

CHALMERS



Interior Design of Cabins for Urban Cable Railway

In the city of Gothenburg

Master of Science Thesis in the Master Degree Programme,
Industrial Design Engineering

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Gothenburg, Sweden 2018

Department of Industrial and Materials Science
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Abstract

Gothenburg is growing and as a part of the city center's transformation a cable railway across Göta Älv is planned for. The cable railway is supposed to be a fully integrated part of the public transportation, which then will be the first of its kind in Sweden. Hence, earlier experiences to build upon are limited and the responsible cable railway project group are working to get a solid foundation for the project.

This study aimed to provide the cable railway project group with an understanding of what is needed for the cabins' interior, in order to achieve a good passenger experience for prioritized passenger groups. These groups are: everyday commuters, senior citizens, pregnant women, families with small children, visually impaired, citizens with different degrees of physical impairments, wheelchair users, bicyclists and tourists.

The work had a passenger centered and inclusive approach, involving possible future passengers in the process. Interviews and observations have been a major part of the study, conducted both in Gothenburg's public transportation and in existing cable railway systems in Europe. It has been investigated what is needed to achieve a good passenger experience, and what the different passengers' requirements are for an attractive journey with public transportation.

A requirement list based on the findings was compiled to be used as a guide for further work. Important aspects to consider regarding the cabins' interior, to achieve the desired passenger experience, was found to be for example an efficient flow, accessibility and possibility to maintain the passengers' perception of having their own personal space.

Based on these findings a concept for the cabins' interior was developed. This work was conducted partly together with possible future passengers, as a part of their involvement in the process as a whole. The concept was tested with a mock-up and test participants, representing the different passenger groups, to evaluate its usability. The results from these tests indicated that it is possible to design a single interior of the cabins that is suitable for all the prioritized passenger groups. Taking the different passenger groups' needs into consideration from the beginning enables achieving a good passenger experience for all.

Keywords: cable railway, public transportation, cabin interior, passenger experience, society for all, user involvement, usability

Preface and acknowledgements

This master thesis is the result of a product development project carried out over the spring and autumn of 2017 at Chalmers University of Technology. The project covered 30 credits and was performed by two students from the Industrial Design Engineering programme at the division of Design and Human Factors, at the department of Industrial and Materials Science.

It has been a long journey, and we have had many persons around us who deserves to be mentioned.

We would like to thank our partners, Västtrafik and Trafikkontoret, as well as the cable railway project group leaders at both organisations, Johanna Möllersten and Per Bergström-Jonsson, for giving us the opportunity to take on this project. To have had the chance to be a part of this project has been interesting, challenging and so much more than we ever expected. It was valuable to us to be provided all the guidance and support throughout the project and to be given the opportunity to conduct observations in existing urban cable railways.

Thanks to the cable railway project group members at Västtrafik for all support, while including us with warmth in the project group during this project. Your thoughts and ideas have been valuable.

Thanks also to our supervisor and examiner, Eva Simonsen and Helena Strömberg, for guiding and pushing us in the right directions throughout the various project stages.

A special thanks to Johanna Möllersten, cable railway project group leader at Västtrafik, for all the assistance, support and cheering, both in and outside the project. We have learned a lot from you, and your presence has really affected our project in many ways.

Finally, thanks to our families and friends for supporting us throughout the project as well as our entire educations. You all know that many hours have been spent on this journey, and you are all a part of making it possible.

Gothenburg July 2018



AnnTherese Johansson



Olle Torkelsson

➤➤ **“Fast track” of the report**

There is not always enough time to go through every detail. Therefore this report includes a “fast track” to get through it in significantly less time than it would take to read it all.

It is recommended to read ‘Introduction to Gothenburg’s cable railway’, starting at page 12, since this is a general introduction to the cable railway project as a whole.

Then, the most important information from each section of the result are compiled in a concluding bullet list, denominated ‘Key aspects’. Reading these bullets will give a brief understanding of the findings and conclusions leading to the deliverables.

And about the deliverables, in ‘Essence of final deliverables’ the interior concept are presented together with the created vision and requirement list. Straight forward, without anything extra added. Page 79.

Finally, the ‘Conclusion’ is found on page 91.

It does not get any quicker to read a thesis. Of course it is still a lot of interesting information throughout the report, so feel free to read it all if the time is available. But for all readers not having too much spare time: follow the tip above and go ahead!

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Introduction

Background

In 2021 Gothenburg will celebrate its 400th anniversary. As a part of this event, the city is planning for an urban cable railway to be built across the river Göta älv. Initially, the idea came from Gothenburg's citizens. It was an answer to the question "How would you like to celebrate Gothenburg's 400th anniversary?", posed by the city of Gothenburg.

It is intended to become a fully integrated part of Gothenburg's public transportation system, and early studies indicated that a cable railway would have the potential to achieve this goal (Göteborg Stad, 2013; Tyréns, 2013). The cable railway would then become a whole new transverse connection across the river, which would relieve the existing infrastructure across the water in the central parts of Gothenburg.

A cable railway is a new type of element in Gothenburg, and to use it in public transportation is something unique to Sweden. However, it could internationally be seen as a trend in urban transportation. They can be found in several urban locations across the world and more systems are currently being planned for (The gondola project, 2017).

Leading Gothenburg's cable railway project are two joint project groups consisting of elements from Trafikkontoret and Västtrafik, which has responsibility for infrastructure respectively public transportation in Gothenburg. These cable railway groups are aiming to create a new alternative way of traveling that is still perceived as a natural part of the already existing public transportation system.

To achieve this Gothenburg's cable railway must meet the passengers' expectations of public transportation, keep up a high capacity and it must also be seen as an attractive choice compared to existing alternatives. To focus on the passenger experience was therefore a natural way to go, in order to obtain an accessible and attractive alternative for the citizens.

Since the concept of an urban cable railway is new to both the cable railway group and the citizens of Gothenburg it is a challenge to ensure all important aspects are covered in the development process. Hence, the cable railway groups seek knowledge broadly and work hard to involve as many different passenger groups and stakeholders as possible throughout the process.

An important part of the overall passenger experience of the cable railway is the passenger's experience inside the cabins. This is where most of the passenger's interaction with the cable railway is happening and with a good experience for the passengers the journey can be more than just a necessary journey. Here, the needs and requirements of a variety of different prioritized passenger groups must be combined; such as everyday commuters, senior citizens and wheelchair users. Taking on this study from the passenger's point of view enables the best possible journey across Göta Älv for the future passengers.

Purpose

The purpose of this thesis project was to provide the anniversary cable railway project group with information and knowledge of how the interior of cable railway cabins can be designed, in order to fit the needs of prioritized passenger groups regarding passenger experience, while keeping a high loading capacity.

The outcome of this thesis project was intended to support the anniversary cable railway project group and their associates in further studies and development of the future cable railway in Gothenburg.

Goal

To fulfill the purpose, this study sought to answer the following questions:

- Which are the needs of prioritized passenger groups for public transportation in Gothenburg?
- How should the interior of cable railway cabins be designed to meet the needs for a good passenger experience for those prioritized passenger groups?

The following deliverables were created to document and communicate the findings:

Vision

To highlight the overall qualities needed to obtain the best possible passenger experience in a cable railway cabin.

Requirement list

To specify requirements that must be fulfilled in order to achieve a good passenger experience.

Conceptual design proposal of the cabins' interior

To create a conceptual interior design, based on the vision and the requirement list, as a foundation for further development.

Scope

The study was based upon a user centered process, and a user involvement approach was utilized to ensure that the needs of potential passenger groups were fulfilled. To work according to society for all principles was seen as a possible enabler for a good passenger experience for all passenger groups.

For the study a selection of prioritized passenger groups that would be taken into consideration was made in dialogue with the cable railway project management. The selection was based upon the expected future passengers and the assumed vulnerability of these when in public transportation. Passenger groups with critical needs, that were suspected to easily be suffering if neglected, were seen as important to take into consideration.

The prioritized passenger groups were: everyday commuters, senior citizens, pregnant women, families with small children, visually impaired, citizens with different degrees of physical impairments, wheelchair users, cyclists and tourists.

Due to the fact that neither manufacturer nor exact cabin model had been determined upon the execution of this study, only approximations of cabin dimensions were used. However, at the time this study was executed there was only two possible manufacturers available; Doppelmayr and Leitner Ropeways. Both these manufacturers' cabin models had very similar dimensions, and hence it was no considerable disadvantage for this study that the manufacturer was not yet chosen.

This study handled the interior furnishing and layout within the cabins. The outcome of the study was intended to be used as a foundation for further development of the cable railway when a manufacturer is chosen and involved in the project. Hence, at this stage little attention was drawn to details and exact models of the furnitures, and instead the overall perception and function had priority. Also, other interior elements such as information boards and safety equipment was not a part of the scope.

A predefined condition for the cable railway was that it should allow for bicycles onboard the cabins. At the time this study was executed it did though not exist a requirement regarding how many bicycles that would need to fit inside each cabin at the same time. For the sake of this study a preliminary decision was therefore issued by the cable railway project management, saying that each cabin should have room for two bicycles onboard. The same guideline was also applied for wheelchairs, walkers and prams.

Introduction to Gothenburg's Cable Railway



General facts

Type of system:

Three cable system (3S). A stable system that enables to achieve a good passenger experience in strong winds (operates in winds up to 28 m/s).

Speed:

18-20 km/h.

Total capacity:

Approximately 2000 passengers per hour and direction.

Capacity per cabin:

25 persons (a total weight of 35x80 kg is allowed by the manufacturers, but in Gothenburg there will be a limit of 25 persons to enable good comfort for the passengers). Each cabin was also estimated to be able to hold two wheelchairs, walkers, prams or bicycles, but then the maximum number of other passengers decreases with three persons per wheelchair/walker/pram/bicycle.

Cabin size:

Floor area about 3x3 m, height approximately 2,10 m.

Number of stations:

Four (Järntorget, Lindholmen, Västra Ramberget and Wieselgrensplatsen. See figure 1).

Duration of journey:

Järntorget-Lindholmen 4,5 min, Lindholmen-Västra Ramberget 3,5 min, Västra Ramberget-Wieselgrensplatsen 3,5 min. Total time approximately 11,5 min.

Frequency of departures:

Every 45th sec.

Travel height above the ground:

About 50-70 m.

Information retrieved from the project manager of the cable railway project group at Västtrafik

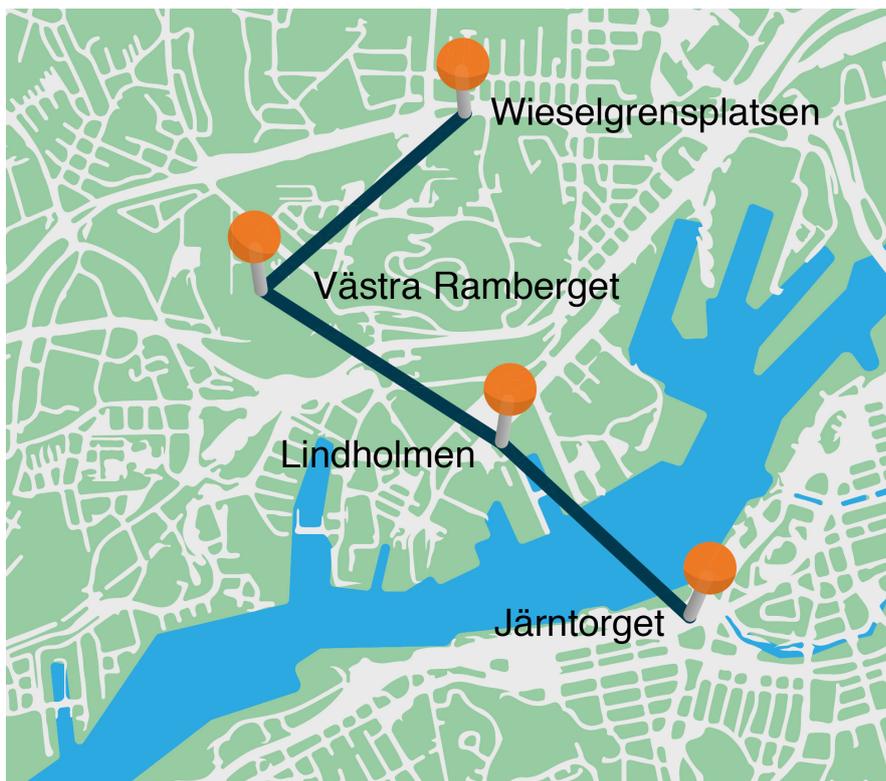


Figure 1. Illustration of approximate position of the cable railway stations.

Boarding and disembarking at station

The boarding and disembarking of the cabins will be performed at two separate locations. When coming into a station, the cabin will be disconnected from the main cable and reduce its speed to a first full stop. While standing still, the doors will open and the passengers onboard will then have 20 seconds to disembark the cabin. Thereafter the cabin slowly starts moving towards a second location where it makes another full stop. New passengers will then have 20 seconds to board the cabin before the doors are closed. The cabin thereafter accelerates to full speed and reconnect to the main cable again. The rest of the cabins suspended will not be affected by the stops other cabins make at the stations, according to the two project managers of the cable railway project groups at Västtrafik and Trafikkontoret.

According to the same project managers, the cabin lacks thresholds and while at a station its floor will be in the same level as the station's floor. This will have a positive effect both regarding passenger accessibility and passenger flow when boarding and disembarking. Passengers having to ascend or descend steps increases required time and physical effort compared to entering floors in the same level (Transportation Research Board, 2003).

Legislation for cable railways

When it comes to legislation, cable railways are currently defined as elevators in Sweden. For this study, it mainly affected for example the requirements regarding fastening of wheelchairs during a journey, that applies to other public transportations. It did not have to be considered here, according to a cable railway project group member with insights in the development of public transportation vehicles at Västtrafik.

Theoretical Framework

User involvement

User involvement is a term referring to varying degrees of involvement from likely users in the development process. It is used to take advantage of users' existing knowledge for e.g. analyzing passengers' needs. User involvement has according to Kujala (2008) shown to be a beneficial approach in the area of gathering passenger insights in early stages of development.

User involvement approaches, such as co-design, refers to the shared creativity of designers and people not trained in design, working together in the design development process (Sanders & Stappers, 2008). Co-design methods, and similar approaches of user involvement, are according to Kujala (2003) considered to be both useful and likely to have positive effects on user satisfaction when applied in early stages of a development process.

In addition to the timing of the commission, the effectiveness of user involvement is dependent on the expected level of innovation in the project development process. When developing radically innovative products, that requires a very different behaviour pattern for the users, it is in general difficult for the users themselves to know their needs (O'Connor, 1998). Hence, the approach is most advantageous while working with products or services possible to relate to the users' earlier experiences.

Since the development of a cable railway in Gothenburg has a passenger focused approach, user involvement was seen as advantageous for the process. It is an efficient alternative to include the passengers and benefit from all their knowledge gained through hours and hours of traveling with public transportation.

Society for all

Warsen and Leander (1999) points out that public transportation is for everyone, which also includes that all passenger groups' needs have to be taken into account while designing for this purpose. The public transportation should meet all those expectations and requirements, setting high standards for the development team.

An environment, product or service should preferably enable all potential users to use it with equal opportunities (Design for all foundation, 2017 and Persson, et al. 2014). Since all users have different capabilities, needs and aspirations, they will not all have identical requirements for the products they use either (University of Cambridge, 2017 and Design for all foundation, 2017).

Design for all foundation (2017) have compiled a list of criteria to be taken into consideration in order to obtain design for all:

Respectful:

It should respect the diversity of users. Nobody should feel marginalised and everybody should be able to access it.

Safe:

It should be free of risks to all users. This means that all elements forming part of an environment have to be designed with safety in mind.

Healthy:

it should not constitute a health risk or cause problems to those who suffer from certain illnesses or allergies. In addition, it should promote healthy use of spaces and products.

Functional:

It should be designed in such a way that it can carry out the function for which it was intended, without any problems or difficulties.

Comprehensible:

All users should be able to orient themselves without difficulty within a given space, and therefore the following are essential:

- Clear information: use of icons that are common to different countries, avoiding the use of words or abbreviations from the local language which may lead to confusion.
- Spatial distribution: this should be coherent and functional, avoiding disorientation and confusion.

Sustainable:

Misuse of natural resources should be avoided to guarantee that future generations will have the same opportunities as us to preserve the planet.

Affordable:

Anyone should have the opportunity to enjoy what is provided.

Appealing:

The result should be emotional and socially acceptable but always bearing in mind the seven precedent criteria.

Several other expressions than design for all are also commonly used within product- and service design, such as *universal design* and *inclusive design*. These denominations are to a large extent similar, especially when the development process' target group is as broad as 'the society in general' (University of Cambridge, 2017). To try working more together towards the same goal Design for all foundation and International association for universal

design have started a cooperation with Art Center College of Design, Helen Hamlyn Centre for Design and Norwegian Design Council where they have agreed to a common framework to follow. The result of this cooperation was a Global commitment towards a society for all (Society for all, 2012). Society for all is actively working to unify the definitions and goals from all different organisations, today using a variety of expressions. By doing this, Society for all becomes a strong collective force driving for example product development in a direction where the society becomes accessible for its entire population.

Usability

Usability is defined by The International Organization for Standardization (ISO, 1998) as:

“The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.”

When working with user centered design, adapting the product or service to human nature is one of the main aspects to consider (Hassenzahl, 2008). ISO’s definition says that a product or service must contribute to reaching the set goal and therefore the reason of use. This can only be successful if the user understand the product and also is able to use it as intended. By understanding the users’ prerequisites, as well as the situation and context a product is supposed to be used in, the usability can be optimised.

Both effectiveness and efficiency can be objectively measured, for example the time it takes to complete a task or the result compared to the required time can be investigated. Usability tests can be used to evaluate products, and also to compare different alternatives in order to find the most effective and efficient ones.

The satisfaction of use is a more subjective aspect, and hence not as simple to quantify as the previously described effectiveness and efficiency. Here, an overlap with user experience can be found, which is presented in the following section.

User experience

User experience is defined by ISO (2010) as:

“A person’s perceptions and responses that result from the use or anticipated use of a product, system or service.”

Another, more narrow, definition of user experience is made by Hassenzahl (2008):

“Momentary, primarily evaluative feeling (good-bad) while interacting with a product or service”.

There are multiple factors contributing to the overall user experience. ISO’s definition is rather wide and could stretch from the feeling a user gets from holding a physical product to how a product or service aligns with the user’s personal beliefs. Hassenzahl’s version is more directly connected to the current experience while using a product or service. However, they are both focused on the user’s subjective experience, and the performance of a product or service regarding this aspect is therefore sometimes difficult to measure.

Karapanos (2010) highlights that a holistic analysis of user experience enables a rich and nuanced view of the case, including that the whole user experience should be seen as more than the sum of its parts. For example contextual studies and taking users’ storytelling into consideration is suggested as useful tools according to Karapanos.

As seen in ISO's definition, it is not only the actual use of a product or service that builds up the overall user experience, the anticipated use is also a part of experience. To achieve a positive user experience it is important that the user's expectations of use are fulfilled (Ludden, Schifferstein & Hekkert, 2012). Therefore, these expectations should preferably be known during the development process of every product or service.

On a rapidly changing market, with a constantly increasing amount of products and services, the user experience often becomes the differentiating factor. To be provided good usability has almost become a basic matter of course, and is no longer necessarily something positively surprising to the users (Jordan, 2000). Hence, the user experience plays a more important role than ever, and is advantageous to use as a foundation throughout all product and service development.

Berg, Pettersson and Zachau (1992) lift the interior of public transportation vehicles as a main part of the passengers' overall experience, especially seats, handheld supports and supports to lean on to. To achieve a good user experience they also highlight the importance of keeping the passenger in focus throughout the development process, and encourage to avoid getting into old habits. Throughout this thesis project, the intended users have been exclusively passengers using public transportation. Hence, the user experience are from now on denoted passenger experience, having an equal meaning as user experience but within the specific area of public transportation.

Summary of theoretical framework

The passenger experience was the main focus throughout this study and development process. To be able to obtain the best possible passenger experience, the cabins had to be suitable for all passengers. Therefore it was crucial to base the study on society for all, since this theory exist to include all users. The usability forms a basic need to fulfill, and hence it had to be good if the desired passenger experience should become reality.

To implement user involvement at an early stage of the study was seen as a key factor in order to fulfill the previously described theories. It was seen as a beneficial and natural way to proceed when structuring the user centered study, and was expected to facilitate the process overall.

Method

Prototyping

Prototyping as a method of visualization, evaluation and validation of concepts is in many cases a central part of product development (Bligård, 2015). The prototype then represents an idea or concept before the product itself exists (Buchenau & Fulton Suri, 2000) and it is used for explorative and evaluative purposes (Bligård, 2015). It also enables for a shared 'design language' and thereby allows for communication both visually and direct between parties (Steen, 2011).

A within product development commonly used kind of prototype is the mock-up, which is a scaled or full-size model having at least partly the functions the real product would have (Bligård, 2015).

