



Stowage Needs in Cars

User Study and Concept Development for Stowage Needs in Cars

Master of Science Thesis in Industrial and Materials Science, IMSX30

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Abstract

This Master Thesis was carried out at the Department of Industrial and Materials Science at Chalmers University of Technology in collaboration with CEVT AB. The Master Thesis was carried out by Karl-Johan Holm and Erik Lexberg, two students in the Product Development master program at Chalmers.

CEVT is a technology developing company for the Geely Group which means that one part of their operation is to develop cars for the Chinese market. Since CEVT is located in Sweden and the engineers mostly have experience of the European market, a knowledge gap exists towards the user needs in the Chinese market. This Master Thesis aims to reduce this knowledge gap towards user needs for stowage in cars. To do so, a user study including interviews, observations, questionnaire and document analysis was carried out, both in Sweden and in China.

The results include a list of 60 items that the Chinese users bring into their cars, the popularity of these items and their preferred placement inside the cars. The results also include a recommendation about changes relating to stowage that has to be done in the car in order to fulfill the user needs. One part of this thesis aimed to investigate how the stowage would be affected in a carsharing situation which also can be found in the result section. One example of solutions needed for carsharing is to have lockable stowage in which the owner of the car can stow their personal belongings when lending it to others.

Lastly, a concept was developed in order to present a solution to one of the issues identified in the study. The concept was a rotatable front passenger seat cushion which enables the user to stow heavy items like bags safely in the front row. Thanks to the modular interface on the back of the cushion, the user can stow a variety of items which are difficult to stow in today's solutions. A few examples of items that are difficult to stow and that can be solved by this concept are: tissue boxes, food and beverage, jackets and purses.

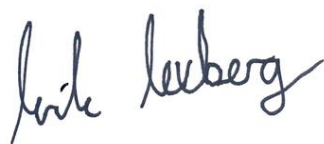
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Erik Lexberg



Karl-Johan Holm

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Abbreviations and definition of terms

CEVT – China Euro Vehicle Technology, Sweden

Ergonomics - Department at CEVT, responsible for ergonomics in the car.

GDPR – The General Data Protection Regulation

IP – Instrument panel

LRI – Lynk & Co Research Institute, China

MSS - Department at Lynk & Co that works with the strategic decisions regarding future car models, sales models and brand image.

Packaging – Vehicle integration department at CEVT

Peer to peer carsharing – Carsharing solution where one individual owns a car and lends it to other individuals.

PPL – Product planning department at Lynk & Co

Stowage – storage inside the cabin that is divided into three main categories: eat and drink, convenience features and small items

SurveyMonkey – Online based survey development software

WeChat – App for social media and other functions in China. WeChat includes messages, networking, electronic payment, online games, telephony etc.

INTRODUCTION

1.1 BACKGROUND

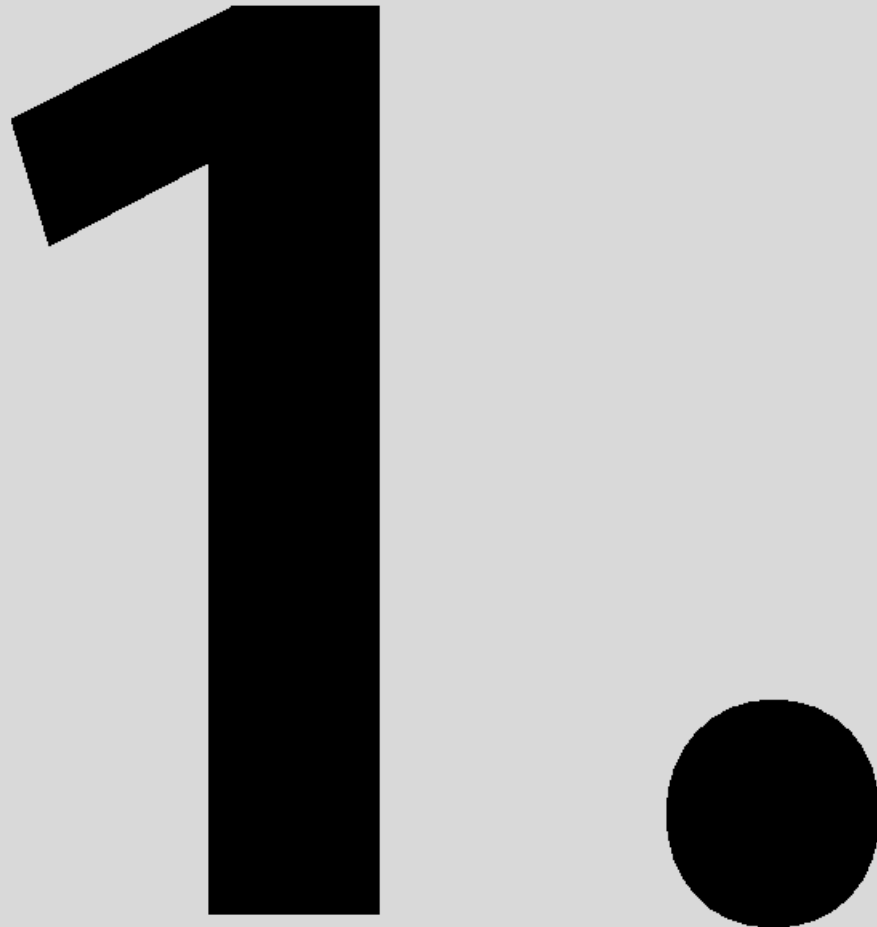
1.2 AIM

1.3 RESEARCH QUESTIONS

1.4 DELIMITATIONS

1.5 PROJECT STRUCTURE

The introduction includes information about the background of the thesis, the aim with the project and what questions that will be investigated. It also contains information about which delimitations that will be set for the project and how the project structure looks like.



1.1 Background

China Euro Vehicle Technology AB, CEVT, is a development center for the future cars of Geely Group. CEVT covers most aspects of automobile development, from the total architecture, powertrain and driveline components, to top hat engineering. The company is located in Gothenburg and Trollhättan. The Geely Group, located in China, was established in 1986 by the founder Li Shufu and introduced their first automotive business in 1997. In the year of 2015, Geely Group had grown into the fourteenth largest car manufacturer in the world and aiming to be among the top ten in 2020. The automotive business consists of several car brands, e.g. Geely Auto, Lynk & Co and Volvo Car Group. These are the brands directly linked to CEVT and is where they operate, which can be seen in Figure 1-1. (CEVT, 2018)

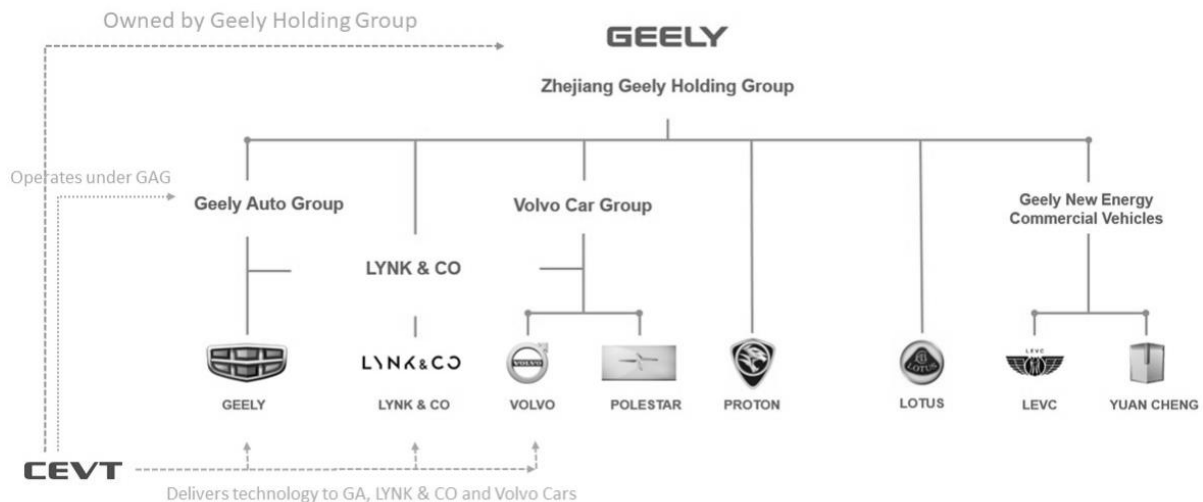


Figure 1-1 CEVT's role in Zhejiang Geely Holding Group (CEVT, 2018)

CEVT primarily supports Lynk & Co, a new car brand, targeting a young, urban audience which fuses Chinese and European influences in their design. Cars are very complex products, take years to develop and tend to adapt slowly to change. At the same time, other technologies and user behavior seems to change with an ever-increasing speed. Lynk & Co aims to develop vehicles for a global market, which poses a challenge for CEVT, since they are delivering technology for Lynk & Co. CEVT already has good knowledge of the Western market, since the company is situated in Sweden, but there exists a knowledge gap towards the Chinese market and that is where this master thesis serves its purpose.

The master thesis will be performed at the ergonomics department at CEVT, who is responsible for requirements regarding the user's physical interaction with the vehicle. The department has responsibility for three attributes: (CEVT, 2018)

1. Ergonomic accommodation, which includes driver position, roominess, in/egress and usage of controls.
2. Visibility, which includes forward-, rearward-, passenger-, and interior visibility.
3. Daily life usage, which includes stowage, flexibility, luggage and user maintenance.

The project focused on Daily life usage, within the area of stowage. Stowage is defined according to three categories:

1. Stowage of small items inside the cabin, relating to compartments such as glove box, door pockets etc.
2. Convenience features, which include power outlets for the user, hooks and sun visor mirror.
3. Eat and drink, which relates to cup holders, trays/tables and cleaning possibilities.

The departments at CEVT already have some ideas about the stowage needs in China, however, the information has never been confirmed or gathered in one place. The purpose of this thesis is to investigate the user needs for stowage in cars for the Chinese market. The project will also serve to validate and gather the information already available in the company. Finally, based on the findings, the project will also include a concept development of a new stowage solution, based on the findings in the study.

There is a strong belief at CEVT that there exist market specific needs which yet is uncovered. Due to the spread location of CEVT (Sweden) and Geely (China) there are of course obstacles to overcome when it comes to sharing knowledge. Even though there is a lot of knowledge at Geely regarding the Chinese market, it is difficult to gather it in a comprehensive way, due to the complexity of the organizations, language barriers and cultural differences. The CEVT vision is “to be a world leading innovation center, creating mobility solutions for a different tomorrow”. (CEVT, 2018) To strive towards this vision, it is crucial to understand and predict future user needs and behaviors. This is especially true for stowage. What items and what technological devices does the users in the Chinese market bring with them into the car today?

1.2 Aim

The aim with this project was to investigate what personal items the targeted market segment brings into their cars and where they prefer to place them. The result shall thereby reduce the existing knowledge gap towards the Chinese market in this area. Furthermore, the project aimed to develop a concept for stowage based on the findings from the study. To reach a successful result, user behavior studies needs to be executed with the users, developers and market analysts in Sweden and China.

1.3 Research questions

The main focus was about the stowage of smaller, personal belongings inside the cabin of the car. Lynk & Co has the ambition to become “the most connected car brand” which means that technical devices and connectivity in general was also under consideration during the study. Carsharing is another important part of Lynk & Co’s business-plan, therefore, the project also focused the development to be applicable in this area. The scope was therefore to include stowage needs and solutions for an ordinary car ownership but with the shared vehicle in mind, so that solutions may be reused in the future.

More precisely, the project aims to answer the following research question, (RQ). Firstly, comes questions regarding the user study.

- RQ1. What personal belongings are the users stowing inside the car today and what are the preferred placements of these items, focusing on the Chinese market?
- RQ2. Among the personal belongings, what are the most common ones?
- RQ3. Is there a need for a specific stowage area for these common items?
- RQ4. How well have the stowage needs been met for these common items in existing Lynk & Co models? If not met, what is needed to fulfill these user needs?
- RQ5. What is the specific user needs in terms of stowage for a shared vehicle?

Secondly, the results will serve as a basis for the technology and company trends analysis and development of a concept solution for potential improvements.

RQ6. What would the needed engineering requirements be to fulfill the user needs for one stowage area in need for improvement, based on the study?

RQ7. How can a product concept be designed to fulfill these requirements?

1.4 Delimitations

User study delimitations:

- Items that are generally stowed in the luggage compartment will not be taken into account, e.g. luggage, sports equipment, building material etc.
- Other car brands and market segments in the Geely Group will not be taken into count when executing the study, the focus is on Lynk & Co and their customers.
- The geographical area was another constraint for the study taking part in China, the target customer is dispersed all over China. However, the surveyed respondents were only located in Shanghai and in Cixi.

Concept development delimitations:

- The development phase was mainly limited due to the time constraint, the major part of this thesis was allocated for the user study. Therefore, the development of the stowage solution was held at a conceptual level.
 - No detail design of components and material selection was performed.
 - Methods such as DFX (Design for: manufacturability, assembly etc.) was not performed.
- The stowage concept was developed to be used in future projects, without having a specific project and car model in mind. However, an existing Lynk & Co SUV model was used as reference during the development, the implementation in other models was not tested.

1.5 Project structure

The project will be divided into three main phases. These three phases, presented in

Figure 1-2, are: Study, Technology and company trends analysis and Concept development. The study is the main phase of the project and thereby also the largest phase, constituting approximately 70 % of the project. The remaining parts, technology and company trends analysis and concept development constituted approximately 5 % and 25 %, respectively.



Figure 1-2 Work phases for the thesis

METHODOLOGY

2.1 USER STUDY

2.2 ANALYSIS OF DATA

2.3 TECHNOLOGY AND COMPANY TRENDS ANALYSIS

2.4 CONCEPT DEVELOPMENT

In this chapter, applied methodology of which this thesis is based presented. The methodology includes theory about the methods but also information about how the different methods were applied in this thesis.



2.1 User study

There are many different paths to choose between when selecting research approach for a project, depending on the scope and nature of the project. The chosen literature for the user study was firstly, a written book by Martyn Denscombe, (2014), comprising a research guide for small-scale, short-time and low-budget research projects. Since this project fits these constraints, e.g. time constraint of 20 weeks and a low budget, the literature was appropriate. Secondly, the “Market Research Toolbox”, written by Edward McQuarrie, (2016), and “Product Design and Development” by Karl T. Ulrich & Steven D. Eppinger, (2012), were also used to further enhance the knowledge about research methodology.

The input for the study was built upon the background of the project, a hypothesis suggesting that there might be differences in user preferences in terms of stowage, between the European and Chinese market. The intended output for the study was to obtain the Chinese user’s preferences in terms of stowage by establishing a customer needs list for stowage in cars and shared cars. The customer needs list will partly serve as basis for setting requirements for the Ergonomics department at CEVT but also for setting requirements for the concept development phase in this thesis.

2.1.1 Research strategy

According to Denscombe, (2014) the first phase of conducting a research is to choose an appropriate strategy. The strategy can be seen as an outline to achieve a specific goal. The goal for this research can be recalled from section **Error! Reference source not found.** which presents a set of research questions, with intended outcome of exploring the needs for stowage in cars and shared cars.

There are three factors in need for attention when selecting a strategy: (Denscombe, 2014)

- Suitability, will appropriate data be received, meaning is the purpose clear and can the strategy provide answers for the questions?
- Feasibility, are there enough resources, time and are the participants accessible?
- Ethics, can the confidentiality and avoidance to any harm towards the participants involvement be guaranteed?

The chosen strategy for this project was the mixed method approach. The intention with this approach is to view the research problem from different perspectives. Meaning that different data collection methods were used during the study: interviews, questionnaires, observations and documentation analysis. By having multiple sources of information, the research problem could be triangulated, meaning that a more complete picture of the problem could be developed. It could also be used for validating the data or developing one method based on the previous, to guide the research (Denscombe, 2014). Figure 2-1 displays how the different data collection methods in the research strategy will serve to capture the user needs. In-house documents and interviews at CEVT will capture the already existing knowledge about the user needs which is needed to move the study forward and to be able to capture and differentiate the new knowledge about the users.

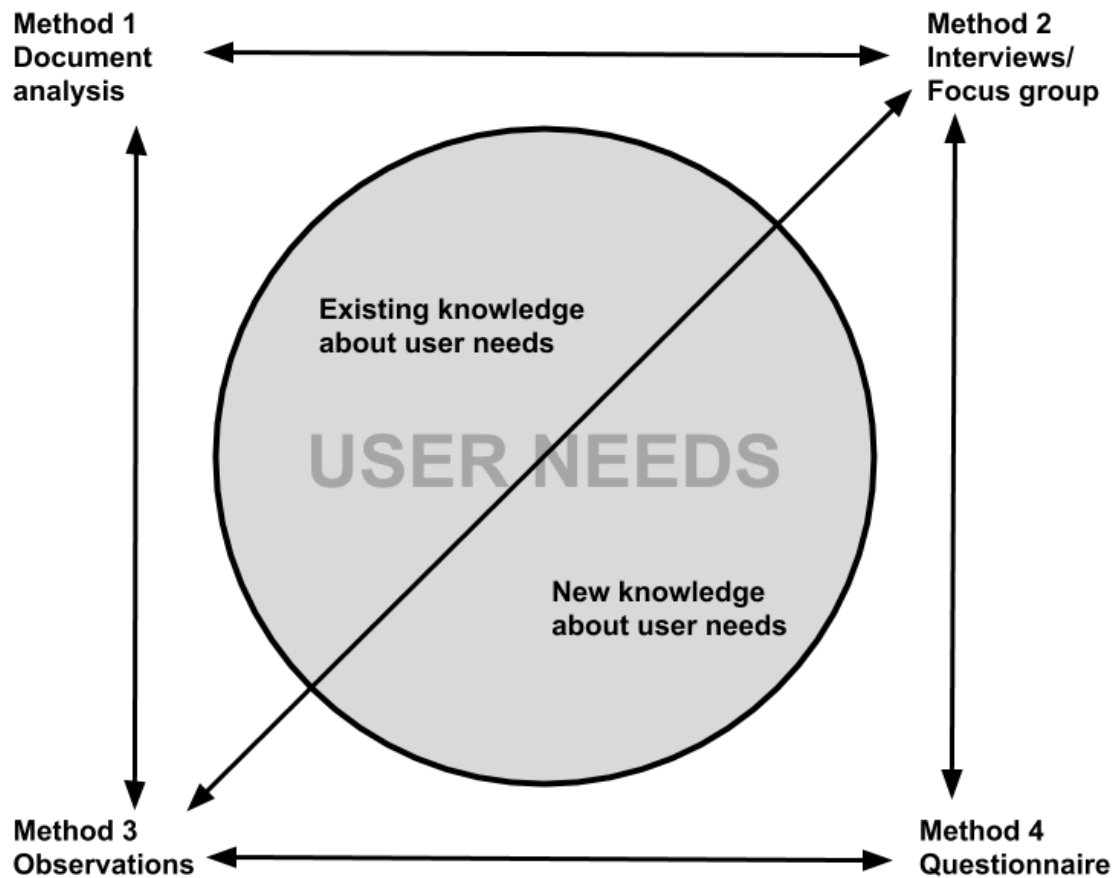


Figure 2-1 Applied data collection methods within the research strategy

2.1.2 Data collection methods

The chosen data collection methods comprise five different methods, in order to capture several points of views and thereby triangulate the problem. The process flow chart for executing this study is displayed in Figure 2-2, with the intended outcome of establishing a customer needs list and reach a decision of area to focus on during the development phase. The data collection methods served different purposes, but all contributed to the final result, the “Analysis of results”. The data collection was carried out in *three parts*, each part was built upon the previous part. In detail, as seen in Figure 2-2, the *first part* of the study was conducted in Sweden, with interviews, focus group and documents analysis, to gather the existing knowledge at the departments at CEVT. The result of this part, the first intermediate results, served as an input for the *second part* of the data collection, with interviews, focus group and observations in China. The intermediate result from the first and second part of the data collection all served as inputs for the *third part*, questionnaire in China. Together these three parts with intermediate results makes up for the *fourth part*, the Analysis of results and the final outputs: Decision of development area and Customer needs list. Each method and implementation will now be described.

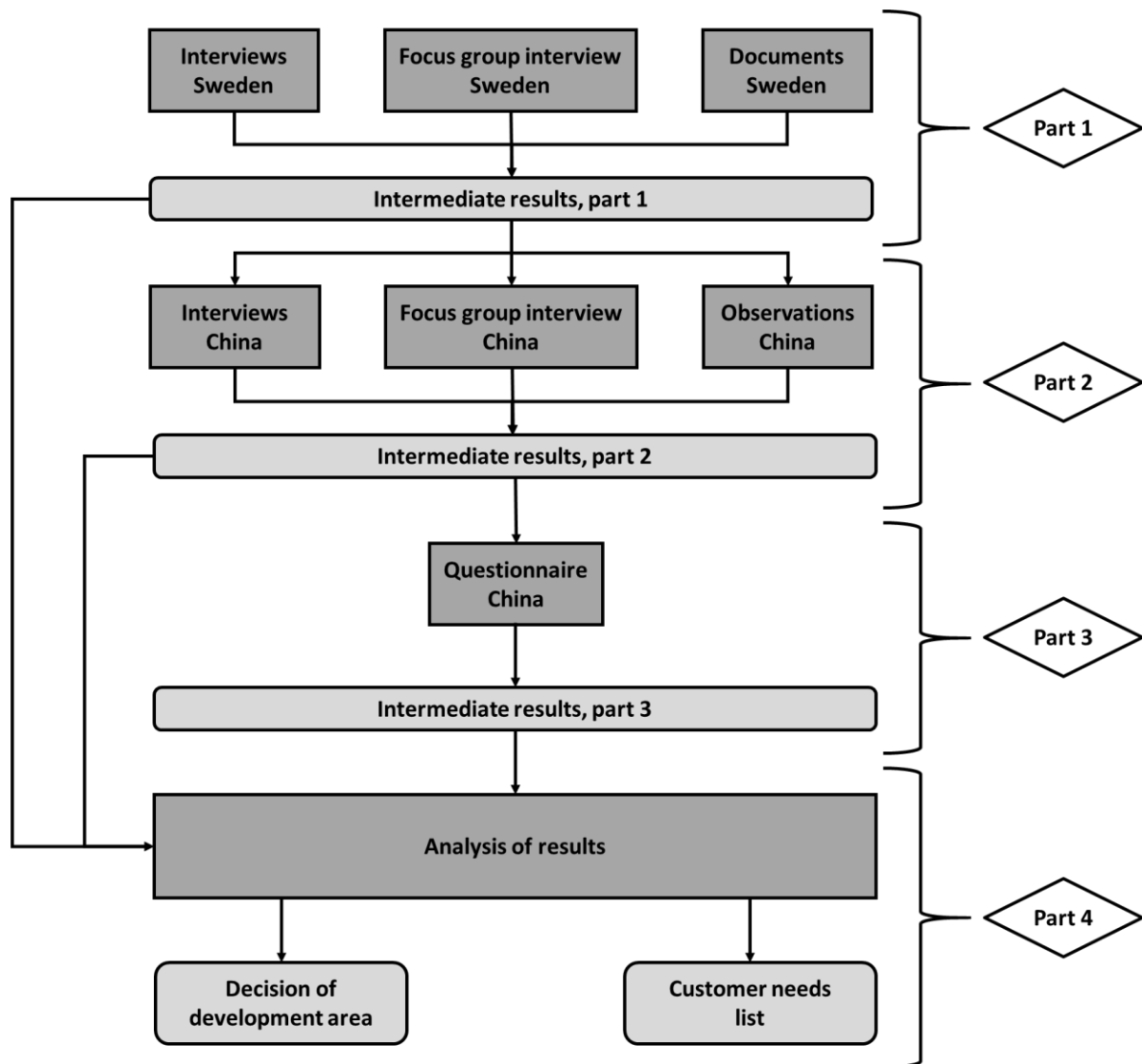


Figure 2-2 Process flow chart of the user study, divided into four parts

Interviews

Interviews are a powerful tool when the purpose is to investigate subjects that are complex and subtle, such things could be opinions, feelings, emotions, experiences, complex issues and privileged information. When conducting an interview there are two types of questions to ask, close-ended and open-ended. Close-ended questions are more appropriate for questionnaires since they are easily analyzed. For face-to-face interviews, open-ended questions are appropriate since these could give more information than expected. (McQuarrie, 2016)

In comparison to questionnaires, interviews are better used early in the process for eliciting customer needs, especially for revealing unanticipated needs (Ulrich & Eppinger, 2012). The required quantity of interviews when researching for customer needs are defined as: “fewer than 10 interviews is probably inadequate, and 50 interviews are probably too many” (Ulrich & Eppinger, 2012). This guideline is built upon research made by Griffin and Hauser, who studied the number of interviews and, or, focus groups needed to reveal most of the customer needs, (Griffin & Hauser, 1993). Since multiple data collection methods was used, acquiring approximately ten interviews seemed appropriate, six interviews at CEVT (Sweden), one interview at LRI (China) and three interviews at Lynk & Co showrooms (China).

For setting up the interviews, a guide made by McQuarrie (2016), was used, displayed in Figure 2-3. The intended output of the interviews at CEVT and LRI was to find out what the departments know about stowage, business models, customer persona, customer feedbacks, and the Chinese customers, in terms of user behavior and items (personal belongings inside the car). The intended output with the interviews at Lynk & Co Showrooms was to reveal the customer's stowage preferences.

I.	Opening
	A. Introductions, purpose
	B. Key orienting questions (job role, applications of the product)
II.	Current situation/issues
	A. Changes in environment
	B. Likes and dislikes regarding existing products
	C. Problems and hassles
III.	Desired future (enhancements, corrections, replacements)
	A. Specific needs and desires
	B. Underlying motivations
IV.	Reaction to concepts (if any)
V.	Miscellaneous issues (e.g., vendor selection process)
VI.	Closing

Figure 2-3 Template for a Discussion Guide, modified from (McQuarrie, 2016)

Mediating tools in form of pictures were used during the interviews. Mediating tools can be described as stimulus for enhancing the focus, discussions and reflection for the interviewee or participants in the study. It is an effective way of work for studies with the purpose of eliciting requirements, describing problems and generating or evaluating concepts (Wallgren, 2017). By having a generic image of the car interior, displayed in Appendix A, the interviewees could more easily display their ideas.

Cultural aspects to consider when conducting interviews in China.

The cultural differences between Sweden and China are important to consider when conducting interviews in China. Rui Torres De Oliveira & Sandra Figueira, (2018), are two researchers that has written an article about the specificities of interviewing in China. This information is general and of course not applicable for all Chinese citizens, but it is important knowledge to have in mind when designing the interviews. The article is based on seven years of work and studies and has resulted in valuable information for this project. A summary of the information presented in the article will be presented under this heading.

Some general recommendations that Torres De Oliveira & Figueira, (2018), state in the article are:

- In the Chinese culture, dignity and prestige are important, which means that it can be difficult to get truthful answers relating errors or mistakes. This also means that the interview could be ended if the interviewee feels that he/she has been offended or has lost his/her prestige during the interview.
- The totalitarian regime may limit foreign researchers to conduct studies in China which makes documentation and approvals important.
- The Chinese people believe in mutual dependence which means that if they give something to someone, they expect something in return. The timespan and the nature of the return is not general but the expectation of getting something in return will remain.

According to Torres De Oliveira & Figueira, (2018), getting an interview could be difficult for foreign researchers without any connections to China. Because of the hierarchy in China there could be difficulties to get interviews if the interviewer has a low status on the hierarchical ladder. According to Torres De Oliveira, he was accepted an interview in less than 22 % of the requests when he introduced himself as a doctoral student. However, when he introduced himself as a senior manager of a multinational firm he got an interview in more than 83 % of the cases. For two master students searching for interviews in a corporate climate in China it is therefore important to have a manager's support to get an interview. If a manager of high status approves the interviews, the employees underneath him/her will in almost all cases accept the interview.

The complexity of the interview should be held low. Short, simple questions stated with an easy language is preferable in order to get the right responses. The level of complexity in language is an important subject since Chinese people might see it as they are "losing face" if they admit having limited English skills. This means that if you ask the interviewee about his/her English skills prior the interview you will get the answer that he/she has good English skills when the reality might be on the contrary. The advice from Torres De Oliveira and Figueira is to keep all interviews with a basic level of English or, if possible, use an interpreter to translate during the interview (Torres De Oliveira & Figueira, 2018). To solve the potential language barrier the project used a translation software application, allowing the participants to speak Chinese and the application would translate it to English.

Focus groups

A "Focus group" discussion is another qualitative research method, like interviews, where a group of selected participants discuss a specific issue lead by a moderator. The focus groups included 6-8 employees at CEVT and LRI, with Chinese origin. The reason for this number of participants is that the group should be small enough that everyone has the chance to express their opinions and big enough that several different viewpoints and opinions contribute to the discussion. A single focus group could generate up to 70 % of the information as separate interviews with all the participants (Hennink, 2013). This is beneficial in order to save time.

The purpose with the focus group interviews was to:

1. Identify their opinions on today's stowage solutions
2. Identify what items the participants bring in to their cars
3. Discuss what items that are specific for the Chinese market, compared to the Western market.

The fourth purpose of the two focus groups was also to pilot the study in China, because it is always preferable to perform a test study to uncover areas for improvements and avoid making costly mistakes which damage the research (Denscombe, 2014). The first pilot study was executed during the first focus group at CEVT, Sweden, with the aim of testing the mediating tools (images in PowerPoint of car interiors and items) and interview techniques before going to China. It was discovered that using too open-ended questions was problematic, a lot of probing was necessary, and the participants tended to use the PowerPoints image for displaying opinions. Therefore, these improvements were made for the upcoming interviews, displayed in Appendix B:

- Instead of only using questions, a set of scenarios were created in PowerPoint. Simple images and arrows could be composed into daily life scenarios which the interviewees could relate to and enhance their thoughts.

