces, interdependent of a casing of the car. A luggage holding net is made approximately vertically behind the backrest of the rear seat in a non-utilization position. Each cross-piece comprises a lengthening piece of the backrest of the rear seat on an adjacent end. A fixing unit fixes the luggage holding net in the non-utilization position.	Pending
Sтивен G. БраунТимоти Р. ПаркинЛеоне Дж. ЕнисМихаел Р. Фаули	US20090001748A1	A firm assembly for an interior of a passenger compartment of a vehicle comprises a first panel, a first shell, and a second shell. The first panel forms interior trim for the vehicle and defines a first receptacle. The first shell defines a convex surface and a concave surface and is removably coupled within the first receptacle so that one of the convex surface and the concave surface is exposed. The second shell defines a convex surface and a concave surface and is matable to the first shell to define a case. The case is removable from the first receptacle.	Pending
Shoichi Tanamoto White Hui Feli Tao	CN204452275U	The utility model relates to an automobile luggage carrier structure. The automobile luggage carrier structure comprises a drawing type storage box at the bottom and rear side wall guard plates located on the two edges of the drawing type storage box. A front luggage carrier cover plate and a rear luggage carrier cover plate are arranged on the drawing type storage box. Cover plate fixing tracks are arranged on the inner sides of the rear side wall guard plates. The automobile luggage carrier structure is low in cost and light in weight. In this way, the storage space of the luggage carrier is changed, large objects can be stored besides, the actual storage space of small objects is enlarged, different requirements of customers are met, and the structure can be applied to SUVs, MPVs and other two-compartment vehicles.	Granted (2015-07-08)
Gerhard Günther, Bernhard Schmitter, Joerg Wichert	DE102013217567A1	The invention relates to a luggage compartment floor, means for a luggage compartment of a passenger vehicle, with at least one first luggage compartment floor element, on the first floor surface to be transported in the luggage compartment objects can be arranged, arranged with two in vehicle transverse direction both sides of the first floor surface guide rails arranged for guiding and securing at least a fixing element for fixing the transported objects and with a vehicle longitudinal direction behind the first boot floor member second boot floor member, on the second floor surface of the transported objects locatable are, the second boot/floor member covering between an at least arranged a section of a below the second luggage compartment floor element storage space closed position and at least one sub-area-releasing open position relative to the first boot floor member is movable, whereby the second luggage compartment floor element two further to the second luggage compartment floor element midweb/gate and relative to the closed position in the vehicle transverse direction on both sides of the second floor surface disposed guide rails for guiding and fixing the fixing element are connected, which with respect to the closed position in the longitudinal direction of the first guide rails connected to this.	Pending
Ford Global Technologies LLC	DE202017103297U1	Vehicle trunk storage system, comprising: a vehicle trunk with a boot floor which defines an opening, and a lip extending around the opening, and a carriage having a compartment and a wheel base, the lip being configured to receive a bottom of the compartment of the car in the trunk.	Granted 2017



## Benchmarked Cars



Figure 36 Benchmarked cars