Interview

Interviews are a verbal form of information gathering from one or several parties (Egidius, 2008). The method is flexible and can be adapted to the current situation and the required type of output data, by varying the level of structure.

A semi-structured approach is a suitable strategy to use when gathering qualitative data (Bligård, 2015). Gathering of passenger insights is preferably conducted through qualitative research techniques, as they often allows for exploration and gaining deeper understanding of the likely users and their needs (Veryzer, 1998).

Semi-structured interviews follow a template, but also allows for improvisation and tweaking the questions, depending on the interviewee's answers or the context of the interview (Egidius, 2008). More structured interviews, following a pre-set template, are instead likely to rather generate qualitative data.

Consultation

Consultation is the process of a discussion with another person or group, often with required expertise, in order to get advice or opinions on a subject. Besides only supply with information, consultation can also aim to support decision making in specific areas.

Observation

Observations are visual studies of processes, with the purpose to study the actual acts and reactions of users towards products or stimuli. Observations are often used as complement to other methods of information gathering, such as interviews, since it enables rather objective studies of events.

There are several types of observations, and which type that is most appropriate to use depends on situation and purpose of the study. Direct observation is when an event of interest is passively studied directly by humans or an apparatus in an unaltered environment. When performing participatory observations the observers can instead be more actively involved and in a way become a part of the event of interest and interaction between users and artefact (Karlsson, 2007).

Observations are either open or hidden, referring to the observed user's awareness of the study. Open observation means that the studied user is aware of the event, but not necessarily have knowledge about the study's focus. Users in open observations are though likely to influence their behaviour in a way that deviate from the real use case, which increases the risk of bias (Jorgensen, 1989). Hidden observation instead enable more realistic studies to be made, but it can also generate large amounts of data which is probably not all relevant to the study's focus.

Affinity diagram

A method used for structuring and creating an overall picture of tasks containing large amounts of data, is creating an affinity diagram. Collected data is typically written on pieces of paper, where one piece of paper contains one unit of data. The data is thereafter clustered into categories based upon perceived affiliation. In turn, the fully established categories are organized according to affiliation in relation to each other. A relationship which is visualized through physical proximities in a tree structure. The strength of the method is that categories emerge naturally, which facilitates the process of understanding complex problems (Kaulio et al, 1999).

Requirement list

A requirement list is a way of spelling out the identified needs of a product or service. By establishing a requirement list, specific and measurable details of product performance are provided. The role of product requirements are to describe the key design variables and leave as little margin for subjective interpretation as possible (Ulrich & Eppinger, 2012).

Co-design workshop

Co-design workshop refers to an activity of user involvement where participants from various user groups actively interact and generate ideas based upon their own expectations and experiences. By interacting and building physical representations of ideas using props in a scenery, the participants have the possibility to quickly evaluate their own ideas and further develop ideas from others. By encouraging the participants to think out loud and comment their actions and creations one can reach a deeper level of understanding regarding participants' needs and expectations (Pettersson et al. 2015).

The method is conducted in a scenery, representing the intended environment, in order to enable participants to obtain a more realistic perception of the situation. The participants are assisted by supervisors, whose jobs are to challenge and spur the participants during the workshop.

Brainstorming

Brainstorming is a generative method commonly used to make a group of people generate a large amount of ideas in a short time. An input in terms of a problem or a theme is given to a group of participants, which then will present ideas to each other through sketches and discussions. No criticism of any kind is allowed during the session. A benefit of brainstorming is that participants can spur each other and further develop each other's ideas (Österlin, 2010).

Brainwriting

Brainwriting is an ideation method used to collectively generate ideas. An input in terms of a problem or theme is given to a group of participants, which then will present ideas to each other through sketches and discussions. The participants write and sketch ideas on a piece of paper and after a set time the participants switch papers with each other to get inspiration from the documented ideas of others. Participants thereafter either work further with others' ideas, or create all new ones. The benefits of brainwriting is that participants can inspire each other without risking their own ideas to be overshadowed by the ideas of others (Österlin, 2010).

Informal evaluation

Informal evaluation is a non-standardized activity used for assessing performance of a product or service. According to an associate professor at the division of Design & Human Factors at Chalmers university of technology it is based upon sound judgement regarding the chances of meeting the current needs. The method can be used to make efficient early selections among

large number of ideas or concepts, in order to narrow down towards finding a suitable solution using more objective evaluations.

The method is subjective, and should therefore not be used as the only alternative for evaluation. However, it is useful to sort out interesting ideas for further and more thorough evaluation.

Focus group

A focus group is a group of six to twelve persons (plus discussion leader), gathered to discuss a particular issue. The discussion leader guides the discussion through predetermined issues but can also allow for participants to develop their own topics of discussion. It is not unusual for product development processes that discussions in focus groups are held to evaluate and assess feelings and attitudes towards a product (Cross, 2008).

Usability test

Usability test is evaluations through observation of participants, representing real users performing real tasks with an artefact. Actions and comments of the participants during the test should be analyzed, preferably resulting in recommendations of changes for improved usability (Dumas and Redish, 1999).

Process

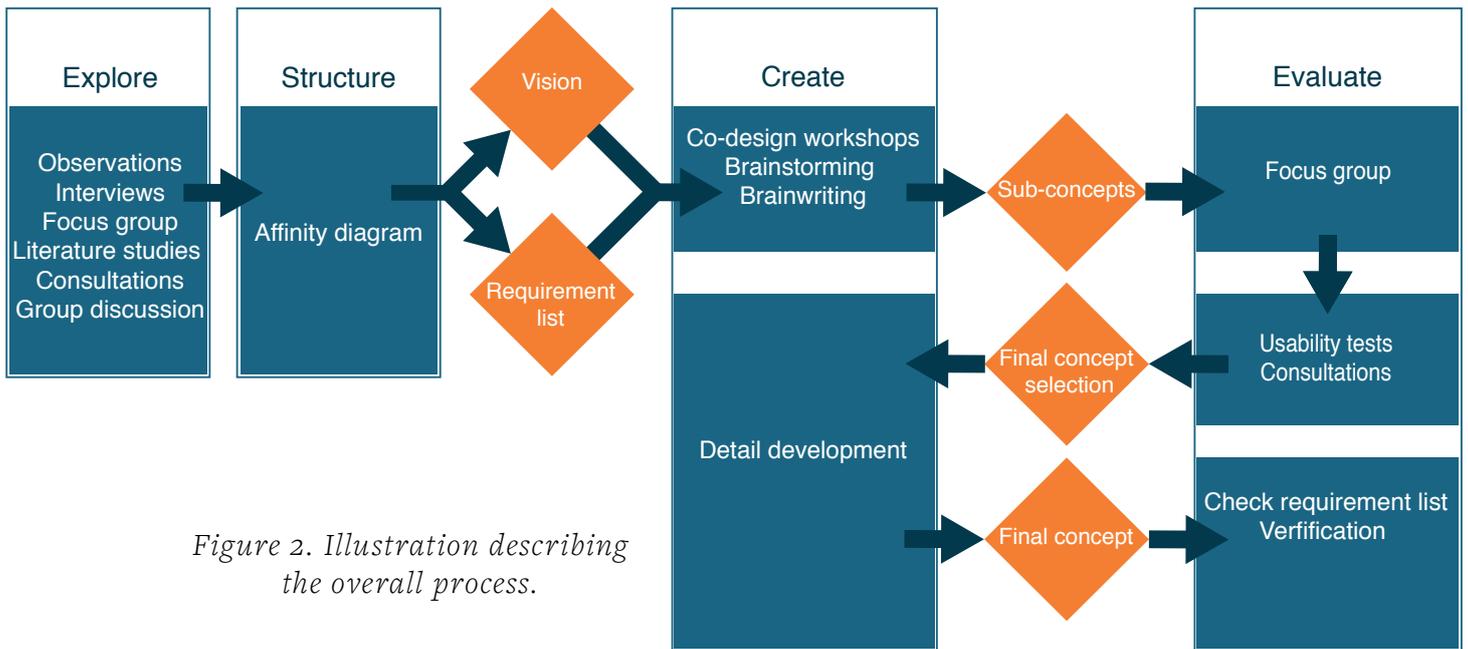


Figure 2. Illustration describing the overall process.

The conducted work process can be described with the overview seen in figure 2. The titles *explore*, *structure*, *create* and *evaluate* corresponds to the type of activities included in the different phases. Within the phases several used tools are listed in blocks, and a more detailed description of these are found later in this chapter. The orange rhombs between the blocks shows created deliverables.

The overview should be seen as a general description, and noticeable is that the iterative approach allowed for the work to go back and forth between the categories when needed. However, some of the major iterations between create and evaluate are shown also in the process overview.

Description of phases

Explore

The explore phase was initially about gaining knowledge of public transportation and cable railways in general. Then it turned into gathering insights about the passengers, to achieve understanding of their current situation and behaviour in public transportation. Focus was first set on gaining a broad general understanding, and later turned into a deeper and more detailed level. All prioritized passenger groups should be acclaimed, and a variety of tools were therefore used to cover them all.

Structure

To ensure that all important gathered insights were taken into consideration in a correct context, the relevant collected data was sorted out, analysed and structured. While this was done it also came clear what aspects that were most crucial to focus on, in order to achieve a good experience for the passengers.

Create

Create was a generative stage that diverged from the insights and conclusions from previous work. The results from the earlier phases were used as a concrete foundation for the development of ideas and concepts, in order to achieve the desired passenger experience.

The ideation and development work were done both within the project and together with potential passengers, as a part of the user involvement approach.

Evaluate

Evaluations have been made throughout the whole process, in order to ensure that the work was directed towards the set goals. The project group as well as potential passengers, experts and the cable railway project group have been involved in different evaluative activities, where the vision and the requirement list have been used as guidance.

Use of mock-up

To gather passenger insights, a simple full scale mock-up of the cabin space was constructed, for participants to experience elementary physical aspects such as form and accessible space. In addition to explorative and evaluative activities, the mock-up was used as a communication medium between parties during the development process.

Details and dimensions of the mock-up can be found in appendix 1.

Participants of interviews and focus group

Interviewees and focus group participants were chosen both through consultation of organisations representing specific passenger groups and through direct contact with individuals associated with one or multiple passenger groups.

According to Griffin & Hauser (1993) several studies indicates that about 80% of user needs are identified after eight to twelve interviews. Based upon these numbers, fourteen individuals was considered an adequate number of interviewees within this study, in order to cover the majority of the passengers' needs. Which passenger groups each of the interviewees represented can be seen in table 1, and the distribution of focus group participants are found in table 2.

Table 1. The fourteen interviewees from one or multiple prioritized passenger groups.

Interviewee ID number	Passenger group(s)	Access to mock-up
1	Visually impaired	No
2	Family with children, everyday commuter	No
3	Everyday commuter	Yes
4	Everyday commuter	No
5	Bicyclist, everyday commuter	Yes
6	Physically impaired	Yes
7	Senior citizen, physically impaired	Yes
8	Senior citizen, physically impaired	Yes
9	Senior citizen, physically impaired	Yes
10	Wheelchair user	Yes
11	Visually impaired	No
12	Everyday commuter	Yes
13	Everyday commuter	No
14	Everyday commuter, pregnant	No

Table 2. Declaration of participants in the focus group.

Participant ID number	Representing passenger group(s)	Access to mock-up
1	Everyday commuter, bicyclist	Yes
2	Everyday commuter, bicyclist	Yes
3	Everyday commuter	Yes
4	Everyday commuter	Yes
5	Everyday commuter	Yes

Phases in detail

Explore

Desired passenger experience

In order to understand the passengers' perspective of a good passenger experience, studies of their ideas of an ideal public transportation trip were carried out through interviews and consultations.

Performed activities:

- Semi-structured individual interviews with fourteen persons of one or multiple passenger groups. Information about the participants are listed in table 1. Focus on passengers' ideal experience in public transportation. A guide to the interviews can be found in appendix 2.
- Consultation with two co-workers from Västtrafik's passenger experience team. Focus was set on sharing insights and knowledge from recent year's studies of passenger experience among Västtrafik's customers. Details can be found in appendix 3.

Current behaviour

In order to understand the demands regarding the cabins from a passenger perspective, studies of current passenger behaviour were carried out through direct observations. Observations were conducted in a serie of different contexts, both in the city of Gothenburg and in two other European cities.

As it did not exist any urban 3S-cable railway systems in Sweden at the time, observations of urban cable railway passenger behaviour were carried out in German and Italian cities equipped with such cable railway systems.

As complement to the observations of European passengers' behaviour in cable railway cabins, observations of Swedish public transportation passengers were carried out. This was a way to be able to assess how Swedish passengers likely would behave in cable railway cabins. All observations were hidden to minimize risk of bias, as passenger behaviour was the main focus. Specifics of each observation setup is described in table 3.

Common focus for all mentioned passenger behaviour studies were:

- Activities which passengers engage in
- Passengers placement in relation to each other
- Passenger accessibility
- Physical support
- Flow and efficiency
- Standing vs. seated passengers
- Visible wear of vehicle furniture

Table 3. The place, type of public transportation, type of observation, and specific focus of the observations conducted.

Place of observation	Type of public transport	Specific focus of observation
Bolzano, Italy	Cable railway (Ritten Cable Car)	Number of seated/standing passengers, passenger positioning, passenger behaviour
Koblenz, Germany	Cable railway (TGD BUGA Seilbahn)	Number of seated/standing passengers, passenger positioning, passenger behaviour
Gothenburg, Sweden	Bus	Passenger interaction with other passengers and furniture, personal belongings
Gothenburg, Sweden	Tram	Passenger positioning, interaction with other passengers and furniture, personal belongings
Gothenburg, Sweden	Ferry (Älvsnabbare)	Bicyclists' behaviour when parking and walking with bicycle

A more detailed description of the observations can be found in appendix 4.

Identify needs

The passengers' needs that had to be met in order to achieve a good passenger experience needed to be identified. Therefore semi-structured interviews, consultations, studies of literature and group discussions were carried out.

Identify needs related to physical impairments

- Consultation with Samverkansgruppen (The collaboration group for physical accessibility in Gothenburg) to gather general information of how physical impairments affect passengers while using public transportation. (details in appendix 5).
- Consultation with physiotherapist, focus on assessing the necessity of physical aid for getting up/down from/to a seated position in the cabin (details in appendix 6).
- Semi-structured interviews with four persons (separately) with varying degrees of, or experiences of, physical impairments. Focus on collecting knowledge of the needs from passengers with different degrees of physical impairments. Interviews lasting 25-60 minutes (interview guide in appendix 2).
- Study of literature in order to gather information of existing recommendations and legislations related to passengers with physical impairments (details in appendix 7).

Identify needs related to pregnancy

- Semi-structured interview with pregnant woman. Focus set on collecting knowledge of needs for pregnant women using public transportation. Interview lasting 50 minutes (interview guide in appendix 2).
- Study of literature, to gather information about the physical and cognitive effects of pregnancy and special needs it brings, while using public transportation (details in appendix 7).

Identify needs related to families with children

- Semi-structured interview with a parent traveling with children in public transportation. Focus of the interview was to collect insights and knowledge about needs connected to traveling when traveling with children in public transportation. Interview lasting approximately 40 minutes (details in appendix 2).
- Study of literature, to gather information about childrens' needs in public transportation (details in appendix 7).

Identify needs related to visual impairments

- Consultation with Samverkansgruppen, to gather information of passengers with visual impairments in public transportation (details in appendix 5).

- Semi-structured interviews with two persons (separately) with varying degrees of severe visual impairments. Focus of the interviews was on how visual impairments affect passengers traveling with public transportation and connected needs related to various degrees of visual impairments. Interviews lasting 25-40 minutes (details in appendix 2).
- Study of literature related to visual impairments. Focus on gathering information of existing recommendations and legislations when designing for visually impaired passengers in public spaces and transportation (details in appendix 7).

Identify needs related to wheelchair users

- Consultation with Samverkansgruppen, to gather information regarding current problems and needs for passengers using wheelchairs in public spaces and transportation (details in appendix 5).
- Semi-structured interview with a wheelchair user. Focus set on how functional spaces should be designed for wheelchair users traveling with public transportation. Interview lasting approximately 40 minutes (details in appendix 2).
- Study of literature related to passengers with physical impairments. Focus on gathering information of existing recommendations and legislations for designing for wheelchair users in particular (details in appendix 7).

Identify needs related to everyday commuters

- Semi-structured interviews with eight everyday commuters (separately). Focus on the needs related to using public transportation on a daily basis. Interviews lasting 25-60 minutes (details in appendix 2).
- Group discussion with approximately 30 high school teenagers. Focus on the needs and desirables related to everyday commuting. Each discussion lasting approximately 15 minutes (discussion topics described in appendix 8)
- Study of literature about designing public transportations and passenger experience in general (details in appendix 7).
- Focus group with bicyclists and three everyday commuters, using a furnished mock-up. Focus was set on evaluation and further development of concepts. Session lasting approximately 45 minutes (details in appendix 9).

Identify needs related to bicyclists

- Semi-structured interview with a bicyclist. Focus set on maneuverability inside cabin, needs related to traveling with a bicycle and bringing belongings. Interview lasting approximately 40 minutes (details in appendix 2).
- Focus group with furnished mock-up participated by two bicyclists. Focus set on evaluation and further development of concepts. Session lasting approximately 45 minutes (details in appendix 9).

Identify needs related to senior citizens

- Semi-structured interviews with three senior citizens (separately). Focus of the interviews were the passengers' needs related to traveling with public transportation as a senior. Interviews lasting approximately 25 minutes (details in appendix 2).
- Study of literature, to gather information about needs related to physical support for senior citizens, applicable on journeys with public transportation. (details in appendix 7).

Integrate in Västtrafik's business

This was an explorative stage about integrating the cable railway cabins with Västtrafik's brand. The cabin interior should align with Västtrafik's visions and existing visual identity.

- Study of literature about Västtrafik and their vision of public transportation, both public and internal documents (details in appendix 7).
- Observation (direct, hidden) with focus on the existing interior design of vehicles used by Västtrafik, to align visual identity of the cable railway cabins (details in appendix 10).

Structure

Compile and structure insights

All gathered data was compiled and structured, in order to become graspable.

- Consultation with a cable railway project group member with insights in the development of public transportation vehicles at Västtrafik. Focus was set on assessing the gathered data and insights to be comprehensive enough to be used as a basis in the upcoming development process (details in appendix 11).
- Affinity-diagram established to structure and compile collected data into categories (details in appendix 12).
- Requirement list developed based upon the collected data. Categorized and structured according to the affinity-diagram (details in appendix 13).
- Establishment of a vision describing the best possible passenger experience for the cable railway passengers (details in appendix 14).
- Consultation with a Ph.D. Student in Human-Machine Systems for the Department of Product and Production Development at Chalmers University of Technology was conducted. Focus was set on verifying structure, comprehensiveness and objectivity of requirements (details in appendix 15)

- Consultation with two members of the cable railway project group at Västtrafik. Focus on aligning the development of concepts and vision with Västtrafiks regarding standards of passenger experience (details in appendix 16).

Create I

Generate ideas based on passenger groups

Ideas were generated based on each passenger group's specific needs and requirements. For this, co-design workshops, brainstorming and brainwriting sessions were conducted.

Generate ideas for passengers having physical impairments

- Co-design workshop (I) with four passengers (separately) and session leaders, using a mock-up. Ideation based on identified passenger needs due to physical impairments. Each session lasting approximately 10-15 minutes (details in appendix 17).

Generate ideas for pregnant women

- Brainstorming session (I) with pregnant woman and session leaders. Ideation based on identified passenger needs due to pregnancy. Session lasting approximately 10 minutes (details in appendix 18).

Generate ideas for families with children

- Brainstorming session (I) with a parent of two small children, traveling with public transportation, and session leaders. Ideation based on identified passenger needs related to traveling with children. Session lasting approximately 10 minutes (details in appendix 18).

Generate ideas for visually impaired passengers

- Brainstorming session (I) with two persons (separately) having varying types of severe visual impairments and session leaders. Ideation based on needs related to passengers having visual impairments. Each session lasting approximately 10-15 minutes (details in appendix 18).

Generate ideas for passengers in wheelchairs

- Co-design workshop (I) with a wheelchair user using electrical wheelchair type B and session leaders, using a mock-up. Ideation based on accessibility and interaction with other passengers. Session lasting approximately 20 minutes (details in appendix 17).

Generate ideas for everyday commuters

- Co-design workshop (I) with mock-up with three everyday commuters (separately) and session leaders. Ideation based on needs related to everyday commuting, each session lasting approximately 15-30 minutes (details in appendix 17).
- Brainstorming session (I) with four persons (separately) commuting on a daily basis and session leaders. Ideation based on found passenger needs related to everyday commuting, each session lasting approximately 10-15 minutes (details in appendix 18).