- Images of a generic car’s interior were printed and laminated to enable each participant to enhance the discussion. This idea was also adopted to the remaining interviews at CEVT and LRI.

The second pilot study was executed in China, at the LRI office, during the project’s second focus group. Again, this focus group served two purposes, collecting data but also testing the questionnaire. This was to make sure that the questionnaire was understandable regarding language and easy to fill in. During this session, the respondents used the new mediating tools where they could use the printed images and mark out where they would like to place their belongings inside the car. This worked out well and therefore became a part in the questionnaire. Thereby, the project could gather quantitative data of the users’ items and preferred stowage placement. The layout of the focus group interviews was based on the “Focus group discussion guide” made by Monique Hennink, (2013), displayed in Figure 2-4.

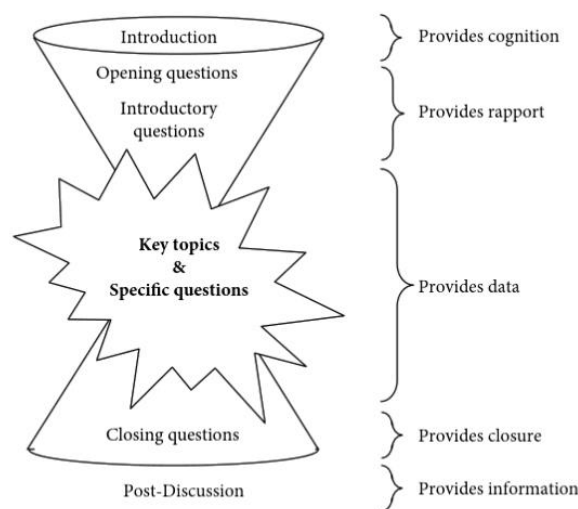


Figure 2-4 Focus group discussion guide, modified from Monique Hennink, (2013)

Documents analysis

Document analysis research relates to data collection in terms of gathering documents. These documents can be written text (e.g. books, articles, reports), digital communication and visual sources. (Denscombe, 2014). The primary documents used for this project comprises company documents, meaning already established information at CEVT and Geely. This research served the purpose of gathering knowledge about what CEVT and Geely know right know about the user preferences for stowage in cars, both in the European market but more importantly in the Chinese market. By obtaining the existing knowledge the project can avoid “reinventing the wheel” and focus on asking the important questions and gain new valuable knowledge. Document analysis is a cheap way of scanning the environment to see what has already been done in a field. (McQuarrie, 2016)

The procedure for collecting documents was similar in all cases. Because of the difficulties of searching the databases at the office, the most promising way of obtaining documents was to use snowballing. Colleagues and interviewees could guide the project to the right people where useful documents could be obtained. Three valuable documents were found which comprised customer feedbacks, the persona of Lynk & Co and a study about stowage preferences in China, similar in many ways to this project. The document analysis served as a complement to the interviews, therefore a small quantity of documents analysis was accepted for the project.

Observations

Observational studies are an effective way of investigating customer needs. By observing people in a context where they use the product, the requirements can arise in terms of problems, compensating behavior, assumptions and comparisons. Observations can be performed in several ways, for example: (Wallgren, 2017)

- Direct observation, something that takes place in front of the observer, like a meeting.
- Participatory observation, where the observer takes part in the activity.
- Self-observation, looking at photos or going through diaries.

Furthermore, the observational studies can be of different nature in terms of natural or constructed. Meaning that the study can take place in a natural situation or a staged situation. The study can also be obtrusive or unobtrusive. The nature of the study will have a large impact on the participants since they will most likely behave differently if they know that they are being observed and are supposed to perform an action in a staged environment. Unlike if the participants were unaware and performing actions in a natural environment, which would make the study more trustworthy. However, there are of course ethical dilemmas to this matter and requires the acceptance and trust from the participants (Wallgren, 2017).

Observational studies can be organized in terms of the structure of procedure, it can be either: (Wallgren, 2017)

- Structured, knowing exactly what to look for during the observation.
- Semi-structured, having some ideas for what to look for during the observation.
- Unstructured, trying to understand the situation and learn new things.

The reason behind selecting observational studies is because the other methods, interviews and questionnaire, cannot capture the problem the interviewee: does not want to describe, does not realize is a problem, compensate for and in general is unaware of. Another benefit is the fact that observational studies are not affected by language barriers (Wallgren, 2017).

The observational studies consisted of three separate studies, with different designs. They were all semi-structured, performed in a natural environment and the participants were unaware of the study. The purpose with the observations was mainly to get a first impression of what items the users bring into the car and where they place them to have as a base for the item list in the questionnaire. The items will also be used to compare the results from the questionnaire in order to verify the results.

The first study took place at a parking lot at LRI. The method consisted of observing 50 different cars by looking inside the windows and observing what items the user had and where they place them inside their cars. Since the first observation study only capture items which the employees keep inside their cars, the next study consisted of a 30 minutes long observation of people walking to and from the parking lot into the office. By using this tactic, items the users have and bring inside their cars could be observed. The third study consisted of observing cars and drivers while riding in taxis. This study was performed to discover items and placement, as well as how the driver might be using certain items and stowage solutions inside the car.

Questionnaire

A questionnaire may be defined as “any fixed set of questions intended to be completed by some group of respondents” and is used to understand the general opinion of the target group of respondents, not individual opinions (McQuarrie, 2016).

Questionnaires are generally divided in three question categories: demographics, descriptive and rating based (Malmqvist, 2017). The following questionnaire guidelines (McQuarrie, 2016) was used during the making of the questionnaire:

- Layout: There should be an introduction to capture the respondents' interests. Begin with interesting and stimulating questions and place lesser interesting questions, e.g. demographics at the end. It is also beneficial to group the questions by content to create a continuous flow.
- Phrasing of questions: The questions should be kept short and with an understandable language. It is also preferable to have close-ended questions (answer alternatives) because it makes it easier for the respondents as well as for the analyst.
- Devising the questionnaire: It is important to estimate the time of completion, only use the minimum number of questions possible and keep the number of answer categories at a necessary level to make it simple for the respondents. Rating-based question are preferred when comparing the importance of objects, rather than using ranking based.

The topics for this questionnaire were chosen to be:

- *The users' daily car usage*
- *The users' perception/rating of stowage*
- *Personal belongings the users bring and have inside their cars*
- *Where do the users prefer to stow their personal belongings?*

The reason for choosing these categories is that they capture a lot of information on how the car is being used, how the stowage is perceived and most importantly what they are bringing inside the cars, in other words, the very aim for this project.

The questionnaire was first established in English and later translated into Chinese by the help of two Chinese native speaking CEVT employees. The language level was kept very basic to make the translation precise. Previous interviews with different departments at CEVT have suggested potential difficulties with the language barrier in China, therefore cautions were taken. By having the questionnaire translated, misinterpretation could be minimized and the completion speed of the questionnaire for the respondents could be increased.

To make it easier for the respondents, the questionnaire consisted of two separate parts. The first part concerned more general questions of the respondent's car usage, perception of stowage and the demographics. This part only had either rating based or multiple-choice answers as option for the respondents, no free text answer options were available to avoid difficulties with the translation. The second part consisted of a check box question where the respondents should mark each of the 60 available items which they either have or bring into their car. Secondly, by using mediating tools, two generic car interior images, one of the front row and one of the second row, the respondents were to mark where they would prefer to stow each of their selected items by simply placing the corresponding item's number in the image. To only use predefined options for potential placement of belongings might have had hindered the respondents free will and the result would have been based on how well the options were stated. By using the plain interior sketches, the respondents could think freely and mark the items' placement based on their own preferences, instead of the authors'. The entire layout of the questionnaire can be seen in Appendix C. The questionnaire was distributed by hand or face-face, using print-outs, this was because of the layout of the questionnaire. The second part where the respondents were to mark their preferred placement of items could not be handled by the software, SurveyMonkey.

2.1.3 Sampling

There are two major types of sampling, the first is representative sampling and the other one is exploratory sampling. Representative sample are commonly used in large-scale projects where the aim is to gather quantitative data to draw valid conclusion about the overall research population. The exploratory on the other hand is used for small-scale projects with the aim to establish qualitative data and discover new ideas or theories of a subject (Denscombe, 2014). The objective of the research was partly to gain a representative view of the target customer but also to gain knowledge from a small set of people with special knowledge in the field.

However, to obtain a representative sample one most firstly understand the population size. In the project's case it relates to all males and females between the ages of 25-35 years, that have a driver's license and falls under the persona of being an urban citizen, the persona will be further explained in 3.1.1 Analysis of internal documents at CEVT. According to CIA World Factbook "China Age structure - Demographics," (n.d.), the population of males and females between the ages of 25-35 year are approximately 230 million in China (2016). Unfortunately, the real population which have a driver's license, falls under the category of urban citizen and can afford a car is very difficult to find. Therefore, the project has chosen the population size to be roughly 120 000 people, which is the sales figures, (CEVT, 2018), of all Lynk & Co cars combined. Because of the limited time frame in China, 3 days being spent at the LRI office in Cixi and two days at three different Lynk & Co showrooms in Shanghai, the aim was to gather between 40-60 answers. The reason for selecting 40-60 is also due to the distribution, which was handing out print-outs. With a 95 % confidence interval, this would give a margin of error of 13-15 % (Graglia, n.d.). If acquiring a lower margin of error, e.g. 10 %, the needed sample size would quickly increase to a sample size of 100 (Graglia, n.d.). The questionnaire resulted in 49 respondents, 23 from LRI and 26 from Lynk & Co showrooms, which resulted in a margin of error at 14 %, at a 95 % confidence level (Graglia, n.d.).

There are also aspects in terms of probability, the selection of population can be of either non-probability or probability nature. The non-probability is suitable for an exploratory qualitative study, were the participants are hand-picked for their relevance towards the topic. The probability sampling is more suitable for the large-scale quantitative survey, were the aim is to reach a representative result for the overall population. (Denscombe, 2014) Because of the limited resources and the study which was performed during five days in China, non-probability sampling was more convenient for obtaining a large set of respondents. The participants for the questionnaire consisted of employees at the LRI office, for convenience, together with customers and employees at three different Lynk & Co showrooms, located in Shanghai. For the interviews and focus groups, the participants consisted of employees at different departments at LRI and CEVT, which are the experts in the field. Employees at Lynk & Co also served as participants, since they have direct contact with the customers.

2.1.4 Ethical considerations

Ethical considerations are an important aspect when conducting research, in order to protect the participants in the study. It is very common that a social researcher needs approval from a local Ethics Committee. At CEVT, there is a department called Data Protection Officer, which handles issues regarding GDPR and who must be consulted before executing any of the project's studies. Thereby, the project can proceed according to CEVT's standards for handling data.

Generally, there are four key principles which underlines the codes of ethics in research, which have been adapted worldwide. The first principle concerns the protection of the participants'

interest, meaning that there should be no consequences for the participants, no physical or psychological harm, the information must be treated with confidentiality and the anonymity must be guaranteed, unless other is agreed upon. Secondly, the researcher must provide the participants with adequate information about the study, make sure the study is voluntary and have the participants' consent. Thirdly, in order to avoid any deception or misinterpretation of the study, the researcher must be open with the intention of the study and present a description, with purpose, of the project. Lastly, the study must comply with the laws in the country the study will take place. For example, in Sweden the GDPR regulation must be considered. (Denscombe, 2014)

To better understand the regulation regarding data handling when conducting studies, the GDPR Project Leader at CEVT was consulted. After explaining the project and study procedure it was concluded that there are certain rules that must be followed. These rules regulate the usage of personal data, which is dependent of the purpose, storage and the access of the gathered data. There is a major difference when gathering data from employees at CEVT, since they have an employment contract where information has been given regarding the data privacy agreement. In contrast, when collecting data from private persons extra information must be given. When collecting sensitive data, e.g. name, gender and age, the interviewee must be informed about the purpose, usage, access and storage time of the data. Because of the fact that no names will be needed during the study, the personal link to the source can be removed and the data is viewed as anonymous and no longer as personal data. However, as stated, the interviewees must be informed prior the study. An advantage of using anonymous data is the potential data transfer between China and Sweden, since the data is not considered personal data, the project can collect data in China and bring it back to CEVT, Sweden, and when analyzed even share it back to LRI, China.

2.2 Analysis of data

There are several ways of analyzing data, each custom made for a specific data collection method. In order to receive the right information from the studies, the right analysis method needs to be used. The analysis of the study served as a basis for the concept development and to reduce the knowledge gap of user needs between the Ergonomics department at CEVT and the Chinese market. The analysis was performed according to the data collection process, recall Figure 2-2 Process flow chart of the user study, divided into four

Analysis of interviews, documents and observations, in Sweden and china

The interviews and observation were all documented during the execution, but also audio recorded, to ensure that no information was lost. The interviews and documents were analyzed by eliciting spoken needs and translating statements in terms of customer needs. The observations were analyzed by eliciting the most common items and their placement, which later was used in comparison to the questionnaire.

Analysis of questionnaire, in China

Quantitative studies like questionnaires often results in a large amount of data. When the 49 questionnaires were collected, the analysis was performed in five steps, according to guidelines made by (Malmqvist, 2017):

1. Create a data set to organize the data.
2. Clean up the data set
3. Analyze basic (univariate) metrics & basic diagrams
4. Analyze relationships between two variables
5. Analyze relationships between three or more variables

The first part of the collected questionnaire print-outs was manually inserted in SurveyMonkey. The demographics, behavioral and rating based questions together with the items list were organized and analyzed using histograms. By using the built-in functions in SurveyMonkey, different relationships between parameters could easily be analyzed e.g. the relationship between demographics and the items list. This allowed for evaluating how the different groups (employees at LRI, Customers and Lynk & Co showroom staff) differ in terms of items and behavior and rating based questions.

The second part, where the respondents could freely mark where they prefer to stow their selected items, could not be evaluated using SurveyMonkey. The data was instead organized and analyzed by using PowerPoint and Excel. To be able to analyze the data, it was first necessary to create zones within the car to be able to organize the widely spread items. By merging all the data into one sheet in PowerPoint, clusters of items could be divided into zones, or stowage areas. The data was then organized in excel according to zones and thereby allowing to see the number of items in each zone. The final step was to create a heat map to visualize the popularity of each zone and create histograms of the items in each zone. The process is visualized in Figure 2-5.

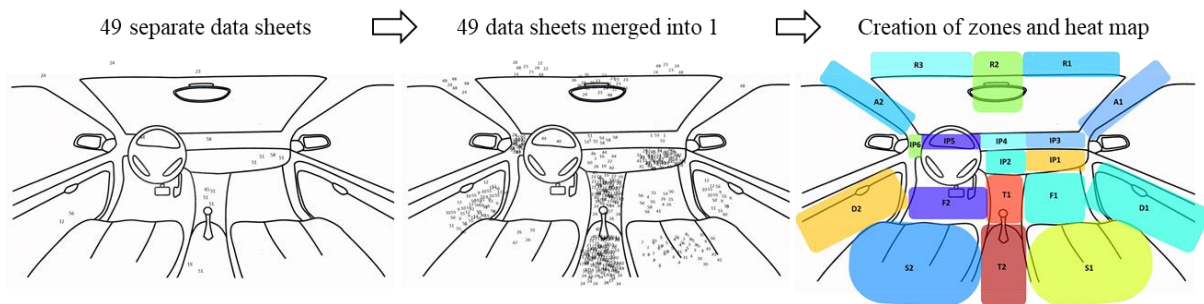


Figure 2-5 Process of analyzing the second part of the questionnaire, placement of items

Analysis of the combined set of data collection methods

Because of the different means of data collection methods, both qualitative and quantitative the combined set of data collection methods was analyzed using the KJ method. The input for this method is all the gathered information during the study and the output is a customer needs list and a decision regarding development area.

The first step in analyzing the data comprises translation to customer needs, since data collection methods rarely express opinions in the form of directly applicable needs or requirements. Therefore, the spoken opinions must be translated in terms of similar written needs, which should be expressed according to: (Ulrich & Eppinger, 2012)

1. What the product must do, not what it might do or even how it should be solved.
2. It should preferably be phrased in positive, non-negative form.
3. The need must also contain the same level of detail as the spoken statement to avoid loss of information.

The data collection methods contained different kinds of information. Therefore, two separate KJ analysis were performed, displayed in Figure 2-6 and Figure 2-7. The first analysis comprised information about the Chinese users' items and the placement of these items inside the cars. The second analysis comprised information about the respondents; spoken needs, experienced problems, values and future market trends.

The process for conducting the KJ analysis was identical in both cases and performed according to "Product Design and Development" (Ulrich & Eppinger, 2012). All needs were committed on post-it notes, organized by color or label to keep track of the owner of each need. Redundant needs were eliminated by grouping statements which expressed identical needs, thereby creating one single statement for all identical needs. The needs were then grouped with 3-7 statements in each group. The statements in these group should express similar need, meaning that they fall under the same technological perspective or assumed physical component. For each group a label was chosen, this label was either picked from one of the statement or invented to generalize the needs in the group. These labels make the primary needs and the group members becomes the secondary needs. The combined set of needs were then organized in a list, the customer needs list. A decision of development area could be reached by evaluating the customer needs, the most preferred stowage placements and discussions with the departments at CEVT.

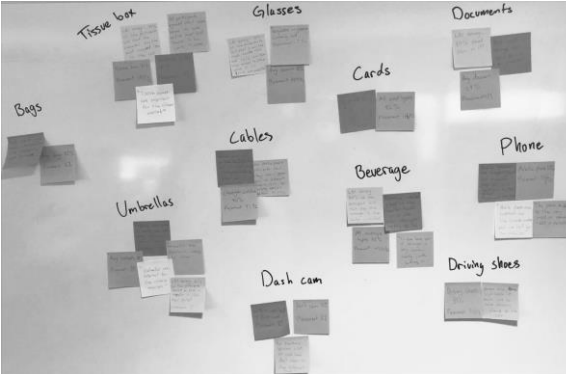


Figure 2-6 KJ analysis for items and placement

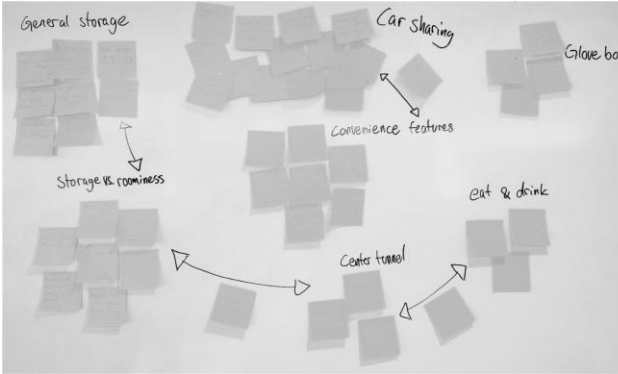


Figure 2-7 KJ analysis for; spoken needs, experienced problems, values and future market trends

2.3 Technology and company trends analysis

When the results from the study were analyzed, a small scale technology and company trends analysis was performed to better understand the market, which the company and product intend to operate within. The analysis purpose was to understand the internal and external forces that might influence the product and company, together with a benchmarking study to enhance the ideation during the concept development phase. The inputs for the technology and company trends analysis were based on the findings from the user study, e.g. interviews from departments at CEVT and LRI. The outputs from this phase were: technology and company trends, to guide the development. Existing stowage solutions to enhance the ideation during the concept generation. The working process for this phase is displayed in Figure 2-8.

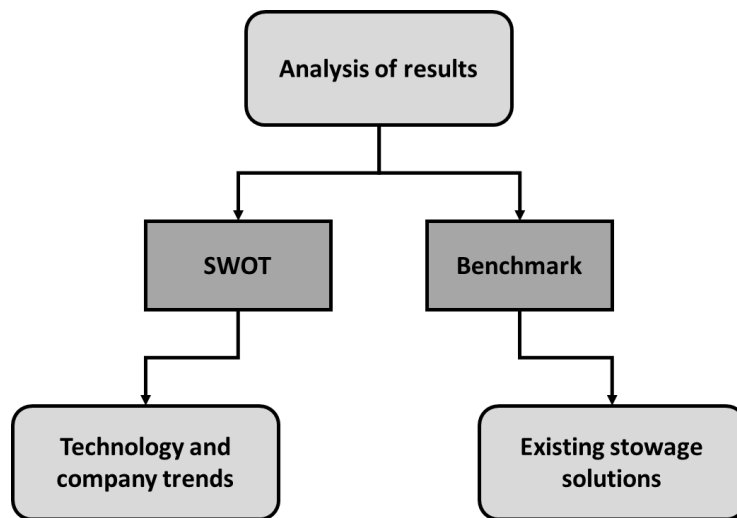


Figure 2-8 Working process for the market analysis

2.3.1 SWOT analysis

SWOT stands for; Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T) where strengths and weaknesses considers the internal resources to succeed with the outcome and opportunities & threats covers external factors that could affect the outcome. These four factors are identified in order to create knowledge about the product or service and could be used to create objectives and goals for the project. (Ulrich & Eppinger, 2012)

In this project the SWOT-analysis was used to investigate how the market could affect the development of the stowage solution. The internal strengths and weaknesses were mostly focusing on the company's market position and corporate strategy while opportunities and threats were focusing on the competition, emerging technologies and changes in the business models for cars. The information from where the SWOT analysis is based on comes from secondary data, gathered during interviews, online sources and internal documents at CEVT. The analysis was conducted by using the guidelines from "Product Design and Development" (Ulrich & Eppinger, 2012):

- Planning the research, setting up a scope and objectives.
- Conduct the information search online, using secondary data, articles and documents online. Internal information from CEVT was collected from interviews with employees.
- The collected information was gathered and structured according to applied area (SWOT).
- The SWOT information was thereafter analyzed, and recommendations were set.

2.3.2 Benchmark for ideation

To better understand the competitive products and realize where to positioning a new product, benchmarking activities are crucial. Benchmarking also provides a valuable source of ideas to use during the concept generation in product development. (Ulrich & Eppinger, 2012) Furthermore, benchmarking could also be used for: identifying customer needs, identifying sub-solutions other company uses and identifying potential suppliers (Otto & Wood, 2001).

For this project, the conducted benchmarking activities aimed to establish a rich source of ideas to use during the concept generation. The scope of the activities was to find stowage solutions that already operates in the vehicle industry, but also more inspirational ideas from the furniture industry.

2.4 Concept development

The concept generation took place in three phases, accordingly to systematic design (Ulrich & Eppinger, 2012): Functional description, Concept generation and Concept evaluation. However, before entering the concept development phase, a requirement list was established to guide the development. The input for the concept development phase was the output from the study and market analysis: Decision of development area, Customer needs list, Market trends and needs and Existing solutions. The output of the concept development phase was a requirement list and final concept, the complete process can be seen in Figure 2-9.

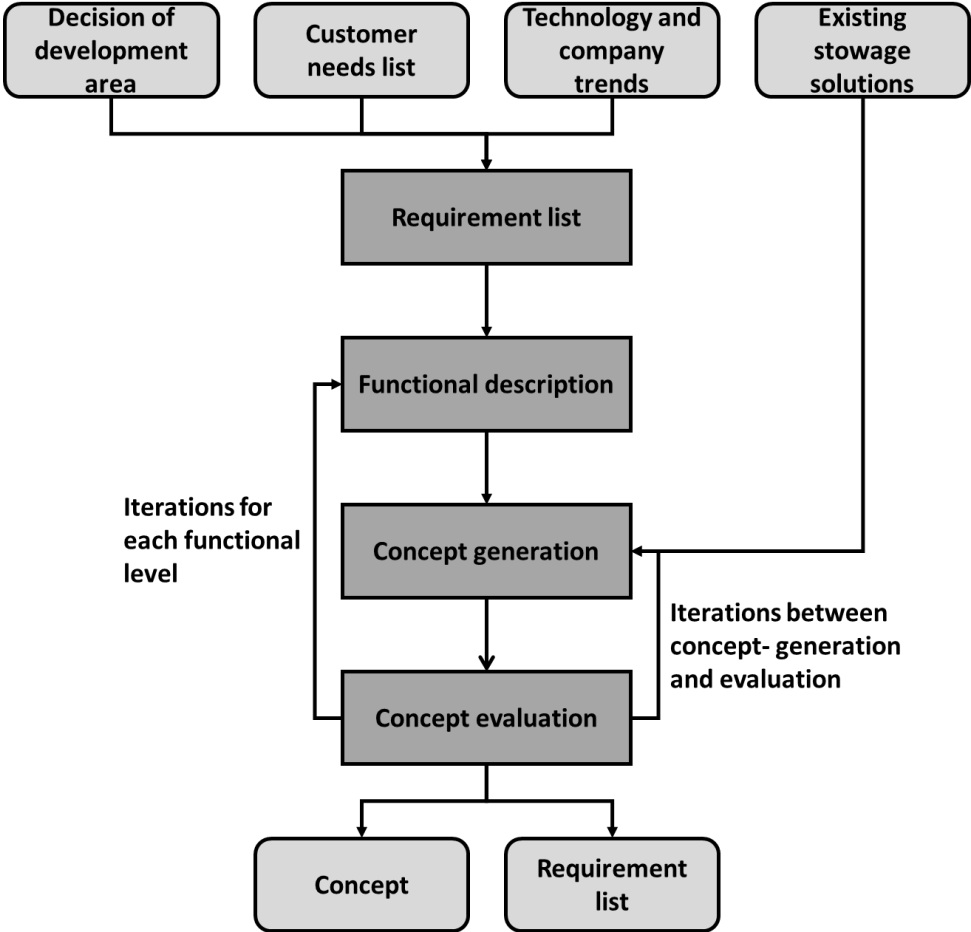


Figure 2-9 Process flow for the concept development

2.4.1 Requirement list

The first step of the concept development phase was to translate the collected and analyzed data in terms of engineering requirements. The outcome of the study and technology and company trends analysis was a set of customers- and market demands and wishes which became the input for the concept development's first step. These demands and wishes were organized in terms of requirements, presented as a requirement list. The purpose of the requirement list was to point out what the product has to do with measurable target values and not to address how the product should solve any requirements. (Ulrich & Eppinger, 2012) The requirement list also states; verification method, whether the requirement is a demand or wish and finally the statement-owner of each requirement, for traceability.

2.4.2 Functional description

The first phase comprises functional description, meaning that the system should be expressed based upon what it does or should do. There are different tools for model this, e.g. using black box diagrams, process flow charts or functions means trees (Ulrich & Eppinger, 2012). The tool used for this project was function means tree. By using the function means tree, the product could be decomposed in levels, starting with top level. The decomposition was executed step by step at each system level, e.g. a set of concepts were generated and evaluated for the top level before starting with the next level.

2.4.3 Concept generation

The concept generation phase's purpose is to derive as many potential solutions for the functions as possible, at each different level. The concept generation was performed step-wise for each level but followed the same principals. By combining systematic methods and creative methods, several ideas for each level could be derived. The systematic method used for the concept generation relates to the conducted benchmark, where stowage solutions in the furniture and vehicle industry were evaluated. The result of the benchmark was used as input for the creative method. The creative method used for this phase was performed using brainwriting (6-3-5 method). The method was slightly modified, two participants had five minutes to generate one idea (instead of three) and afterwards another five minutes to build and continue working on the other person's previous idea before starting a new cycle (Ulrich & Eppinger, 2012). The ideas were illustrated using images and words. The session was set to be carried for one hour, which would have given potentially 24 ideas per function. The second level, the sub-functions, were identically generated as for the top level.

2.4.4 Concept evaluation

The last phase, evaluation phase, was based on systematic methods using matrices. In this manner, the process will be documented, requirements will be integrated in the decision making and different perspectives will be accounted for. The matrices used for this project were Elimination matrix, Pugh matrix (concept screening matrix) and Kesselring matrix (concept scoring matrix) (Ulrich & Eppinger, 2012).

The first step was to evaluate the top-level concepts, by firstly using an elimination matrix to ensure redundant concepts were eliminated in advance. The elimination matrix removes concepts which directly can be seen to; not to fulfill the main problem and demands, are regarded as too costly and are not realizable. The remaining concepts were further evaluated using a Pugh matrix. By selecting a set of criteria, which can be wishes or demands which are beneficial to fulfill more than the target value, the generated ideas were evaluated against a reference (one of the ideas) whether they were better (+), worse (-) or equal (0) in performance for each criterion.

The outcome of the matrix is a ranked list of concepts where the best concept is set as new reference for the next round, until the best concept was selected twice in a row. For each round, new ideas could be generated by combining concepts and update concepts to enhance the performance and turning (-) into (0) or (+) (Ulrich & Eppinger, 2012).

The evaluation cycle was performed slightly differently for the second level. The concepts were firstly evaluated through the previously used elimination matrix. Secondly, a Kesselring matrix was used instead of the Pugh matrix. The reason for this decision was because it provides more precision of the assessments. It is also preferable when the solutions have been more developed in detail. Even though both the top level and second level concepts were developed by using sketches in a similar level of detail, the second level concepts were of lower complexity and could be evaluated more comprehensively than for the more complexed concepts in the top level. The Kesselring matrix works in a similar manner as the Pugh matrix, only that weight factors are added to the criteria and grading scales for criteria fulfilment. The criteria were adapted for each subfunction and the value scales for the grading were of subjective manner, e.g. very good → very bad. Each concept then receives a score based on the fulfillment level of each criteria and thereby provides a ranked list of the concepts. (Ulrich & Eppinger, 2012)

After each iteration of the decision matrices, reflections of the results were made to ensure: the significance of the results, the balance between grades and reliability of weights, scales and grades. (Ulrich & Eppinger, 2012)

2.4.5 Concept prototype and verification

The winning concept from the evaluation phase was prototyped using 3D modeling in Catia v5. Instead of designing a new seat from scratch, an existing seat model was used and redesigned to fit developed concept. By having an existing model as base, continuous evaluation and evaluation could be a part of the design. By having the existing model, available space and components to reuse could be analyzed. The existing model was analyzed in CAD software and in physical form.