Generate ideas for passengers with bicycles

- Co-design workshop (I) with a bicyclist, a bicycle and session leaders using a mock-up. Ideation based on identified needs related to bringing a bicycle into tight spaces, storing a bicycle and interaction between passengers bringing a bicycle/the bicycle itself and other passengers. Session lasting approximately 30 minutes (details in appendix 17).

Generate ideas for senior passengers

- Co-design workshop (I) with mock-up with three senior citizens (separately) and session leaders. Ideation based on found needs related to aspects of aging. Each session lasting approximately 10-15 minutes (details in appendix 18).

Generate ideas for multiple passenger groups

To compile, align and further develop the created ideas into solutions including all passenger Groups, a final brainwriting session was conducted.

- Brainwriting session with the project members. Focus set on further developing subconcepts aligned with society for all, by generating partly new ideas and merging the output from previously generated concepts (details in appendix 19).

Distinguishing ideas

To start narrowing down the great number of created ideas an informal evaluation was performed, taking overall potential, feasibility and compatibility with all passenger groups into consideration. The requirement list was used as guidance. Two subconcepts with high potential and one reference concept were selected for testing and further development.

Direction of development

Through the informal evaluation conducted in the previous step three subconcepts with potential were selected and was about to be further developed through user involvement.

Evaluate I

- Focus group session with two session leaders and five participators representing bicyclists and everyday commuters. A furnished mock-up was used for the session. Focus was set on evaluating and further developing subconcepts. Session lasting approximately 45 minutes (details in appendix 9).

Create II

- Brainstorming session (II) with the project members. Focus was set on generating complementary ideas and further develop the accessibility inside the cabins. Passenger groups that got special attention here were bicyclists, physically impaired and wheelchair users (details in appendix 20).

Evaluate II

Testing cabin concepts

To assess the subconcepts' performance and fulfillment of passengers' needs evaluative usability tests were conducted. The tests simulated an as realistic experience as possible regarding the aspects in focus for each test. (picture from the usability tests is shown in figure 3).

- Usability capacity test with 25 passengers from the passenger groups everyday commuters, families with children and senior citizens. Focus set on evaluating usability and maximum capacity of the subconcepts with several passenger groups simultaneously (details in appendix 21).
- Usability scenario test with 25 passengers from the passenger groups everyday commuters, families with children and senior citizens. Focus set on evaluating the flow and the passengers' overall experience (details in appendix 21).

Create III

In this generative phase the subconcepts were further developed together with both experts and potential passengers.

- Co-design workshop (II) with a wheelchair user interacting in furnished mock-up. Focus set set on evaluating and increasing usability and accessibility for wheelchair users. Workshop lasting approximately 45 minutes (details in appendix 22).



Figure 3. Photo of the conducted usability test.

- Consultation with an expert in public transportation design, involved in the development of public transportation vehicles at Västtrafik. Communicating the layout through simple CAD-sketches. Focus set on verifying the overall design and aligning the final concept with Swedish standards of public transportation (details in appendix 23).

Final concept selection

Based upon the qualitative and quantitative findings throughout the study, a final concept selection was conducted, choosing the most suitable concept that combined the needs from different passenger groups for a good passenger experience for everyone.

Evaluate III

The evaluation phase was dedicated for verifying the final concept selected in previous phase and further develop the concept on detail level. A process which to a large degree was conducted with competence from external expertise and personnel from the cable railway project group at Västtrafik. Through the final phase all deliverables were developed, finalized and verified.

Verification of deliverables

In order to finalize the study result, the deliverables were verified by external expertise and members of the cable railway project group.

- Verification of final concept against requirement list (details in appendix 15).
- Consultation with two members of the cable railway project group at västtrafik. Focus set on verifying the study's result and deliverables together with the cable railway project group (details in appendix 25).

Result

Passenger insights

Accessibility

Interviews indicated that many impaired or in some aspect vulnerable passengers often feel unseen. As a reaction to this perceived situation, one interviewee (Int. 11) said: *“we just want to get the feeling of being thought of”*. This comment became a lead phrase for the following work within this study, to always keep in mind that all passenger groups should understand that they have been considered.

Wheelchair users

Wheelchairs are divided into different groups according to size and type. One of these groups consists of manual wheelchairs, which often are the smallest models. In addition to manual wheelchairs a variety of electrical wheelchairs are used, and these are divided into three classes: A, B and C. Class A are compact wheelchairs primarily intended for indoor use and the smallest of the three electrical types. Class B are wheelchairs both for indoor and limited outdoor use and class C are larger wheelchairs mainly intended for outdoor use. Today a lot of varieties regarding size are present in class C, and due to this there are limited measurement recommendations to be found for this group (Svensson, 2015).

When Västtrafik is developing vehicles for public transportation in Gothenburg they rely on directives from the European Union, saying that a space intended for wheelchairs should measure at least 130x80 cm (length x width). The used measure of the wheelchair itself is 120x70 cm, and it is valid for a manual wheelchair according to a cable railway project group member at Västtrafik. Since the cable railway, at the time this study was conducted, was

categorised as an elevator according to national regulations the requirements for wheelchairs in elevators were also current. The Swedish Standard SS-EN 81-70 (referred to in Svensson, 2015) requires a minimum of 200x140 cm to consider an elevator suitable for a wheelchair.

In addition to these measures requirements for public spaces and areas for other facilities than buildings have been considered. According to BBR 3:113 (referred to in Svensson, 2015) the measures of an electric wheelchair intended for limited outdoor use (also known as class B) should be dimensioning when assessment regarding accessibility is made. There should also be room for maneuvering a wheelchair, and if these requirements are fulfilled the space is categorised as accessible. BBR recommends a circular area of at least 150 cm in diameter to enable accessibility for a class B wheelchair.

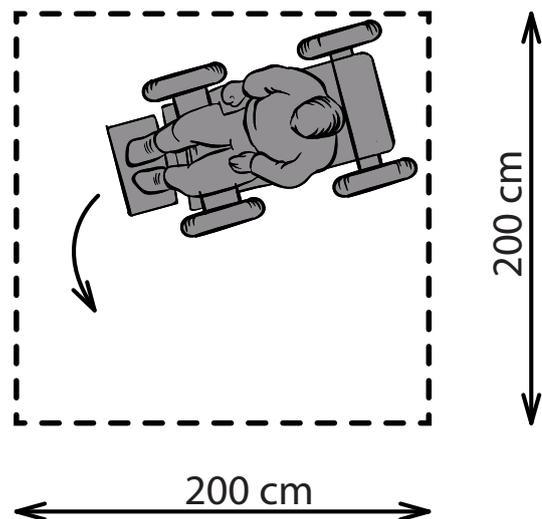


Figure 4. A squared area of 200x200 cm, where a class C wheelchair can turn.

ALM 5§ (referred to in Svensson, 2015) determines a circle with a diameter of 200 cm to be a suitable area when assessing the accessibility of an electric wheelchair built for mainly outdoor use (classified as class C). In addition to this, a squared space of 200x200 cm (as can be seen in figure 4) is considered to enable these class C wheelchairs to turn around, if driving forward and reverse (Svensson, 2015). A slightly smaller area, a circle with the diameter of 180 cm, should according to EN 12184:1999 (referred to in Svensson, 2015) be enough for a wheelchair of class B to turn around without having to reverse.

A manual wheelchair is considered to be able to turn around freely and comfortable within a 150x150 cm free space. Hence, if the requirements for wheelchairs of class B are fulfilled, manual wheelchairs users will have good conditions. Other measures that could be beneficial to consider is that two wheelchairs of class B can pass by each other if the passage's width is at least 160 cm, illustrated in figure 5, and a wheelchair driven by a helper requires about 175 cm in diameter to turn, as can be seen in figure 6 (Svensson, 2015).

A prerequisite for all the above mentioned free spaces to work for the wheelchair users is that it should be obstacle free. Any edge, protruding support or other objects encroaching the space decreases the possibility these passengers have to maneuver around (Svensson, 2015).

During observations and interviews it became clear that in existing public transportation solutions in Gothenburg maneuvering possibilities often lacked, due to a very limited amount of free space. This meant that it took extensive time and effort to board and disembark

vehicles when using a wheelchair. The most tangible problem was to fit a wheelchair into the designated area, which often was framed by physical boundaries (Int. 11).

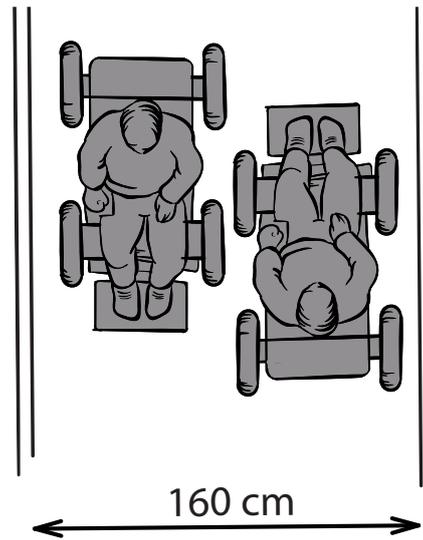


Figure 5. Recommendations of measurements enabling class B wheelchairs to pass by each other according to Svensson (2015).



Figure 6. The required diameter for a wheelchair driven by a helper to turn according to Svensson (2015).

A passenger request that occurred in an interview was that it should be possible for more than one wheelchair user to travel in the same cabin, to enable these passengers to travel with company. Interviewee 11 commented that it was often not possible for him to travel together with his wife in existing public transportation, since the vehicles could be limited to take no more than one wheelchair at the time. It was also mentioned that wheelchair users often got to sit where they could not see out through the vehicle's windows, and that: *"You are sitting in kind of a stall"*. It was also requested to be able to sit in the direction of travel. Overall, the wheelchair users did not feel prioritized and they had a wish to get the same opportunities as other passengers did (Int. 11).

One aspect that was a bit contradictory was whether it was preferred to have designated areas for wheelchairs or not. According to interviewee 11 and 13 it was desired to have specific and clearly marked places for wheelchairs and physically impaired passengers. But at the same time observations showed that many wheelchair users preferred other placement than the intended.

Within this study it was decided to not specify designated areas for any type of passenger, to counteract negative special treatment of any passengers and give everyone the same freedom of choice.

Key aspects for wheelchair users

- An electric wheelchair is expected to be able to turn around in an open space of 200x200 cm.
- It was requested to enable wheelchairs to be placed in the direction of travel.
- Capacity for more than one wheelchair at the time was desired.
- No designated areas for wheelchairs was used within this study.



Physically impaired and elderly

To be physically impaired could for example mean a limited mobility due to reduced functionality in arms, hands, torso or legs and it also includes decreased balance. Persons with physical impairments could be in need of different physical aids, such as wheelchairs, walkers or canes. Their need of physical aids often leads to limited access to free hands to use for support etcetera, and they could therefore be seen as “functionally one-handed” (Svensson, 2015).

Elderly often experience similar symptoms as physically impaired, resulting in for example difficulties to walk. But it can also be reduced reach and decreased sight or hearing. Some have just one of these impairments, but it is also common to suffer from a combination of two or more, and therefore experiencing larger limitations (Svensson, 2015).

The reduced mobility affects the speed of movement, and hence it could be problematic for these passengers to board and disembark public transportation vehicles. In interview 9 the following was said: *“I don’t have time to get off the tram, I can’t rise before the vehicle is standing still”*. In general, it is beneficial to keep large accessible spaces obstacle free. This was highlighted both by Svensson (2015) and in interviews with elderly and physically impaired passengers. Svensson pointed out that thresholds and other physical irregularities poses a risk for accidents. Interviewee 8 also said that: *“If we do get a large space to use for turning, it wouldn’t be a problem”*, emphasizing the importance of enough space to be able to move around inside the cabins.

Due to the passengers’ limited vigour and mobility, sufficient support while seated, sitting down and getting up is needed. *“Backsupport is important”* according to interviewee 9, who also claimed that armrests are preferred in relation to other types of handheld supports found inside public transportation vehicles in Gothenburg. The benefits from armrests compared to other alternatives, as well as the need of back support, was also attested by a consulted physiotherapist.

Something that was mentioned in multiple interviews, among others interview 8 and 9, was the desire of having accessible seats or places right inside the cabins’ doors. It was also requested in these interviews to have physical supports starting directly from the doors, leading to suitable seats or places. All supports should have high contrasting colouring, in order to be easy detectable also for those with reduced sight (Svensson, 2015).

Svensson (2015) highlights the needed possibility to hold on to supports with a “full handhold”, as shown in figure 7, which facilitates for those with reduced ability to grasp objects. More details regarding physical supports will be found in the section Physical support starting at page 52 below.

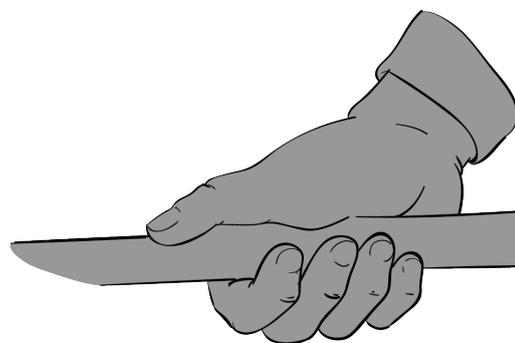


Figure 7. “Full handhold”.

When it comes to walkers, Västtrafik base their development on the reference measures 80x60 cm (length x width) regarding the actual walker, according to a cable railway project group member at Västtrafik with insights in the development of public transportation vehicles. However, according to Svensson (2015) it is difficult to walk backwards with a walker and a free space of 150x150 cm is required to turn around. Also, in interview 10 the interviewee requested to be able to keep the walker close to the seat. An example of a generic walker can be seen in figure 8.

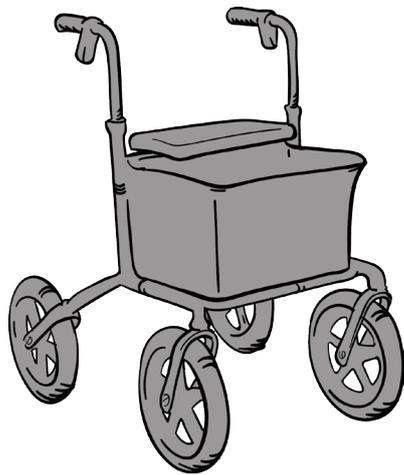


Figure 8. Generic example of a walker.

Key aspects for physically impaired and elderly

- To board and disembark can be problematic.
- Open spaces are helpful, but must be kept free from obstacles.
- Armrests and support for the back were desired.
- It was requested to have an accessible seat and physical support close to the doors.
- An open space of 150x150 cm are required to turn a walker around.



Visually impaired

Visual impairments cover a broad range of different symptoms, resulting in anything from slightly limited sight to full blindness. More severe impairments result in difficulties to pass large open spaces, avoiding obstacles and knowing one's position (Svensson, 2015). An example of this was given in interview 1: *"I don't want to walk longer distances in open spaces"*. An insight from interviews were that it was sometimes more important for these passengers to be able to stay right inside the doors than to have a seat. Comments like: *"I prefer if there is a space to stand directly inside the doors"* and *"I never go far inside a tram looking for a seat"* occurred during interviews (Int. 1 respectively Int. 12). *"Sometimes I stand in the area designated for prams"*, said interviewee 1, regarding that the most easily accessible areas are the most attractive and useful for her. However, if seats should be used, interviewee 12 requested permanent seats as a complement to foldable ones, since the foldable seats can be tricky to handle.

The areas where visually impaired passengers should move around need to be obstacle free and decluttered according to both interviews and Svensson (2015), in order to prevent accidents. A passenger with an escort requires an open space of at least 120 cm width to be able to pass, and about 200 cm for these two persons to be able to pass another passenger. If a passenger have a guide dog the equipage is free to move when the width reaches 110 cm.

An important support for visually impaired passengers is continuous tactile guidance (Svensson, 2015). It must be mounted in a way that enables the passengers to follow the support with their hands, without hitting their fingers on brackets or other objects in the surroundings. Unfortunately it was seen in Bolzano's cable railway cabins that the handrails were both discontinuous and had misplaced brackets interrupting the rails. A better example was found in Gothenburg's trams, where interviewee 1 thought it worked good. She also said that a useful physical guidance should be possible to follow throughout the vehicle.

According to Svensson (2015) handrails should measure 4 cm in diameter, and be placed on a height of 90 cm above the floor. Also recommended is following the colouring systems found in BBR 3:122 and 3:1423 as well as ALM 7 and 11 §§ (referred to in Svensson, 2015).

“Preferably, all cabins should look the same, then you know how they look”. This was a statement from interviewee 1, and it aligns with Svensson’s (2015) conclusion about that it is beneficial to have similar designs of spaces to facilitate recognition. Interviewee 1 continued with saying: *“It’s good to know exactly where to go when you board the vehicle”* supporting the conclusion of Svensson (2015); that a feeling of safety is created by knowing what to expect. Svensson also advocates a simple and logic plan, since that would aid the creation of a mental picture of the room. It should contain guide paths to follow and important areas should be highlighted with contrasting colours (Svensson, 2015 and Int. 12).



Key aspects for visually impaired

- Permanent seats close to the doors was requested.
- Recommended to avoid enforced walkways in open spaces.
- Continuous physical guidance should be provided directly from the doors.
- Handrails should be 4 cm in diameter and placed 90 cm above the floor.
- It was preferred to have identical cabins.
- Important areas should be marked with high contrast.

Pregnant women

It came clear during interview 15 that pregnant women are in need of good physical support, something that was confirmed by Kroemer (2006). According to Kroemer pregnant women often have difficulties remaining standing for longer periods of time. Interviewee 15 said *“The perspective is changed through a pregnancy. Now I prioritize to find a seat before getting to my destination sooner”*. Hence, having seats available was crucial for this passenger group while traveling.

The interviewee said that back support was important for her, and that it had to be of sufficient height which for her was at least shoulder height. Steady seats with high back supports were recommended by Kroemer (2006) as well. Armrests would be another desired feature according to interviewee 15, to facilitate getting up and down from the seat.

Key aspects for pregnant women

- Need of seats with high back supports.
- Supportive armrests were desired.



Families

Observations showed that most children were very interested of the view and wanted to see as much as possible of the surroundings outside the cabins. As a result of this, children tended to climb up in the seats in order to get a better angle. This was especially noticeable in Bolzano where all seats were facing into the cabins, and hence the children could not see through the windows without sitting on their knees turned around in the seats. In Koblenz the seats were turned the other way, enabling also the small children to sit on their bottoms and still get the desired view. It was also possible to stand close to the windows in Koblenz, which many children did looking both forward and down on the water. The same behaviour was described in interview 2, where it was stated that the family's children wanted to watch the outside while traveling with buses or trams.

Interviewee 2 talked about the need of having supervision of the children at all times. It was also important for interviewee 10 to be able to have the pram close to the seat. This was something that was obvious according to Berg, Pettersson and Zachau (1992), as well as that those seats should be easily accessible.

In addition to this, it was desired to have seats available for the children, since it was more stable for them to sit down than to remain standing. Permanent alternatives to foldable seats were requested, as it would be easier especially for smaller children to sit on those (Int. 2).

It was difficult to find sufficient space for prams in both Koblenz's and Bolzano's cabins. Once a pram was loaded into a cabin it was problematic for pas-

sengers to pass by. In Bolzano it was possible to place a smaller pram in the inner corners, taking up fairly few seats, but in Koblenz prams could not get much further than right inside the doors. Back in Gothenburg an interviewee (Int. 15) asked for open spaces to be able to maneuver the pram, and also not having any bars placed inside the doors interrupting those open spaces.

According to a cable railway project group member at Västtrafik, the used reference measure for prams made for one child is 60x80 cm (width x length). When it comes to double prams the measure can vary largely. As a reference for this study a model called *Emmaljunga Double Viking* was used. This pram measure 79 cm in width, and was the largest model found on the Swedish market while investigating the alternatives within this thesis project. Another reference used was the so called "*Stockholmsmättet*", which refers to a width of 75 cm (Stockholms Läns Landsting, 2014). This measure is commonly used within city public transportation to ensure prams can pass doors and fit in spaces etcetera.

Key aspects for families

- Desired to enable a good view for children without them having to place their feet on the seat.
- To keep supervision of children at all times should be enabled.
- Commonly used minimum measure adapted for prams' width: 75 cm.
- Västtrafik's reference measure for prams: 60x80 cm (width x length).

Passengers with bicycles

In a study conducted by Gullers Grupp (2016), it is made clear that many passengers would like to bring bicycles in the vehicles of Gothenburg's public transportation. It is however currently not allowed in other vehicles than the ferries across Göta Älv and local trains. Therefore, it was not surprising that most of the potential passengers participating in interviews, focus groups and tests were positive to the fact that the planned cable railway should allow for bicycles on board.

At the same time passengers whom might bring their bicycle, knew that it probably would not be all smooth for the other passengers inside the cabin. Interviewee 3 said: *"I would have felt 'oh no, how disturbing I am' and therefore left the bike instead"*.

During a focus group a passenger with a bicycle thought that he would probably lean the bike on to the wall or foldable seats. If not, he would probably sit down where he could keep the bike next to him during the journey. The same participant mentioned the fastening devices used on Öresundstågen (see figure 9) as a good solution if the bicycle should be fastened, an opinion that the other focus group participants agreed to.

The cabins used in Koblenz's cable railway were in many ways narrow and inaccessible for passengers with brought belongings, such as bicycles. If a bicycle was brought on the journey, it was often loaded last and then unloaded first when arriving the next station, since it was difficult for other passengers to pass by when the bicycle was placed inside the cabin. This was no major problem when there was just two stations in the system, but with Gothenburg's planned four stations it would set higher demands regarding the possibilities to load and unload a bicycle at any time. Bolzano's cable railway did to some extent have similar problems, since it was difficult to pass by a bicycle inside the cabin, due to the rails in the middle of the cabins. But the solution as a whole was more spacious than Koblenz's.



Figure 9. Fastening device for bicycles on Öresundstågen.



Figure 10. Bicyclists leading the bicycle on their right side when boarding one of the ferries that are used for public transportation in Gothenburg.

Regarding how a bicycle is loaded and unloaded, the small study of passengers traveling with one of Västtrafik's ferries in Gothenburg showed that 98 out of 98 lead their bicycles on the right side of their bodies, as shown in figure 10. As a result of this, in combination with testing during interviews, it was concluded that it is most beneficial to turn a bike around anti-clockwise, since that would be the most space efficient. In one of the interviews (Int. 6) it was said that *"I don't want to reverse the bike, either on the way in or out of the cabin"*, and hence it was due to her preferred to turn the bike around inside the cabin if possible.

Key aspects for passengers with bicycles

- Need of open spaces to accommodate a bicycle.
- Fastening devices found at Öresundstågen was useful.
- Bicycles were lead on the right side of the bicyclists, facilitating anti-clockwise turns.



Reason to choose the cable railway

In a study conducted by Expedition Mondial (2017) on behalf of Västtrafik, two very different reasons for choosing to travel with the cable railway came clear.

One of the reasons were to simply take the fastest and smoothest way with public transportation. If other alternatives would be more advantageous regarding these aspects the cable railway would most likely not be chosen as transportation for this group of passengers. This is typically everyday commuters that use public transportation as an efficient way to get to and from their work. Comfort and to have a pleasant journey could add on to the experience, but might not be seen as absolute top priorities. During interviews comments like: “*A cable railway is nothing peculiarly. I should move from A to B*” (Int. 8) appeared.

The other identified group had the journey itself as goal, it was seen as a spectacular activity to take the cable railway and look at the view. This group could be tourists, but also citizens from Gothenburg traveling with the cable railway as something extra in the everyday life. However, the view was the main attraction and prioritized for this passenger group.

Västtrafik’s intention was, in line with Expedition Mondial’s recommendation, to focus on the experience for the everyday commuters in first hand. As a complement to this, the tourists’ interests would be prioritized to as large extent as possible, without disturbing the experience for the commuters.

Key aspects for choosing cable railway



- Two main reasons for choosing the cable railway:
 - For efficient commuting.
 - For pleasure.
- To provide a smooth and efficient commuting was prioritized.

One design vs. multiple designs

During the thesis project it was mentioned comments both pro and against a single design of the cabins. Both wheelchair users and bicyclist thought it would be beneficial to have some empty cabins in the system, that would enable these units to travel together with minimal interference and disturbance of others. At the same time the Collaboration group for physical accessibility advocated solutions that were not separating some passengers from others. They preferred solutions where impaired passengers would not have to behave any different from other passengers. One specific advantage of a single design of the cabins was that it would facilitate for visually impaired to know what to expect before entering a cabin.

However, since the cable railway is something all new to Gothenburg, it is developed more or less from scratch. This enables most parts to be well adapted to the current conditions from the beginning, if all important aspects are taken into consideration from the start of the development. Hence, it seemed possible to find a single design that could be suitable for all passenger groups. If a single design could be proven to fulfill the requirements it would then be preferred to avoid multiple different solutions.



Key aspects for cabin design

- A single design would preferably be applied to all cabins.

Flow and efficiency

“Well, that’s the most important in public transportation: the flow. That it works. It’s not amusement journeys” (Int. 14). This is a comment from an interview with a commuter, and it is similar to comments from many other interviews within this study as well. The flow and efficiency during a journey with public transportation seemed to be the most important aspect to consider to achieve a good passenger experience for commuters, based on what was said in interviews. The same conclusion was also drawn in Expedition Mondial’s study (2017); to travel with the cable railway must be faster, smoother and smarter than the alternatives if everyday commuters should chose this way when heading to work.

As a part of this smooth and flowing experience, the boarding and disembarking phase turned out to be crucial, based on both tests, focus groups and interviews. An example from an interview is *“Since it is so short journeys it is probably most important to get on and off easily. There can’t be troubles around the doors”* (Int. 14). Warsen and Leander (1999) also highlight the importance of the passengers’ experience during these phases as a major part of the overall experience.

When looking into short journeys, with just a few stops included, in Gothenburg’s existing public transportation it was seen that passengers tend to stay close to the doors throughout the journey. This situation was commented by interviewee 5, who found it very annoying when other passengers were blocking the doors instead of using the rest of the vehicle’s internal space. At the same time interviewee 14 said *“If you’re getting off you don’t want to be trapped inside”*, showing the reason

for passengers staying adjacent to the doors. These insights led to a conclusion about that it must be possible to maintain a good flow within the cabins, especially close to the doors.

In addition to the commuters' desire to achieve a good flow, it is crucial for physically impaired and elderly passengers to be able to board and disembark the cabins within reasonable time. The studies conducted by Gullers Grupp (2016) and Västra Götalandsregionen (2016) underlined that it must be easy to board and disembark the vehicles, especially for elderly, physically impaired and passengers with prams. An earlier mentioned comment from interview 9, *"I don't have time to get off the tram, I can't rise before the vehicle is standing still"*, further confirmed the problem. Easiest and shortest possible way from the doors to a suitable place or seat was considered to be a solution in this situation.

Existing solutions, both in Gothenburg, Koblenz and Bolzano, were limited when it came to accessibility for wheelchair users and passengers with for example prams, walkers or bicycles. It was requested in Gullers Grupp (2016) to have a more flexible interior in the buses for line 16 in Gothenburg. The participants in the study suggested comfortable foldable seats as an alternative, giving more free space for passengers with belongings of different kinds. It was seen during observations in Gothenburg's public transportation that these belongings, such as prams, often had to be left at a different location in the vehicle than the passengers were able to sit in. Hardly surprising, this was something undesirable according to this study.

In Bolzano it was possible to fold a part of the bench away (see figure 11-12), creating more free space within the cabins, but the solution was not easily detected. Without the bench folded away the free space inside the cabins were limited, mostly due to a support placed in the middle of the otherwise open space. However, the situation in Koblenz was even worse, since the interior placement did not leave much free space at all. Passengers bringing any larger belongings were forced to keep these right inside the cabin's doors, hindering other passengers from moving around.



Figure 11. Foldable seat in one of the cabins at the Bolzano Rittner Seilbahn.



Figure 12. Upfolded seat in one of the cabins at the Bolzano Rittner Seilbahn.

It was concluded throughout this study that it must be possible for all passengers to stay out of the main flow. An interviewee (Int. 9) commented that “*You shouldn’t have to be afraid of getting run over*”, which was an indication of this need. It was also seen in both Koblenz and Bolzano that it was easy for passengers for example traveling in a wheelchair to end up sitting right in middle. This meant that these passengers both often ended up in the main flow and were sitting in the center of others’ view, causing an unpleasant feeling.

Another insight from observations was that neither Koblenz’s or Bolzano’s cable railways had more than a start and an end station. Hence, the flow inside the cabins did not affect the passenger experience to any higher extent, since all passengers was boarding and disembarking at the same time. In Gothenburg the situation will not be the same, due to the planned four stations along the railway. Instead, passengers will have to board and disembark while other passengers do not, and vice versa. This will lead to a much higher demand regarding the flow inside the cabins, to maintain a good passenger experience throughout the journey.

Key aspects for flow and efficiency



- An efficient flow was considered to be one of the most important aspects.
- Flow when boarding and disembarking was especially crucial.
- Accessible seats close to the doors were required to facilitate boarding and disembarking for vulnerable passengers.
- It was desired to keep brought belongings, such as prams, close to oneself.
- Passengers should preferably be enabled to stay out of the main flow.

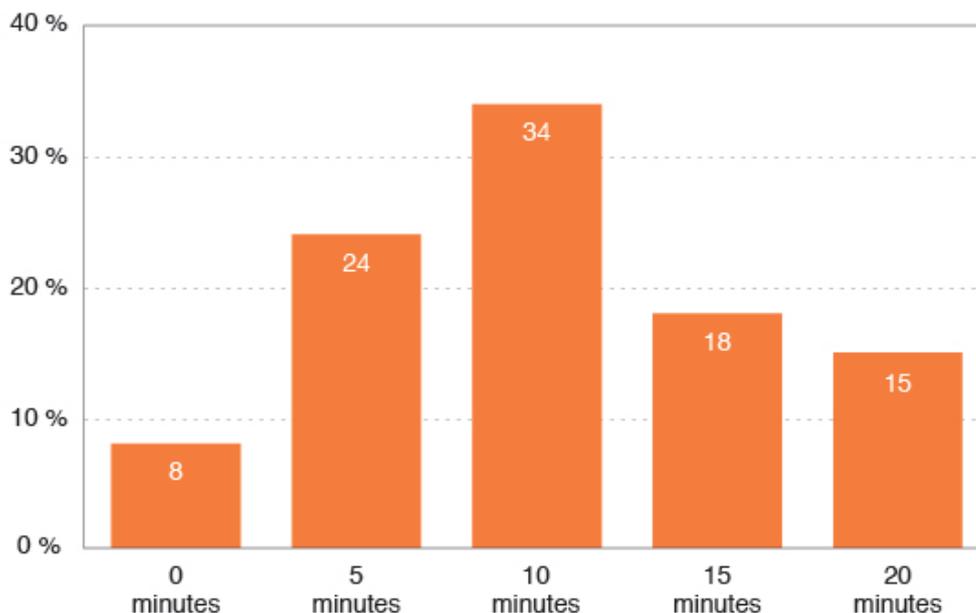
Standing vs. seated

In a study conducted by Västra Götalandsregionen (2016) the question “During rush hours, for how long is it OK for you to stand up on trams and buses?” was answered by 6338 respondents. As seen in graph 1, 33% could accept standing for 15 minutes and an additional 34% could stand for maximum 10 minutes. Gothenburg’s cable railway were planned to take 11,5 minutes from start to end station, which means a rather high percentage of the passengers could accept standing during most of the journey. But there was also 8% that needed to be seated all the time.

In interviews a variety of attitudes to standing were presented; “I chose to stand, it’s better for my back” (Int. 8), “If I’m just traveling four minutes I almost don’t bother to sit down...” (Int. 3) and

“I want to sit down and lean against something” (Int. 5) were just a few comments heard. Some passengers felt that maximum capacity was prioritized before a high number of seats, but most agreed about that at least some seats were needed anyway. Most passengers were also unanimous regarding that if the cabin was not crowded they would likely be seated. In addition, it was seen during observations that seated passengers in non crowded vehicles tend to stretch out when possible.

Interviewee 12 concluded the situation with the comment “You have different favourite places at different stages of life”. Regarding flexibility, interviewee 3 said “A good thing with the buses is that you can chose how to travel based on the situation you’re in today. Like ‘today I have brought this with me, and then I’d like to sit down”.



Graph 1. Distribution of answers to the question “During rush hours, for how long is it OK for you to stand up on trams and buses?” adapted after Västra Götalandsregionen (2016).

Flexibility due to situation seemed to be a key to find a good balance between the number of seats and space adapted for standing passengers. Berg, Pettersson and Zachau (1992) summarised that those passengers not getting a seat would of course have wanted more seats. And also that those seated would have got higher comfort from more space for their legs, but the opposite applies for the ones standing. Hence, foldable seats or supports to lean on to was suggested as a part of a balanced solution.



Key aspects for standing vs. seated

- 67% of the passengers could accept standing for 10 minutes.
- 8% of the passengers needed to be seated at all times.
- Flexibility was requested, regarding seats or places to stand.

Physical support

All vehicles in public transportation where passengers are expected to travel without sitting down must give other alternatives for support. Both in observations and interviews (among others Int. 6 and 10) in Gothenburg it came clear that passengers in general wanted something to hold on to during a journey. However, the visit in Koblenz and Bolzano proved that this type of cable railway move smoothly, not at all like existing buses and trams in Gothenburg. Most of the time it was barely needed for passengers standing on both feet to hold on to something. It was though preferred to have some physical support for example while the cabins passed the towers, due to sometimes unexpected movements.

The cabins in Koblenz were clearly designed for seated passengers, and there was not much support for hands available. In Bolzano a support was placed in the cabins' middle, making it reachable from almost all the cabin, but it did also take up what could have been free space to use for wheelchairs or prams etcetera.

It seemed as passengers in general preferred vertical handrails, before horizontal alternatives, something that was both seen during observations and discussed in interviews. An efficient solution found in Gothenburg's public transportation was handrails leading from the seats' backrest and up to the ceiling.

As earlier mentioned it would also be beneficial for elderly and physically impaired to have handrails that allow for a full hand grip to be used. Regarding these passenger groups it was more important to have something steady to lean on to than to just grip (Svensson, 2015), and hence horizontal handrails would also be needed.

It was prioritized, especially for vulnerable passengers, to have steady available supports within reach. Interviewee 8 and 9 said that they needed something to hold on to directly while entering the vehicle and interviewee 10 mentioned that it could sometimes be difficult to reach the handrails inside the doors of Gothenburg's trams. To have guidance all the way from the doors to a suitable place or seat was also something requested for visually impaired passengers. Rigid supports were preferred before for example slings hanging from the ceiling (as seen in figure 13), and these slings were often seen as a last way out (among others Int. 14 and 15).

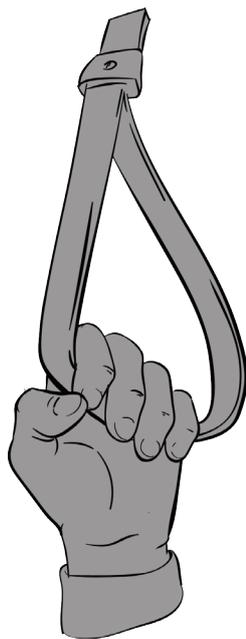


Figure 13. Sling hanging from the ceiling.

In interviews, such as interview 8, it was often mentioned that backrest was desired while seated, which aligned with insights from observations. Koblenz's cabins lacked backrests, but then some passengers tried to lean on to a metal fence in the middle even though it was clearly uncomfortable (shown in figure 14).



Figure 14. Metal fence in the middle of Koblenz's cable railway cabins.

A feature that could be both very helpful and disadvantageous was found to be armrests. To have armrests was requested from elderly and physically impaired as well as pregnant women. The presence of those would help these passengers to get up and down from seats, but it was also mentioned during interviews with for example a physiotherapist that the armrests could be in the way for other passengers. Interviewee 10 said "I want armrests, something to hold on to to get up" and in contrast it was heard from interviewee 15 that "Armrests are in the way more than they're helping". Hence, if armrests should be a part of the interior they should preferably be possible to fold

away. Supports to lean on to was popular among passengers in Gothenburg, something that came clear both during observations and interviews (Int. 6 and 14 among others). This alternative was attractive for shorter journeys, instead of finding a suitable seat. According to interviewee 14 *“You can relax when leaning against those supports. Rather than than just standing”*. When supports were not available passengers could also be seen leaning on to vertical handrails or walls inside vehicles, something that was also mentioned as an alternative due to interviewee 13 and 14.

Bolzano’s cabins had a version of support to lean on to, seen in figure 15, but the horizontal rail above it made the support difficult to use since the passengers’ heads were on the same height. It was also placed rather high, resulting in shorter passengers having problems to get support other than for the lower back. In contrast a better solution was found to be to combine foldable seats and supports to lean on to. When the seats were not used for sitting they were folded up and could instead be used to lean on to. Some different examples of this were found in Gothenburg’s public transportation, see figure 16.

To summarize, supports needed to be varied and flexible. Some passengers wanted to use their hands to get supported and some wanted the opposite. Hence, alternatives for both would preferably be provided.



Figure 16. Support to lean on to in Gothenburg’s public transportation.

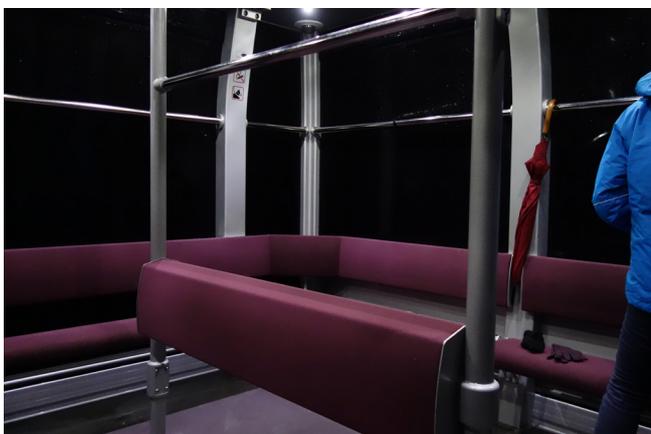


Figure 15. Support to lean on to in Bolzano’s cable railway cabins.

Key aspects for physical supports



- Handheld supports were needed.
- Steady supports directly inside the doors would be beneficial.
- Slings hanging from the ceiling is preferably avoided.
- Back supports and armrests were requested.
- Supports to lean on to were frequently used in Gothenburg.
- Different alternatives for physical support is needed.

Passengers in relation to each other

Berg, Pettersson and Zachau (1992) described in *En gemensam resa mot bättre vetande om stadsbussar* that if passengers in public transportation achieve a feeling of having their own territory, their psychological comfort is increased. The passengers' need of that physical territory as well as personal integrity and perceived safety, is also highlighted by Warsen and Leander (1999). It was furthermore discussed in interview 6; "You want to have your personal space". A clear connection was therefore found between maintaining one's personal space and obtaining comfort.

Hall (1966) described humans in western cultures as having four interpersonal distances, presented in table 4. A generic visualisation is also to be seen in figure 17.

To enter someone's personal zone is normally an indication of familial relationship (Hall, 1966). However, in modern western cities exceptions from these zones are often current in crowded situations, such as in public transportation. This entails all passengers must accept to let some

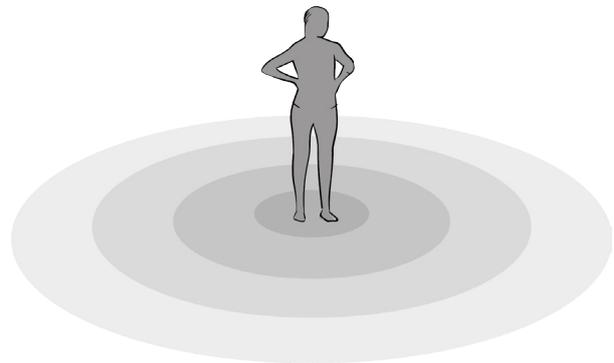


Figure 17. A visualisation of the four interpersonal zones.

of their personal space go, in order to enable the common journeys, which is a trade that must be remembered while designing these environments. Since the cable railway cabins measure 300x300 cm in total, fellow passengers will guaranteed be at least within the social zone but likely also significantly closer. Two concrete examples of how this can affect the passengers are the unwillingness to have other passengers passing by, close behind one's back, while seated and the disinclination of eye contact.

Table 4. Hall's four interpersonal distances.

Interpersonal zone	Distance from body	Description
Intimate zone	0-45 cm	Intimate relationships.
Personal zone	45-120 cm	Friendly conversations.
Social zone	120-360 cm	Brief acquaintances.
Outer zone	360-760 cm	Public zone.

To make eye contact with others is one of the behaviours that changes when getting into impersonal situations, such as in public transportation. It can be perceived as disturbing and is therefore avoided (Karlström, 1998). This was verified in interviews, when comments like; *“I never sit opposite another passenger... ..It is unpleasant to sit and look at someone”* (Int. 3) occurred. Berg, Pettersson and Zachau (1992) talks about that passengers have to stand many compromises while sharing environment with people they normally would not have socialised with. Hence, they suggest that the seats’ placement should not always impose passengers to make eye contact.

It was seen in both Gothenburg, Koblenz and Bolzano, that passengers tend to spread as much as possible when choosing where to sit or stand. In Bolzano’s cabins, the passengers entering first, often chose a corner to sit in. When all corners were filled, the next passengers placed themselves in the middle of the seat row between the corners. A similar behaviour was found in Gothenburg and Koblenz, where passengers chose a free pair of seats, before a single free seat, even when traveling alone. In interviews, requests for a possibility to sit separated from others appeared, as a way to know that no one is going to sit down next to them (for example Int. 13).