The prototype was made in a conceptual level, meaning no detail design. This gave restriction to what could be verified, only requirements which do not demand a high level of detail design was evaluated e.g. stowage volume capacity, reachability and original seat functions. The evaluation of volume capacity and the maintaining of original seat functions was verified virtually in Catia. The reachability was analyzed by using Ramsis Automotive, a software which allows for evaluating ergonomics by the help of manikins.

RESULTS

3.1 USER STUDY

3.2 ANALYSIS OF STUDY

3.3 DECISION ABOUT DEVELOPMENT AREA

3.4 TECHNOLOGY AND COMPANY TRENDS ANALYSIS

3.5 CONCEPT DEVELOPMENT

3.6 CONCEPT PRESENTATION AND VERIFICATION

In this chapter, results from the user study, the technology and company situation and the concept development will be presented. The result from the user study first will be presented in three parts followed by an analysis. Thereafter follows the technology and company trends analysis and concept development for a specific development area, based on the user study findings.

3.

3.1 User study

The user study was divided into four main parts, one part in Sweden, two parts in China and one analysis part, recall Figure 2-2 Process flow chart of the user study, divided into four parts. In this section, the intermediate results from the three parts of the study will be presented separately, followed by an analysis of the three parts combined in the end of the chapter.

3.1.1 Intermediate results part 1 – Interviews, focus group interview and document analysis in Sweden

The results from the first part of the data collection will be presented in this section. The data collection included six interviews, one focus group interview and three sales documents. The purpose with the interviews was to get a first insight into what the business model looks like, how the different departments work with stowage and to get a brief perception of which items that the Chinese users brings into the car. The focus group also served as a pilot study to test the mediating tools (images in PowerPoint of car interiors and items) and interview techniques before entering the second part of the study.

Interviews with departments at CEVT and Lynk & Co

Interviews were held with employees from four different departments:

- Ergonomics - department at CEVT, responsible for ergonomics in the car. (Two interviewees)
- Packaging - department at CEVT, responsible for integration between the different technical systems in the vehicle.
- MSS - department at Lynk & Co that works with the strategic decisions regarding future car models, sales models and brand image.
- PPL - department at Lynk & Co, responsible of planning the development of future products. (Two interviewees)

The following text is a summary of the most valuable information gathered from the six interviews.

On the 26th of March 2018, Lynk & Co revealed that they will introduce their first car on the European market in 2019 and will thereby become the first global Chinese car brand. An important factor for this project will be if, or how the brand will differentiate the models between the different markets. As known before, several other brands, including Volvo, Audi and Mercedes have different versions of their models in China and Europe but should this be the case for Lynk & Co as well? According to the interviewee from MSS, the base models (outer and inner measurements) will be the same for both markets. The differences will mainly be about the styling and segmentations for the cars. The luxury levels will probably be different interior materials, rim and seat options. This means that the stowage solutions will be the same and thereby must satisfy the customer needs in both China and Europe at the same time.

Lynk & Co also strives to become “the most connected brand” in the car industry. To do so, it is important to know what it actually means to be most connected. The interviewee from MSS explained that it refers to that Lynk & Co needs to be on the cutting edge of technology regarding screens, connection inputs and interface towards the user. The trends for the interior technology are pointing to smaller dashboard screens and larger infotainment screens on the instrument panel.

Lynk & Co values roominess in their cars and especially perceived roominess. According to the interviewee from MSS, a future C-segment car (e.g. Volkswagen Golf, Opel Astra, Ford

Focus) should have the same perceived roominess as a current D-segment car (e.g. Volkswagen Passat, Audi A4, BMW 3-series). Lynk & Co are working with this issue in several different areas, but one characteristic factor is the wide wheel base and the long distance between the wheel axels. This information is important to have in mind when developing concepts for stowage solutions since an increased stowage space and perceived roominess could become a trade-off where you cannot have both. One interviewee from the ergonomics department however, argued for that stowage and perceived roominess does not have to be a trade-off since smart storage solutions does not have to take that much space. They also said that perceived roominess could be about creating a feeling of space rather than actual space.

All interviewees agreed on that cars with automatic gearboxes and electric motors usually has more free space to utilize thanks to smaller and fewer components. All Lynk & Co cars have automatic gear boxes today which is something that could potentially provide more efficient stowage solutions in the front row. All interviewees also agreed on that the center tunnel will disappear in the future, but they did not agree on how to utilize this space. The interviewee from Packaging said that the center tunnel should be used to create more space in the front row while the ergonomics department argued for that the space should be utilized for more innovative storage solutions.

One of the main topics during these interviews was about how cars will be used, by whom and for what in the future. One person thought that storage will be less prioritized because of the new usage of the cars, which in his opinion was subscription models, short time renting and robot taxis. He compared the storage in the future cars with the storage in public transportation where you do not request long time storage. Others agreed about the change in usage but argued for that storage will be more important since for example short time usage of cars could mean that you want to bring items that usually are placed in the trunk into the car. PPL and Ergonomics were also arguing for that the need for safe, lockable storage is becoming more important in a shared vehicle situation, especially if a “Peer 2 Peer” solution is used.

In the end of each interview, the interviewees were asked about their knowledge about what items the Chinese segment brings into the car. Some general answers for all interviews were: umbrellas, tea thermoses, driving shoes and tissue boxes.

Focus group 1 - Employees of Chinese origin at CEVT

The focus group consisted of four people, all male, ages 25-40 years old and all of them employed at CEVT with a Chinese background. The initial plan was to have a focus group of seven to eight participants with mixed genders, to capture the target user. The meeting was scheduled with a mix of five males and two women, however due to late cancellation the two women and one male could not participate.

The first question tested whether or not the participants have experience of using a car in general, using a Lynk & Co car and using a car in daily commute. All of the participants had experience of driving a car, two had experience of at least test driving a Lynk & Co and one had experience of using a car in his daily commute. The majority of the participants were usually sitting in the front seat or in the driving seat. Two participants mentioned that they sometimes sit in the back seat together with their children.

The next question comprised what a typical car journey could look like for the participants. One of the participants said that he mostly used his car in China during vacations, going on short shopping trips with his wife and kids which usually took half an hour or going on longer trips

which could take a few hours. The participants argued that public transportation or shuttle bus is very common and convenient for daily commute in bigger cities and that people mostly use personal cars for shopping and longer trips. However, in suburban areas or in the country side, using the car for daily commute is more common.

The next question was asked to see what personal belongings or items the participants bring in to their car and items which they always have in their car, focusing on China. Below follows a list of items and their stowage places brought up by the participants, it could be items that themselves use or that they believe that is commonly used in China.

- *Power bank*
Very common device to bring around all the time. The reason for not using the car charger is that it feels safer and more convenient to bring the power bank, according to one participant.
- *Wi-Fi dongle*
A small device which receives internet connection and provides wifi for the mobile users in the car, for a certain fee, mostly used because the data is limited on their phones. Often cheaper to use a Wi-Fi dongle than buying extra or more data on the phones. Commonly placed anywhere on the center tunnel console.
- *Drink*
To have some sort of beverage is very common, usually mineral water (plastic bottle). But one participant expressed some danger of stowing water bottles openly in the car, exposing it to sunlight, which could cause fire or burning damage when the water bottle focuses the sunlight. Thermos is also very common. Placed in the designated cup holders or in the glove box to avoid the fire hazard.
- *Umbrella*
According to all participants, umbrellas are commonly used in China. It can be used as protection from both rain and sunshine, used throughout the entire year. In some cars, there exist dedicated spots (compartments) underneath the driving seat where an umbrella could be placed. Other options are to place it on the back seat, on the floor both in front and second row or in the compartment in the door
- *Mobile Phone & holder*
The phone is always in the car, stowed and not in pockets or bags. It is important for GPS and answering calls. It is unusual that companies in China provides phones for their employees, meaning that most people tend to have only one phone. If you sit in the back seat, the participants either place the phone on the seat or in the door compartments. In the front seat, the participants usually place their phones in the compartment underneath the infotainment system, in the front part of the center tunnel. It could also be further back, in the middle of the center tunnel, where some cars place their cup holders. It is also very common that people purchase add-on holders so that the phone could be placed on the air-condition vents, on the instrument panel or on the windshield.
- *Dashcam*
For insurance policies, a lot of cars have dashcams on the instrument panels. However, this device is most likely mounted and fixed onto the instrument panel.
- *Tissue box*
All participants agreed that tissue boxes are among one of the most common items to always have in the car. Some even had multiple boxes, one in the front and one in the back. The reason was for cleaning one's hands, because it is common to eat in the car,

e.g. snacks (and sometimes meals). Stowage place, according to the participants, could be; above the glove box on top of the instrument panel, on top or inside the compartment under the armrest in the tunnel console.

- *Cables*
One participant mentioned that they use a greater variety of different cables in China, for charging devices. The cables could be of different outputs and lengths. The cables are usually placed in the center tunnel console or in the door compartments. One of the participants said that cables are more frequently used than wireless charging since the phone cannot be used during wireless charging.
- *Wipes (cleaning tissues for the interior part of the car)*
Two participants mentioned that cleaning wipes could be common and that they are placed in the door compartment.
- *Sunglasses or driving glasses*
Sunglasses or glasses used for driving is a common phenomenon which could be brought in or always stowed in the car, usually in the center tunnel console, under the armrest.
- *Driving shoes*
One of the participants brought up that women wearing heels tend to have driving shoes, which they switch to while driving a car.

The next question regarded difficulties of stowage, whether the participants had any experience of items which were extra difficult to stow. As all participants already mentioned, it is common that people purchase phone holders, since most cars has insufficient stowage possibilities for phones. The reason was that they wanted to have the phone visual when driving, for GPS and managing calls. Another item with stowage difficulties was the tissue box, since it comes in many different sizes and shapes. Fragile goods e.g. alcohol beverages, (eggs) etc. are usually just put on the back or front seat so that you have visuals on them while driving.

The last question aimed to investigate what the participants believe is important, in terms of stowage, in a shared vehicle situation. More specific, a situation where a private person can purchase and own a car and lend it to other people when not using the car themselves. The response from the participants were in general that they would prefer to remove their personal belongings when lending the car to another user, rather than keeping it in the car.

There were also other comments, a bit unrelated to the stated topic, but with valuable information about stowage. One of the stowage solutions in the door, the small compartment which can be used as a handle when opening the door, is uncommonly used. Sometimes it is used as a small trash bin, because there is no good place in the car to stow trash. Another comment from one of the participants which had experience of test driving a Lynk & Co car said that the stowage in general were quite similar to other car brands in China. The back seat is best for eating, but the cup holders in the back seat, placed inside the armrest were not commonly used by the participants.

Analysis of internal documents at CEVT

In the interview with PPL, a discussion about existing knowledge about the customer and their needs emerged. PPL in China had made a study to identify the persona of the typical user and what the users think of the Lynk & Co cars. According to this study, the typical customer is a married male with an average age of 36 years. He is well educated and has an average monthly household income of 21 000 RMB which is converted to approximately 28 300 SEK (Oanda Corporation, 2017). The customer has a general interest in technology and digital products and

seeks satisfaction in material goods. Lynk & Co describes the users as people that are “Chasing for an urbanized life with fun, quality, and style”. They are quality-driven and are willing to spend time to investigate information about the car and the competitors before making a purchase decision. They want a unique design of the car and are willing to pay for technology as long it brings them joy and convenience in their life. The car is not only for transportation, it is also a toy.

The Lynk & Co 01 got a lot of positive feedback from the users but in an investigation made by the Customer Satisfaction team at Lynk & Co, there were some parts with the car that the users complained about, five of them relating to stowage:

- Usefulness of front cup holders
- Usefulness of center console storage
- Usefulness of rear cupholders
- Location/arrangement of storage spaces
- Usefulness of glove box

3.1.2 Intermediate results part 2 – Interviews, focus group interview and observations in China

In this section, the results from the second part of the data collection will be presented. The data collection was executed at LRI in Cixi and at Lynk & Co showrooms in Shanghai. The data collection includes four interviews, one focus group interview and 6 observations. The purpose with the study was to identify what items that the Chinese market brings into the car and to gather useful information for the creation of the questionnaire. The purpose with the first interview was also to investigate what information that the ergonomics department already knew about the stowage preferences from the users.

Interview with representative from the ergonomics department at LRI

The ergonomics department at LRI made a survey about stowage preferences that were distributed through WeChat in the beginning of 2019. The survey received 306 answers where most of the participants were employees at Geely in Cixi which means that they all had an engineering background and knowledge/interest in cars. The aim with the study was to investigate what items that the users bring into the car and where the items are placed. The survey was however limited to the designated stowage areas like glove box, cupholders, door storage etc.

From the study were a number of items listed as “the most wanted items in the car”, these can be viewed in Table 3-3-1 . The most wanted item which over 90 % of the respondents brought into the car was the phone. Other popular items were the tissue box, bottled drinks, umbrellas and insulation cups.

Table 3-3-1 LRI survey - most wanted items

Phone	(90 %)
Tissue box	(72 %)
Bottled drink	(62 %)
Umbrella	(52 %)
Insulation cup	(46 %)

In relation to the designated stowage areas, the most used items can be viewed in Table 3-2.

Table 3-2 LRI survey - Most wanted items in relation to the designated stowage areas

Stowage area	Item	Selected by (%) of respondents
Cupholder in center tunnel	Beverage	(84 %)
	Mobile phone	(51 %)
	Change, key, invoice	(50 %)
Cupholder in center tunnel (beverage only)	Bottled drinks	(73 %)
	Insulation cup	(61 %)
	Canned drinks	(49 %)
Door storage	Bottled drink	(73 %)
	Umbrella	(62 %)
	Towel	(38 %)
Door handle	High speed card	(36 %)
	Not used	(33 %)
	Phone	(33 %)
Storage box left side of steering wheel	Driver’s license	(42 %)
	Not used	(39 %)
	High speed card	(33 %)
Storage under infotainment	Phone	(78 %)
	High speed card / access card	(53 %)
	Change, key, invoice	(50 %)
Armrest storage	Change, key, invoice	(58 %)
	Receipts	(39 %)
	Tissue box	(35 %)
Glove box	User manual	(90 %)
	Insurance papers	(82 %)
	Reflective vest	(32 %)

An interesting part with this data is that the Tissue box is the second most used item in the car, but at the same time, it is only in top 3 stored items for one of the designated stowage areas in the car.

Mobile phones are the most used item in the car according to the survey. The interviewee was asked why, and the answer was that the users in China prefers to use the phone for applications like navigation, answering phone calls or text messages instead of using the infotainment system as support. This information in combination with a comment from the focus group who said that the infotainment system is seldom used in cars at the Chinese market strengthens the hypothesis.

Focus group interview with employees at LRI

In order to increase the knowledge about the stowage preferences at the Chinese market, a focus group interview was made with employees from LRI. The participants were all employees at Lynk & Co research institute and had roles within the packaging and the ergonomics departments. A total of 6 participants attended the focus group, four men and two women. According to the interviewees, the stowage spaces are defined by identifying which items that should fit in the stowage space, then, the volume is calculated, and the stowage space is modeled by the packaging department.

The focus group continued by a question about how they perceive stowage in cars. The participants had different views on how it should look like. A discussion about storage in the second row of the car started and the opinions were divided into two groups. The first group talked about that the most important aspect for the second row is leg room and shoulder space. The other group talked about a higher demand for storage in the second row since the children often rides in the back seat and they need storage more than space.

The next phase of the focus group was a discussion about the usage of cars in China. As a mediating tool, several scenarios, visual in Appendix B, were used to support the discussion. The scenarios were divided into different situations, for example daily commute to work, long distance travel to visit family or short distance travel to shopping malls or restaurants. It seemed like the most commonly usage of the cars was:

1. Daily commute to work, alone in the car
2. Short weekend trips to eat or do shopping, together with family
3. Long distance travel to family in other regions, together with family

The interviewees did not describe any need for stowage of specific items in the different situations. The stowage need was more general and adapted to the items that the customers had expressed a need for. The most critical stowage need was for umbrellas in the front row since umbrellas are important for the users in China. The cupholder was also an important stowage area that needed to be improved.

Observations of user behavior

The first observation was performed at a parking lot outside the Geely office where 50 cars were observed during a two-hour period. The purpose with the observation was to identify visual objects and their placement in the cars. A recording device was used to make voice recordings of what items that were visual in the cars. The information that was recorded was later documented and analyzed. Pictures was not taken to respect the privacy of the car owners. The results from the observations can be summarized as;

- 50 of 50 cars had visual charging cables in the center stack.
- 40 of 50 cars had a visual tissue box, located on top of the IP.
- 35 of 50 cars had:
 - an umbrella often located in the door storage
 - a dashcam located on the windshield beside the rearview mirror
 - a highspeed card located on the windshield beside the rearview mirror
 - beverage containers about 50cl, located in the center tunnel or the door storage
- 30 of 50 cars had:
 - a thermos often located in the center tunnel
 - a phone holder located beside the infotainment system
 - lucky-charms placed on the IP or hanging from the rearview mirror.

Since the first observation only showed what items that the car owners left in their cars, another observation was made. In order to investigate what items, the users bring to and from their cars, an observation of people going to and from the Geely parking lot was made. For 30 minutes were everyone that left or entered the parking lot observed, and the general trend for the observed people was:

- Umbrellas are important for the Chinese market. The weather was mostly sunny on the day of the observation but almost everyone had an umbrella in their hand or attached to their backpack.
- Mobile phones are also an important item for the Chinese population. They are frequently used and usually held in the hands and not stowed away in their pockets.

- Backpacks were the most commonly used bag type during the observation. The bags were of standard size and in many cases was a thermos and an umbrella stowed in the side pockets of the bag. Purses were also popular but mainly used by females entering and leaving the parking lot.

After the first and second observation, observations had been made on what items that are visual in parked cars and what items that the car owners brings from and to the cars. There could however be items hidden in the bags that are frequently used in the cars that had not been seen yet. Information about how the items are used in the cars could not be gathered from the previous observations either. Therefore, a third observation type was needed. In order to investigate the hidden items and the usage of the items in the cars, inside-car observations needed to be executed. The observations were performed from four taxi-rides with taxis that had the same layout and design as normal cars. The result from these observations were:

- Mobile phones are frequently used for navigation, phone calls and voice messages by the drivers.
- The beverage containers in the cars were usually about 50cl but in some cases bigger.
- Tissue boxes and towels are frequently used and there are usually more than one of each in the cars.
- Phone holders placed beside the infotainment system was used in all observations.

Interviews with three salespersons at Lynk & Co showrooms in Shanghai

To investigate the voice of the customer, three showrooms for Lynk & Co cars were visited in Shanghai. One salesperson was interviewed at each showroom. The purpose with these interviews was to investigate what complaints the customers expresses towards the salespersons. The salespersons have the closest contact with the customers and are therefore an important source of information.

All interviews started with an open question about what the customers says about the stowage in the cars. The first interviewee responded that she has heard customers complain about lack of stowage space in the cars, especially in the trunk but also in the tunnel console. She explained that the customers are expressing more and more need for storage space in the trunk of the car. She continued to talk about the second row of the Lynk & Co models, some customers had expressed that there is too little leg space in the second row, but she also said that if the customers want to ride in the back seat they will probably choose another brand anyway. She also expressed that the cupholders in the doors and in the center-console are not designed for a variety of sizes on the beverage which means that they are usually too small. According another interviewee, most customers are satisfied with the stowage solutions in the cars and those that had complaints were “picky”. The interviewee did however express a need for bigger storage in the doors in order to stow bottles with a bigger size which was in line with the comment from the previous interviewee. The last interviewee expressed that the customers are most concerned about the roominess in the backseat while stowage is not that prioritized according to the interviewee. However, the interviewee expressed a need for storage of umbrellas in the cars since there is no good space to place wet umbrellas right now. The first interviewee also expressed the need for stowage of umbrellas when asked about most used items in the car.

3.1.3 Intermediate results part 3 – Questionnaire of stowage needs in China

The last part of the study includes a questionnaire to identify how the car is being used and most importantly, what specific items the people are bringing and having inside their cars and where they would prefer to stow them. The questions and the answer alternatives were based on the information from the intermediate result in “part 1” and “part 2” of the study. The

questionnaire was divided into two steps, the first one containing demographics, descriptive- and rating based questions. The second step includes an interactive assignment where the participant had to mark which items they would like to place where in the cabin.

3.1.4 Results of questionnaire, step 1

The intention with the first part was to receive data of the respondent’s behavior and to some extent satisfaction in the area of stowage, which is categorized in the tree areas, eat and drink, convenience features and personal items. The option of carsharing was also tested.

Demographics

As Figure 3-1 displays, the questionnaire was distributed in three different groups of people, in total there were 49 respondents, all questions in the questionnaire were answered by all respondents. The goal was to survey a population that uses cars in general, not specifically users that own a Lynk & Co car. 23 respondents were from the LRI, at the ergonomics and packaging department. This population is familiar with working with cars and might have a different mindset then a population that does not work with cars. The people at LRI was surveyed due to the convenience, since they were sitting in the same office but also because of their knowledge about cars and the Chinese market. The next group, which is labeled as customers, are potential Lynk & Co customers that were encountered during the visits at three different Lynk & Co showrooms in Shanghai. In total there were 16 customer respondents at the showrooms together with 10 respondents from the staff working at the showrooms.

Within this total population of 49 respondents, 67 % were males and 33 % were females, displayed in Figure 3-2. Which is a fairly good ratio, based on the fact that Lynk & Co targets equally men and women. Unfortunately, only 12 % of the surveyed customers were women, but these numbers were expected since Lynk & Co’s current sales figures says that roughly 90 % of its customers are men. There was no selection of respondents involved in the distribution of the survey, the population were based on the availability of employees at LRI and the people working or visiting the Lynk & Co showroom.

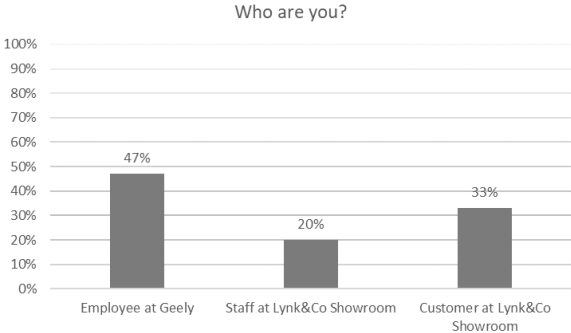


Figure 3-1 Graphical image of the respondent groups

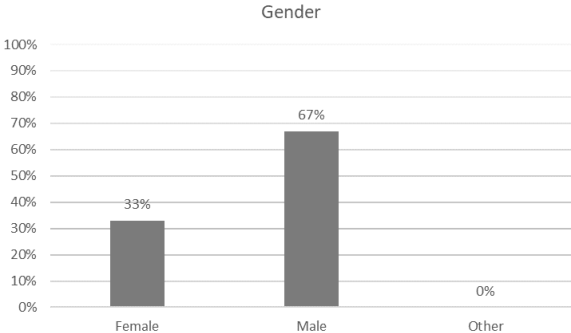


Figure 3-2 Graphical image of the respondents' gender

The majority of the respondents, 84 %, owned a car which is preferable since the goal was to find people with experience of using a car regularly. Even though 16 % did not own a car, only 6 % answered that they have never used a car during a typical week, which shows that most respondents have good experience of traveling by car. As Figure 3-3 displays most respondents uses a car frequently, in a manner that most probably is daily commute.

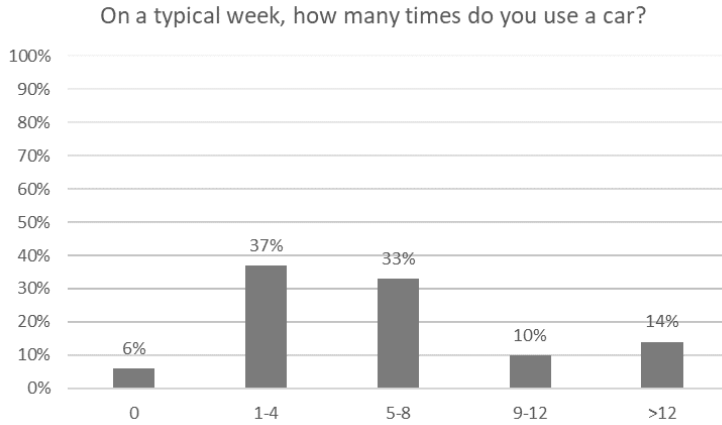


Figure 3-3 Graphical image of how often the respondents uses a car, during a typical week

Eat and drink

In collaboration with the previous question, the respondents were also asked how often they consume food and beverage inside the car during a typical week. The answers were mostly, approximately 60 %, 1-4 times a week. The reason for this question was to find out the importance of the eat and drink features inside the car. A follow up question was also asked, whether the respondents experience it easy to consume food inside the car. The experience was mixed as Figure 3-4 shows, with the majority either experience it easy, difficult or being neutral.

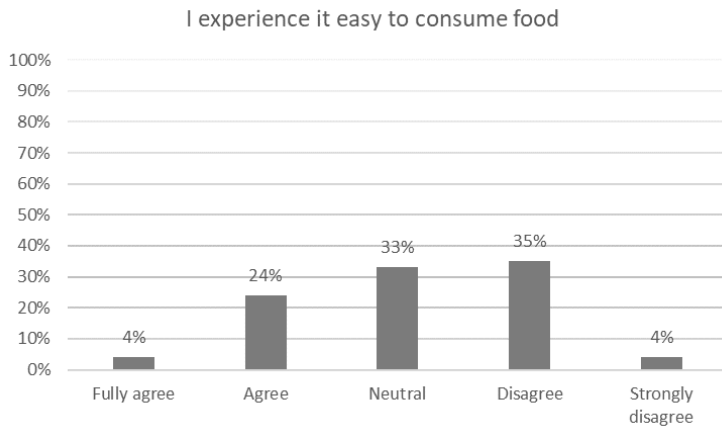


Figure 3-4 Graphical image of how the respondents experience consuming food inside the car

Stowage

The respondents were also asked what type of car they usually use, in order to see if the car type could play a difference in the satisfaction and experience of stowage. The most common car used by the respondents were either Sedan (37 %) or SUV (45 %). When the respondents were asked if they were satisfied with their stowage solutions and experienced it easy to stow items inside their cars, most people were satisfied. As Figure 3-5 and Figure 3-6 displays, 24 % were dissatisfied with the stowage solutions and 16 % experienced it difficult to stow their items inside the car. The answers were further analyzed depending on car type and the result did not differ significantly between SUV and Sedan users, the Sedan users were slightly more satisfied with their stowage solutions. It is notable that the Sedan users were more satisfied since SUV's tend to have more and larger stowage solutions.

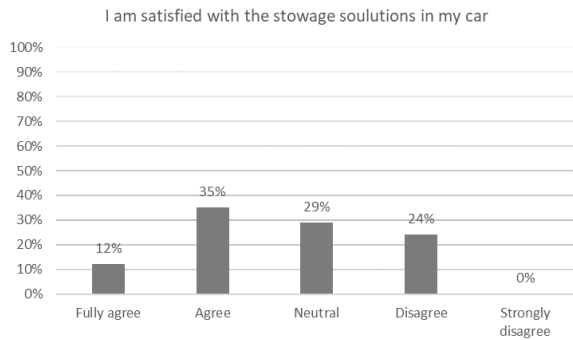


Figure 3-5 Graphical image of the respondents' satisfaction with stowage inside their cars

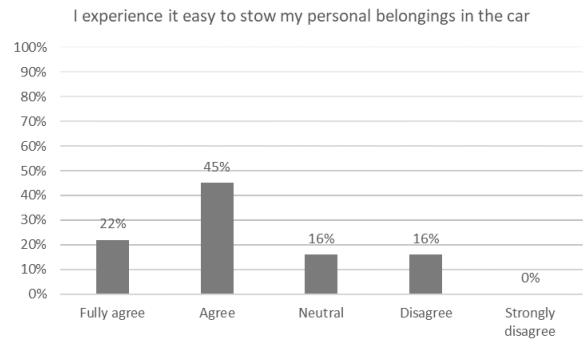


Figure 3-6 Graphical image of the respondents' experience of stowing items inside their cars

Convenience features

Three questions of the questionnaire were dedicated for evaluating convenience features, more precisely the need for supplying and stowing electrical devices. The study showed that most respondents carry at least one electrical device in their car, in many cases more as Figure 3-7 shows. The respondents were also asked whether there are enough power outlets for their electrical devices in their cars and if they want the option to have wireless charging inside their cars. The result showed that most people were satisfied with the amount of power outlets, only 14 % disagreed with the statement and the majority would like to have wireless charging, see Figure 3-8.

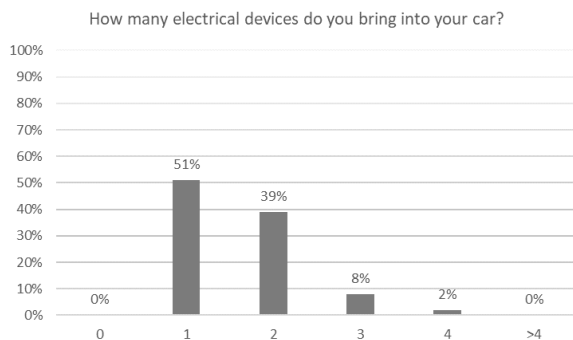


Figure 3-7 Graphical image of how many electrical devices the respondents bring inside their cars

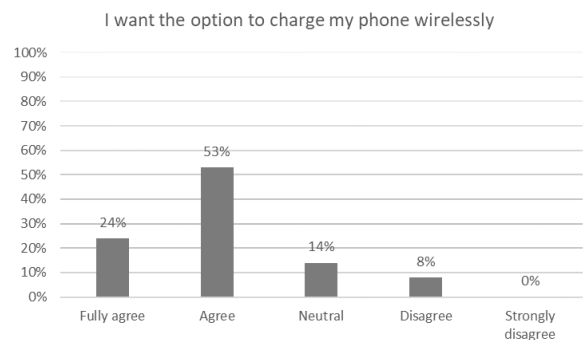


Figure 3-8 Graphical image of the respondents' opinions on wireless charging

Carsharing

The questionnaire also tested whether the respondents would consider using carsharing in the future, meaning that the users do not own cars, but can rent one via a subscription payment method or only pay when using the car. The results were mixed as Figure 3-9 displays and when analyzing for patterns inside the surveyed group, the results are quite similar for both employees at LRI customers and staff. It is not a surprising result when bearing in mind that it is a rather new phenomenon.