Passengers in Gothenburg, in general, show acceptance towards crowded journeys during rush hours (Gullers Grupp, 2016). The same study did though highlight that less crowded journeys were perceived as much more comfortable and attractive. Hence, to minimize the perception of crowdedness enables an enhanced overall passenger experience.

According to an expert in public transportation design, a rule of thumb commonly used by Västtrafik when designing interior environments in public transportation, is to have a maximum of four individuals per square meter.

Key aspects for passengers in relation to each other

- Passengers perception of having personal space experience increased passenger comfort.
- Enforced eye contact should be avoided.
- Seats should preferably not be turned to each other.
- The perception of crowdedness should be counteracted.



Passengers' activities during a journey

It was possible to see some differences between the passengers' behaviour in Koblenz's cabins compared to Bolzano's. These differences were considered to be connected to the difference in purpose of traveling; Koblenz had almost exclusively tourists, and Bolzano had a mixture of tourists and commuters. In Koblenz, the passengers paid much attention to the view, taking pictures and talking to each other about what they observed. In Bolzano, a similar behaviour was seen among the tourists, but in addition many commuters used the cable railway as a daily transportation. The commuters in Bolzano instead had much in common with the commuters in Gothenburg. The conclusion was therefore that in this sense, traveling with cable railway is similar to other public transportation.

Activities addressed by commuters, seen during observations as well as mentioned in interviews and focus groups were:

- Using a mobile phone
- Watching the view (absently)
- Reading a book/
magazine/newspaper
- Talking to passenger(s)
in company

Since the journey with Gothenburg's cable railway is planned to be no more than 11,5 minutes, the participants in this study concluded themselves that they would likely not have time for much activities during a journey. The same was also mentioned by Gullers Grupp (2016), summarising that for example enabling work to be done during the journey was not as important for short journeys, as for longer commuting.

A selection of comments from interviews, regarding what activities the passengers would like to address during a journey of 3,5-11,5 minutes is presented in figure 18.

"If the journey is 4-12 minutes I won't be doing anything. I'll probably stand watching the outside or other passengers" (Int. 14)

"I listen to music and look out through the window" (Int. 6)

"I just let the time pass by" (Int. 8)

"I use my phone, maybe I read the newspaper" (Int. 5)

Figure 18. A selection of comments regarding what activities passengers would address during a journey of 3,5-11,5 minutes.

Another way of seeing the time spent in a public transportation vehicle was found in *Utformat för kvalitet* (Wassén and Göthlin, 1993); *"It is about a useful function that gives the passenger the well being and satisfaction that transform the journey from lost time to a moment of enjoyment and well spent lifetime"*

Key aspects for passengers' activities

- Common activities addressed during a shorter journey:
 - Using a mobile phone
 - Watching the view (absently)
 - Reading a book/
magazine/newspaper
 - Talking to passenger(s)
in company



Freshness

According to both literature and interviews, the cabins' freshness was important in order to obtain a good passenger experience. Participants in this study said "*It should be intact, clean and functional*" (Int. 14) and "*Clean and tidy inside of the vehicle is important!*". It aligns with the preference of Warsen and Leander (1999), stating that a clean and fresh environment inside vehicles must be maintained.

One way to enable long-term freshness inside the cabins would be to facilitate the cleaning process. Surfaces that are easy to clean is advantageous also for passengers with allergies, since they can suffer from particles in the dust (Svensson, 2015). In Bolzano it was seen during observations that the interior cleaning went smooth, due to the floor being all decluttered. All seats were attached to the walls, and the only item being mounted to the floor was the support in the middle. Seats being mounted to the floor, or close to the floor, would instead aggravate the cleaning and should therefore be avoided due to Berg, Pettersson and Zachau (1992).

Regarding how to obtain freshness for seats, different opinions were heard in interviews. Interviewee 14 thought it gave a more pleasant feeling when having textile on the seats and that the textile on existing seats in Gothenburg's public transportation were surprisingly fresh. On the other hand, interviewee 10 thought it was unhygienic with textile on seats, and that it was unpleasant to sit with bare legs in direct contact with it. According to interviewee 8, it was far more important that the seats were easy to keep clean, than that they were comfortable.

Another aspect noticed, both in observations and interviews, was the need of counteracting passengers placing their feet on surfaces intended for sitting. During observations in Gothenburg, passengers were seen placing their feet on the seat in front of them, inbetween the lower part of the seat and the backrest, while there was a distance between these. If seats were turned, facing each other, some passengers also tended to place their feet on the opposite seat. This behaviour was perceived as disturbing to passengers participating in interviews, for example (Int. 8 and 13).

Key aspects for freshness

- Cabins' freshness was important for passengers' experience.
- It was advantageous to facilitate cleaning, for example by not attaching seats to the floor.
- The design should counteract passengers placing their feet on the seats.



View and direction of seats

Most passengers participating in interviews, were positive to being able to look at the cable railway's surroundings. It was commonly mentioned, that they like to sit and observe the outside in existing public transportation, and thought they would do the same in a cable railway as well.

“I think it's nice to look outside” (Int.3), “I sit and watch the outside. I'm very interested in what's going on out there” (Int. 9) and “It's a bit boring when you travel with subway, you would have wanted to look outside” (Int. 14) were all comments from interviews.

In contrast, interviewee 8 said *“I've seen the river. When you've traveled with the cable railway twice you've seen it all”.*

Expedition Mondial's study (2017) concluded that tourists valued the view, but commuters did not. Despite this, it was mentioned as something important in most interviews conducted as a part of this study. It was therefore concluded that there was probably mainly a difference in *how* these different passenger groups used the view. The commuters did also value the view to some extent, although not as a main attraction but as a relaxing pastime. It was seen in observations that commuters tended to pay more attention to their mobile phones than to the outside view, but it was not unusual to see them absently watching the outside either.

In Koblenz, it was very clear that the passengers chose seats according to direction of travel, all passengers sat down facing forward. In Bolzano, it had to be a compromise, since the seats closest to the direction of travel were turned with the backrests forward. The passengers were not able to sit in the direction of travel and have a good forward view at the same time.

In Gothenburg, both observations and interviews indicated that passengers in general preferred to sit in the direction of travel.

An aspect to consider when it came to direction of seats was motion sickness. It occurs when movement perceived by visual stimuli contradicts the movement perceived by the vestibular sensory system (Benson, 2002). Turner (1999) claimed that motion sickness can be significantly reduced by providing a good forward view. He thereby suggests maximised external visibility for all passengers in order to reduce motion sickness. In two interviews (Int. 3 and 15), it was also said that the interviewees get sick while traveling backwards.

It was concluded within this study, that it would be beneficial to provide a good view for the passengers, preferably in all four directions, but especially forward. The good view should also be available for all passengers, independently of placement inside the cabins, if possible.

Key aspects for view and direction of seats

- Enjoying a pleasant outside view was seen as a main attraction for tourists, and a relaxing pastime for commuters.
- Seats should preferably be placed in the direction of travel.



Perceived safety

The study conducted by Expedition Mondial (2017) concluded that perceived safety onboard the cabins was one of the passengers' main priorities. This was aligning with the overall perception from this study, where the safety was a frequently mentioned subject in interviews and focus groups.

Examples of what was brought up when talking to potential passengers, were that it was desirable to see the entire cabin, and not have a large number of other passengers moving behind one's back while seated. In interview 10 the following was said: *“Safety before view. I don't want to sit with my back towards the inside of the cabin”*.



Key aspects for perceived safety

- The perception of safety onboard was considered very important by the passengers.
- It was desired to be able to see the entire cabin.
- It was seen as an uncomfortable experience having a large number of passengers moving behind seated passengers' backs.

Integration in Västtrafik's business

Västtrafik's vision

The following vision was stated in Västtrafiks årsredovisning 2016 (Västtrafik, 2017):

“Våra kunder ska resa med oss för att de vill, inte för att de måste”

Translated to english the same vision becomes:

“Our customers should travel with us because they want to, not because they have to”

Västtrafik's visual identity

Västtrafik has got similar blue textiles on the seats in most of the vehicles used within their business. The pattern varies to some extent, but it is still overall perceived as a similar fabric due to the structure and colour as shown in figure 19. The choice of textiles allow all different seat models to be perceived as suitable within Västtrafik's visual identity, despite sometimes large deviations in design.

Handrails and other important areas in general, share a similar yellow colour, to contribute with a high contrast to the surroundings. This contrast facilitate for many passengers to easily find a suitable support during the journey.

To achieve an aligning experience when entering a cable railway cabin as when entering a bus or tram in Gothenburg, it would be beneficial to continue using seats and textiles of similar types. The same also applies for the colouring and dimensions of handrails.



Figure 19. Collage of existing interior in public transportation vehicles used by Västtrafik. Top left: Fredrik Tellerup (2013), top right: @bussarlerum (2016), bottom left: @bussgbg, bottom right: Anton Andersson (2015).

Vision

The vision was based on findings from the pre-study, and highlighted the essence of prioritized aspects, that was identified together with Gothenburg's cable railway project group. It combined desired qualities that were frequently mentioned during interviews with Västtrafik's own vision. This resulted in a common vision for the passengers' and Västtrafik's interests. It was used as guidance throughout this thesis project, to ensure the work was aiming towards the desired results and kept in line with the cable railway project as a whole.

*”A **smoothly** flowing and **uncomplicated** journey, in a **clean** and **comfortable** environment, enabling **all passengers** to get a **relaxing rest** with a **view** of Gothenburg.”*

Requirement list

The insights gained throughout the pre-study lead to the compiled requirement list. It covers all aspects found to be important regarding the study's scope for the cabins' interior design, in order to achieve a good passenger experience for all.

The full list can be found in appendix 13, but below a brief summary of the five requirement groups are presented, together with some examples from each group.

Flow

According to the pre-study, one of the most important aspects to take into consideration was the flow inside the cabins. It was frequently mentioned during interviews, that it was important to have a smooth and trouble free journey with easy boarding and disembarking. Hence, these requirements must be taken into consideration while developing the interior. Requirements found in this group are for example *The concept should contribute to optimized use of the space while crowded* and *The concept should enable passengers to embark and disembark without disturbing fellow passengers.*

Accessibility

One of the main prerequisites for the thesis project, was that the cable railway should be accessible for all prioritized passenger groups, and hence the interior needed to be accessible as well. However, different passenger groups sometimes had needs that resulted in possibly conflicting requirements. A thorough work has therefore been done in order to find the common denominators, to enlighten the possibilities rather than the limitations. As a result requirements like *The concept should be obstacle free* and *The concept should have no fixed objects on the cabin floor* arised.

Personal space

Another frequently mentioned type of requirements was regarding passengers' personal space. This group of requirements mainly cover the passengers' feelings of having enough space and privacy. It contains requirements such as *The concept should avoid placing passengers seated face to face* and: *The concept should counteract passengers feeling intruded.*

Physical support

As a main theme, this group gathers requirements that aims to provide the passengers with support at all times. It takes into account that passengers does not always have the possibility to get supported by their hands, meaning that the concept needs to provide a variety of support opportunities. As a result of this, requirements such as *The concept should provide physical aid while standing or moving around inside cabin* and *The concept should provide various resting opportunities: sit down, stand up, lean while standing* are part of this group.

Added value

This group collects different types of requirements covering a variety of aspects. They have in common that they all create opportunities to give the passengers that “little extra” that possibly improves their experience. Within the group for example requirements like *The concept should allow passengers to sit in the direction of travel*, *The concept should provide possibility to fasten bicycles* and *The concept should counteract that passengers place feet at surfaces intended for sitting* are to be found.

Concept development

The different sessions of brainwriting, brainstorming, co-design workshops and so on, resulted in a broad variety of ideas and solutions. From all these ideas, two subconcepts were selected for initial testing. These two were considered to be able to fulfil the different passenger groups’ needs and requirements found during the pre-study.

As a complement to the two chosen concepts, an empty cabin was used as a reference for the tests. This enabled the boarding and disembarking times , as well as the perceived crowding inside the cabins to be compared to something neutral while testing.

Neither of the concepts had specified places for wheelchairs, prams, bicycles or walkers. Instead, the aim was to give these passengers the same freedom of choice regarding placement as other passengers already had.

Subconcepts

Subconcept 1, reference concept

The first subconcept was, as earlier mentioned, an empty cabin. This concept contained no seats or supports of any kind, and the open space was therefore 300x300 cm. It can be seen in figure 20.

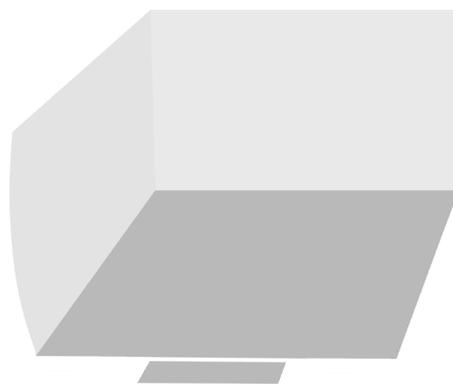


Figure 20. Subconcept 1, reference concept.

Subconcept 2

A simple sketch of subconcept 2 is shown in figure 21.

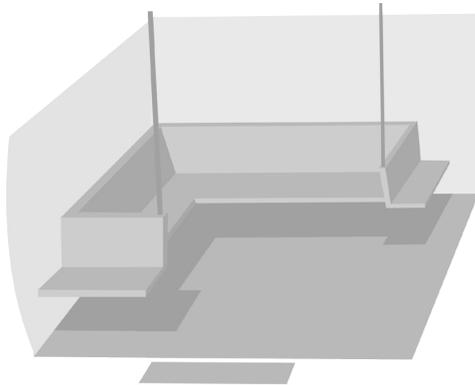


Figure 21. Subconcept 2.

Seats

An L-shaped row of seats was located in the left back corner. Two pairs of permanent seats were placed perpendicular to the L-shape in both ends, facing out through the cabin's walls. This subconcept had a total number of seven seats, facing either in the direction of travel or towards the doors.

Open spaces

An open square space of 200x200 cm were placed right inside the doors, stretching all the way to the cabin's front.

Support

Two vertical handrails went from the ceiling and down to the inner backrests of the two double seats.

Subconcept 3

Figure 22 shows a simple sketch of subconcept 3.

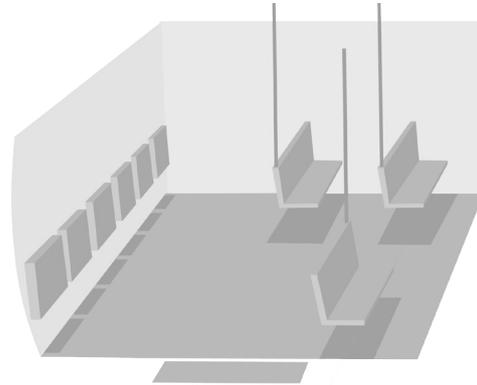


Figure 22. Subconcept 3.

Seats

Six permanent seats were placed in pairs in the cabin, two directly to the right side of the door, two on the opposite side to the left and two right behind to the left. In the back of the cabin six foldable seats were placed along the wall. It all summed up to twelve seats, all facing forward.

Open spaces

A squared open space of 200x200 cm could be found starting directly from the cabin's doors. It went all the way from the foldable seats in the back to the permanent seats in front of the cabin. In addition to this square, two smaller spaces were also available; one in front between the two pairs of permanent seats, measuring 150x85 cm, and one in the back left corner in between the foldable seats and the last row of permanent seats, measuring 130x100 cm.

Support

Three vertical handrails went from the ceiling down to the inner backrests of the three permanent double seats.

Evaluation and elimination of subconcepts

The three subconcepts were evaluated through a practical test including a mock-up. This test checked the subconcepts against four of the requirement list's five categories; flow, personal space, physical support and added value. To evaluate the last category, accessibility, a separate test with a representative for wheelchair users was done.

During the test using a mock-up 25 participants were present. First, a maximum capacity test was performed where all participants should board and disembark the cabin at the same time.

In addition to the maximum capacity test, a scenario based test with simulations of four stations was ran through. The number of participants boarding and disembarking at each station can be seen in table 5.

Table 5. Number of participants boarding and disembarking at each station.

	Participants boarding/ disembarking
Station 1, in	13
Station 2, in	7
Station 3, out	10
Station 3, in	5
Station 4, out	6

The full test result can be found in appendix 27.

Subconcept 1 Flow

In figure 23 the use frequency of the cabin's space can be seen. Here the placement of each test participant is marked by a triangle with the sharp end representing the passenger's face. One layer is added at each station throughout the test. As a result, the darkest nuance can be found at the most frequently used areas.

In subconcept 1, it is clear that most test participants kept close to the walls, especially in the cabin's front. Some spread placements are also found in the middle of the cabin, but these areas were not used more than a few times. Overall, most of the cabin's space were used and the least used area was found right inside the door.

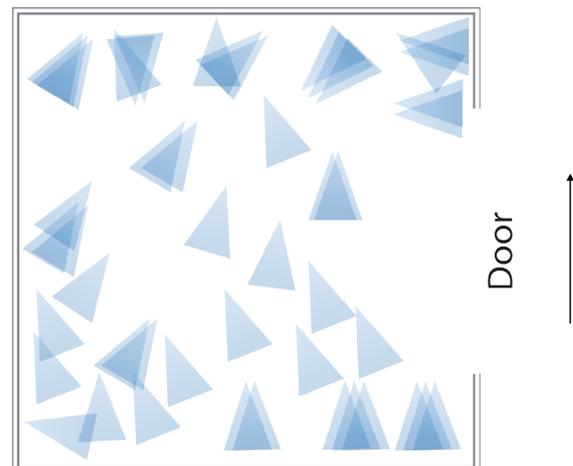


Figure 23. Use frequency of subconcept 1's space.

A summary of the movement made in the cabin's different areas during the full scenario test can be found in figure 24. The more passengers moving within each area, the darker colour. White areas had no passengers at all passing during the test. For details regarding this analysis, see Appendix 21.

Figure 24 shows that subconcept 1's main flow was slightly shifted to the back of the cabin. Around the most busy area, large areas were available for the passengers to be placed out of the main flow.

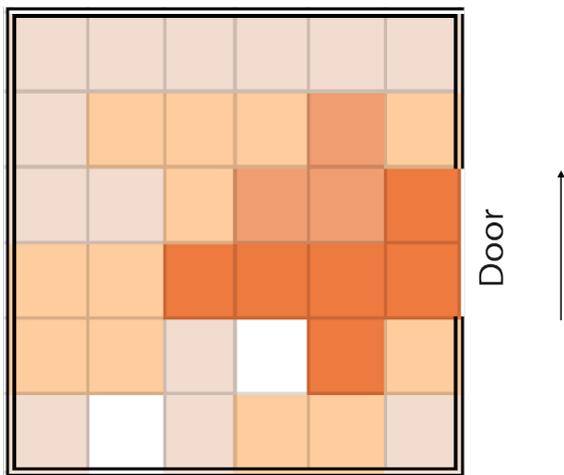


Figure 24. Movement inside subconcept 1, where the higher degree of opacity the higher number of passenger passed through

Accessibility

The representative for wheelchair users considered an all empty cabin to be the most suitable solution for wheelchair users. Hence, subconcept 1 would be optimal for that specific group of passengers. No furniture or supports placed in open spaces meant no objects to take into account when maneuvering around.

Personal space

The test participant's tendencies to mainly place themselves spread along the walls, could depend both on the fact that it would provide support during the journey, as well as a desire to keep maximum distance from other passengers. The middle of the cabin was filled last, as can be seen in figure 25, where the number inside each triangle corresponds to the order the test participants placed themselves in the cabin.

It can be seen that participant number 16 and 19 stayed close to the doors, narrowing the available path for later entering participants. When these participants entered, they probably perceived the cabin as almost full, and therefore tried to keep distance to others by staying right inside the doors. Despite this, a participant said "It feel as if here is enough space for everyone", an opinion that appeared to be shared by all test participants.

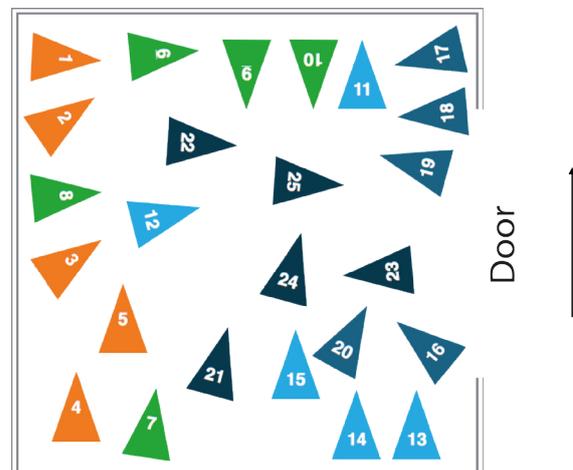


Figure 25. Order of chosen places in subconcept 1.

Physical support

This subconcept did not have any seats or supports, and no comments were left regarding this aspect. The test participants were instead focused on the spacial perception. It would though probably have been different if the mock-up would have moved during the test, which is a difference that should be taken into consideration regarding all three subconcepts.

Added value

As earlier mentioned the test participants thought it was enough space inside the cabin to hold all intended 25 passengers. Some participants spontaneously said that the cabin's size was larger than expected, something that probably contributed to a more spacious overall perception.

No specific comments were left regarding view or direction of travel.



Key aspects for subconcept 1

- The space is enough to hold 25 persons comfortably.
- The most optimal solution for wheelchair users.
- Not contributing with any major positive values for the other passengers' experience.

Subconcept 2

Flow

When testing subconcept 2 it came clear that the seats were attractive, since these were frequently used throughout the test. As seen in figure 26 all seats were used most of the time, with one exception; the seat in the corner. One participant said *"It's not as easy to get out of there as it is from other places of the cabin"*, and thought that was a reason for not choosing that seat.

Beside the seats, popular places were the corner directly to the right inside the door, and the area next to the handrail attached to the seats closest to the door. The participants avoided the open space in front of the corner seats.

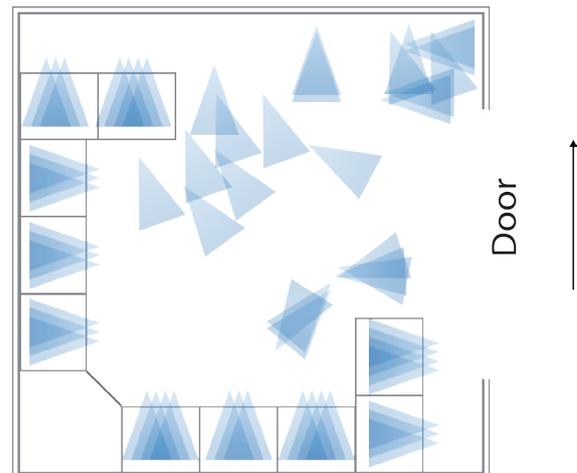


Figure 26. Use frequency of subconcept 2's space.

Comments like *"Smooth to move in and out"* and *"It's a very open plan, that's probably why it's so easy, nothing gets in your way"* were told. This testified an overall satisfaction among the participants regarding the flow.

The main flow was concentrated to the center straight inside the door, and thereafter rather evenly distributed in the cabin. If not seated, the calmest area to be positioned outside the main flow would be on the right side inside the door or in front of the corner seats. It can all be seen in figure 27. Squares marked with an 'x' are seats.

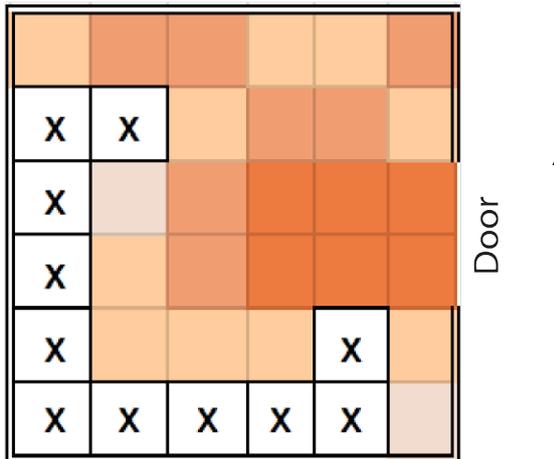


Figure 27. Movement inside subconcept 2, where the higher degree of opacity the higher number of passenger passed through.

Accessibility

Subconcept 2 would be a suitable solution for wheelchair users, according to the representative for wheelchair users. The subconcept offered a good opportunity also for wheelchair users to get a view out through the front windows, to the right when entering through the door.

He was though sceptic to the limit of 200x200 cm for maneuvering, and thought that might be too narrow for some large electric wheelchairs. The open area of 200x200 cm should according to Svensson (2015) be enough also for electric wheelchairs, but it was mentioned that the size of those chairs can differ largely.

Personal space

When discussing subconcept 2 after the test, the participants highlighted three aspects;

"It felt more spacious with seats than without."

"The seat in the corner was not optimal."

"The pair of seats were the most attractive."

The reason that made subconcept 2 perceived as more spacious, than the empty first subconcept, was the fact that some participants were seated, and hence gave more free sight for the ones standing. One participant said *"I experienced that it was more space with this solution than the empty one, since people ended up in different levels"*. Another also said *"I think it becomes a more relaxed atmosphere in the cabin when people are seated"*.

Regarding the seat in the corner, the participants thought it was too restricted space for the legs. It became an awkward situation sitting so close to others, and one participant said *"You have to know the ones you're seated next to, because you sit very tight"*. Another opinion, based on the need of personal space, was that every second seat tended to be taken in the L-shaped corner. This meant that later entering passengers would have to be seated in between two strangers, something that was perceived as uncomfortable and some passengers would might remain standing instead.

"The seats in the front are really the best" and *"I was seated in the front and there I had lots of space! It didn't feel tight at all"* was said regarding the front pairs of seats. It was said that the other pair of seats, directly to the left when entering through the door, also were desirable.

This comments were mirrored in the participants behaviour during the maximum test, showed in figure 28. Both the pairs of seats were then taken first, together with one of the seats in the corner. As next step more seats in the corner were taken, but the ones in the angle were taken last. In addition, it could be seen that the open space in front of the corner were the last to be filled.

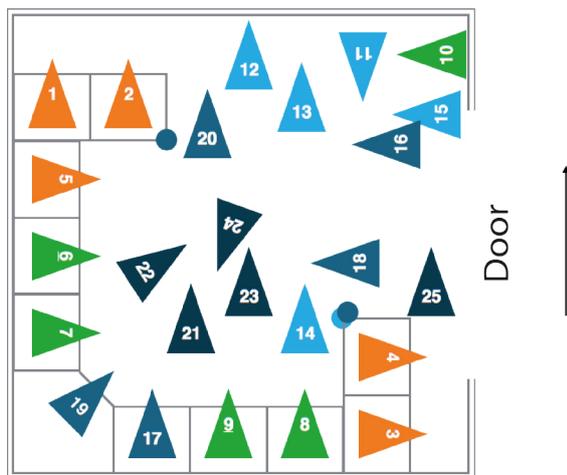


Figure 28. Order of chosen places in subconcept 2.

In a similar way as during the test of subconcept 1 two participants, this time number 16 and 18, stayed rather close to the doors, causing some hindrance for the last participants entering. The reason was considered to be the same as for subconcept 1, that these participants thought that the cabin was almost full and tried to stay out of other participants' personal space by stopping close to the doors.

The overall perception of the space was positive, all participants thought it was still enough place to hold 25 passengers. Most of the participants did also get the kind of place they would like to, though not everyone.

Physical support

Some comments occurred regarding a lack of supports to hold on to; *"It felt like it was a handrail missing to the right in the front. There was just a very large empty area without anything"*. More general thoughts about missing handrails were also present.

Added value

The view and to be able to sit in the direction of travel was the subjects most discussed. The following comments were said by different test participants:

"I think you want to sit down and look outside in the direction of travel"

"It was easier to find a place with good view now"

"It should be turned right, in the direction of travel"

"A good spot in a cable railway for me is when you can look outside, and that was better now when people were sitting down"

The test participants were in general positive to subconcept 2's design, and both increased view and the possibility to sit down in the direction of travel were considered as advantageous.

Key aspects for subconcept 2

- The L-shaped row of seats did not work efficiently when crowded.
- The flow inside the cabin was satisfying.
- Good opportunity for wheelchair users to get an outside view.

Subconcept 3

Flow

The overall impression from the test of subconcept 3, was that the seats were desirable. It can be seen in figure 29 that all of the seats were frequently used, and the permanent pairs of seats to a slightly higher extent than the foldable seats. The participants not seated, were rather evenly spread in the open spaces, most of them facing forward.

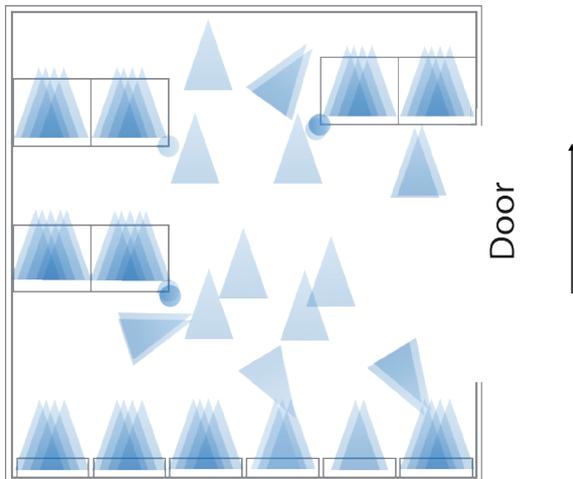


Figure 29. Use frequency of subconcept 3's space.

The main flow in subconcept 3 was more spread out, than in subconcept 1 and 2. About one meter into the cabin, the flow was spread in three directions; in front between the permanent seats, straight forward to the second row of seats and to the back as shown in figure 30. The calmest area outside the main flow could be found in the left back corner in the direction of travel. In addition to this, a calmer open area was found in the right back corner, directly inside the door.

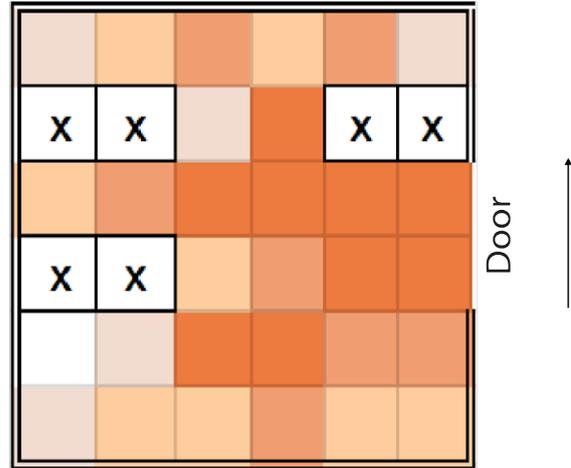


Figure 30. Movement inside subconcept 3, where the higher degree of opacity the higher number of passenger passed through

Accessibility

The representative for wheelchair users felt that wheelchair users would have enough space to maneuver and to be placed in different areas of the cabin. The same scepticism regarding the open space of 200x200 cm as for subconcept 2 was though still present.

He had a thought on how to further improve the experience for wheelchair users; if one of the permanent seats in front was removed, it would enable a wheelchair to be placed in front in line with the row of seats. It was possible with the current design as well, but if one seat was taken away it would probably enable other passengers to pass by also when the wheelchair is placed there. The seat that would be advantageous to eliminate are marked in figure 31.

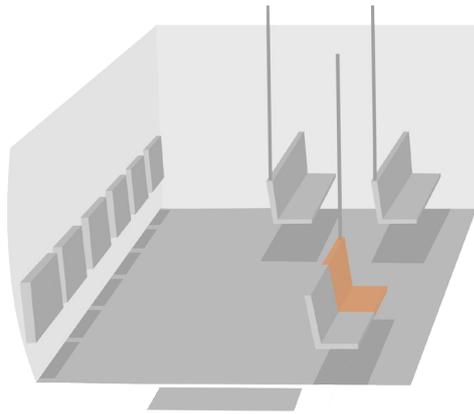


Figure 31. Illustration showing which seat that would be advantageous to eliminate in subconcept 3.

With the suggested change, subconcept 3 was considered to be the most beneficial alternative (including seats and handrails) for wheelchair users.

Personal space

Due to the seats that were taken first, was the so called "permanent seats", especially those closest to the walls, they were the most desired. It can be seen in figure 32, where the seats next to the walls were occupied first during the maximum test. Seats in between other passengers and the middle of open spaces, were as earlier seen less popular, but were however chosen before standing for most participants.

Because of the placement of participant number 20, it was difficult for the last five passengers to get further into the cabin. This was, once again, the same behaviour pattern as seen during the test of subconcept 1 and 2. However, during the common evaluation, no negative comments were said regarding the perception of space inside.

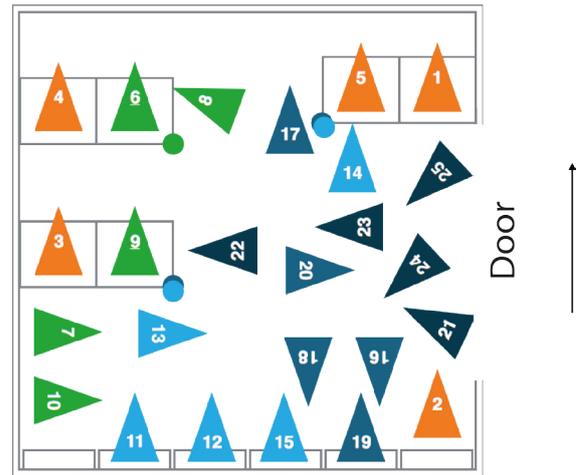


Figure 32. Order of chosen places in subconcept 3.

It was by someone found to be slightly awkward to be seated in the back if other passengers were standing right next to the seats;

"I thought it was a bit odd to sit in the back when others stand in front of you. You sit right towards the open space with a lot of strangers right in front of you".

The foldable seats in the back were though in general, seen as something positive;

"Since you can fold the seats down, depending on how many passengers there are you can chose weather to sit or stand".

Physical support

Most comments regarding physical support were positive for this subconcept. The participants did to a high extent, feel that they had the support they needed within reach; *“It was good that there were three handrails to hold on to”*. Someone did also comment that they were missing something to hold onto in subconcept 2, but did not experience the same with this subconcept.

All participants said during the evaluation that they got the kind of placement they wanted with this subconcept.

Added value

To have all seats in the direction of travel was obviously valuable for the test participants, both comments and behaviour during the test were aligning here. A comment from a participant was *“I thought this one was better (than subconcept 1 and 2). The seats were better placed and you had a better view forward”*.

This subconcept was perceived as very spacious according to the participants, and comments like *“It was more open spaces”* and *“It looked much more spacious in this last one”* did occur. One participant also said *“It felt more spacious having foldable seats”*.

The same positive effect on the view as for subconcept 2 was seen here, when some participants were seated.

Key aspects for subconcept 3



- Would be suitable for wheelchair users with minor modifications.
- All seats were used.
- The flexibility with foldable seats was advantageous.
- Good access to handrails.
- Was perceived as the most spacious subconcept.

General insights from evaluation of subconcepts

The time it took for all the participants to board and disembark each subconcept during the maximum capacity test, can be seen in table 6. The time required for each step of the scenario based test are found in table 7.

As seen in table 6, none of the subconcepts were boarded within the intended 20 seconds during the maximum test, not even the empty subconcept 1. Disembarkation was overall faster, and here subconcept 1 was emptied within 16 seconds and subconcept 3 was close to the limit with 21 seconds. The fact that it was not possible to board and disembark 25 persons within 20 seconds, must be taken into consideration. For example some kind of warning signal would probably be advantageous and supportive for the future passengers.

* The result from subconcept 3's maximum capacity test was considered to be slightly misleading, as the cabin's boarding time was significantly affected by a single participant's behaviour, the earlier mentioned number 20. The total time required for boarding was 32 seconds, but then approximately five seconds passed in a "locked situation" where the last participants entering waited for number 20 to move further. Eventually, the last participants decided to pass by the participant standing still, and then the rest of the boarding was quick. In a scenario where the passengers know about the time limit for boarding and disembarkation, this locked situation is probably less likely to last as long, and hence the estimated boarding time of 27 seconds would might be more realistic than the measured 32 seconds.

Table 6. Time required for 25 test participants to board and disembark the cabin.

(Seconds)	Subconcept 1	Subconcept 2	Subconcept 3
25 persons, in	25	27	27/32*
25 persons, out	16	24	24

Table 7. Time required for boarding and disembarking at each station of the scenario test.

(Seconds)	Subconcept 1	Subconcept 2	Subconcept 3
Station 1, in	11	13	14
Station 2, in	9	12	12
Station 3, out	11	7	13
Station 3, in	5	8	6
Station 4, out	5	9	10

Regarding the scenario test, all stages were finished within the intended 20 seconds, with a margin. At some stations as little as five to six seconds was required to board or disembark. In most cases subconcept 1 was the most efficient solution, which was not surprising since no seats or handrails were placed inside and the participants, therefore could move freely. The needed time did though not differ largely when the two subconcepts with seats and handrails were compared to the empty cabin, which was an interesting finding.

Noticeable is, that the participants within this test, did not know about the time limit. It was desired to evaluate if boarding and disembarking was possible to complete without stressing the passengers. It was however observed during the test, that the participants were surprisingly calm and likely not acting fully realistic for public transportation. Hence, the required time identified during the test was probably slightly longer than what would be necessary in reality.

To have seats in the cabins was desirable for most test participants. It was seen in the test of both subconcept 2 and 3, that the seats were used to a high extent and participants also expressed the positiveness of having seats. Although, it was also seen as beneficial to be able to chose whether to stand or to be seated from time to time.

The seats were said to give a positive effect also on the view and perception of spaciousness, since it meant that passengers ended up in different levels. The participants did in general like the seats placed in the direction of travel, and preferred seats with a good forward

view. The seats in front of the cabins were taken first, both in subconcept 2 and 3. It was also seen, that a majority of the participants were facing forward in the scenario test, especially during the test of subconcept 3.

It was seen in all three subconcepts, that participants tended to stay close to the walls, either standing or seated. They used the center and open spaces only when the outer areas were taken. However, when participants entering considered the outer areas to be occupied by others, they tended to stop close to the door instead. This meant, that they ended up standing in, or in close proximity to, the main flow and therefore hindered other participants to pass. This was seen as a problem due to the need of personal space, when passengers try to keep maximum distance to others, while in a small common space, and something that is difficult to avoid.

Key aspects for general insights



- 20 seconds is not enough to board or disembark 25 persons (if time limit is not known).
- Little difference between subconcepts regarding time needed for boarding and disembarkation.
- Seats gave a positive effect on view and perception of spaciousness.
- Seats in the direction of travel were appreciated.

Choice of concept for further development

The choice of which concept to develop further, was based upon three parts:

- The participants attitudes and feedback given during the test
- The evaluation done by the representative for wheelchair users
- A check against the requirement list

The test result was overall positive, none of the subconcepts did get a particularly negative review. But according to the participants it was clearly preferred to have seats, and hence subconcept 1 was not as attractive an option as the later two.

The difference between subconcept 2 and 3 was not overwhelming, although considerable advantages could be found in subconcept 3. Most obvious was that all seats were used, maximising the cabins' full capacity, together with good access to supports. Subconcept 3 did receive the largest amount of positive comments of the three concepts, and most remarkably it did almost not get any negative comments at all. When asking the participants the straight question of which subconcept they preferred, subconcept 3 was chosen. They thought that subconcept 2 was not bad, but subconcept 3 was the best.

When the representative for wheelchair users evaluated the subconcepts, the empty solution was the most advantageous. But if the solution should have seats and handrails subconcept 3 was picked as the best alternative, given that the suggested changes were done.

As the subconcepts were checked against the requirement list, it came clear that subconcept 3 had best chances of fulfilling the needs of all passenger groups together. The importance for passenger groups such as pregnant women, physically impaired and elderly, to have seats was taken as a heavy argument. Subconcept 3 was also advantageous for example when it came to having seats in the direction of travel, and to maintain passengers' perception of having their personal space.

Overall, subconcept 3 was rated highest, and hence this subconcept was chosen for further development.

Key aspects for choice of concept for further development



- All subconcepts did get positive comments in tests, but subconcept 3 was most liked.
- Subconcept 3 had best opportunities for wheelchair users of the two having seats and handrails.
- Subconcept 3 was considered to have best possibilities to fulfil the requirement list.
- Subconcept 3 was chosen for further development.

Refinement of chosen concept

Since subconcept 3 was chosen as the single solution to work further with, it will henceforth be denoted *the concept*.

The result given in the conducted test and through the evaluation with the representative for wheelchair users, was very positive. It all showed that the concept had good opportunities to work for different passenger groups, without need of comprehensive changes.

One detail that though needed some more consideration, was whether the concept should have a single or a pair of seats in front to the right. It was mentioned during an interview, that the interviewee would like to have a possibility to sit separately. This opinion did get lower priority during the initial development phase, due to a desire to maintain a high capacity for seated passengers. However, while getting response from the representative for wheelchair users about that it would enhance their experience if they could be placed in the cabins' front without disturbing the flow, the priorities were reconsidered. Since a change to a single seat seemed to be beneficial for several passenger groups it was decided to accomplish.

The row of foldable seats was considered being able to be used as support for standing passengers, when not in use as seats for seated passengers. A variety of alternatives were found among existing solutions in public transportation, and an illustration of how it can be done are shown in figure 33. A solution like this would mean even more flexibility being added to the concept, since standing passengers get alternatives to handheld supports without taking away possibilities to sit.