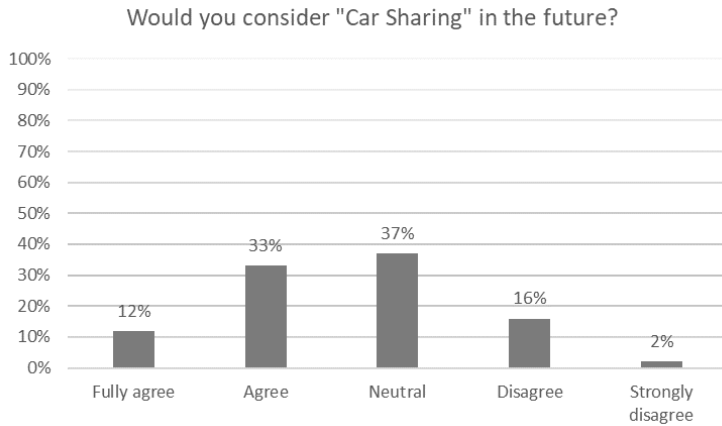


Figure 3-9 Graphical image of the respondents' opinions on Carsharing

Results of questionnaire, step 2

The intent of the second step was to receive data of the most common items the Chinese users have or bring inside their cars and where they would prefer to stow these items.

Personal items inside the car

The result from the question regarding what items the respondents have inside their cars are displayed in Figure 3-10 and Figure 3-11. These are the 30 most common items the respondents answered that they have inside their cars. The remaining items can be viewed in Appendix D, since they only have been selected by 24 % and less of the respondents in the study. When analyzing how the result differ among the three groups of respondents, customers, Lynk & Co staff and Geely employees, it could be seen that the ranking for all items varied a lot. However, 80 % of the 30 most selected items were identical for the three different respondent groups. When further investigating the differences between males and females, for the combined set of respondents, similar results were seen, 83 % of the top 30 selected items were identical but with varied ranking. It was also seen that items such as purse, makeup and driving shoes were more popular within the female population.

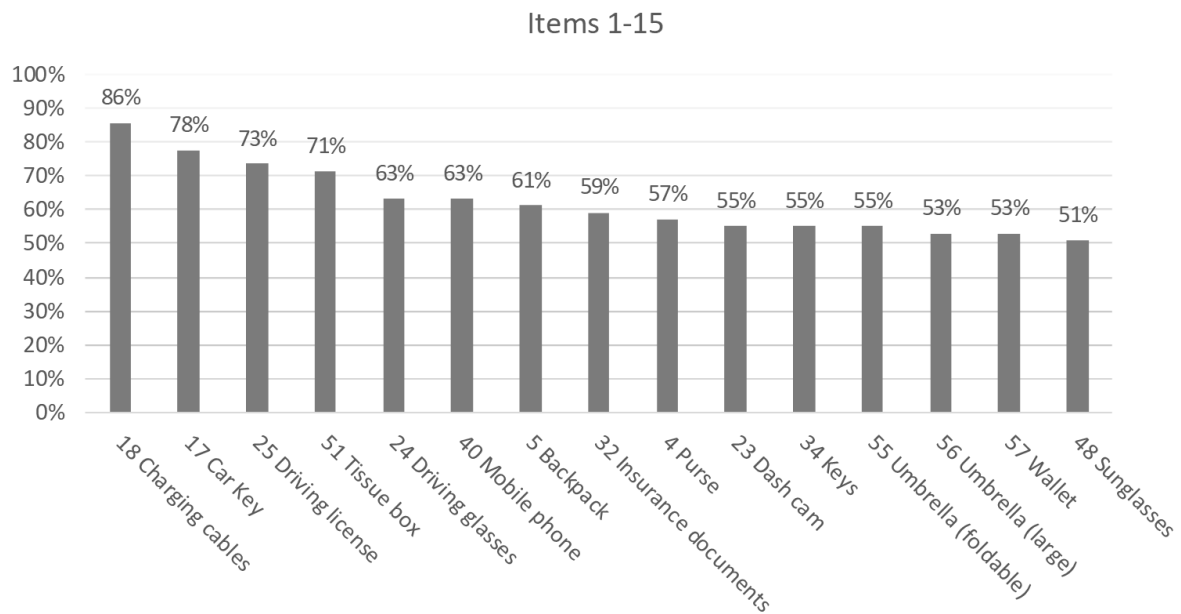


Figure 3-10 Graphical image of the 1-15 most common items the respondents have inside their cars

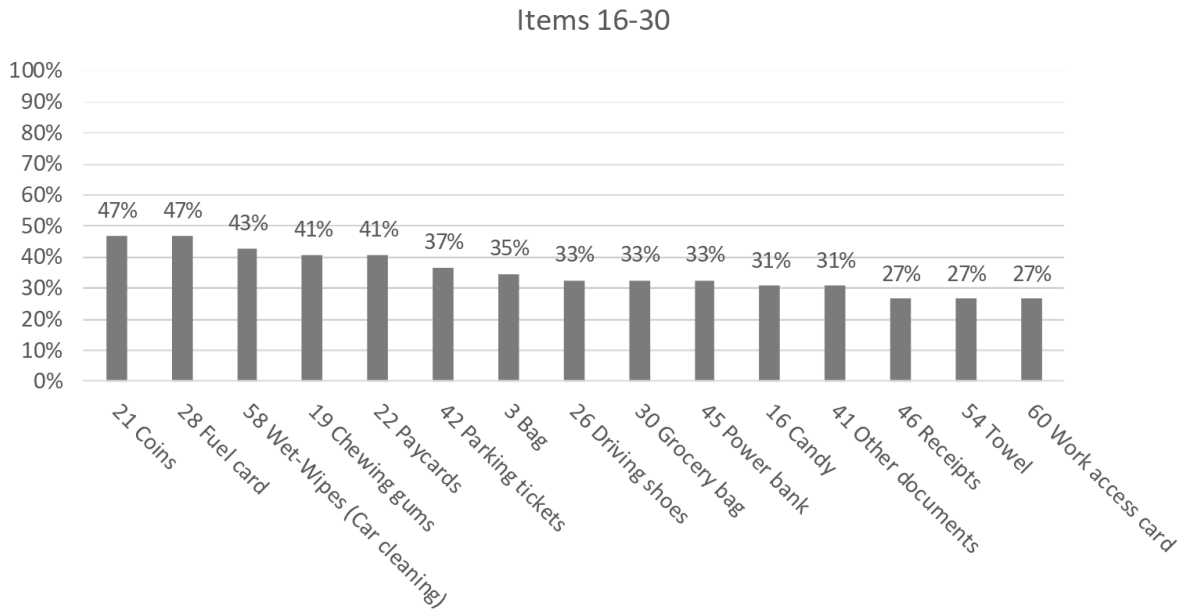


Figure 3-11 Graphical image of the 16-30 most common items the respondents have inside their cars

Many of the 60 selectable items in the questionnaire items list are similar in their three-dimensional form or serve similar purpose and could therefore be viewed as equivalent. To get a more holistic view of the most common items, a clustered graph was established, displayed in Figure 3-12. In this graph, all the bags have been group into “Any Bag” and all cleaning equipment such as tissue box, wet-wipes and towels are group into “Cleaning” etc. Meaning that the group “Any Bag” will receive a mark if either one of the bag options were selected.

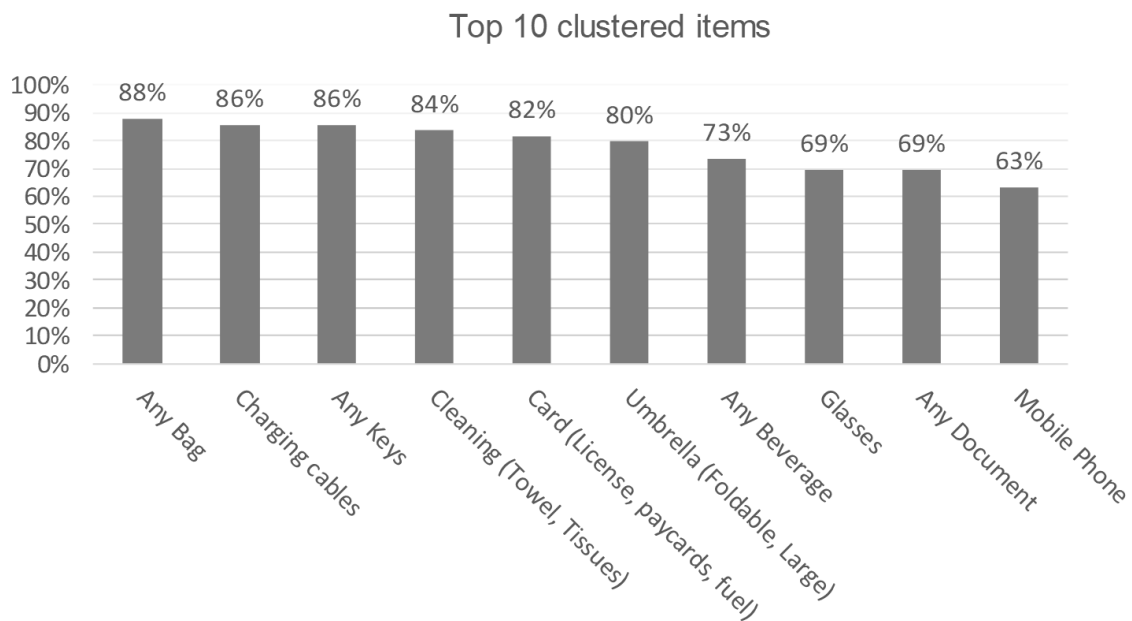


Figure 3-12 Graphical image of the clustered 10 most common items the respondents have inside their cars

The respondents had 12 different beverage types to choose from in order to investigate how the cup holders should be modeled. The distribution of answers is presented in Figure 3-13 and shows that the most used beverage type is the 500 ml bottle (89 %) followed by the 500 ml thermos (42 %).

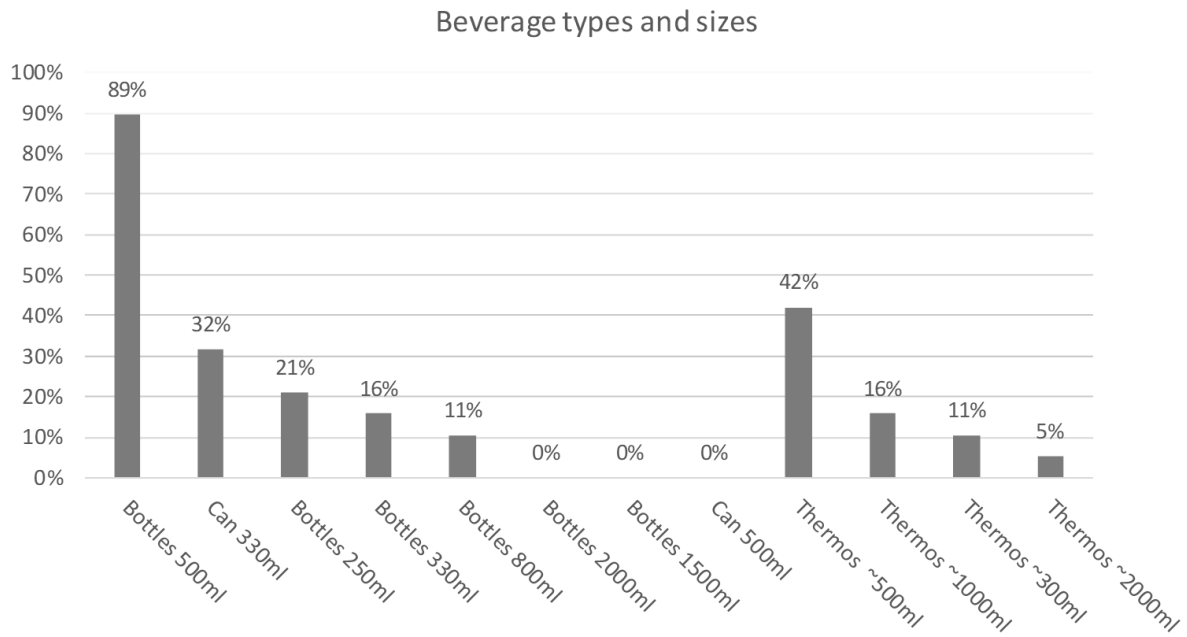


Figure 3-13 Graphical image of the most common beverages the respondents have inside their cars

Placement of the items

In the last section of the questionnaire, the respondents were asked to mark where in the car, front or second row, they would prefer to stow their items. All items were marked from 1-60 so that the respondents could place the corresponding item's number in the image. The two images used for this exercise displays a generic image of the interior with no predefined stowage solutions. This was done to enable the respondents to disregard the reality and place their items where they would like to, without bearing in mind the existing solutions.

The front row image is displayed in Figure 3-14, with all numbers of the corresponding items marked by the 49 respondents merged together. The numbers form clusters of the areas where the respondents prefer to place their items.

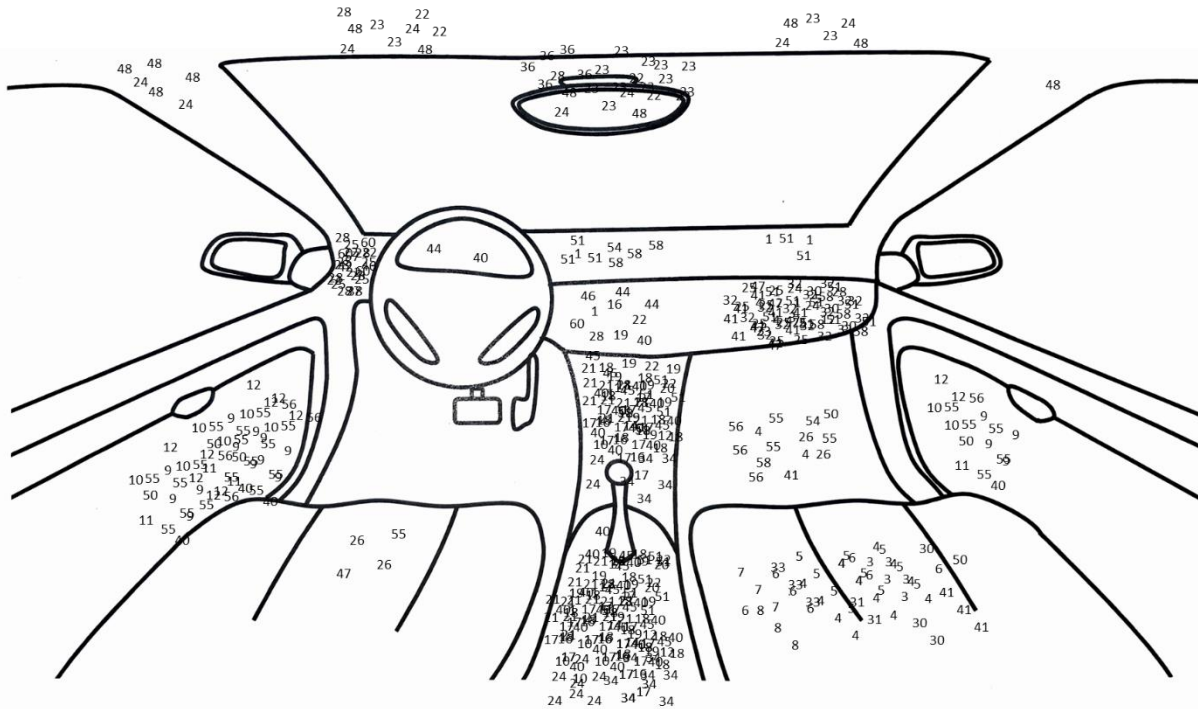


Figure 3-14 Image of the front row with all respondents' marks merged together

To further analyze this image, the clusters of numbers are transformed into labeled groups, forming an area for stowage, displayed in Figure 3-15. In this manner, the image becomes more comprehensive and the areas are color coded based on the number of items that are placed inside each area. The scale goes from zero items, to the maximum of 162 items, dark red. The most preferred areas of stowage are located at T2, T1, IP1, D1 and S2. Area T2 is the most selected area, with a total mark of 168 items. The items usually had smaller dimensions in T2, such as charging cables, keys, mobile phone and wallet but larger items as tissue boxes and bottles could also be found here. T1 are similar to T2, with the exception of having a smaller number and spread of items. IP1 are selected mostly for stowage of documents and driving license, items which commonly are not frequently used. However, a smaller number of respondents would also prefer to stow their tissue box and grocery bag in this area, IP1. The area D1, driver's door, is where the majority of the respondents would prefer to place their umbrella, the foldable model. Items like bottles, towel, coins and parking tickets were also placed here. The last area S2, front passenger seat, were the preferred placement for larger items which the user brings with them in and out of the car. All kinds of bags were marked in this area, but also laptops and documents.

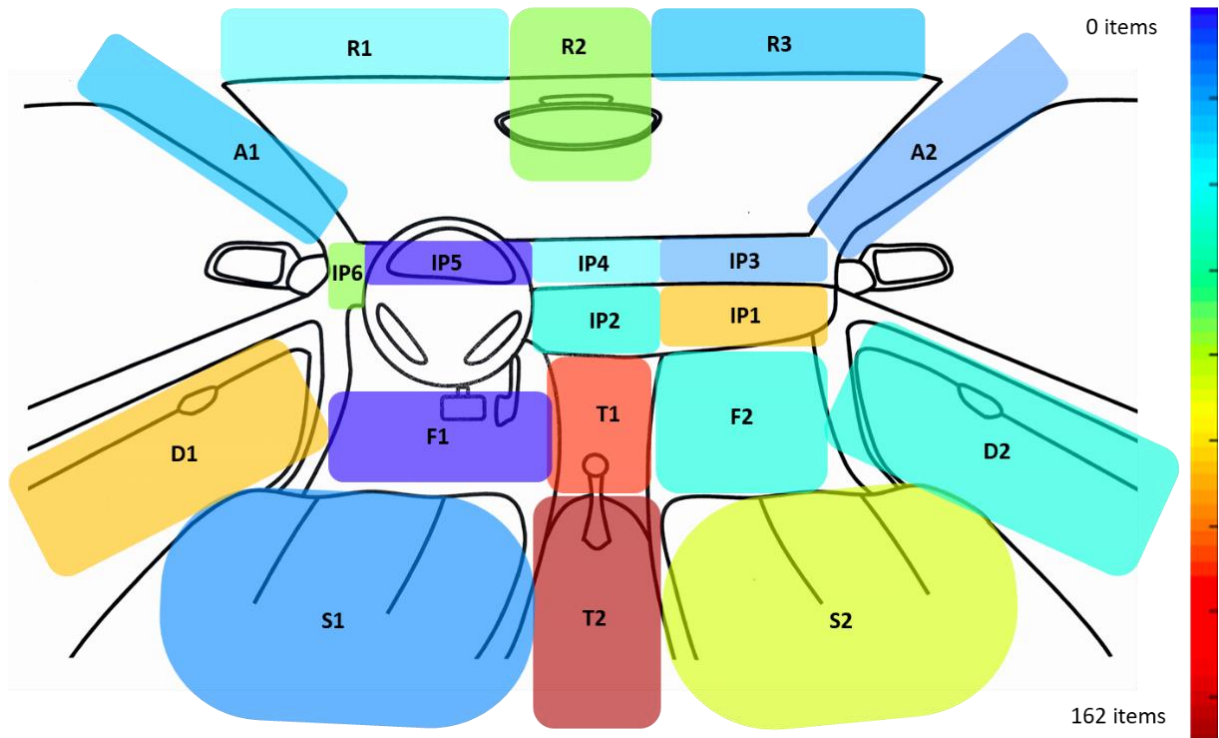


Figure 3-15 Image of the front row divided into zones

The results for the second row image, with all marks, can be seen in Figure 3-16. As the figure displays, some respondents have selected to stow items in the trunk, and since the trunk is not within the scope for this project it has been disregarded. Compared with the front row, the respondents have chosen to place fewer items in the second row.

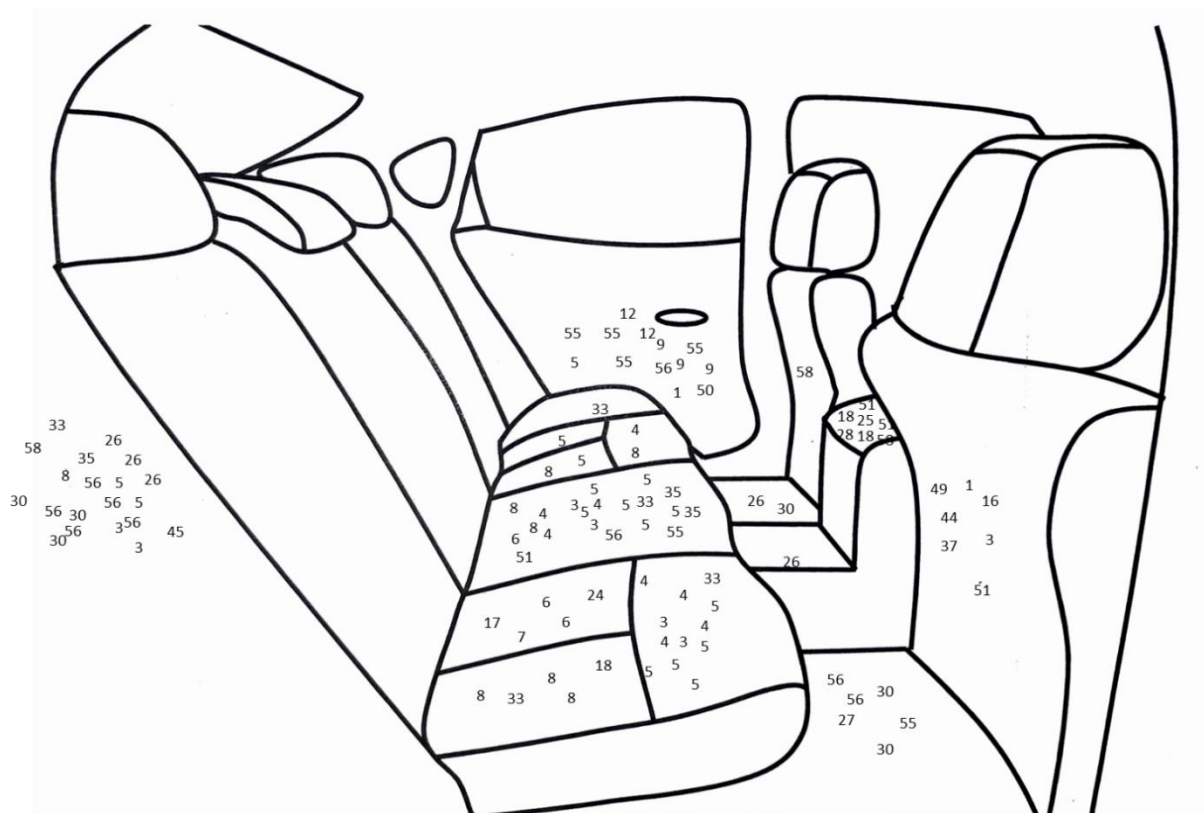


Figure 3-16 Image of the second row with all respondents' marks merged together

The regrouping into stowage areas for the second row are displayed in Figure 3-17, with the exception of the trunk. As mentioned, there are fewer items placed in the second row, the most marked area, S4, only contains 21 items compared to the 168 items placed in front row area T2. The seat areas, S4 and S5, are selected for placing different kinds of bags, similar as the front passenger seat S2. The image of the second row only visualizes one of the back doors and it is therefore assumed that the door area, D3, has been used for both doors. Therefore, the area D3 will be viewed as both left and right back door. The preferred placed items in D3 was foldable umbrellas and bottles.

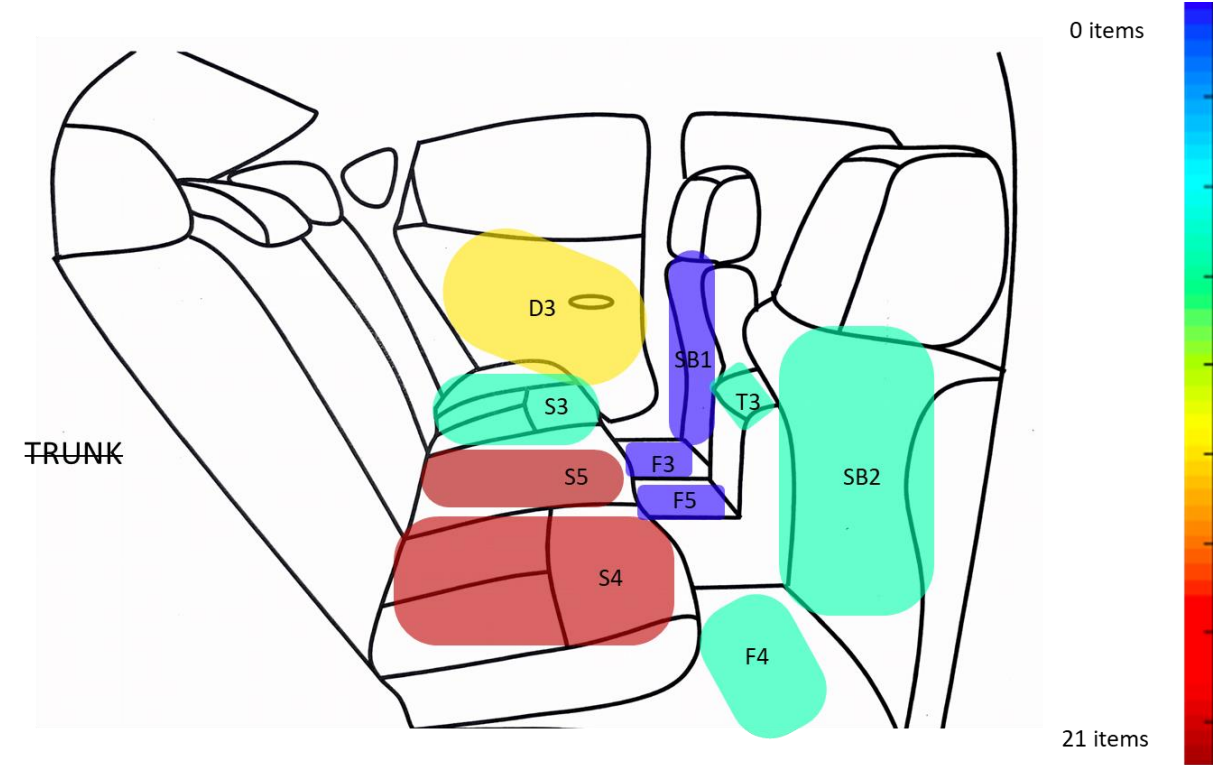


Figure 3-17 Image of the second row divided into zones

3.2 Analysis of study

In this chapter, the result of the study (intermediate results part 1-3) will be analyzed and connections between the different collection methods will be presented.

3.2.1 The most selected items and their preferred placement

In this section, data from interviews, focus groups, observations, documentation and the questionnaire were analyzed, categorized and grouped by the KJ-method. Comments from each data collection method were written on post-it notes and grouped together based on item type and preferred placement in order to see what information that was confirmative and what information that was contradictory.

Bags, all types clustered

The seven different bag types, clustered together, were with 88 % of the responses, the most chosen item in the questionnaire. The preferred storage spot for the bags was in section S2, which is the passenger seat in the front row. Some respondents also placed the bags in section F2, S4 and S5. The popularity of the bags was confirmed by the observation of the users entering and leaving the parking lot. Most people that left the parking lot wore backpacks which was the most popular bag type for males while purses were the most popular bag type for females.

Charging cables

Charging cables, often placed in section T1 and T2 (tunnel console), was chosen by 86 % of the respondents which makes it the second most chosen item in the questionnaire. The popularity of the charging cables was confirmed by both the focus group in Sweden, and from the parking lot observations in China. One interesting remark from both the observation and the focus group is that multiple charging cables are used in the cars. From the observation it was also noticed that most of the cars had an integrated wireless charging pad but had several charging cables anyway.

Cards, all types clustered

82 % of the participants in the questionnaire said that they stow at least one card type in the car. Several respondents also said that they stow all available card types in their cars at the same time. The preferred stowage area for cards was in section IP6 or in section T2. From the observations it was noticed that several cars owners stowed pay cards in section T1. It was not possible to verify if section IP6 and T2 was used for stowage of pay cards since these stowage areas usually are closed.

Umbrellas, all types clustered

In the questionnaire, umbrellas were divided into foldable umbrella and large umbrella, chosen in 55 % respectively 53 % of the responses, but clustered together were they chosen in about 80 % of the responses. The umbrella was one of two items that were confirmed in all five data collection methods. In both the questionnaire and in the survey made by LRI was the door pocket the most popular storage spot in the car. This placement was also confirmed in the observations where umbrellas were visual in the driver's door pocket in several cases. One interviewee expressed that the door storage is inconvenient since she wanted to stow other things in the door storage that could become wet by the umbrella. The general comment however, was that umbrellas are important for the Chinese market and that there is a need for improvement of the storage for umbrellas.