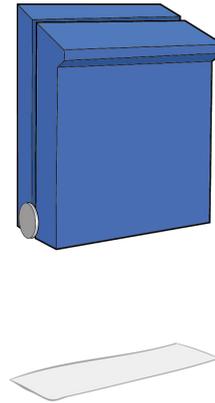


Figure 33. Possible design of foldable seat.

Hence, a similar solution was considered to be advantageous for the cabins. The choice of exact design of these would though have to be taken in a later stage of the development process, as earlier described.

When the concept was chosen, the interior design was taken to a more detailed level. The dimension of all handrails was set to 4 cm in diameter, due to recommendations from Svensson (2015). It was planned to add handrails along the cabins' walls, to enable passengers to follow these all the way from the doors into the cabins. A horizontal rail was also added in the cabins' front. Figure 34 shows an approximated placement of these, but further testing would be required to determine exact placement.

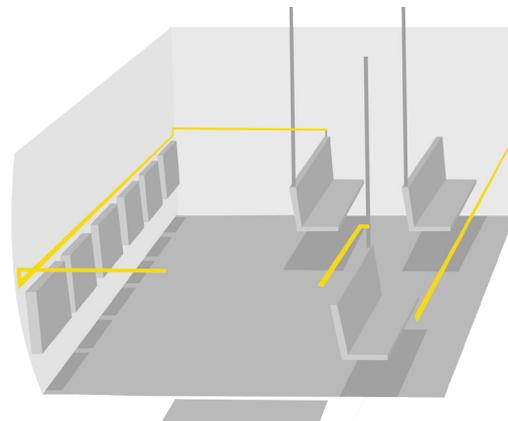


Figure 34. Illustration of subconcept 3 with highlighted horizontal handrails, marking their approximate placement.

In a consultation with an expert in public transportation design, measures used within development of vehicles for public transportation in Gothenburg was applied to the concept. These measures were for example the recommended distance between two rows of seats, and the height of seats (all recommended measures can be found in appendix 23). This input was used together with the reference measures earlier, given by a cable railway project group member with insights in the development of public transportation vehicles at Västtrafik, regarding prams, walkers and wheelchairs. The resulting measures for the cabins' interior can be seen in appendix 28.



Key aspects for refinement of chosen concept

- One seat was removed.
- The foldable seats were recommended to be designed as supports for standing passengers as well as seated.
- Dimensions of handrails and measures for the interior was set.

Evaluation of refined concept

Consultations

Final evaluations were done together with an expert in public transportation design, involved in the development of Västtrafiks public transportation vehicles, as well as the project group manager at Västtrafik for Gothenburg's cable railway and a member of the cable railway project management group with insights in the development of public transportation vehicles. During these evaluative meetings, the concept was discussed and evaluated. The feedback given from all three experts was positive, and the concept was considered to be suitable and well applicable in Gothenburg's cable railway cabins. Also, the refinements, such as eliminating a seat, were agreed on.

During the consultation with the cable railway project management group the concept's consistency with the created vision was evaluated. They thought that the vision both was conforming with the cable railway project and that the developed concept harmonised with it.

Together with the project group manager, the concept was also checked against Västtrafik's vision. It was considered to be well aligning with the vision, and also in line with the cable railway project as a whole.

Accessibility of handrails

An additional analysis was made, to verify the accessibility of handrails. An approximation of the areas where a handrail can be reached are visualised in figure 35, where these areas are marked in orange. As seen, only the grey area in the open space are separated from where the passengers can reach a handrail, and the floor area of the cabin was therefore considered to be well used. The last space left was seen as something positive, since this is likely to be free from standing passengers and therefore potentially will enable boarding and disembarking passengers to move around easier.

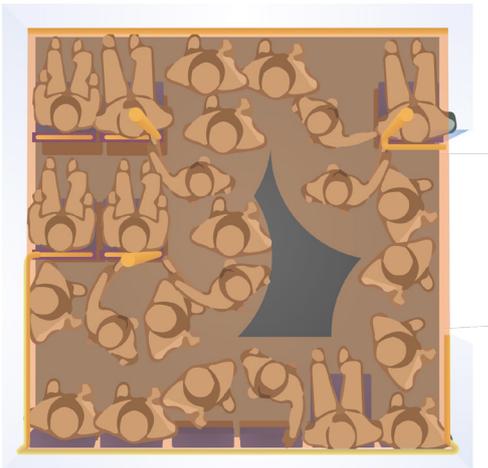


Figure 35. Overhead illustration of the concept showing areas with access to physical support.

Verification of concept against requirement list

The final concept was verified against each of the requirements set earlier in the study. The full result of the verification are presented in appendix 25.

Most of the requirements turned out to be fulfilled by the concept. Only three guidelines were considered not to be met;

- 1.8 *The concept should contribute to belongings not occupying space intended for passengers.*
- 5.10 *The concept should admit wet umbrellas to be kept on a distance from passengers.*
- 5.14 *The concept should provide support for crutches while not used.*

All three of these guidelines were considered minor aspects, and did therefore not get as much attention during the development phase as other, higher prioritized requirements. Hence, it was not surprising that these guidelines were not fulfilled.

The most noteworthy was the detected risk of not being able to board and disembark the cabins within the designated 20 seconds. Worth to mention once again here is though that the test participants did not know about the time limit, and did therefore probably not stress.

➤➤ Essence of final deliverables

In this chapter, the essence of the result is presented in its most concentrated form.

Vision

*”A **smoothly** flowing and **uncomplicated** journey, in a **clean** and **comfortable** environment, enabling **all passengers** to get a **relaxing rest** with a **view** of Gothenburg.”*

Requirement list

The requirement list consists of a total of 68 requirements structured in the following five groups:

- Flow
- Accessibility
- Personal space
- Physical support
- Added value

The requirements have to be met in order to achieve a good passenger experience inside the cable railway cabins.

The full requirement list can be found in appendix 13.

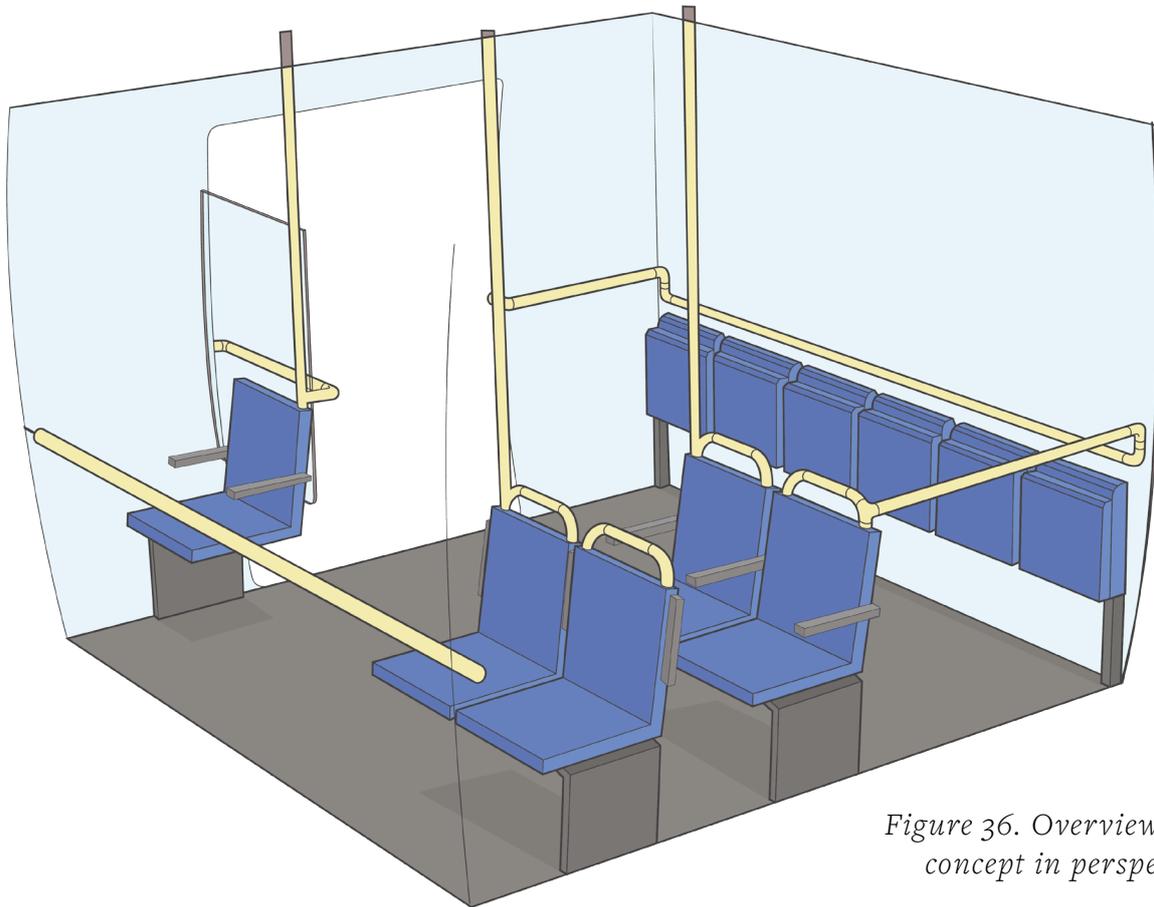


Figure 36. Overview of final concept in perspective.

Final concept

Cable railway cabins for Gothenburg's citizens

The idea about building a cable railway in Gothenburg, was initially an idea from the citizens. Hence, it has been prioritized to develop the cabin interior *for the citizens* of Gothenburg. They are the future passengers, and it is important to ensure the best possible experience during a journey, for each and every one of them.

Efficient flow

One of the found key aspects to achieve a good passenger experience is to have an efficient flow inside the cabins. This flow enables all passenger groups to share the same space, without negative interference with each other.

Identical cabins

The developed concept that can be seen in figure 36, enables all cabins to be identical, since the design is adapted for such a broad variety of passengers with different requirements. This decreases the need of special treatment of already exposed passenger groups, such as wheelchair users.

It also facilitates for visually impaired passengers, as they can learn how the cabins are designed and know what to expect for the next journey.

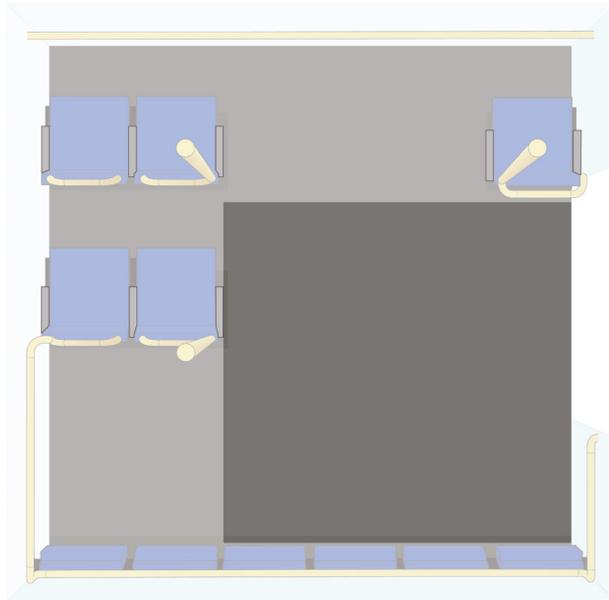


Figure 37. Final concept seen from above. The open space of 200x200 cm marked in darker grey.

Open flexible spaces

The 200x200 cm open space starting directly inside the cabin's doors (see figure 37) enables all wheelchairs, up to class C, to turn around freely. It also serves as a flexible area where prams, bicycles, walkers and larger baggage can be placed where it is most suitable for the passengers from time to time. Each cabin easily takes two of these units at the same time, making it possible to travel with company. The cabin does not have any dedicated areas for any type of passengers, and hence, all passengers have the same freedom of choice when it comes to preferred placement.

Another aspect that opens up the space, is that all seats are attached to the cabin's walls, which leaves the entire floor free. This both facilitates cleaning and increase the margins for turning wheelchairs, since there is less to hook into. It also enables seated passengers to stretch out their legs.

All seats in the direction of travel

Each cabin has a total of eleven seats available. All of them are placed in the direction of travel, to provide a better possibility to enjoy the view as well as to contribute to a more pleasant journey. This direction of seats also counteract motion sickness.

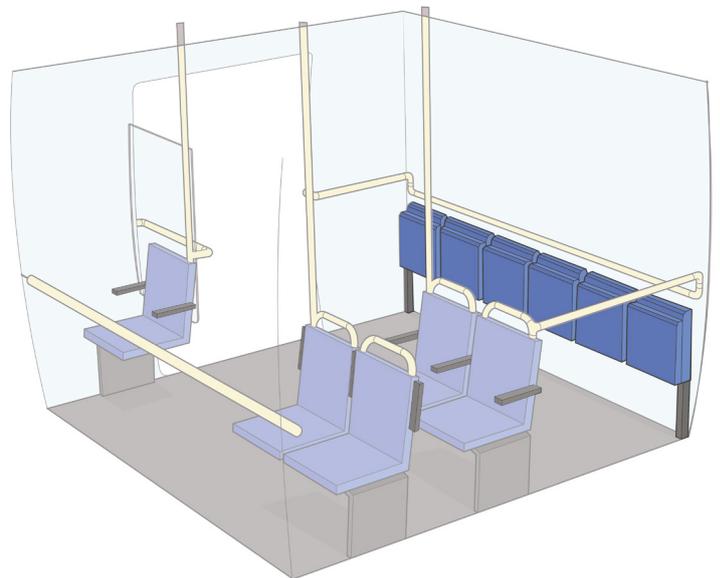


Figure 38. Foldable seats in the back highlighted.

Foldable seats

In the back of the cabin a row of foldable seats is placed, as figure 38 shows. These seats can be used for sitting, for example next to a wheelchair or pram. While folded they can also be used as supports to lean on to, which entails they provide an alternative and space efficient type of support.

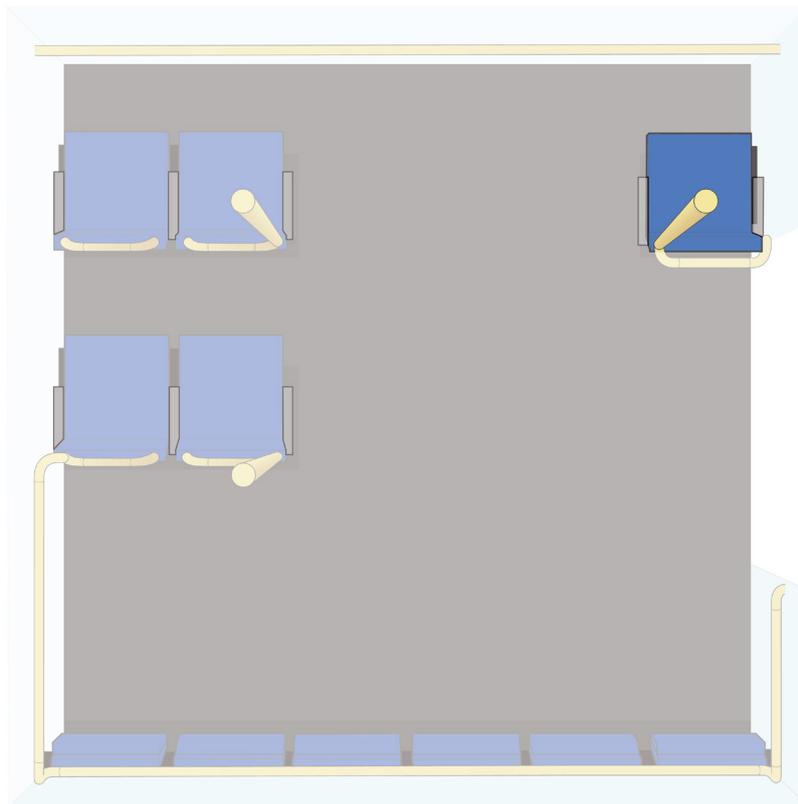


Figure 39. Single seat in the front highlighted.

Stand-alone seat

As seen in figure 39, a single seat can be found right next to the door. This is an alternative for passengers that want to sit by themselves, but it also opens up a free area in front of the cabins, enabling for example a wheelchair user to sit with a great view. A transparent barrier is placed behind this single seat, to separate a seated passenger from the flow through the doors.

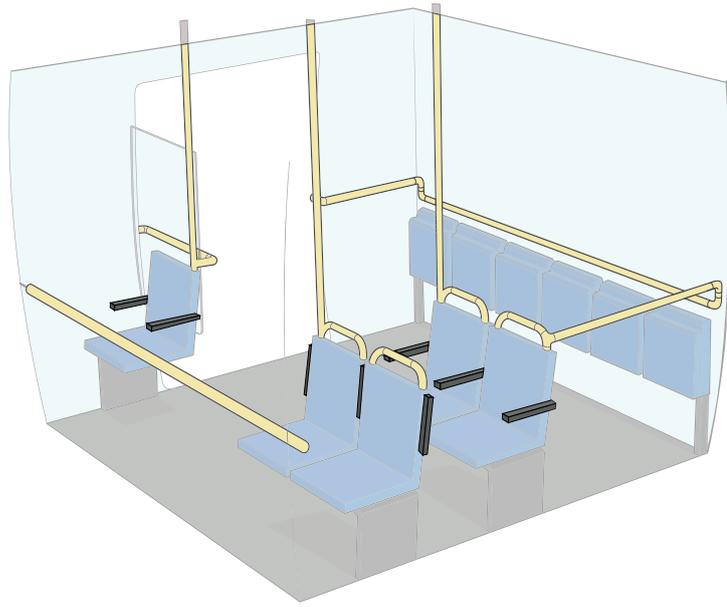


Figure 40. Accessible supports highlighted.

Accessible supports

Continuous handrails, highlighted in figure 40, are present all the way from the door to different kind of seats and areas in the cabin, to make it all easy to access. They have a high contrast color to facilitate detection, also for visually impaired and elderly passengers. In addition, the seats have foldable armrests that can be used when needed, but also folded away to avoid hindrance. The handrails are reachable almost anywhere in the cabin, giving an opportunity to a steady journey, also while standing and thereby enabling use of the vast majority of the space inside. The orange area in figure 41, shows where physical support is available. The grey area is the the only spot left without proximity to a support, and will because of this likely be free from standing passengers. Hence, a natural possibility to move around when boarding and disembarking is created.

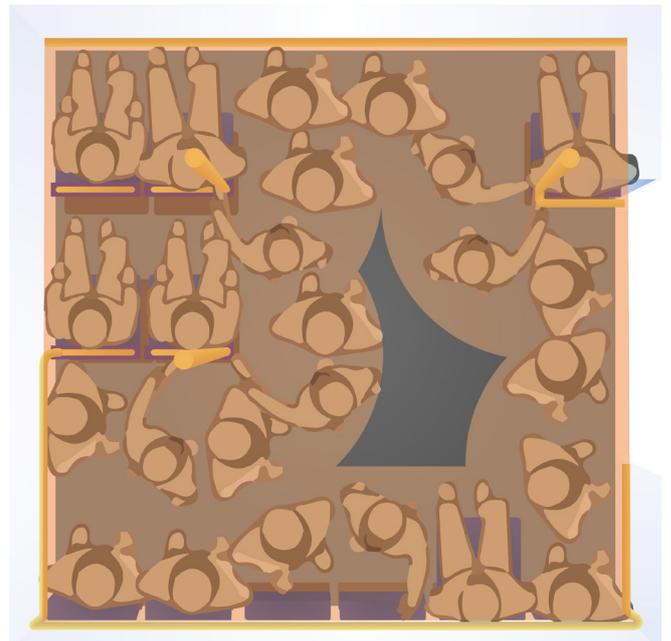


Figure 41. Area where physical support is available marked in orange.

Discussion

General

Fresh start -optimizing solutions

Cable railways are new to Sweden, at least as a part of public transportation. This gives both new challenges and fresh opportunities, regarding the development. Since there is no history or existing solutions in Sweden to take into account, there is a chance to start all over and build a more or less optimal solution from scratch. In this case, it is then possible to consider many different passenger groups at an early stage, and therefore work to combine their needs and requirements from the very beginning.

Early tests showed that it is possible to take many different passenger groups into account and still obtain high efficiency for the cabins. Relatively simple solutions that are well thought through makes a difference for vulnerable passengers, without meaning major compromises for other passengers. For example, to replace the double seats to the right in front of the cabins with a single seat was from the beginning a way to create more free space with a good front view, to enable wheelchair users to be placed between the right and the left seats. But this solution turned out to be suitable for other single passengers as well, who simply wanted to sit on their own. So, by adapting to the needs of one passenger group, benefits for other groups were gained at the same time.

Existing solutions tend to focus a lot on a limited group of passengers. For example, the interior design found in Bolzano seemed to be optimized for everyday commuters, resulting in a solution where all seats were placed along the walls facing into the cabins. One of the strongest benefits with the concept developed as a part of this thesis project, is that it is suitable for many different passenger groups instead of focusing on just one or two. This makes the concept rather unique and something new to the field. Instead of separating different passenger groups the developed concept merged all needs together, creating a feeling of inclusiveness for everyone.