Tissue box

The tissue box was the second item that was confirmed by all study methods. 71 % of the respondents wanted to stow one in the car and the most wanted storage area for the item was in IP1 and in T1/T2. 72 % of the users in the LRI study said that the tissue box was the most needed item in the car which corresponds to the answers in the thesis study. This was also verified from the observations where about 8 of 10 of the cars had a visual tissue box in the car. One variation between the questionnaire and the observation was the placement of the tissue box. As written before, most respondents wanted to place the tissue box in IP1 or in T1/T2 but in the observations was the tissue box placed on top of IP3. This could mean that the users could not place the tissue box where they wanted because of lack of space in section IP1. The general comment from the interviews and focus groups was that the tissue box is important for the Chinese users and that it is one of the most commonly used items in the car.

Beverage, all types clustered

72 % of the participants from the questionnaire said that they had some kind of beverage in the car. The most popular beverage type by the users was a 50 cl plastic bottle and the second most popular was a 50 cl thermos. The preferred storage spot for beverage is in section D1/D2 and in T2. This information is confirmed by the observations but contradictive to the LRI survey where the result show that the preferred storage spot is in section T1. According to the interviews and focus group in China, the preferred beverage container is made from plastic rather than aluminum.

Glasses, all types clustered

In the questionnaire, glasses were divided into sunglasses and driving glasses but for this analysis are they grouped together. 69 % of the respondents said that they bring glasses into the car and the preferred storage spot was in A1, R1, R2 and R3. This information is contradicting to the data presented in the survey from LRI where 33 % brought glasses and the most used storage area for the glasses was in T2. The reason for this could be that the roof storage was excluded in the LRI survey. There were also comments in the focus group that confirmed that there was a need for storage of glasses in the cars.

Documents, all types clustered

Both the LRI study and the questionnaire in this project shows that it is usual to store documents like insurance papers, user's manual and other documents in the car. The most selected storage area for the documents were in section IP1.

Mobile phone

According to the questionnaire, the mobile phone was only used by 63 % of the participants and the preferred storage area was in section T1 and T2. This data is contradicting to the findings in the observations and interviews. The comments from the observations says that mobile phones are frequently used for navigation, phone calls, voice messages etc. The placement of the phones was usually not in section T1/T2 either but in section IP2. The same goes for the interviews where several interviewees said that the phone is important for the Chinese users and that they are more used for navigation than the infotainment system.

Dash cam

55 % of the participants in the questionnaire said that they use a dash cam in their cars with a preferred storage area in R2. This percentage is lower than the percentage in the observation which said that about 7 of 10 cars had a dash cam in section R2. The participants in the focus

group in Sweden said that the reason for dash cams in the cars was that the car owners gets a lower insurance fee if they have a dash cam in the window.

Driving shoes

33 % of the participants in the questionnaire said that they use a different pair of shoes while driving. The preferred storage area for these shoes was in section S1 and F2. According to the focus group were these driving shoes used by women that uses high heels at the office but does not want to drive with them.

3.2.2 The voice of the customer in relation to the market and the engineers at CEVT

In this section, data from interviews, focus groups, observations, documentation and the questionnaire were analyzed, categorized and grouped by the KJ-method. Comments from each data collection method were written on post-it notes and grouped together based on comments and opinions about stowage in order to see what information that was confirmative and what information that was contradictory.

Storage vs. roominess

The fact that the Chinese population values leg space in the second row is well-established within the automotive industry and several of the Chinese interviewees has verified this statement during the study. However, there are some statements from the interviews that contradict this. During the focus group at LRI, two engineers discussed a trend shift in which the users are more concerned about good storage for their kids in the second row. Some sales persons at the Lynk & Co showrooms also expressed that the customers have begun to ask for more storage space in the trunk. Furthermore, information about that the most common way to use the car is daily commute alone in the car points at that the second row is seldom used and should thereby not be prioritized. One could argue for that the Chinese market is changing and that the leg space is getting less prioritized but at the same time does the sales persons and the market analysts talk about that the Chinese customers still values the leg space when they chose which car to purchase. The recommendation from this would be to develop cars with both the ability to create legroom and to store items in the second row or in the trunk of the car. One solution could be to enable the users to decide for themselves if they want the storage space or the legroom by creating a modular interior.

General stowage

The data from the questionnaire showed that most participants were satisfied with the stowage in their cars while 23 % of the participants expressed that they were not satisfied. Since 23 % is a noteworthy amount but there was no possibility write free text in the questionnaire, the interviews could be used to seek the answer on the problems with the stowage. From the interviews and focus groups, were these the main problems with today's storage:

- No place to throw trash
- To little storage space in the door pockets
- No good place to store tissue boxes
- No good placement for fragile goods
- No good umbrella storage
- No good placement for big items in the cabin

As can be seen above, there were no common agreement about what the main problem with the stowage was. The conclusion could be that the storage situation needs to be improved in most parts of the cabin.

Convenience features

Lynk & Co wants to become the most connected brand on the market and to become this, they need to be on the cutting edge of technology with most focus on connectivity, screens, inputs and interface towards the user according to MSS. From the study, it was clear that the Chinese users were attached to their phones and used them frequently in their cars. Several different interviewees said that the infotainment system is seldom used in China. Others said that it is highly important to be able to see the screen on the phone while driving and that there is no good place to stow the phone at the moment. A high number of the participants in the study expressed that wireless charging is an important feature in the cars but at the same time charging cables was the most used item according to the questionnaire. This altogether could mean a several different things, but one hypothesis is that the layout of the IP with big screens obstruct the users from placing their own phones at the IP with good visibility. That charging cables was the most selected item could be because there still exist many phone models that are not compatible with wireless charging, but it could also be because the charging pads are placed where it is difficult to view the phone while driving. The recommendation from this information would be to enable the users to choose if they want to use the existing infotainment system or if they want to use their own solutions in a more convenient way. Another recommendation would be to enable the users to charge their phone wireless while placing it on the IP.

Center tunnel

The center tunnel, also called section T1 and T2 in this thesis, was the most popular stowage area according to the second part of the questionnaire. The participants did not only place the highest number of items in the center tunnel, but also the biggest variety of items. Some interviewees also said that the cupholder in the center tunnel is an important feature that must function well. The reason for the popularity of the center tunnel is probably because of the closeness to the driver and the easily accessible stowage solutions. From the interviews however, some interviewees claimed that the center tunnel will disappear in the near future. One of the reasons was to create more leg space and perceived roominess while another reason was connected to the interior design. If the center tunnel is removed it is important to create a compliment for the stowage that fulfills the user needs. The recommendation is then to create a stowage area where it is possible to stow and organize a high variety of small items in a reachable distance to the driver.

Eat and drink

Most respondents in the questionnaire were neutral to the question “do you think it is difficult to eat/drink in the car”. In one of the focus groups however, several participants said that it was difficult to eat in the cars because of the lack of space to place the food. One of the interviewees at a Lynk & Co showroom claimed that the only food that is consumed in the car is snacks and no proper meals which eliminates the need of any space to place the food. One consistent comment from the respondents in the interviews was about the importance of functional cupholders. Altogether, it seems like the respondents think that there are some difficulties with consumption of food in the cars but that the most important function is to stow beverage.

Glovebox

The glovebox is the only area where most participants in the study agree – it needs to be improved. One participant described it as a “refrigerator for documents” (some gloveboxes has a cooling function from the air conditioner to chill bottled drinks) while another participant said that he wanted to remove it completely. Most participants placed documents such as user manual, insurance papers etc. in section IP1 (where the glovebox is placed in most cars) which strengthens the previous statements. The insurance documents and the user manual are used a

few times per year which raises the question if such a centralized area could create more value by storing other items. The recommendation would be to find another place to store important documents and change the area to something more value adding. Several interviewees have been talking about a user manual storage under the driver seat which could be a good solution.

Carsharing

Carsharing, together with autonomous driving is a central part in the evolution of the car industry at the moment. There are several carsharing services like Sunfleet available but there is no car model that is adapted to the new way of ownership on the market, but several car companies have released concepts that are somehow adapted to carsharing. The typical respondents in the questionnaire were neutrally set to carsharing and were using a car about 1-8 times per week for daily commute to work, shopping trips or long-distance trips to visit their families. These three types of car usage have all different needs for storage which could enable for different car models for each type of usage. The important factors for stowage in a carsharing situation is the ability to safely stow personal items in the car, that the stowage areas are easily cleaned, and the stowage areas are intuitive and easily used.

3.2.3 Customer needs list

From the analysis of the study, a number of customer needs were extracted and categorized. The customer needs are described with short sentences including the need and preferred stowage area in some cases. The customer needs can be viewed in Table 3-3. The categories are not organized according to importance, nor are the listed needs.

Table 3-3 Customer needs list

Nr	Category	Need
1	<i>Safety</i>	
1.1		Safe stowage of fragile goods in the cabin
1.2		Stowage of transparent bottles without risk of fire
1.3		Safe stowage of heavy bags in section S2
2	<i>Small items</i>	
2.1		Stowage of umbrellas in section D1-4
2.2		Stowage of wet umbrellas without affecting other items stowed in section D1-4
2.3		Stowage of a variety of tissue box sizes in IP1 and T1-R2
2.4		Stowage of tissue box within reach for the driver
2.5		Stowage of glasses at eye level
2.6		Stowage of driving shoes in section S1 & F2
2.7		Designated area for disposal of thrash in the front row
2.8		Increased storage space in section D
2.9		Designated stowage area of phones in visible position for the driver (IP area)
2.10		Stowage solution in front row for organizing a variety of small items
2.11		Increased functionality of stowage in IP1
2.12		Stowage solution for cards in section IP6 and/or T1-T2
2.13		Stowage of documents in IP1

3	<i>Convenience features</i>	
3.1		Two charging outputs in section R2 for Dashcam + ETC
3.2		Increased privacy when connecting phone to infotainment system
3.3		Possibility to charge electronical devices wireless
3.4		Possibility the charge phone and use it at the same time
3.5		Multiple charging outputs for cables in the front row
4	<i>Eat & drink</i>	
4.1		Stowage of at least 50 cl thermoses in section D1-D2 & T2
4.2		Simplify consumption of food inside the car
4.3		Increase functionality for cupholders with a higher variety of beverage types and sizes
4.4		Stowage of at least 50 cl plastic bottles in section D1-2 & T2
5	<i>Roominess</i>	
5.1		Increased storage space in the trunk
5.2		Multifunctional stowage solutions to improve roominess and stowage in the cabin
5.3		Increased leg space and sufficient stowage in second row
6	<i>Carsharing</i>	
6.1		Private stowage of personal items (when the car is used by 3 rd part user)
6.2		Intuitive solutions for stowage
6.3		Different car models for different situations
6.4		High cleanability of stowage areas

3.3 Decision about concept development area

In order to take a decision about which area that should be in focus during the concept development, several factors needed to be taken into account. From the results, four rough concept ideas were created:

- New design for the door pocket
- New design for the glove box
- New stowage solution for an umbrella in the front row
- New solution for the storage in the center tunnel

These four development areas were based on the most used items, the most used stowage areas and information about needs from interviews, observations and focus group discussions. This information was then presented to the ergonomics department and the product planning department to get feedback about which area that they would like to see a concept from.

After the presentation, the joint comment was that all concept ideas were interesting and had potential for further development. However, the recommendation was to work with a concept at a higher level and try to come up with an idea for how to develop a stowage solution for the driver when driving alone. One interesting finding from the study was that the passenger seat is often used as a stowage spot for big items like bags. This, in combination with the information about that the center tunnel (area T1 and T2) may disappear in the future and that it was the most selected area for stowage of small items, lead to the decision of developing a new stowage solution for the front passenger seat when it is not used as an ordinary seat. The solution should be able to stow both big items like bags but also small items like wallets, keys and phones.

However, before starting with this, it was necessary to decide what business and car model to focus on during the development, since many of the requirements might be redundant depending on chosen models.

The aim of the project is to develop a concept with focus on the carsharing business model. Carsharing can be referred to many different applications. For example, it can mean: Point to point station-based carsharing, where a company owns a fleet of cars, with dedicated parking lots for the customers to use via phone, or Peer to peer carsharing, where the customers owns the cars but can chose to lend it to other users for a fee. Together with the Ergonomics department, a gate meeting was held to agree upon which business and car model the project should base the development on. For this project, the business model Peer to Peer was chosen together with a Lynk & Co SUV model as reference car for the development.

3.4 Technology and company trends analysis

This chapter comprises the technology and company trends analysis, divided into SWOT and Benchmarking for ideation, with the purpose of investigating what is happening on the market now and in the future.

3.4.1 SWOT analysis

In Figure 3-18 is the SWOT analysis visible. The information in the SWOT is based on information that has been gathered during the project together with some assumptions and guesses. SWOT stands for Strengths, Weaknesses, Opportunities & Threats. These categories and their relation to the project will be presented below. The SWOT was made to support the concept development and to avoid unforeseen threats. It was also used for concept evaluation.

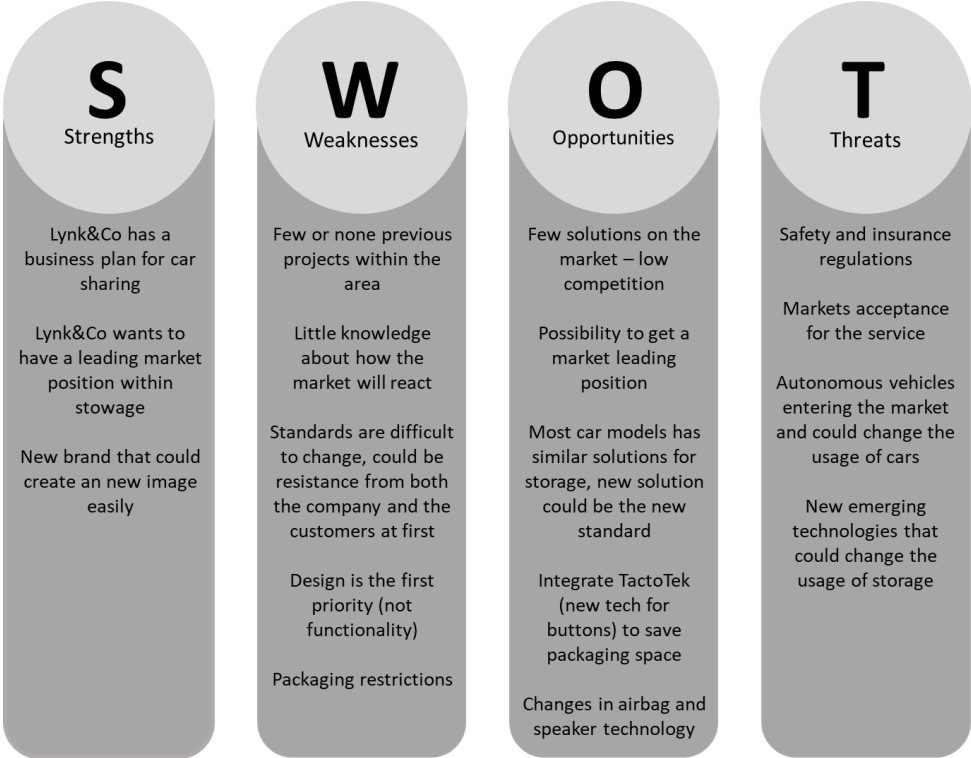


Figure 3-18 SWOT analysis for storage in shared cars

Strengths

The main strengths that could support the change of storage solutions in the front row is that Lynk & Co is a young brand with a plan to create a business model based on carsharing. Another strength with Lynk & Co is that a new brand has the possibility to create something different and create a new segment at the market. For more established brands is this often more difficult to rebrand since the customers already has a perception of how the brand should be and look like.

Weaknesses

The weaknesses with a change of storage solutions in the cars are mainly caused by the organization itself. If the idea would be noticed by the innovation department, there will probably be some resistance from other departments in the organization. The car industry is based on design and safety to a wide extent, this means that functionality could become a lower prioritization while deciding upon interior concepts. Another weakness is that there is little existing information about how the market would respond to a concept that does not follow the

design pattern that other brands follow. Another problem with the automotive industry is the lack of space inside the cars which could limit the concept.

Opportunities

There are some carsharing alternatives on the market today, both business to customer, like Sunfleet but also customer to customer like zipcar. However, these services are still based on cars that are designed for regular ownership. Right now, there is an opportunity to develop a car that is more adapted for shared ownership since no other car brand has released any car model for this segment. TactoTek is a company that develops an innovative compliment for buttons in cars. This could create new opportunities to change the way that the interior is modeled in cars since this technology could provide more space for storage solutions. There are also trends that shows that the original placements of speakers and airbags could be moved to new locations thanks to new technology which also could create new space for storage.

Changing consumer behavior is also an important factor. For example, the status symbol of owning a car is decreasing and owing a car is not viewed as important as in the past. People are moving to be more open minded towards not owning a car, which opens up for the new market of shared economy, carsharing and P2P carsharing. (Gao, Sha, Daniel, & Baan, 2016) There are potential profits to gain from entering the new market of shared economy and not only focus on traditional car sales. Between November 2017 and November 2018, the number of carsharing apps users have increased from 3,89 to 9,53 million monthly users, in China. Meaning that only a small share of the population is using the carsharing alternative. (Statista, n.d.)According to a survey made by McKinsey (Baan, Gao, Wang, & Zipser, 2017), 52 % percent of the respondents could image a life without a car, consumer tends to move on to be less brand loyal, in car connectivity is important and shared mobility is rising, especially among the young audience.

Threats

There are however some threats for this kind of solution. Laws and regulations could have high impact on the concept if it involves moving the airbag, changing the seat and so forth. Another threat would be if the development of autonomous vehicles is faster than expected and that the seating arrangement in the cars could be changed which would make the investigation in this project unnecessary. The forecast however, says that a progressive scenario could be that 15 % of the cars are fully autonomous year 2030.

People today tend to use their car as all-purpose vehicles, e.g. commute, vacations and shopping, but this might change in the nearby future. Consumers tend to adopt using tailored solutions, available in their smartphones, which might lead to specialized vehicles, developed for each purpose of mobility. This will alter the design of the future car, for example, vehicles designed for e-hailing services would focus on robustness, comfort and high utilization. (Gao, Kaas, Mohr, & Wee, 2016) The interior design is one aspect of how cars could be changed to adopt for carsharing, another one is the user's behavior in relation to stowage. The conducted survey suggested items which the users are bringing and having inside their cars, with the emerging market of carsharing and not owning cars, the requirements for stowage would most likely change. The stowage for these vehicles would only consider items which the users bring with them, in and out of the vehicle.

3.4.2 Benchmarking for ideation

In this section, seat and stowage solutions from different application areas was benchmarked. Since most cars on the market has similar layout of the storage will other products, like home furniture, also be evaluated. The benchmarking was used as support for the idea generation of concept for the seat stowage.

Seat stowage solutions

Space is often a crucial factor in public transportation applications since the purpose is to transport a high number of passengers at the same time. In trams for example, the seats in the entrance are often foldable to create more space to stand when the tram is crowded in rush-hours. A visualization of the mechanism of a foldable seat in a Västtrafik bus is visual in Figure 3-19.



Figure 3-19 Foldable seat in public transportation (own picture)

There are also examples of seat transformations in order to create stowage in cars. In pick-up cars like Chevrolet Colorado and Honda Ridgeline, some solutions for stowage under the seats in the second row exist. The stowage under the seats are made to stow items that usually would be stowed in the trunk since pick-ups has a flatbed instead of a trunk. The seats in these examples are folded like the previous example in Figure 3-19 but has stowage areas under the seat.

Home furniture, IKEA

Ikea is a furniture retail specialized in modular, space effective and cheap solutions for home interior. Ikea is extra interesting in this project since their products are all about creating the best possible stowage for their customers. The benchmark was performed at Ikea in Bäckebo, Gothenburg during approximately 2 hours. Following comes some interesting findings that could be integrated in the concepts.

The first trend, that is visual in Figure 3-20 and Figure 3-21, was the hollow surface which let the customer customize the storage after their own needs. Different small items can be mounted to the surface thanks to a hook that may be attached in the holes from any direction. The additions offered by Ikea ranged from simple hooks and straps to storage containers and ledges that could be mounted anywhere on the surface.



Figure 3-20 Wall with modular storage interface 1(own picture)

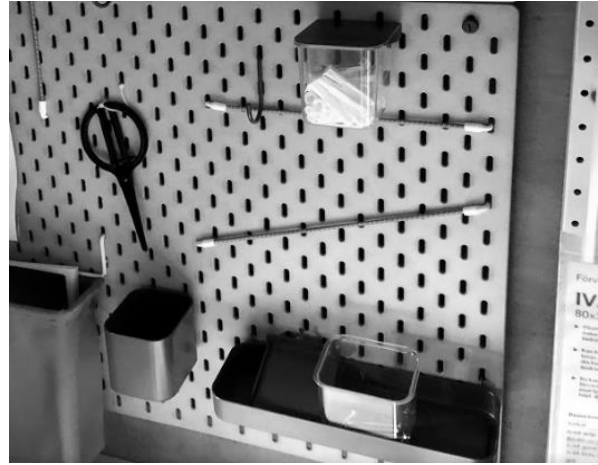


Figure 3-21 Wall with modular storage interface 2(own picture)

In Figure 3-22 is a module for stowage inside a wardrobe visible. The intended purpose of the module is to create stowage for jewelry like rings, necklaces and watches but it worked as a good solution for stowage of credit cards and coins. The module was made of soft foam, shaped into lines and clothed in fabric. Another interesting stowage solution, visual in Figure 3-23, was that the traditionally “magnetic kitchen knife stand” were used as a stowage solution for home offices. Add-ons like hooks and ledges were available to purchase in order to customize the stowage solution. In addition to that, it was also possible to mount own items like keys and phones with a casing with steel or magnetic material.



Figure 3-22 Wardrobe module for storage of small items (own picture)



Figure 3-23 Wall mounted, magnetic storage panel (own picture)

Induction charging of electronic devices is an option for most new car models, this trend was also actual for Ikea and their furniture which is visual in Figure 3-24. Most of the furniture, especially the furniture for bedroom and living room had integrated induction charging. The charging pads were about 8 cm in diameter and 1.5 cm thick and only connected to a wire. There were also interesting solutions for smart storage of phones like in Figure 3-25 available at Ikea.



Figure 3-24 Induction pad for charging (own picture)

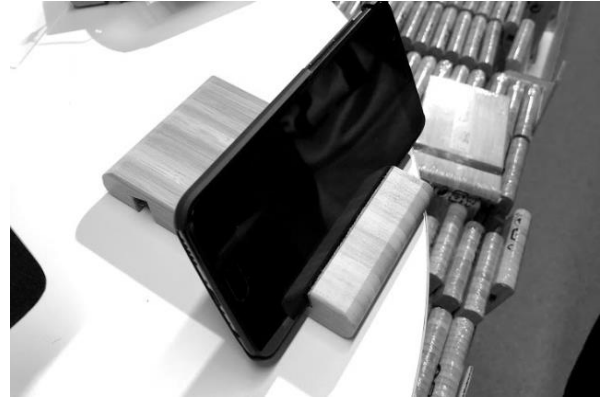


Figure 3-25 Phone and tablet stand (own picture)

Fiat Centoventi, innovative car interior concept

Fiat Centoventi is a car concept from Fiat that was presented during the 2019 Geneva car show. Fiat describes the concept as a “White canvas ready to be painted” since most of the car is customizable. The customer may choose the design of the roof to the bumpers by them self in order to make the car fit the customer’s needs. The most interesting part for this project however, is the customizable interior. The surface of the IP is entirely based on holes where different objects could be attached which is visual in Figure 3-26. This means that the user can decide which size of cupholders they want, which speaker system or if they want hooks to hang grocery bags or purses. The IP storage solution is similar to the modular wall storage from Ikea, visual in Figure 3-21.



Figure 3-26 Modular IP concept in the Fiat Centoventi (own picture)

Another interesting detail of the Centoventi concept is that the front passenger seat could be changed to fit a number of different applications. In Figure 3-27 are two alternatives visual, a regular seat and a child seat. According to Fiat’s webpage, there will be additional modules like a dog cage, a storage box and a basket to purchase. This creates additional freedom to customize the interior for the customer, but Fiat does not present any solution for storage of the modules when they are not used.



Figure 3-27 Modular seat configuration for the front passenger seat (own picture)

The Fiat Centoventi had also removed the traditional door pockets and replaced these with two horizontal rails where the customers can choose what to place on them. There was not much available information on how these rails should be used more than the image visual in Figure 3-28.



Figure 3-28 Modular rail concept for the door storage (own picture)

Hidden stowage area in Volvo XC40

The trunk of the Volvo XC40 has an interesting solution for hidden stowage, visual in Figure 3-29. The floor is built by two plates that can be folded and placed vertically to display a hidden stowage space. The plate closest to the back also has three hooks designated for grocery bags.



Figure 3-29 Hidden stowage area (own picture)

Hidden stowage solution in center tunnel

Another interesting solution for hidden stowage in cars is the jalousie lid which can be viewed in Figure 3-30. The solution exists in most car models, but the solution is still interesting because it is easy to use and looks good.



Figure 3-30 Jalousie for hidden cupholders (own picture)

3.5 Concept development

In this section, a concept for stowage will be presented. The final concept is based on the result from the study, the technology and company trends analysis and the ide generation methods presented in this chapter.

3.5.1 Translating customer needs to requirements

The first step of the concept development phase is to gather all spoken customer needs and wishes from the user study and translate them in terms of engineering requirements. These requirements together with gained knowledge from the department at CEVT and the technology and company trends analysis constitute the requirement list. The list, an excerpt in Table 3-4, displays each requirement or wish with the corresponding target value, verification method and stakeholder. The entire list can be found in Appendix E.

Table 3-4 Excerpt from the requirement list

Requirement list		Target	R/W	Verification	Met	Stakeholder	
1.	Stowage capacity for items (minimum volume of the solution)	length*width*height [mm ³]					
Big items	1.1	The solution must be able to provide stowage for a backpack	≥280*160*400	R	Virtual analysis (Catia V5)	Y	Users
	1.2	The solution must be able to provide stowage for a briefcase	≥380*80*280	R	Virtual analysis (Catia V5)	Y	Users
	1.3	The solution must be able to provide stowage for a duffelbag	≥500*250*270	R	Virtual analysis (Catia V5)	Y	Users
	1.4	The solution must be able to provide stowage for a grocery bag	≥240*120*450	R	Virtual analysis (Catia V5)	Y	Users
	1.5	The solution must be able to provide stowage for a satchel	≥380*60*300	R	Virtual analysis (Catia V5)	Y	Users
	1.6	The solution must be able to provide hanging of a jacket	≥N/A	R	Virtual analysis (Catia V5)	Y	Users

The requirement list is divided in 8 categories:

1. Stowage capacity for items (minimum volume)

These are requirements that sets the minimum volume space the solution must provide to be able to stow the items the users have expressed that they would prefer to stow in the area under development. They are divided in: big items e.g. bags and small items e.g. tissue box. The measurements were based on assumptions by selecting the most purchased products on the Chinese E-commerce Aliexpress.

2. Stowage capacity for items (minimum load to carry at rest)

These requirements state the minimum load (the weight of each item) that the solution must be able to carry. The weight was estimated by weighting each item, bags were filled with user specific items for each bag e.g. briefcase was stuffed with a laptop, a notebook and a lunch box.

3. Reachability

These requirements were set by guidance from the Ergonomics Department at CEVT and evaluation in Ramsis, a software for testing ergonomics.

4. Roominess of cabin

According to the users and CEVT it is important to maintain the roominess of the car; therefore, a requirement was set to not alter this.

5. Logics

To make the solution intuitive, requirements were set to make the interaction logic. Meaning that e.g. a handle that operates a lid should have identical movement as the lid, if you lift the handle the lid should follow in the same direction.

6. Maintenance

These requirements ensure the durability of the solution, since it must be able to hold for many different users in a carsharing environment.

7. General properties

One of these requirements regards the cost which must be kept low, however there is yet no exact target value. This can be seen as a guideline when evaluating concepts to strive for inexpensive solutions.

8. Original seat functionality

Requirements were set to maintain the original functionality of a seat, based on existing Lynk & Co models. The solution should be applicable in the nearby future and therefore be similar to existing driver seats, thereby minimize the development of new components.

Requirements regarding safety is not considered in this project, e.g. safety which requires the seat to handle impact forces in a crash scenario. Furthermore, the requirement list is established for guidance of the development, thereby having no solution specific requirements since the project will not cover any detail design of components.

3.5.2 Division into main-functions and sub-functions

In order to create structure to the concept development, a function means tree was made. The function means tree, visual in Figure 3-31, has two hierarchical levels of functions and means that was evaluated in two steps. The first functional requirement (main-function) was to transform the front passenger seat into a stowage area. To support this function, several design parameters (concepts) were evaluated. The next hierarchical level held three different sub-functions with respective concepts that then was evaluated individually in order to fulfill the customer requirements for each sub-function. Lastly, the winning sub-functions synergies was verified to ensure that the different functions were functioning together.

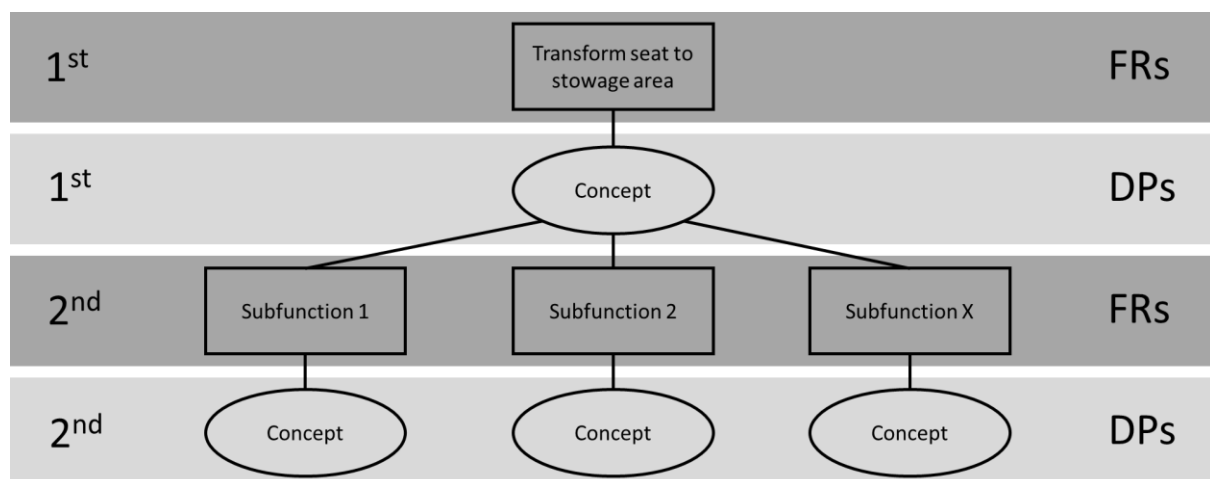


Figure 3-31 Function-means tree for transforming the seat to a stowage area

3.5.3 Main-function - Transforming passenger seat to stowage area

In this section, five different concept solutions to transform the passenger seat to a stowage area will be presented. The concepts were made on a top-level without detailed solutions for the stowage. These top-level solutions will later be evaluated with an elimination matrix in order to limit the further development with concepts that does not fulfill the identified needs and requirements. The concepts were developed through brainstorming and inspiration from the market research of existing solutions.

Concept 1, Public transportation

In Figure 3-32, is the first concept called “public transportation” visible which was inspired by the folding seats at the busses and trams in Gothenburg. The main idea with the concept was to create two different functions with the same concept; firstly, to create more stowage space in the front row and to create a solution where the user does not need to place items on the seat which could damage it. Secondly, to create the more leg space in the second row or alternative create more storage space if the second row seats are folded. The folding function is enabled by hinges but the bolsters in the seat could create problem to fold the seat properly. The stowage of small items would be placed on the back of the cushion but there could be reachability problems with that placement.

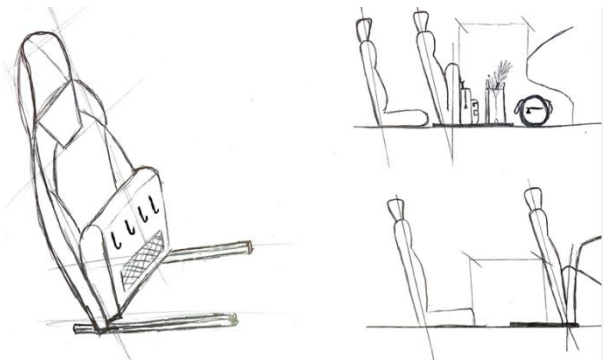


Figure 3-32 Public transportation

Concept 2, The box

The second concept, visual in Figure 3-33, is called “the box” since the cushion acts as a lid for a stowage box under the seat. The cushion can be placed in a vertical position if the driver needs to stow bigger items like grocery bags or similar, but it can also be used as a hidden stowage spot when it is closed. The folding function is possible by hinges with a safety-lock function which can hold the cushion vertical if needed. Here could small items be stowed on the back of the cushion, facing the driver.

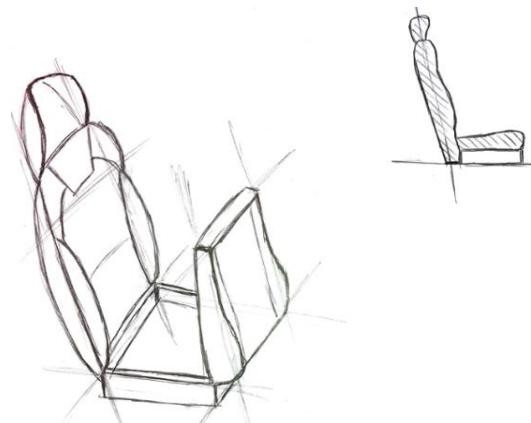


Figure 3-33 The box

Concept 3, Seat belt hooks

The third concept, visual in Figure 3-34, is called “Seat belt hooks”. The concept was based on the mechanism of an ordinary seat belt which enables the user to safely secure bags or jackets of different sizes in the passenger seat. The solution is however limited to big items only but is also the cheapest one to create.

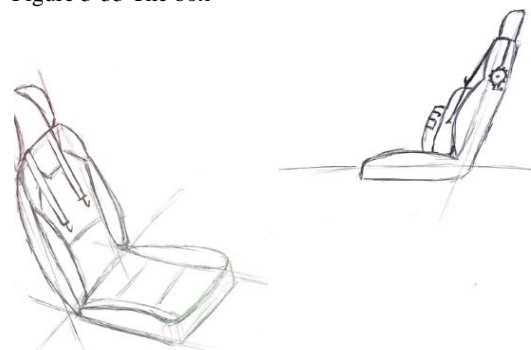


Figure 3-34 Seat belt hooks

Concept 4, Kangaroo pocket

The fourth concept, visual in Figure 3-35, is called “the kangaroo” concept since it is inspired by the kangaroo pouch. The expandable pocket can be hidden while a passenger is riding in the seat but can also act as a pocket for bigger items like bags. Smaller items could also be stored in separate stowage areas on the inside of the pocket.

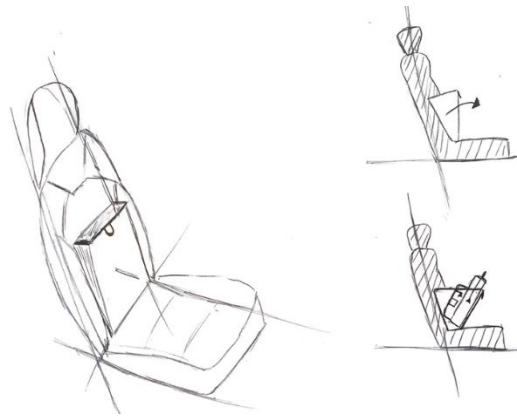


Figure 3-35 Kangaroo pocket

Concept 5, No seat at all

The fifth concept was to completely remove the seat and replace it with another solution for stowage. This solution was inspired by the Volvo XC90 Excellence and the Lounge Console Concept where the front passenger seat is removed and replaced with a footrest. In this case, the concept would be focused on stowage for the driver rather than comfortability for the passenger in the second row.

3.5.4 Evaluation of top-level solutions

Since it was time-consuming and expensive to evaluate concepts that does not fulfill the basic needs in terms of functionality, safety, cost etc., the top-level concepts were evaluated through an elimination matrix and two Pugh matrices and the ones that did not fulfill everything were removed.

Elimination matrix for the five top-level concepts

The elimination matrix, visual in Figure 3-36, shows that only concept 1 and 2 passed the elimination. All concepts were evaluated from six categories and the ones that got at least one “-“ were eliminated. The concepts that did not pass the matrix were eliminated because they did not fulfill all demands, which could be verified on a conceptual level, presented in section 2.4.1. Concept 3 were unable to stow small items, concept 4 unable to stow big items and concept 5 lacked the basic need of providing a seat when not used for stowage.

Elimination matrix for Top level solution							Criteria fulfilment: (+) Yes (-) Remove (?) More info needed	
Solution alternative	Solves main problem	Fulfils all demands	Compatible/Realizable	Reasonable cost	Safe	Enough information	Decision: (+) Continue (-) Remove (?) More info needed	
							Comment	Decision
1	+	+	+	+	+	?	Good solution, but bolsters could be a problem	?
2	+	+	+	?	+	?	Bolsters and width could be a problem	?
3	+	-	+	+	+	?	Cannot stow small items	-
4	+	-	-	+	+	?	Cannot stow big items	-
5	+	-	+	+	+	?	Solution needs to provide for seating to passenger	-

Figure 3-36 Elimination matrix of the top-level solutions

Pugh matrix for the two remaining top-level concepts

The two remaining concepts from the elimination matrix were compared with a reference solution by eight different criteria that were identified in the study. In the first Pugh matrix, visual in Figure 3-37, were the two concepts compared with an ordinary passenger seat in a Lynk & Co car. Both solutions were better in stowage but worse in seat comfort and thereby got the same net value. In order to differentiate the two concepts between each other, concept 2 were set as the reference solution, visual in Figure 3-38. When the first solution was compared to the second one, the net value became -1 which means that concept 2 passed and was the main-function concept that got chosen for further development. The main reason that concept 1 was eliminated was because of the reachability issues of stowing small items on the back of the cushion.

Criterion	Alternative			
	REF	1	2	
Stowage of big items	REFERENCE	+	+	
Stowage of small items		+	+	
Items cannot damage seats		+	+	
Seat confort		-	-	
Hidden stowage		+	+	
Leg space in back row		+	0	
Reachability for the driver		-	0	
Stowage of fragile items		+	+	
Sum +			6	5
Sum 0			0	2
Sum -		2	1	
Net value		4	4	
Ranking		1	1	
Further development		Yes	Yes	

Figure 3-37 Pugh matrix 1

Criterion	Alternative		
	REF (2)	1	
Stowage of big items	REFERENCE	0	
Stowage of small items		-	
Items cannot damage seats		+	
Seat confort		0	
Hidden stowage		-	
Leg space in back row		+	
Reachability for the driver		-	
Stowage of fragile items		0	
Sum +			2
Sum 0			3
Sum -		3	
Net value		-1	
Ranking		2	
Further development		No	

Figure 3-38 Pugh matrix 2

3.5.5 Sub-functions – Increase usability of stowage area

The winning concept, "The box", enabled stowage of big items in the box and small items on the back of the cushion. However, after benchmarking of how the seat is constructed in existing Lynk & Co models, it was realized that the box will be too deep and thereby unreachable for the driver. This led to a positive outcome since the box could be divided into two sections which became the first sub-function. The upper section could provide for stowage of big items and the lower could become a hidden, lockable stowage for items that is not frequently used. Since one of the outcomes from the study was that privately owned car, used for carsharing needs this kind of stowage, it was beneficial in both aspects.

Another finding from the study was that the user brings a high variety of items into the car which makes it difficult to provide for one stowage solution that fits all users. This led to the

decision to have a modular interface on the back of the cushion which also became the second sub-function.

As mentioned before, users brought a variety of items into the car and the stowage need of these items differ from each other. The third sub-function was therefore concepts of different stowage solutions for the most popular items in the study. Since the interface is modular, more solutions for this sub-function could appear in the future.

In total, three sub-functions, which can be viewed in Figure 3-39, were identified for stowage in the front passenger seat. Other, more technically detailed sub-functions, like opening and closing mechanisms, material choice etc. will not be evaluated in this thesis since these are outside of the scope. These technical functions will be solved by re-using existing technologies that are used in cars.

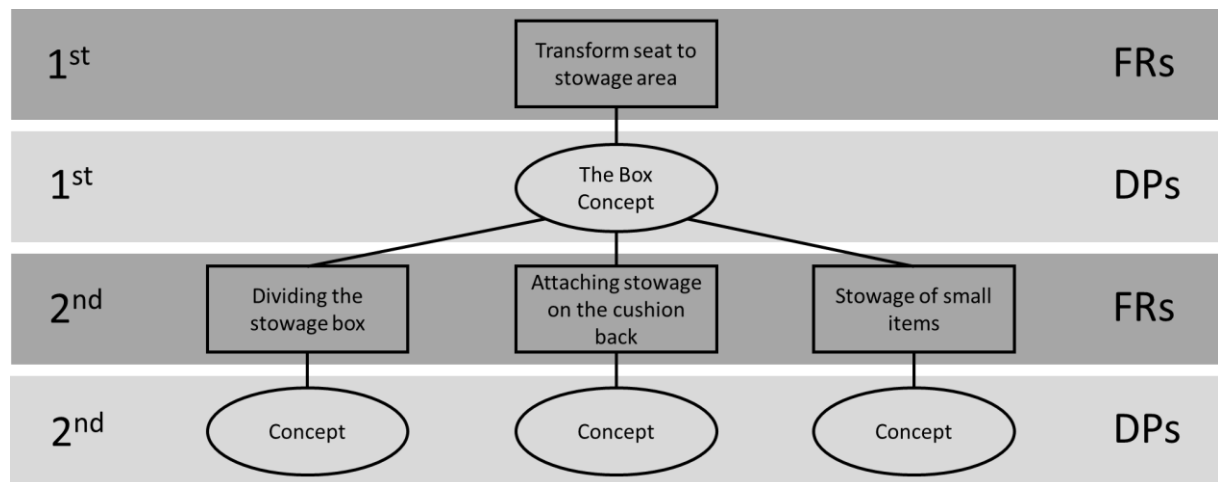


Figure 3-39 Function-means tree for "The Box"

Concepts for dividing the stowage box

Three different concepts for dividing the storage box were developed and can be viewed in Figure 3-40. The concepts were developed through brainwriting and benchmarking of similar applications areas for the car industry.

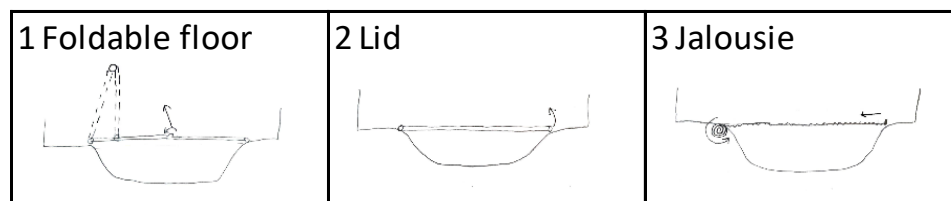


Figure 3-40 Three concepts for dividing the stowage box

Concept 1 - Foldable floor

The first concept, "Foldable floor" is based on the floor solution in the Volvo XC40, presented in section 2.3.2. The idea with the concept was to have two hard plates, connected to each other by a soft seam. The floor is opened by pulling a strap, connected on the soft seam upwards. The plates are then sliding in two rails until they are positioned together, and the lower section is visual.

Concept 2 – Lid

The second concept for dividing the floor, “Lid” is based on a normal lid solution for a box. The lid is mounted by hinges in the front of the stowage box and a lock in the back. When opened, the lid is leaned towards the back of the cushion to view the lower stowage box.

Concept 3 – Jalousie

The third and last concept for dividing the stowage box is called “Jalousie” and is based on the same technique as the jalousie covers presented in section 2.3.2. The lid is built of many thin plates connected with soft seams which enables the lid to be rolled together when opened.

Concepts for attaching stowage on the cushion back

Four different concepts of interface solutions for attaching the stowage are visual in Figure 3-41. The concepts are all supposed to be placed under the cushion so that they are facing the driver when the seat is open.

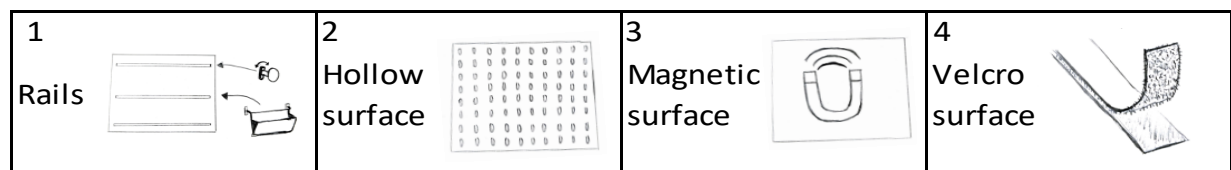


Figure 3-41 Concepts for attaching stowage on the cushion back

Concept 1 - Rails

Interface where the stowage solutions are attached on rails through hooks. The stowage solutions can be moved among the rails in the Y-direction.

Concept 2 – Hollow surface

Concept inspired by the Fiat Centoventi- and the Ikea wall-interfaces presented in section 2.3.2. The stowage solutions are attached anywhere at the surface thanks to the hollow structure.

Concept 3 – Magnetic surface

The third concept is inspired by fridges and fridge magnets. By creating a cushion back in metal would it be possible to attach the stowage solutions through a magnetic interface.

Concept 4 – Velcro surface

Velcro surface which makes items that has the opposite side of the Velcro attach anywhere at the surface.

Stowage of small items

In this thesis are small items defined as the items that are usually stowed in the center tunnel, glove box or other compartments inside the cabin. Examples of these items are; phones, wallets, keys, cards, purses and tissue box. These items all have different sizes and shapes which makes one specific stowage solution ineffective. In Figure 3-42 are twelve different concepts for stowage of small items presented. The idea is to enable a third party to develop add-ons to the interface that gets selected after the evaluation but for this thesis a few of these concepts were modeled as examples and are based on the customer needs from the study.

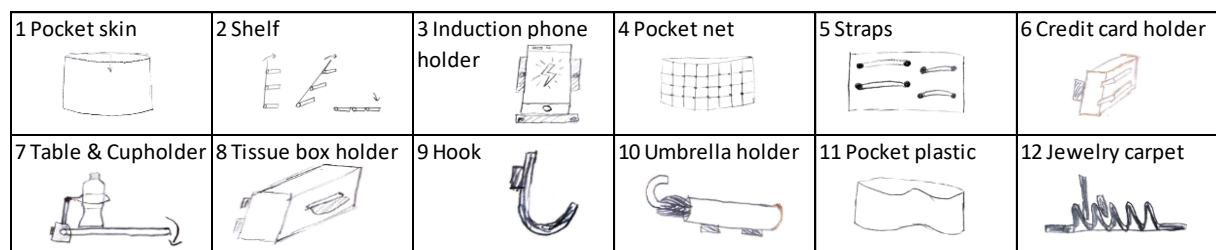


Figure 3-42 Concepts for stowage of small items

3.5.6 Evaluation of sub-functions

In this section will the different concepts for the sub-functions “Dividing the stowage box” and “Attaching stowage on the cushion back” be evaluated with one Kesselring matrix each. The criteria in the Kesselring matrix were all based on requirements and wishes from section 2.4.1.

Concepts for dividing the stowage box

The concepts for dividing the stowage box were evaluated with a Kesselring matrix by five different weighted criteria, visual in Figure 3-43. The five criteria and their weightings were: Lockability (4), Space efficient solution (5), Load capacity (5), Low complexity (4) and Easy access to handle (5). The weightings were based on the gained knowledge from the user study, depending on what was perceived as most important for the users and the departments at CEVT. The third concept, “Jalousie”, got the lowest score mainly because the solution had the worst space efficiency and the accessibility to the handle. The other two concepts had similar scores but the second concept, “Lid” lost because of the space efficiency and the accessibility to the handle.

		Kesselring matrix - Divide the stowage box							
Criterion		Solution alternative							
		Ideal		1		2		3	
	w	v	t	v	t	v	t	v	t
Lockability	4	5	20	4	16	5	20	3	12
Space efficient solution	5	5	25	4	20	3	15	2	10
Load capacity	5	5	25	4	20	5	25	3	15
Low complexity	4	5	20	4	16	5	20	3	12
Easy access to handle	5	5	25	5	25	3	15	3	15
T = $\sum tj$		115		97		95		64	
T/Tmax		1		0,84		0,83		0,56	
Ranking		x		1		2		3	

Figure 3-43 Kesselring matrix for the three lid concepts

Concepts for attaching stowage on the cushion back

The four concepts for attaching stowage on the cushion back were evaluated with a Kesselring matrix by five different weighted criteria, visual in Figure 3-44 Kesselring matrix for the 4 attachment concepts. The four criteria and their weightings were: Low complexity (4), Logics (3), Load capacity (5) and Durability. The clear winner from the Kesselring matrix was concept 2, “Hollow surface”, because of its high load capacity, durability and logic interface.

		Kesselring matrix- Attaching stowage on the cushion back									
Criterion		Solution alternative									
		Ideal		1		2		3		4	
	w	v	t	v	t	v	t	v	t	v	t
Low complexity	4	5	20	3	12	3	12	4	16	4	16
Logics	3	5	15	2	6	4	12	4	12	5	15
Load capacity	5	5	25	4	20	5	25	1	5	2	10
Durability	4	5	20	3	12	4	16	5	20	1	4
T = $\sum tj$		80		50		65		53		45	
T/Tmax		1		0,63		0,81		0,66		0,56	
Ranking		x		3		1		2		4	

Figure 3-44 Kesselring matrix for the 4 attachment concepts

3.6 Concept presentation and verification

In this chapter, CAD images and renderings of the final concept will be presented. The different sub-functions be described and an verification towards the requirement list will be made.

3.6.1 Concept presentation

In Figure 3-45, a rendering of the winning concept, “The Box” is presented. The cushion can be opened to a vertical position where it can be locked in order to work as an additional stowage area thanks to the modular interface. In this section, the concept will be presented in more detail with renderings and drawings of the different functions.



Figure 3-45 Cad rendering of the main function – transform seat to stowage area

Dividing the stowage box

In Figure 3-46 is a CAD drawing of the “Foldable floor” concept. The two plates are connected to each other through a soft seam which enables the plates to fold together. The first plate, marked with a “1” in the figure, is fixed in one side which results in that the two plates gets folded when the user pulls the strap attached in the middle of the seam. The lower stowage box has enough room to stow five 50 cl bottles of beverage when the lid is closed.

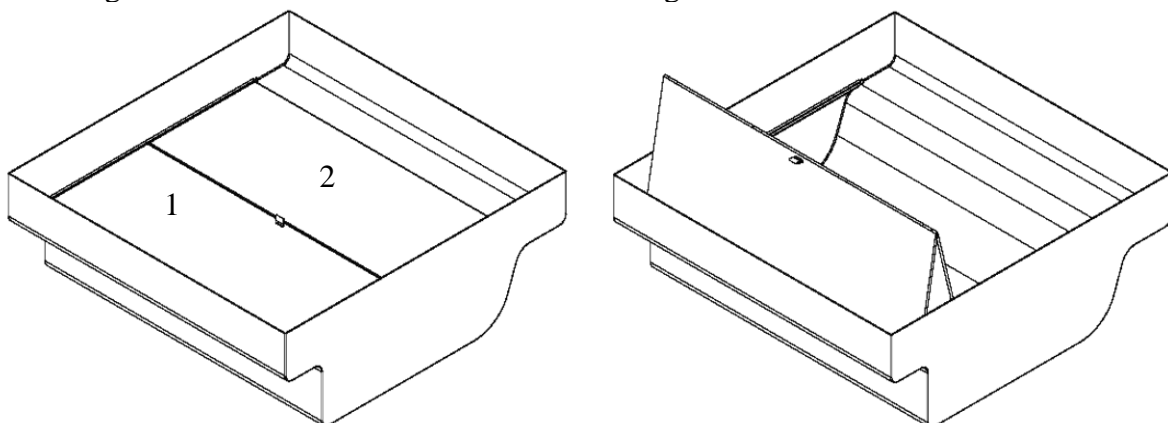


Figure 3-46 Closed and opened lid for the lower stowage box

Attaching stowage to the cushion back

In Figure 3-47 is the winning concept for attaching stowage on the cushion visible. The high number of interface holes enables the user to a high level of customization when attaching items. The positive outcomes with this solution are firstly, the possibilities for a high variety of items that can be attached but also the ergonomically aspect that people with long arms can place the items further away and those with short arms can place their items closer.

The modular interface covers only half of the cushion back and the other half is covered with an expandable pocket. There are two main reasons for this;

1. The center tunnel covers about half of the cushion back which makes it inconvenient for most attachments.
2. There is a need for stowage of small items, e.g. wallets and keys when the cushion is closed which makes a pocket necessary.

In Figure 3-48 is an example of the opposite side of the interface attached to a hook. The interface is built of plastic with a rubber edge on the outer part which has a higher diameter than the hole. This creates a resistance which holds the item attached to the cushion back.

Stowage of small items

As written before, the study resulted in a wide variety of small items but there were some items that were more popular than others. The items that were modeled for the concept can be viewed in Figure 3-49. The tissue box was one of the most selected small items during the study and thereby one of the modeled items as proof of concept. Another item that was modeled for the concept was the foldable table with an integrated cup holder since only 28 % of the participants in the study thought that it was easy to consume food in the car. A hook and a purse were also modeled since several female participants raised the issue of finding any good location to stow purses.

The purpose with the two pockets mounted on the back of the cushion was to stow other small items like wallets, keys etc. to ease the pressure on the center tunnel. In Figure 3-50 are two different CAD renderings to illustrate two configurations for stowage of small items on the back of the cushion.

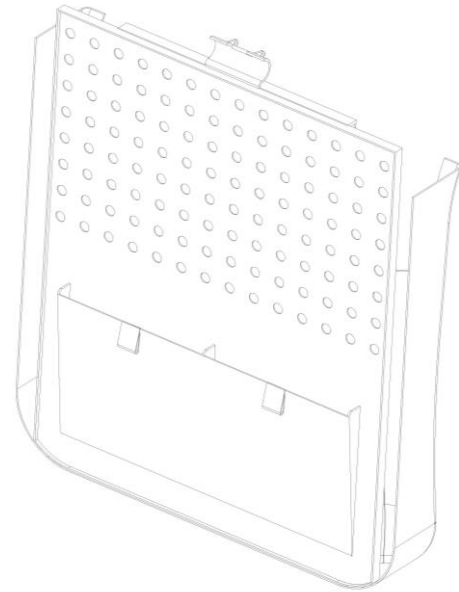


Figure 3-47 CAD drawing of the cushion back interface

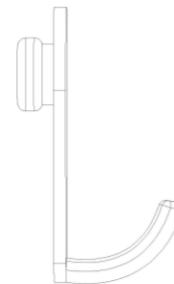


Figure 3-48 Interface attached to a hook

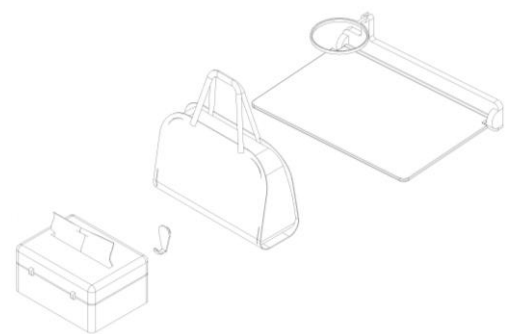


Figure 3-49 four example items to attach at the cushion back



Figure 3-50 CAD renderings for stowage of small items

Lock and rotational mechanisms

The mechanism for opening the cushion, visual in Figure 3-51 is a spring-loaded catch that opens when a force is added to the strap. The locking mechanism is integrated in the cushion and attached to the frame of the seat when closed. The strap allows the user to open the cushion from a seated position in the driver seat.

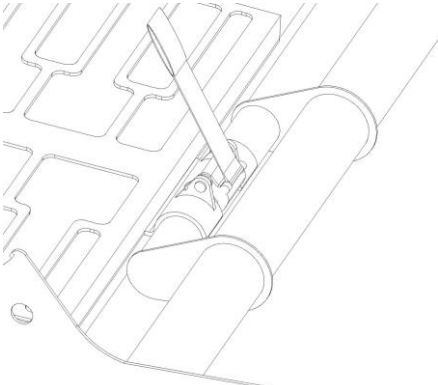


Figure 3-51 Lock/opening mechanism for the cushion

In the front of the seat frame is the cushion mounted with two bearings and a locking mechanism, visual in Figure 3-52. The locking mechanism works by a spring-loaded pin that locks the cushion in a specific position. The lock is released when the user pulls the handle, visual in Figure 3-53.

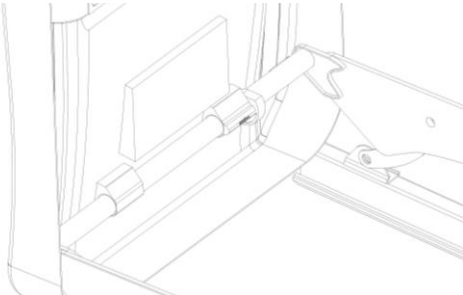


Figure 3-52 Bearing and lock mechanism for the cushion

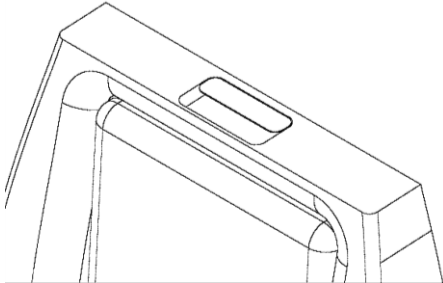


Figure 3-53 handle for closing the cushion

3.6.2 Concept verification

The concept verification aims to test whether the constituted requirements were fulfilled by the developed concept. Because of the conceptual level of the prototype, requirements that demands a higher level of detail design, e.g. exact component design and material selection, could not be verified. The requirements that could be tested will now be described.

Volume capacity of items

The volume requirements are divided in big and small items. The big items must be able to be stowed inside the solution while the solution is active (without a passenger). In the case of the presented concept, "The Box", it means that the big items must fit inside the seat while the cushion is activated, folded upwards. By evaluating the concept virtually in Catia v5, and applying the big items inside, visual in Figure 3-54, it was verified that all of them could be fitted inside. The small items were validated in the same manner, with the exception of having to be fitted both while the stowage is activated and deactivated, meaning when the cushion is open and closed.



Figure 3-54 Volume capacity for "The Box"

Reachability

To evaluate the ergonomics perspectives in terms of reachability for the driver, a software called Ramsis Automotive was used together with real life testing. For the real-life testing, an employee at the Ergonomics department was used (Male, 166 cm in height). The person could not reach the opening and closing mechanism while in driving position, one hand on the steering wheel and the feet positioned on the pedals without altering the upper body position. A reaching movement had to be done in order to reach the opening and closing mechanisms. The movement that had to be done could be described as not forced, only a small movement of the upper body had to be done. This was expected, because of the limited reachability a driver has when in driver position, only compartments very close can be reached e.g. the tunnel console compartments. During this evaluation, it was also realized that the reachability was highly affected by the seat positions, if the driver seat was not in line with the passenger seat, the movement needed to reach became forced and uncomfortable.

The reachability was also tested in Ramsis, using a manikin. The manikin used for this testing was a Chinese woman, again 166 cm tall. This woman is rather tall for the Chinese population, approximately 80 percentile, meaning 80 % is shorter than this person. For this manikin,

average body proportions were used for its height. The result is depicted in Figure 3-55 and Figure 3-56, which displays the needed movement to reach, while seated but not in driver position. The movement is not forced, the opening and closing mechanism can easily be reached with small adjustments of the body.

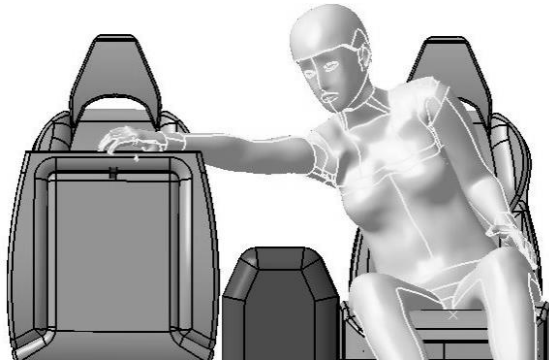


Figure 3-55 Ramsis verification of reachability for closing handle

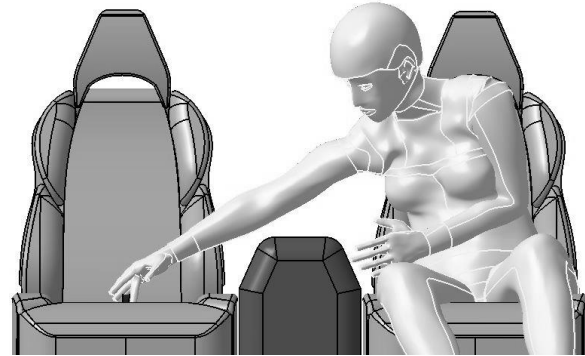


Figure 3-56 Ramsis verification of reachability for opening strap

Performing ergonomics evaluation virtually was rather time-consuming and therefore only a small test could be executed. It is recommended to continue with this testing and evaluate different people, for example, evaluate with different settings for the manikin, selecting lower percentiles. A 10 percentile woman would be beneficial to test, using different proportion of the body.

While the testing showed that the maneuvering mechanism could not be reached from a driving position, small adjustments of the body is necessary. However, the project believes is acceptable since it should not be operated while driving. This is important to avoid accidents caused by the driver losing focus on the road. The requirements regarding reachability for the stowage rotational mechanism needs could be stated as fulfilled but would require further evaluation to narrow down the requirement. The clearance requirement could be stated as fulfilled by the design, which allows for 20 mm clearance per finger, for the opening and closing mechanisms.

Roominess

The requirement regarding roominess was also verified virtually, by examining the prototype and compare with a real car model and a 3D model of the same car model. The roominess was not affected in front row at all, here, the solution occupies the same space as the original seat. However, it was seen that in the back/second row, the roominess for the passenger's feet could be affected. Depending on how far underneath the seat the passenger would place their feet, the box could interfere. In a normal seating position, the feet would not interfere with the passenger, since the box does not overlap the existing carpet which goes in-between the two stands where the seat's rails are connected, displayed in Figure 3-57.

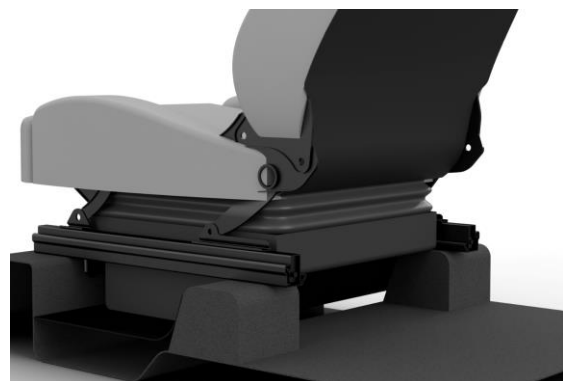


Figure 3-57 CAD rendering of roominess behind the front seat

Logics

The logics requirement was evaluated virtually by examining the operating process for the user when transforming the seat, folding the cushion up and downwards. The opening operation functions by allowing the user to grip the strap and lift the cushion upwards in the same pulling direction. The closing mechanism works in the same manner, a handle is pulled in the same direction as for the cushion going to closing position. Thereby verifying the logics requirement.

Original seat functionality

The original seat functionality was examined by comparing the concept with the existing solution virtually. The majority of the seat functionality could be verified by visually observing that the original functions were not altered in the concept, e.g. backrest rotation around the Y axis, seat adjustment in X-direction, seat heater, crash beams were all maintained as in the original seat. Remaining requirements could not be verified, it would require a detail design and real-life testing.

3.6.3 Concept renderings in car environment

To Verify how the concept would look like in a real environment, CAD renderings of the concept were made in a Lynk & Co model. The renderings show the concept in different situations, presented in figures below.



Figure 3-58 Closed cushion



Figure 3-59 Opened cushion stowing a purse and a backpack



Figure 3-60 Opened cushion stowing a purse and a tissue box



Figure 3-61 Opened cushion stowing a table and a bottle placed in a cupholder



Figure 3-62 Opened cushion showing a open, lower stowage box packed with five 50cl bottles

DISCUSSION

4.1 DISCUSSION ABOUT RESULTS

4.2 DISCUSSION ABOUT METHODOLOGY

4.3 RECOMMENDATION AND FUTURE DEVELOPMENT

The discussion will be presented in three parts. Firstly, the results will be discussed regarding the study and the concept development in relation to the research questions. Secondly, the methodology and the process for the project will be discussed. Lastly, a recommendation for future development will be presented.

4.

4.1 Discussion of results

This thesis aimed to answer seven different research questions presented again below:

- RQ1. What personal belongings are the users stowing inside the car today and what are the preferred placements of these items, focusing on the Chinese market?
- RQ2. Among the personal belongings, what are the most common ones?
- RQ3. Is there a need for a specific stowage area for these common items?
- RQ4. How well have the stowage needs been met for these common items in existing Lynk & Co models? If not met, what is needed to fulfill these user needs?
- RQ5. What is the specific user needs in terms of stowage for a shared vehicle?
- RQ6. What would the needed engineering requirements be to fulfill the user needs for one stowage area in need for improvement, based on the study?
- RQ7. How can a product concept be designed to fulfill these requirements?

The first two research question, were about what personal belongings that the Chinese users bring into the car, where they prefer to place them and what items that were most commonly used. The thesis resulted in a list with 60 different items, that are popular among the Chinese users. These 60 items were evaluated in the questionnaire where 49 respondents answered which of the items that they use and where they preferred to place them. Most items that the Chinese users brought into the car were similar to the items in Europe. However, there were some items that stood out as market specific or more commonly used for the Chinese market, for example: the tissue box, umbrella, phone holder, dashcam, driving shoes and charging cables. This was based on the experience from the project members and the employees at the Ergonomics department at CEVT, since no study for the European market was performed. The study helped answering what items that are most common but also their preferred placement in the car which makes RQ 1 and 2 complete. There could be some items that this study did not cover in other regions of China than where this study took place but there would probably not be any critical items since they probably would have been mentioned by the engineers at LRI in that case.

From the beginning, the question “what items does the users bring into the car” was the key question, but during the thesis, the most interesting result came from the question about where the items should be placed and why. Research question three and four, were about how the stowage solution looks for the most commonly used items and if the needs have been met in existing Lynk & Co cars. To answer this, you need to have in mind that there are a high variety of small items and only a few possible stowage solutions in cars. The study revealed that most small items were stowed in the center tunnel which, if the center tunnel were to be removed, would create stowage problems for these items. Another finding was that the tissue box does not have any convenient stowage spot in reach for the driver which needs to be improved. Umbrellas are another item that are important for the Chinese users and the stowage of umbrellas were raised as an issue throughout the whole study. Most cars, including the Lynk & Co models does not have any designated stowage area where the users can stow wet umbrellas without damaging other items or making the interior wet.

For a shared vehicle solution, like Peer to Peer carsharing, it is important for the users to be able to hide their personal belongings that they do not take with them when they leave the car. Items like, cables, tissue boxes fuel cards etc. seldom leave the car which makes it important to be able to hide these items. On the other hand, people that rent the cars in a Peer to Peer solution will also be dependent on stowage for the items that they bring into the car. This altogether, makes it clear that there needs to be an additional stowage solution in cars used for carsharing to avoid stealing stowage space for the ones renting the car. In the concept, which this thesis

resulted in, is a new stowage area utilized which could be used for carsharing. The lower stowage box is big enough to stow five bottles of 50 cl beverage which probably would be enough for the items that needs to be hidden. However, the concept is developed for an SUV which enables this extra space under the seat which is not the case for a lower car model.

The requirement specification list, divided into eight different categories and a total of 44 requirements, was developed for the seat stowage concept, based on the findings in the study. The final concept met 19 of these 44 requirements which were all requirements that could be verified without further development and prototyping of the concept. The requirement specification list does not include detailed requirements for material properties etc. since these could not be evaluated in this thesis. The concept fulfills all requirements for stowage of small and big items which can be seen as a success since that was the main function of the concept. The problem with the concept however, is that the stowage area can only be utilized if there is no passenger located in the seat. This is a negative aspect since the concept should solve the stowage shortage if the center tunnel was removed. Another aspect that needs further investigation is how the concept affect the roominess of the back seat. There should not be a major problem with roominess based on the CAD renderings but as described in this thesis, the Chinese market value the roominess in the second row highly. Overall, does the concept and the requirement list need further development but as a conceptual idea based on the study it can be viewed as a success.

4.2 Discussion of methodology

The working process for this master thesis was divided in three phases, user study, technology and company trends analysis and concept development. Several methods were used throughout the project, with a predefined plan for execution, where the methods were built upon each other. The applied methods will now be discussed regarding the performance, reliability and potential improvements for each method.

Firstly, the research strategy, Mixed methods approach, turned out to be beneficial for the project. By having multiple data collection methods, different techniques could be utilized to capture the user needs. Furthermore, the uncertainty whether a method would function as planned during the study in China could be minimized by having multiple methods at hand. Where some methods failed to deliver, other methods could complement by having different techniques. For example, methods which rely on the communication skills between the moderator and participants could be complemented by having methods such as observations to capture needs without facing the language barrier. The working procedure of starting the study in Sweden before going to China was an important factor in order to avoid making costly mistakes by asking the wrong questions. One downside of using the mixed methods approach was the difficulties to organize and analyze the different data sets. It was difficult to maintain an even distribution of the five methods, e.g. the questionnaire became more extensive than the documents analysis.

Interviews at CEVT and LRI worked out as planned, the major issues occurred during the interviews at Lynk & Co showrooms. The communication was more difficult than expected and the language barrier became a huge obstacle. Fortunately, a mobile application had been downloaded prior the interviews which could translate fluently when speaking to it. However, the translation was not perfect, and it was difficult to reach any depth of the interviews, they had to be kept at a very basic level. It would have been very beneficial to have a translator present during the interviews, because the showrooms could have been a large source of information. There were many customers present during the time spent at the showrooms and

it would have been rewarding to have interviews with real customer, with no experience of working with cars. The interviewees at the showrooms gave the impression of being careful or restrained when answering and trying to avoid making negative comments of the Lynk & Co brand. This was some of the cultural aspects the project members were aware of after having read Torres De Oliveira's & Figueira's (2018), study. However, by being prepared with a translation application and prewritten questions in Chinese, some valuable information could still be obtained about the user's stowage preferences.

The first focus group interview in Sweden was very productive. The Chinese colleagues at CEVT had valuable information to guide the upcoming studies. They had good knowledge of common items in China, of which many were confirmed during the study in China. The interview also tested mediating tools and the way of phrasing question which later could be improved to strengthen the upcoming studies. The focus group in China was not as productive. The language barrier was more difficult even though communication aiding tools had been prepared. The interview still resulted in good information and piloted the questionnaire which was improved after the interview, by adding the interactive part (mark placement of items).

The document analysis was by far the least extensive method, only three documents were gathered. However, the documents contained valuable information about the persona, stowage survey and customer feedback. Because of the document structure at CEVT it was rather difficult to search for information, using snowballing turned out to be more rewarding. One problem with this method was the limitation of databases, the project could only access CEVT's database. If access would have been granted to LRI, a larger set of documents could have been obtained. The problem is that CEVT and LRI are two separate companies working together but not sharing all the information. The three gathered documents were all established at LRI, but had been transferred to CEVT, meaning that there could possibly exist even more valuable information about customer needs and customer feedbacks.

The observations worked out very well, it could be implemented without any obstacles and little preparations. The observations were valuable in the manner that it was the only method which could guarantee truthful answers and thereby validate the other data collection methods and at the same time provide the project with new data. There was no language barrier which could affect the results, the only disadvantage was the fact that no cars could be entered at the parking lot, only observed from the outside. The optimum would have been to have participants displaying their cars and at the same time perform an interview to realize potential problems the participant encounter. However, that would have been too time-consuming and would require the acceptance and willingness of the participants, which most likely would be difficult. To improve the method, several parking lots should have been covered, not only the Employee's parking lot at Geely. It would be beneficial to cover a larger quantity of car rides, which was the initial plan. By using Didi, the Chinese version of Uber, the project intended to perform several car rides with private person taxis. However, foreigners could not use this application because of the payment method, requiring a Chinese bankcard.

The questionnaire was the performed quantitative data collection method and was built upon the previous ones. All previous gathered data could be investigated in the questionnaire and thereby the project could obtain quantitative data of the most common items and opinions. Some qualitative data could be obtained through the interactive part where the preferred placement could be linked to the items. Though, there still exist uncertainty of the level of truthfulness of the answers, the impression was that some respondents might have misunderstood and marked placement where they usually place their items instead where they

would prefer. One misunderstanding was captured by the project, the results first showed that the most common bottle size was a 2 L bottle, instead of 50 cl which a follow up study later revealed. Apparently, the units, which was written in centiliters (cl) had confused the participants which commonly only use milliliters (ml) and liters for displaying volume of beverages. The participants had misunderstood 200 cl for 200 ml and thereby selecting the largest bottle, closest to 500 ml (50 cl). A benefit with the questionnaire was the avoiding of language barrier, the predefined questions could easily be analyzed in SurveyMonkey. One drawback was the absence of optional comments to questions regarding perception, it would have been valuable to have comments on why the participants for example does not feel satisfied with the stowage solutions. Another drawback was the quantity of answers, to lower the margin of error or receive a representative sample for a greater population, at least 100 answers should have been gathered (Graglia, n.d.). However, in regard to the constraints, timeframe and the layout of the questionnaire, 49 answers are still at satisfactory for this project. The answers were similar to those received from the other methods, which strengthens the validity. In hindsight, a larger focus could have been placed at the Showrooms for this method, which turned out to be a rich source of information with many customers, as earlier mentioned. The Lynk & Co staff was very cooperative and was helping to survey the customers.

As stated earlier, one of the drawbacks with using the mixed methods approach was the analysis of the combined set of data. The questionnaire first part was easily analyzed using SurveyMonkey's built in functions, where relations between questions could be tested. The second part had to be analyzed using excel, but the result turned out well when the marks could be merged to one image and a heat map could be created. This analysis was helpful when evaluating what stowage area to focus on. When analyzing the qualitative and quantitative data together, the KJ analysis was a very effective tool to organize and categorize the different user needs and thereby create a basis for the customer needs list.

The technology and company trends analysis only constituted a small part of this master thesis, but it was an important factor in order to realize the potential opportunities and threats when developing the concept. For example, new technologies such as CEVT's newly acquisition of TactoTek could have been useful to minimize the packaging space for electric surfaces to use as controllers. On the other hand, potential threats were realized, e.g. the emerging autonomous cars which most likely will change the entire interior layout, directly affecting the architecture of the seat. The SWOT analysis main purpose served to guide the development. The other part of the technology and company trends analysis which had a large impact on the concept development was the benchmarking for ideation activity. This greatly enhanced the ideation during the brainwriting sessions. Trends within the furniture and vehicle industry could be merged into the concept.

The last phase of this project was the concept development phase. The initial plan was to present a sketched concept of a stowage solution, as a result of the user study. However, the end result became a 3D modelled concept in Catia v5. Since this phase only constituted for approximately 25 % of the project it became a bit stressed during the last weeks, more time would have been suitable for this phase. Methods such as rapid prototyping and concurrent engineering would have been suitable to enhance the development. This concept development could only evaluate concepts based on sketches and assumptions, it would have been fruitful to develop concept to a higher level. However, by using functional analysis and decision matrices the development could still be developed with the requirements as guidance and a concept proposal based on the user study could be presented.

4.3 Recommendation and future development

Based on the findings from study, the project members would like to make some recommendation to continue and bring the work with stowage forward, at CEVT. The 60 most common items have been identified and placed in a ranked list, the most popular items should be further investigated. It is recommended to study how the generic shape and volume of these popular items should be modelled, to enable a standard for evaluating stowage solutions based on what people prefer to stow in the compartments in regard.

The study also identified items that are in need for improvements in terms of stowage. It is recommended to, based on the customer needs list, set new requirements, so that new solutions could be developed to fulfill these needs, e.g. dedicated stowage for: (wet) umbrella, tissue box. Depending of the future of the center tunnel, if removed, the development must take into account the stowage of small items, which will need a new place, close to the driver. Another recommendation is that a large focus should be placed on the stowage design in shared vehicles, “Peer-peer”. The interviews revealed that a private lockable compartment is needed, but is important to understand where to place this compartment. It should not alter the original stowage for the drivers but at the same time has to be convenient and easy to access. The SWOT analysis revealed that the consumer behavior is rapidly changing in China, relating to car ownership, more and more people are becoming openminded for shared vehicles. It is therefore important to continue studying the stowage needs for these cars. It is also important to understand the user behavior for these vehicles, people now tend to use their cars as all-purpose vehicles which might change in the nearby future, when people seek tailored solutions accessible via their phones. It is important to understand whether the car should be designed for specific user purposes and thereby whether the stowage should be similarly purpose specific.

Another interesting finding was the relationship between the Chinese users and the mobile phone, which several times was expressed to be important in their daily life. They expressed concerns for privacy issues when connecting their phones to the infotainment systems, they did not want private messages and calls showing up on the screen for everyone to see. The study showed that the user preferred to use phone holders and use the mobile separately for navigation, voice messages and calls, instead of connecting to the infotainment system. The user study also said that the user value wireless charging, however, contradicting to that statement, the study also said that the user used cables and phone holders for their phones. The conclusion for this behavior could be connected to the fact that the users cannot utilize nor see their phones while charging wirelessly. Instead, the users relied on phone holders and cables, so that they could place their phones at satisfactory and still be able to charge it. Therefore, it is recommended to further investigate how the infotainment system’s interface should be designed to satisfy the users and encourage them to use it. Furthermore, investigate the placement of the wireless charging, to satisfy the need for usability of mobile phones while charging. These are some of the potential areas of improvements.

If CEVT would decide to continue this study, with further investigations, it is recommended to reach out to LRI. The gathered customer feedback documents revealed that LRI has a customer database, where customers could be accessed for feedback studies. It is recommended to continue field studies, preferably at Lynk & Co showrooms where customers could be surveyed, though, a translator would be suitable to use. It is important to focus the study towards shared vehicles, find users that utilize shared vehicles in their daily life.

The project members have some recommendation for future development of the concept. Firstly, the concept needs to be iterated further using decision matrices, to decide upon the exact solutions for technical functions e.g. the spring-loaded rotational mechanism of the cushion, the lock mechanism for private stowage etc. It is recommended to implement a “Boss” function to allow the driver to place the passenger seat in the right position, while seated. Because the evaluation displayed some reachability issues when the driver seat and passenger seat were not in line with each other. The concept needs to be detail designed to allow for testing.

The project realized some potential issues when developing a new seat, which most likely will be difficult to alter. Therefore, the concept has to reuse as many parts as possible to minimize cost. There are also the packaging aspects, which need to be evaluated, to make sure that the original functions, e.g. seat heater, positioning mechanisms, can cooperate with this concept. The presented concept can be seen as a guideline for further development, in it is present form, it solves the stowage needs for big items as well as for small items. The concept enables a food tray, tissue box holder, hooks and possibilities to develop a large variety of more stowage solutions, by using the modular interface. The interface could also be implemented in other stowage area to enable a customizable interior, where the users could decide for themselves and purchase their add-ons, based on preferences. For example, the interface could be reused for the second row, by placing the interface on the backside of the front row seats, allowing for a higher level of customization, depending on preferences. The main idea with the modular interface is to be reused for many different stowage areas and allowing people to customize their stowage. Even though people tend to have similar items inside their cars, as the study revealed, people still has their own preferences and it is difficult to design to satisfy all.

CONCLUSIONS

5.

The project was based on a hypothesis that market specific needs exist for the Chinese market, regarding stowage in cars. Furthermore, the project initiator, CEVT AB, wanted a user study to be performed to map the stowage user needs regarding items that are brought inside the car. The project background resulted in the following aim: Study what items the target market segment brings inside their cars and where they prefer to place these items. Based on the findings from the study, the project also aimed to develop a concept, focusing on one stowage area. The aim was broken down in seven research questions, which the project has worked to answer:

Firstly, the user study for the Chinese market resulted in an items list, containing the 60 most commonly used items inside the car, presented in a ranked list based on popularity. Corresponding to the items list, a map was established, displaying where the items are preferably placed inside the car, color coded to see the most preferred stowage areas. These two results are directly linked to the stated research question 1 & 2: *“What personal belongings are the users stowing inside the car today and what are the preferred placements of these items, focusing on the Chinese market?”* and *“Among the personal belongings, what are the most common ones?”*. Thereby, the fulfillment of these research question can be concluded. The results were based on a population located in Shanghai and Cixi, therefore, there exist some uncertainty whether the results are applicable for other geographical locations in China.

Secondly, a customer needs list, containing information about the user’s perception of stowage. Some of the key findings were the tissue box, umbrella, bags and mobile phone which did not have a suitable stowage area. The list also displayed needs for a shared vehicle, Peer-peer, with key findings being the need for private lockable stowage, for the car owner, while maintaining the original stowage areas for the renting users. This result could conclude the fulfillment of research question 3 & 4 *“Is there a need for a specific stowage area for these common items”* and *“How well have the stowage needs been met for these common items in existing Lynk & Co models? If not met, what is needed to fulfill these user needs?”*. Research question 5, *“What is the specific user needs in terms of stowage for a shared vehicle?”*, can to some extent be concluded as fulfilled. However, it is recommended to continue study these needs, by conducting studies only focusing on shared vehicles and study people using carsharing daily.

lastly, a requirement list for a specific stowage area, the area which is currently occupied by the passenger seat, was established to satisfy the related customer needs. Based on this requirement list, a concept was developed, transforming the passenger seat into a new stowage area. The concept solves the problem of stowing big and small items, safely on the passenger seat. The concept also satisfies the need for private, accessibly and lockable stowage for a Peer-peer car. The concept was developed to a conceptual level and require further development, which was set as a limitation for this project. Similarly, the requirement list need to be continuously updated as the concept develops further. Thereby concluding the fulfillment of research question 6&7: *“What would the needed engineering requirements be to fulfill the user needs for one stowage area in need for improvement, based on the study?”* and *“How can a product concept be designed to fulfill these requirements?”*

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APPENDIX

A – Generic car interior images for the first and second row.

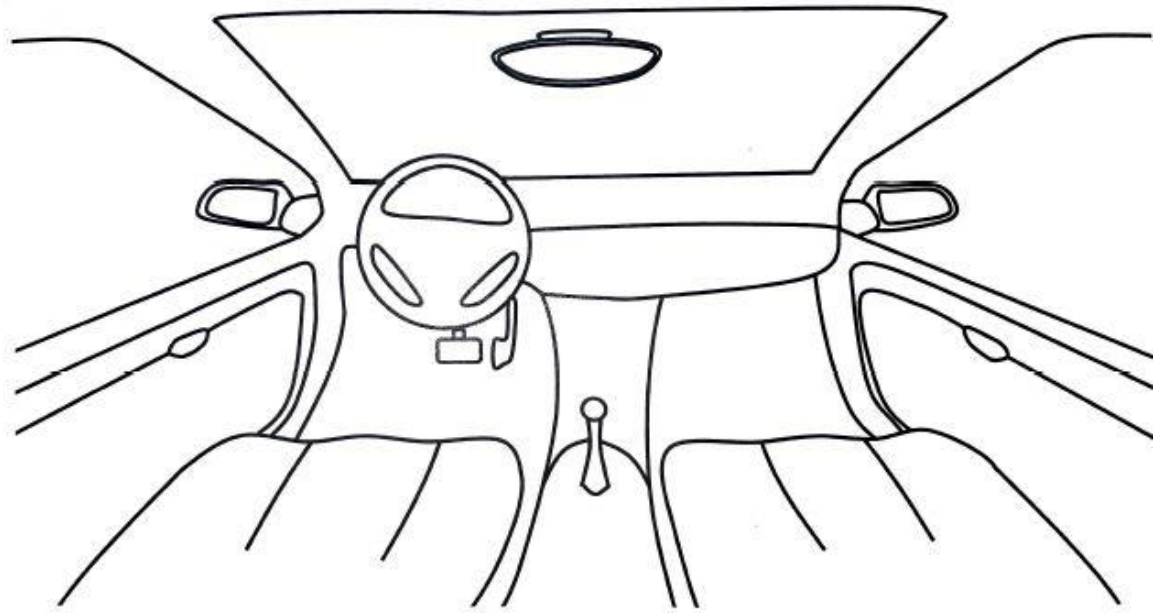


Figure 7-1 Generic image front row

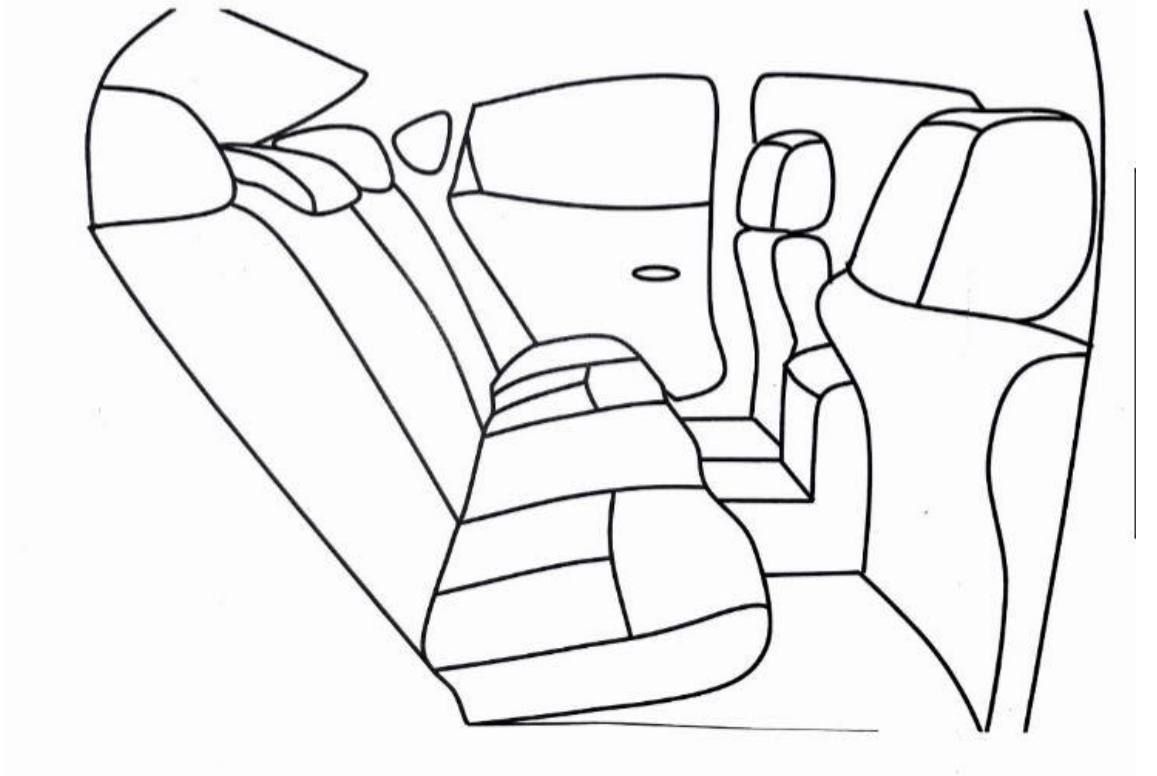


Figure 7-2 Generic image second row

B – Scenarios for the focus groups

每日通勤

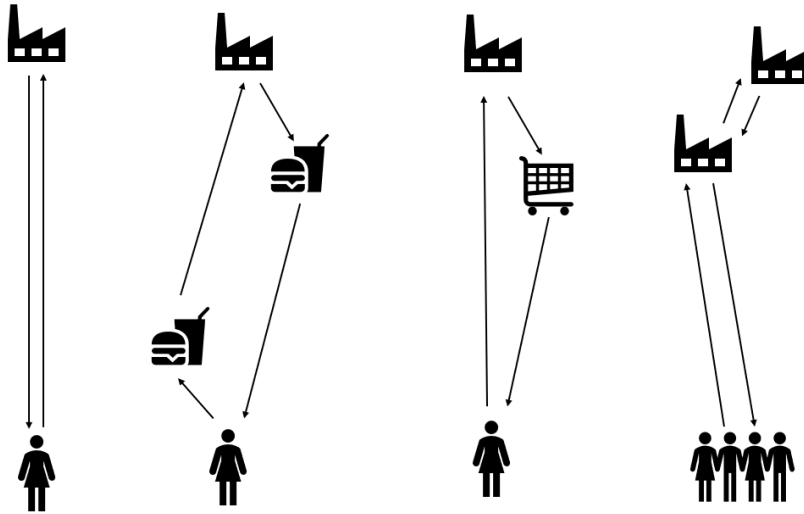


Figure 7-3 Scenarios

假期旅行

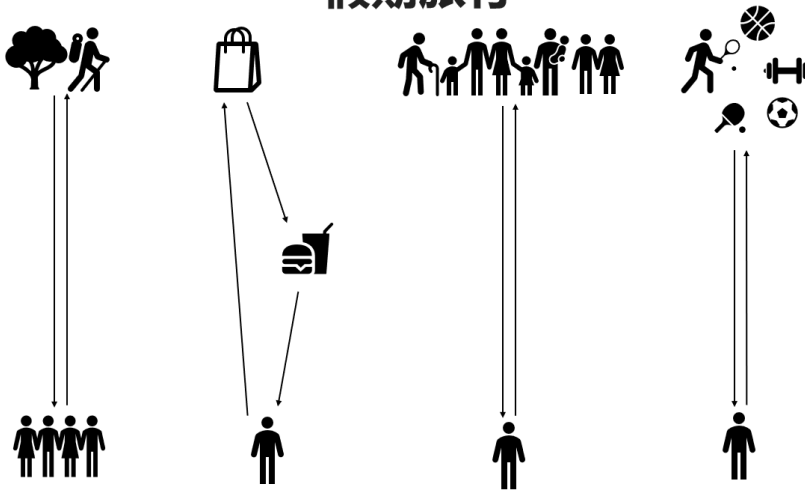


Figure 7-4 Scenarios

其他情况



Figure 7-5 Scenarios

C – Questionnaire layout

关于汽车储物性能的调查问卷

- 请选择最适合您体验的答案，并为每个问题选择一个答案

通常情况下，以下几种情形在一周中发生几次：	0	1-4	5-8	9-12	>12
用车次数？					
在车内喝饮品？					
在车内吃东西？					

- 您有车吗？
 - 是
 - 没有
 - 不，但我打算买一辆
- 你会考虑将来使用“共享汽车”吗？(类似于“共享单车”)

完全同意	同意	中立	不同意	强烈反对

- 你经常使用哪种型号？



- 请选择最适合您体验的答案，为每个问题选择一个答案

在您平时的驾车旅程中：	完全同意	同意	中立	不同意	强烈反对
我对我车里的储物解决方案非常满意。					
我认为在车内吃东西很方便。					
我总是用杯架来装我的饮料。					
我发现在车里给手机充电很容易。					
我想通过无线方式为手机充电。					
我可以轻松地将我的个人物品存放在车内。					

- 您在用车时携带多少电子产品？(手机，电脑，平板电脑)

0	1	2	3	4	>4

- 性别
 - 女
 - 男
 - 其他

感谢您的参与！

Figure 7-6 Questionnaire, first page

Select all items you usually have or usually bring into your car

选择你通常拥有或通常带进你的车的所有物品。

1. Air freshener / 空气清新剂
2. Aspirin / 阿司匹林
3. Bag / 袋
4. Purse / 手提包
5. Backpack / 背包
6. Briefcase / 公文包
7. Duffel bag / 羽绒服包
8. Satchel / 挎包
9. Bottles (~200 cl) / 瓶子(200厘升)
10. Bottles (~150 cl) / 瓶子(150厘升)
11. Bottles (~80 cl) / 瓶子(100厘升)
12. Bottles (~50 cl) / 瓶子(50厘升)
13. Bottles (~33 cl) / 瓶子(33厘升)
14. Can (33 cl) / 罐(33厘升)
15. Can (50 cl) / 罐(50厘升)
16. Candy / 糖果
17. Car key / 车钥匙
18. Charging cable / 充电线
19. Chewing gums / 口香糖
20. Cigarettes / 香烟
21. Coins / 硬币
22. Pay cards / 支付卡
23. Dash cam / 行车记录仪
24. Driving glasses / 眼镜
25. Driving license / 驾驶执照
26. Driving shoes / 鞋
27. Escape hammer / 逃生锤
28. Fuel card / 加油卡
29. Flashlight /
30. Grocery bag / 购物袋
31. Headphones / 头戴耳机
32. Insurance documents / 保险单据
33. Jacket / 夹克
34. Keys / 钥匙
35. Laptop / 笔记本电脑
36. Lucky charms / 幸运符
37. Magazine / 杂志
38. Makeup / 化妆
39. Mints / 薄荷
40. Mobile phone / 移动电话
41. Other documents / 文件
42. Parking tickets / 停车票
43. Pencils / 铅笔
44. Phone holder / 手机座
45. Power bank / 移动电源
46. Receipts / 收据
47. Reflective vest / 反光背心
48. Sunglasses / 墨镜
49. Tablet (iPad) / 平板
50. Tea Thermoses / 热水瓶
51. Tissue box / 纸巾盒
52. Tokens (car wash, grocery cart) / 代币
53. Toll ticket / Highspeed card / 通行费票
54. Towel / 毛巾
55. Umbrella (foldable) / 可折叠的伞
56. Umbrella (large) / 雨伞
57. Wallet / 钱包
58. Wet-Wipes, (car cleaning) / 湿纸巾 (汽车清洁)
59. Wi-Fi dongle / 无线上网卡
60. Work access card / 门禁卡

Figure 7-7 Questionnaire, items list

您一般会把这些物品放置在车内什么位置呢？
请您将第二页所选择的物品 **前方** 对应的序号，填入下图中

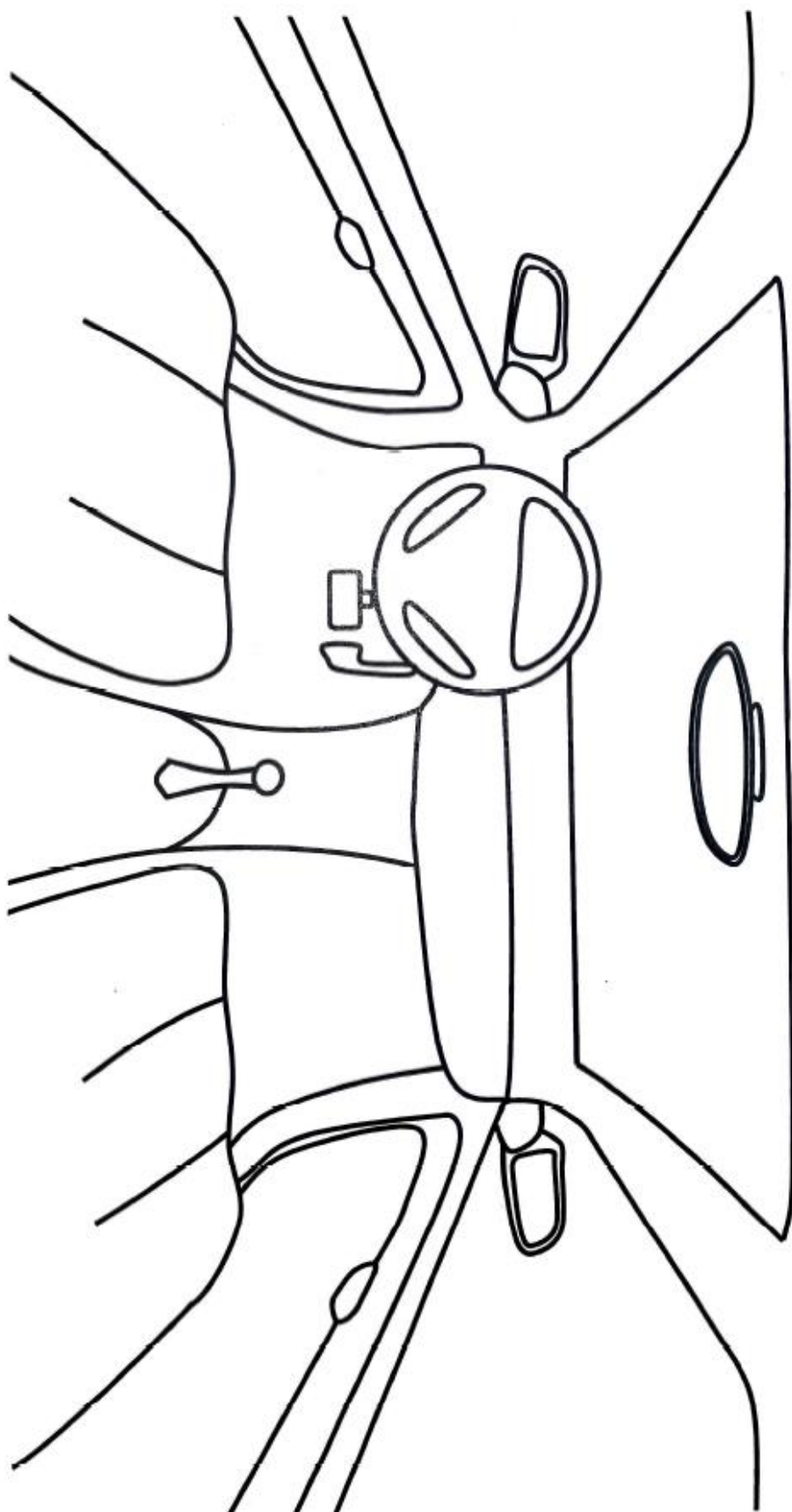


Figure 7-8 Questionnaire, placement first row

您一般会把这些物品放置在车内什么位置呢？
请您将第二页所选择的物品 **前方** 对应的序号，填入下图中

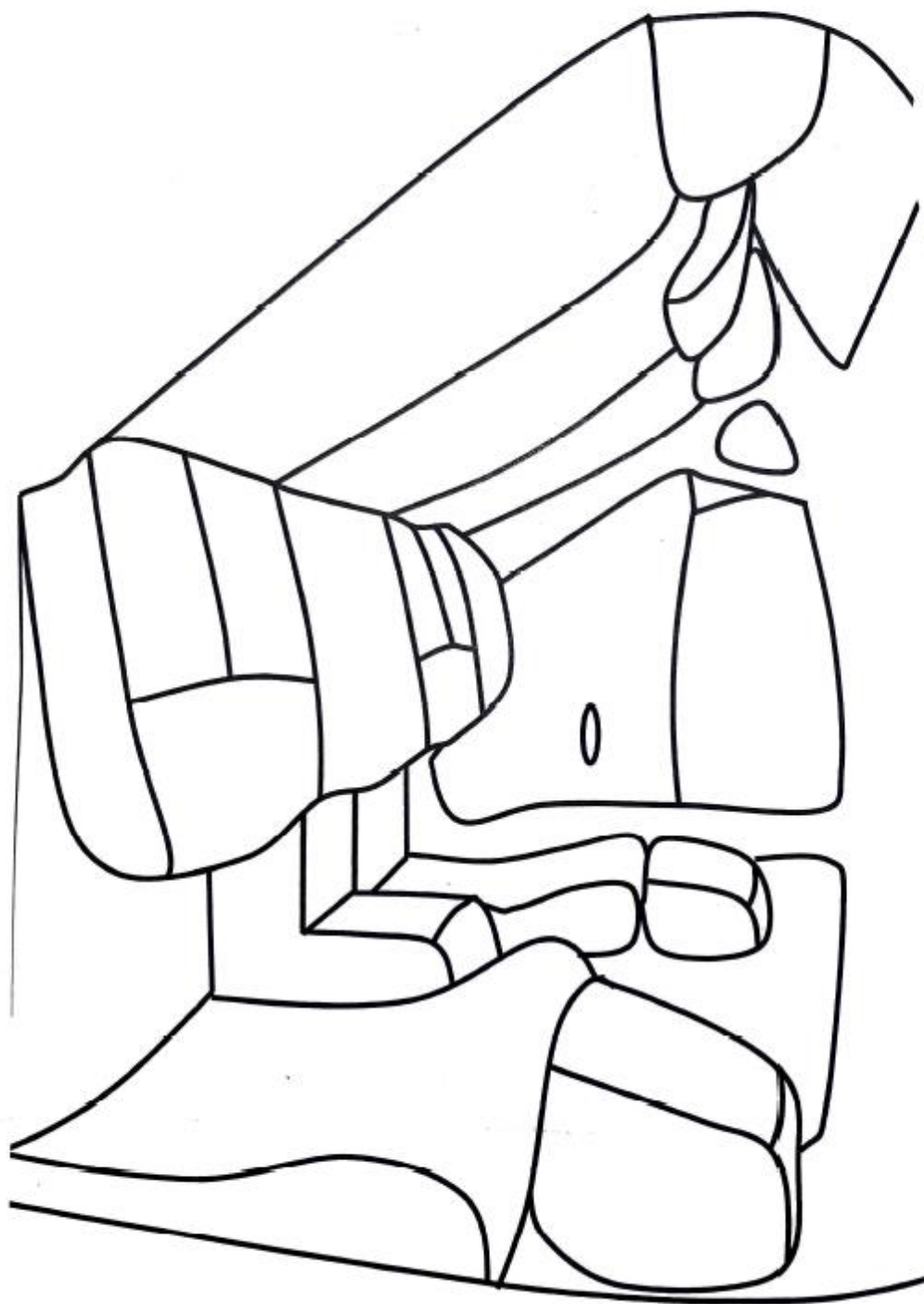


Figure 7-9 Questionnaire, placement second row

D – Most wanted items in the car (bottles excluded)

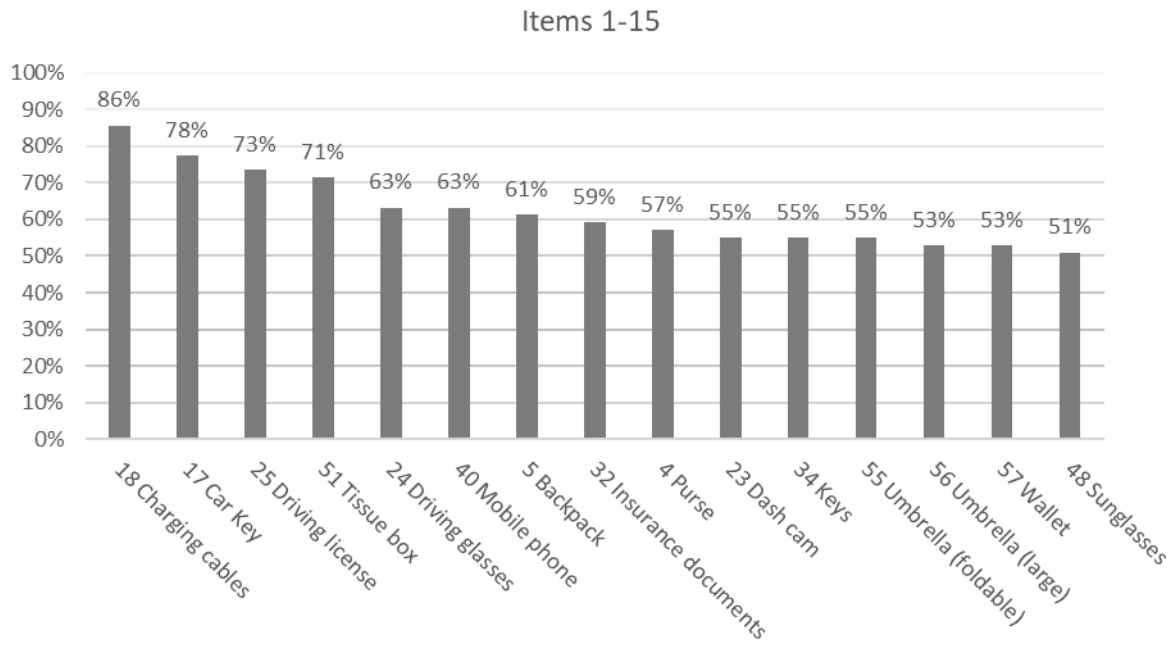


Figure 7-10 Graphical image of the 1-15 most common items the respondents have inside their cars

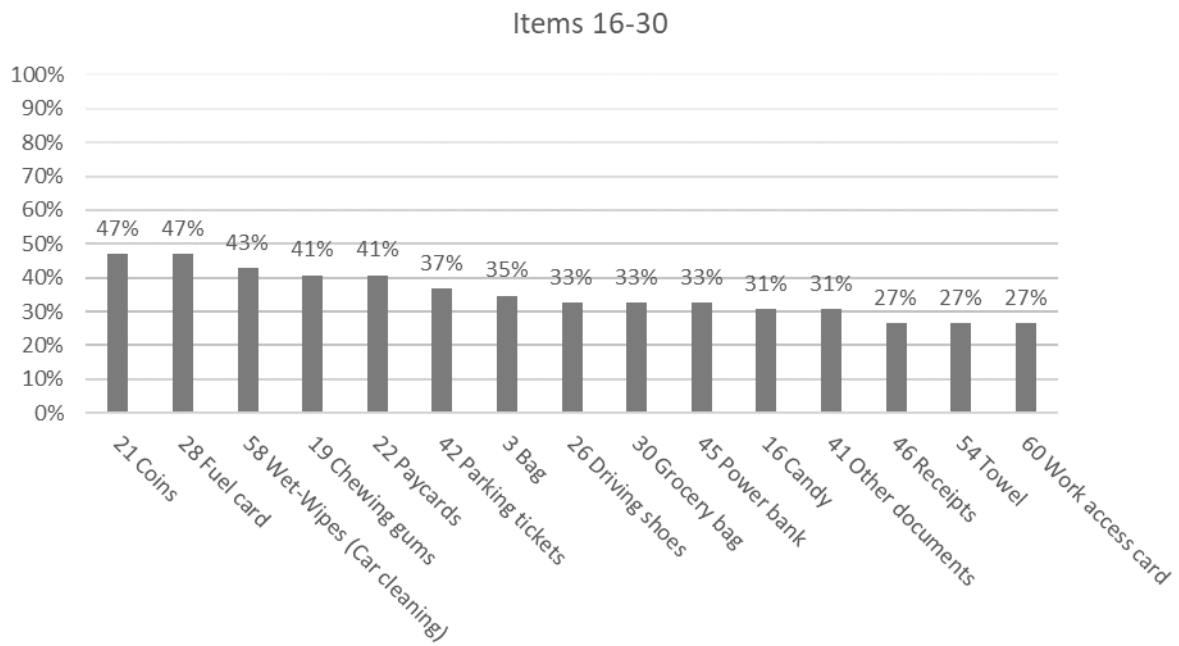


Figure 7-11 Graphical image of the 16-30 most common items the respondents have inside their cars

Items 31-41

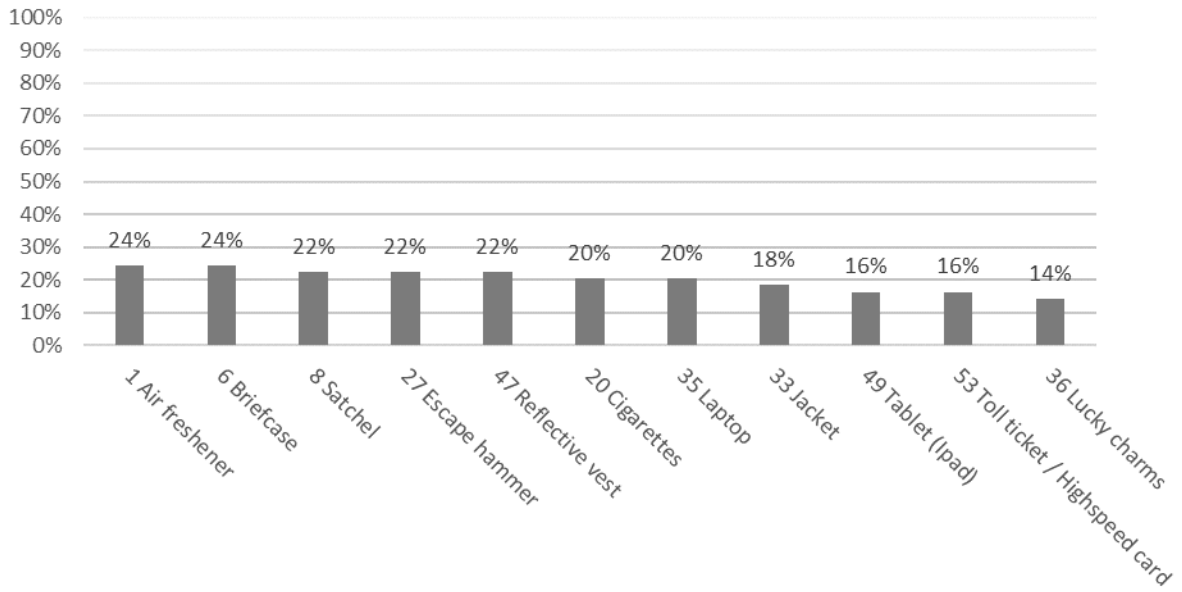


Figure 7-12 Graphical image of the 31-41 most common items the respondents have inside their cars

Items 42-52

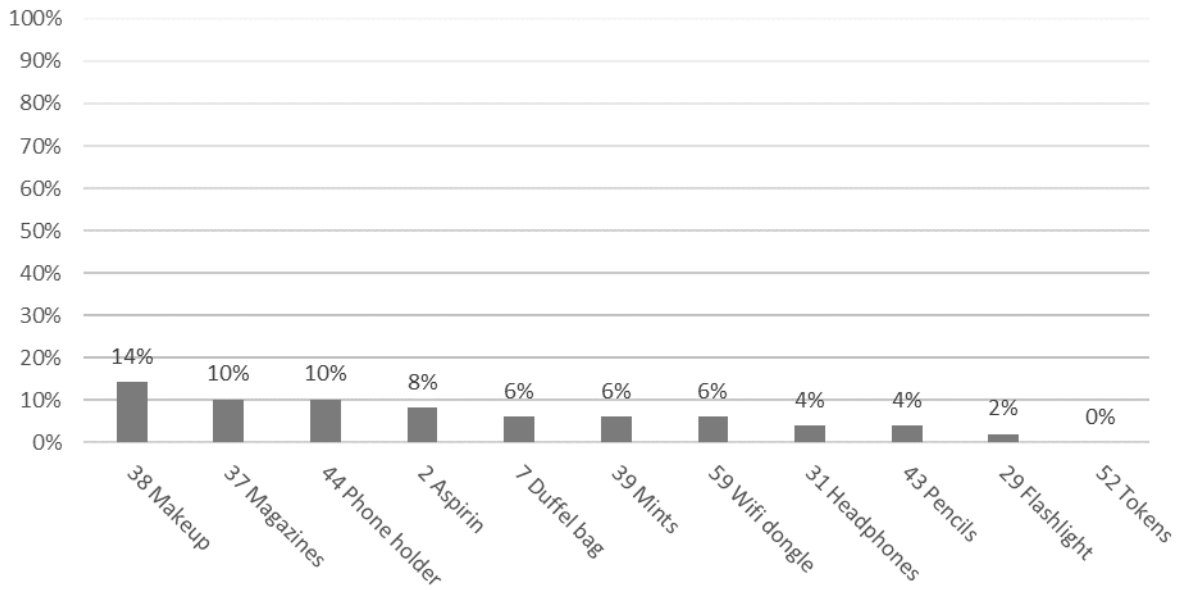
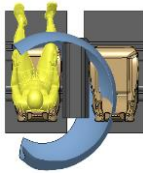


Figure 7-13 Graphical image of the 42-52 most common items the respondents have inside their cars

E – Requirement specification list

Table 7-1 Requirement specification list

Created: 2019-05-01		Acronyms:		R: Requirement		Y: Yes, N:No	
Updated: 2019-05-22				W (1-3): Wish (1 high importance, 3 low importance)		N/A: More info needed	
Requirement list			Target	R/W	Verification	Met	Stakeholder
1. Stowage capacity for items (minimum volume of the solution)			length*width*height [mm^3]				
Big items	1.1	The solution must be able to provide stowage for a backpack	≥280*160*400	R	Virtual analysis (Catia V5)	Y	Users
	1.2	The solution must be able to provide stowage for a briefcase	≥380*80*280	R	Virtual analysis (Catia V5)	Y	Users
	1.3	The solution must be able to provide stowage for a duffelbag	≥500*250*270	R	Virtual analysis (Catia V5)	Y	Users
	1.4	The solution must be able to provide stowage for a grocery bag	≥240*120*450	R	Virtual analysis (Catia V5)	Y	Users
	1.5	The solution must be able to provide stowage for a satchel	≥380*60*300	R	Virtual analysis (Catia V5)	Y	Users
	1.6	The solution must be able to provide hanging of a jacket	≥N/A	R	Virtual analysis (Catia V5)	Y	Users
Small items	1.7	The solution must be able to provide stowage for a purse	≥215*70*150	R	Virtual analysis (Catia V5)	Y	Users
	1.8	The solution must be able to provide stowage for a 50 cl bottle	≥210*32*2*pi	W1	Virtual analysis (Catia V5)	Y	Users
	1.9	The solution must be able to provide stowage for a pair of shoes	≥N/A	W1	Virtual analysis (Catia V5)	Y	Users
	1.10	The solution must be able to provide stowage for a tissue box	≥160*120*80	W1	Virtual analysis (Catia V5)	Y	Users
	1.11	The solution must be able to provide stowage for a 15" Laptop	≥375*255*24	R	Virtual analysis (Catia V5)	Y	Users
	1.12	The solution must be able to provide stowage for a foldable umbrella	≥330*30*2*pi	W1	Virtual analysis (Catia V5)	Y	Users
2. Stowage capacity for items (minimum load to carry at rest)			Kg				
Big items	2.1	The solution must be able to hold a backpack	≥5.5	R	Virtual simulation (Catia V5)	N/A	Users
	2.2	The solution must be able to hold a briefcase	≥5	R	Virtual simulation (Catia V5)	N/A	Users
	2.3	The solution must be able to hold a duffelbag	≥7	R	Virtual simulation (Catia V5)	N/A	Users
	2.4	The solution must be able to hold a grocery bag	≥6	R	Virtual simulation (Catia V5)	N/A	Users
	2.5	The solution must be able to hold a satchel	≥4.5	R	Virtual simulation (Catia V5)	N/A	Users
	2.6	The solution must be able to hold a jacket	≥1.3	R	Virtual simulation (Catia V5)	N/A	Users
Small items	2.7	The solution must be able hold a purse	≥0.9	R	Virtual simulation (Catia V5)	N/A	Users
	2.8	The solution must be able to hold a 50cl bottle	≥0.5	R	Virtual simulation (Catia V5)	N/A	Users
	2.9	The solution must be able to hold a pair of shoes	≥0.7	R	Virtual simulation (Catia V5)	N/A	Users
	2.10	The solution must be able to hold a tissue box	≥0.2	R	Virtual simulation (Catia V5)	N/A	Users
	2.11	The solution must be able to hold a 15" laptop	≥2.7	R	Virtual simulation (Catia V5)	N/A	Users
	2.12	The solution must be able to hold a foldable umbrella	≥0.7	R	Virtual simulation (Catia V5)	N/A	Users

3. Reachability							
3.1	The driver must be able to operate the stowage transformation while in driving position, see figure to the right for reachability area while in driving position. Manikin: (Woman, 166cm, height percentile=80)		W3	Virtual analysis (Ramsis)	No	CEVT AB	
3.2	The driver must be able to operate the stowage transformation while seated but not in driving position.		R	Virtual analysis (Ramsis)	N/A	CEVT AB	
3.3	The user must be able to operate the stowage solution with a clearance for the hand.		R	Virtual analysis (Catia V5)	Y	CEVT AB	
4. Roominess of cabin							
4.1	The solution must not decrease roominess inside cabin	0% increase of occupied volume space	W1	Virtual analysis (Catia V5)	N	CEVT AB / LRI / Users	
5. Logics							
5.1	The solution must be intuitive for the user	The seat transformation must follow the movement of the user operating it	R	Virtual analysis (Catia V5)	Y	CEVT AB	
6. Maintenance							
6.1	The solution must be durable, handle many different users	Lifetime \geq X years	R	Prototype testing	N/A	CEVT AB	
6.2	The solution should be easy to clean	Exposed parts must be removeable	R	Virtual analysis (Catia V5)	N/A	CEVT AB	
6.3	The solution must be water resistant	100% water resistant	R	Material selection	N/A	CEVT AB	
7. General properties							
7.1	The solution must have a low production cost	\leq X SEK / component	R	Cost calculation	N/A	CEVT AB	
7.2	The solution must provide private stowage accesible only for the owner	Lockable compartment	W1	Virtual analysis (Catia V5)	N/A	CEVT AB	
7.3	The solution must not damage stowed items while driving	No damage	R	Prototype testing	N/A	CEVT AB	
8. Original seat functionality							
8.1	The solution must allow for adjustment of the seat in X-direction	Identical as an existing Lynk & Co model (X)	R	Virtual analysis (Catia V5)	Y	CEVT AB	
8.2	The solution must allow for adjustment of the backrest around the Y-axis	Identical as an existing Lynk & Co model (X)	R	Virtual analysis (Catia V5)	Y	CEVT AB	
8.3	The solution must be compatible with a electrical adjustable seat.	Identical as an existing Lynk & Co model (X)	R	Virtual analysis (Catia V5)	N/A	CEVT AB	
8.4	The solution must be compatible with a mechanical adjustable seat.	Identical as an existing Lynk & Co model (X)	R	Virtual analysis (Catia V5)	N/A	CEVT AB	
8.5	The solution must not alter the heating functions of the seat	Identical as an existing Lynk & Co model (X)	R	Virtual analysis (Catia V5)	Y	CEVT AB	
8.6	The solution must not alter the crash beams surrounding the seat.	Identical as an existing Lynk & Co model (X)	R	Virtual analysis (Catia V5)	Y	CEVT AB	
8.7	The solution must be comforatable when used by a passenger	Identical as an existing Lynk & Co model (X)	W1	Virtual analysis (Catia V5)	N/A	CEVT AB	
8.8	The solution in use must not damage or create any wear on seat clothing	0% wear and damage on seat	R	Virtual analysis (Catia V5)	Y	CEVT AB	
8.9	The stowage solution must not trigger "seatbelt pressure scensor" while stowing items	No signals when the seat is transformed and in use for stowage	R	Virtual analysis (Catia V5)	N/A	CEVT AB	

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