Preparation for further work

Gothenburg's cable railway group has got a broader knowledge and a better foundation for further work than before, due to the requirement list and the conceptual interior design developed in this study. This entails a solid base to start from when cooperating with a future manufacturer. By knowing Gothenburg's passengers' needs, the possibilities to achieve a suitable and successful result increase.

Applicable in public transportation in general

Some of the needs and requirements regarding the interior are also applicable outside the cabins, which makes them useful also for other parts of the cable railway project, such as the stations' development and design. In addition to this, the findings compiled in the pre-study could be applicable for other areas of traffic as well as for cable railways. Many of the passengers' needs and requirements are just as relevant and useful to keep in mind while developing a tram in Gothenburg as it is for a cabin. The same passenger groups that are expected to travel with the cable railway will probably also use other types of vehicles. Hence, the requirement list can be further used if supplemented with specific aspects for the new area of use.

Time required for boarding and disembarkation

As seen in the test result, none of the subconcepts were boarded within the intended 20 seconds. When testing disembarkation, only subconcept 1 was emptied within time, but subconcept 3 was close, with 21 seconds. In the scenario test though, all subconcepts were conducted within the limited time. Worth to mention again is that the participants were not aware of the time factor during the test, and hence they likely did not try to be fast.

A conclusion drawn from this is that the time is a critical factor when many passengers are boarding or disembarking at the same time. However, since the time limit was passed already with the empty subconcept 1 and the differences between the subconcepts were rather small, it was here considered to be a problem mainly due to something else than the interior design. It was seen as likely that the problem will decrease if the passengers are aware of the time limit, but it must anyway be further investigated.

An aspect worth paying attention to is also that this test did not include any critical passenger groups. Vulnerable passengers would probably require more time for boarding and disembarkation than an average commuter.

Method used

Positive results based on thorough pre-study

By carefully mapping the conditions and performing simple tests at an early stage, the risk for need of late reconstructions decrease. Late changes are known to be expensive (Thomke & Reinertsen, 2012), and hence it is beneficial to avoid the risk of those. As this is the first urban cable railway of its type in Sweden, it is even more important to ensure that the understanding of the conditions are sufficient, since there is no earlier experience to lean on to.

Since much time and effort were put into the initial pre-study, in order to understand the passengers and their needs, already the early concepts could be developed in a suitable way. This was confirmed by the first test, where both concepts did get a rather satisfying result. The results from the test could therefore be seen as a proof of the pre-study's reliability, and that it had been applied in a proper way.

User involvement

To have potential future passengers involved in the study enabled new aspects to come out. Many important thoughts and experiences were shared already during the first traditional part of the interviews, but when the participants got to try different solutions and ideas themselves even more insights came clear. Noticeable is though, that the participants' design ideas from these sessions did not result in any actual concepts, but it was instead a useful tool to open up for deeper understanding of their situations.

Self-reported data

During interviews passengers explain their personal version of situations and experiences. It is never guaranteed that what is told by one interviewee is in line with what another interviewee would reproduce, or that it corresponds to what actually happened. This behaviour could be both conscious and unconscious, and is something to always take into consideration when using self-reported data.

However, in this study the passengers' personal experiences were of great importance, since the passenger experience was a main focus. Hence, the risk of incorrect or misleading data had to be accepted and somehow overlooked since the interviews were such a direct way to get to the passengers' experiences. These experiences are always more or less subjective, but by finding common denominators the overall experience for the different passenger groups could be increased.

Involving passengers in non existing solutions

In this study there was a risk of bias when talking to possible future passengers about a public transportation that does not yet exist. Since they in this case had little or none own experience from traveling with cable railways, especially in urban environments, all shared opinions are based on expectations and experiences from other public transportation systems. Kujala (2008) also enlighten the risk of turning to expected future users of non existing products, saying that it is not obvious whom these might be when the product actually enter the market.

Using a mock-up

The use of a simple mock-up gave the participants something concrete to refer to while talking about their situations and needs. This seemed to facilitate for them to think one step further, and to easier relate to the possible experience of a journey. Most obvious were their reflections regarding the actual size of the cabins. In addition to the difference it made for the participants, the mock-up enabled tests that highlighted insights that were not known to the designers before. One concrete example was the L-shaped seat in the corner of Subconcept 2, a solution that seemed to be popular while seen in Bolzano's cabins. But when staging more crowded journeys back in Sweden the L-shaped seats instead was seen as impractical and something that forced passengers too close to each other.

Keeping participants focused on topic

A new type of public transportation arise many questions among the future passengers. Initially, these questions in general appeared to be more important to the participants than the intended topic of the interviews. It was mainly thoughts regarding safety inside the cabins, when traveling together with other passengers. In addition to this, for example questions about tickets and placement of stations were frequent. Since these questions covered aspects possibly causing much impact on the passengers, it was not surprising to hear them. Therefore, these questions seemed difficult to avoid and instead had to be answered whenever they appeared, in order to be able to continue with the interviews.

Apart from causing longer interviews, this probably did not affect the final result to any larger extent. It was however advantageous to be well prepared for these general questions, as they needed to be answered before the interviewees could shift their focus to the intended topic.

Limitations

Impossible to do interviews in Koblenz and Bolzano

Due to concerns regarding the public procurement of the manufacturer of the cable railway, no personal contact was allowed during the study trip to Koblenz and Bolzano. It would have been desirable to perform interviews with passengers and staff, to get a deeper understanding of how the existing cable railways was being perceived. Instead, the study trip was limited to observations, and had to be supplemented with interviews performed back in Sweden. These interviews did though focus on the perception of other types of public transportation existing in Gothenburg (buses, trams and boats) and could therefore not be guaranteed as something fully applicable for cable railways. If the passengers' experience differ largely between traveling with a cable railway and other public transportation vehicles there is a risk that a not applicable base of experiences was used within this study. If that is the case, the result could be twisted in a direction suitable for other public transportation vehicles rather than a cable railway.

Changed plans regarding mock-up

Initially, an already existing full scale mock-up was planned to be used for the tests. Later in the process it did though turn out to be impossible, since the mock-up could not be moved to an accessible location. Hence, the tests had to be replanned and modified to be executed in another way. A much simpler version of the cabin was then built for the tests, without walls and ceiling. This probably affected the feeling of being inside a closed space, but still made it possible to investigate the possibilities to move around inside a cabin. The presence of walls and ceiling might change the perception passengers get of how crowded the cabins are, and is therefore something that would be important to investigate further.

Effect of height and movement

All tests throughout this study have been conducted at ground level. In contrast the actual cabins would move around approximately 50-100 m above ground. The effect of the height have not been investigated within this thesis project, but is most likely an affecting aspect when it comes to overall passenger experience. It could for example affect which seats the passengers tend to chose and how close to the walls they are willing to stand.

It is also likely that passengers might act differently while in a cabin that is moving. Probably the use of supports will be more frequent than what has been seen during tests with a stationary mock-up.

Recommendations for further work

First steps

The tests performed within this thesis project gave a first prediction of the concept's usability, and the results were promising. However, these tests did not involve all passenger groups together at the same time. Further testing would be required to ensure the cabin's interior is suitable for a combination of for example everyday commuters, families with prams and wheelchair users.

Another possible passenger group that was not included in the tests was visually impaired or blind persons. Due to the limitations of the mockup used, such as the facts that it had no walls or solid interior to use as tactile guidance, visually impaired could not get a fair opinion about the concept and was therefore not invited to participate. This passenger group was consulted at an early stage of the study, to take their needs and requirements into consideration, but will later also need to be a part of further tests.

An advantageous solution and a natural next step would be to build a full scale mock-up of a cabin with the conceptual interior. This would be a realistic environment to test the concept with both visually impaired persons and the combinations of different passenger groups. To have both walls and ceiling will probably enhance the feeling of being inside an actual cabin, and it would also enable visually impaired to get sufficient feedback from the environment.

While working with the full scale mock-up, it would also be possible to try appropriate heights of the seats. Especially important is to consider which seats to raise, in order to choose seats easily available for those who need to sit higher without affecting the view of other passengers.

Following these steps some details have to be set, such as the exact type of seats and handrails. Regarding the handrails another aspect to investigate is the more precise placement and connections of these. Here the visually impaired is an important passenger group to consider, and the accessibility for them will be beneficial to test with a full scale mock-up.

During the study some requests regarding facilitated placement of belongings emerged. Some aspects are mentioned in the requirement list, in the category *Added value*. The developed concept does at the moment not pay any special attention to this aspect, but is instead in line with today's existing solutions in other public transportation. It is therefore room for some possible improvement, in order to make it easier to travel with belongings.

Finally, to broaden the scope more passenger groups should get involved in the tests. For example persons with cognitive impairments and pet owners, since none of those have been taking part in tests so far.

Approach to participants

As mentioned in the discussion, it became clear during the process that because a cable railway is something all new to many people a lot of curious questions arise. Even though general information regarding the cable railway was given initially, many questions were asked throughout interviews and tests, and these questions often did not relate specifically to the addressed topic. It was a valuable insight for the students to realize that an even more thorough introduction to the new transportation system was needed in order to later keep the participants focused on the intended topic.

Hence, it is recommended to gain a broad and thorough knowledge regarding this kind of subjects before interacting with participants. It will most likely facilitate reaching the desired outcome of interviews, tests and so forth.

Conclusion

The anniversary cable railway project was provided with information and knowledge of how the interior of cable railway cabins can be designed, in order to fit the needs of prioritized passenger groups regarding passenger experience, while keeping a high loading capacity. A vision, requirement list and a conceptual design proposal of the cabins' interior were delivered to fulfil this purpose of the thesis project.

Following the vision and requirement list steers the cabin interior development towards a good passenger experience. The compiled knowledge behind the requirement list is valuable in order to understand the list itself as well as the consequences if it is not fulfilled.

The developed concept proved that it was possible to cater to all defined needs without having to waive either capacity, comfort or a good flow within the cabins. The design enabled the prioritized passenger groups to travel without adaptations, which possibly make them all become equal passengers to some extent. This was something unusual within public transportation, and the findings could be beneficial to apply to other areas of traffic as well.

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Appendix

Appendix 1.

Mock-up details

The mockup used throughout the various project phases was built upon nine free standing wooden stands, placed as seen in figure A.

All nine stands had a height of 0,6 m and a screw mounted on the top, in which a cord was attached. It connected all stands into a closed squared space of 3x3 m with an opening of 1,4 m on one side representing cabin doors, in accordance with approximate cabin measures.

To enhance the feeling of enclosure, sheets of fabric were mounted over the stands and cord reaching the floor. Since the cabins were deemed likely to have mostly transparent windows the construction of the mock-up was considered to provide a good enough balance between perception of enclosure and realistic level of view outwards.



Figure A. The mock-up as it was used in various phases in the project.

Appendix 2.

Semi-structured interview

Desired passenger experience interviews

Semi-structured interviews were conducted to gather information about desired passenger experience during travel, as well as for gathering insights about needs for the cable railway cabins. Due to pedagogical and structural reasons the interviews were divided in two parts. Part 1 related to desired passenger experience, while part 2 related to passenger needs.

When possible, the mock-up was used during the interviews, as a mean to provide the interviewees with a greater understanding of the cabin, by experiencing the cabin size. Table 1 and 2 on page 26 in the process chapter, declare interviewees and their access to the mock-up. To direct the interviewees' answers, from overall experience with public transportation towards the experience during the actual travel, interviewees were asked to focus their answers to the experience during the journey on a public transportation vehicle.

Props:

Mock-up

Documentation:

Audio recordings, photos and written documentation.

Interviewees:

14

Supervisors/interviewers:

1-2

Duration:

Part 1: approximately 10 minutes

Part 2: approximately 25-60 minutes

Part 1 - Interview guide

Desired passenger experience

- How would an ideal traveling experience with public transportation be like for you?
- What do you see yourself doing during such a trip?
- What is the interaction between fellow passengers and yourself like?
- How do you travel?
- What do you want to get out of an ideal trip?
- What are the most important aspects to fulfill, in order to improve the trip?

Part 2- Interview guide

Passenger needs

- What do you occupy yourself with, when traveling with public transportation today?
- What is positive with traveling with public transportation today?
- Are there any aspects or solutions that simplifies your traveling experience?
- Which aspects affects your impression of public transportation negatively?
- Are there any problems or difficulties you are facing?

Additional questions for impaired interviewees:

- Do you face any problems or difficulties in public transportation?
- Can you give examples of good/bad solutions and design in existing vehicles?
- Does it matter if the seats are individual or not?
- Do you prefer to stand or sit when you travel?
- Is there anything that is particularly good/bad for the experience of the sound environment?
- When it comes to horizontal bars for guidance, what do you prefer? (material, design, placement)

Appendix 3.

Consultation I

Passenger experience with Västtrafik's passenger experience team

Västtrafik has over the recent years conducted several studies regarding the passenger's experience of their services. This was a part of their comprehensive work performed to achieve better knowledge about their customers and their needs. The outcome of these studies, was used as a foundation within the organisation to make sure all work was aiming towards a better experience for the passengers.

To obtain this information about Västtrafik's passengers' experience and how the organisation worked towards improving passenger experience, a meeting with co-workers was set up adjacent to the conducted interviews with prioritized passenger groups.

At this meeting, Västtrafik's existing insights and data on passenger experience from recent studies was discussed with two co-workers from Västtrafik's passenger experience team (lasting approximately one hour). The focus of the meeting was Västtrafik's four identified categories of passengers (based on experience and traveling habits) and how the needs for a desirable passenger experience shifted between the four categories. The meeting consisted of a review of Västtrafik's recent studies of passenger experience in public transportation, followed by a discussion and instruction of how the data should be correctly interpreted.

Appendix 4.

Observations I

Passenger behaviour

The observations were ongoing documented, in written text and/or photos.

Cable railway

The staff at the two cable railway systems were informed about the study to be conducted on beforehand, all other aspects of the observations were hidden. There was however no interaction with the staff during the study itself.

Quantitative data of passenger placement and number of standing passengers was noted on to templates, showing an overall view of the cabins, as shown in figure C.

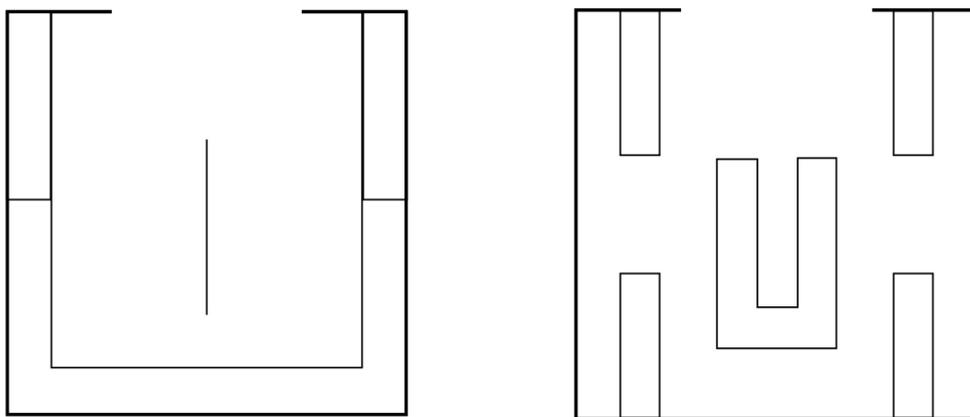


Figure C. Template showing an overview of the cable railway cabins used for mapping quantitative data during observations in Koblenz and Bolzano.

The observers were the last passengers to board and disembark the cabins, and the observers' placement inside the cabin varied based on situation in order to affect other passengers as little as possible, and thereby reduce risk of bias on passengers' behaviour and choice of placement.

To cover the behaviour of different passenger groups, observations were spread out over different hours of the day, based on opening hours. Table A-E declares data from the observations conducted on various means of public transportation, over different hours of the day. The observers traveled both in pairs and individually.

Bolzano, Italy

Table A: Data of the observations conducted from the inside of cabins and at stations in Bolzano, Italy.

Number of observers	Number of trips made (per observer)	Time of day observing	Total time observing (per observer)
2	10 (both ways)	08-22	Approximately 11 hours

Travel time was approximately twelve minutes, therefore observations were specifically focused on changes in passenger behaviour and activities over time. Focus was also set on passenger behaviour when boarding and disembarking the cabins at the stations.

Koblenz, Germany

Table B: Data of the observations conducted from the inside of cabins and from ground level in Koblenz, Germany.

Number of observers	Number of trips made (per observer)	Time of day observing	Total time observing (per observer)
2	4 (both ways)	09.30- 19.00	Approximately 12 hours

Travel time about seven minutes, observations were specifically focused on passenger placement and activities during shorter trips.

Bus
Gothenburg, Sweden

Table C: Data of the observations conducted on buses in Gothenburg, Sweden.

Number of observers	Number of trips made (per observer)	Time of day observing	Total time observing (per observer)
2	Approximately 50, resp. 20	07.00-24.00	Approximately 7 hours resp. 3 hours

Observations on board buses were conducted on daily basis, over the time period of a couple of weeks. Travel time varied between 5-10 minutes. Observations were primarily conducted on weekdays during rush hour and therefore specifically focused on passenger behaviour and activities during shorter trips.

Tram
Gothenburg, Sweden

Table D: Data of the observations conducted on trams in Gothenburg, Sweden.

Number of observers	Number of trips made (per observer)	Time of day observing	Total time observing (per observer)
2	Approximately 150 trips	07.00-24.00	Approximately 50 hours

Observations onboard trams were conducted on daily basis, over the time period of a couple of weeks. Travel time varied between 5-20 minutes. Observations were primarily conducted on weekdays during rush hours and focused on passenger behaviour and activities during both short and longer trips.

Ferry
Gothenburg, Sweden

Table E: Data of the observations conducted on Ferries in Gothenburg, Sweden.

Number of observers	Number of trips made (per observer)	Time of day observing	Total time observing (per observer)
1	2 (Both ways)	12.00-13.00	Approximately 1 hour

Observations onboard ferries were conducted on a single occasion on a weekday at midday onboard the ferries and ferry terminals. Travel time was approximately 6 minutes. Focus of the observations were primarily focused on bicyclists behavioural patterns, especially when boarding and disembarking.

Appendix 5.

Consultation II

Samverkansgruppen

Samverkansgruppen (The collaboration group for physical accessibility in Gothenburg) consists of representatives from The technical administrations of the City of Gothenburg and three member organizations of HSO Gothenburg (the local department of The Swedish Disability Federation in Gothenburg). These three member organisations are:

- RiG - Reumatikerdistriktet i Göteborg (Rheumatic association of Gothenburg)
- DHR - Delaktighet, Handlingskraft, Rörelsefrihet (Participation, Decisiveness, mobility)
- SRF - Synskadades riksförbund (The national association for visually impaired)

The purpose of the meeting was to gather basic first-hand knowledge about needs of passengers with various impairments and thereby create some initial awareness of their situation.

Questions regarding public transportation and passenger experience were asked in a semi-structured manner, allowing representatives for the organisations to describe basic but essential problems and needs with public transportation.

Duration:

approximately 60 minutes

Interview guide:

- What does an optimal trip with a public transportation vehicle include for members of your organisations?
- Are there any obstacles when traveling today? If yes, which?
- Which needs are prioritized?
- Are there any special parameters that are important to take into account and consider, when meeting members of your organisations?

Parallel to the discussion about passenger needs, a number of proposed potential participants/interviewees of passenger groups to contact and involve in the process were brought up.

Appendix 6.

Consultation III

Physiotherapist

In order to identify the needs of physical aid for physically impaired and senior citizens, a physiotherapist was consulted.

The consultation was focused on whether it was necessary to equip the cabins with physical aid for passengers getting up and down from/to seated position. Furthermore, it was discussed what kind of support that was useful for these passenger groups. It was also discussed how supports could be designed, in order to be efficient and helpful for these passengers in need of support.

Appendix 7.

Study of literature

The study of literature was primarily based upon published material available at Chalmers library and through its accessible databases and publicly available websites on internet. However, in order to align the work with Västtrafiks business, both internal and external documents from Västtrafik were studied as well.

Databases:

Chalmers Publication Library
Google Scholar
Scopus
SpringerLink
Summon Chalmers
Swepub
Wiley Online Library

To gather relevant literature, a set of keywords was established (listed below) containing a number of keywords used both individually as well as in various combinations, in order to find as much relevant information as possible.

Keywords:

Cable railway
Cable ropeway
Urban
Public transportation
User experience
Passenger experience
Passenger quality
Universal design
Inclusive design
Interior design
industrial design
User driven innovation
Accessibility
User involvement
Product development
Usability
UX
Accessibility
Pregnancy
Ergonomics

The collected material was critically examined. Based on an assessment of relevance to project topic, the material was either dismissed or considered as valuable finding to take into consideration in the development process.

Appendix 8.

Group discussion

To gather information about needs and desirables related to everyday commuting, two group discussions with highschool teenagers, conducted by personnel at Västtrafik were observed. Focus of the discussion was set on the cable railway as a whole and the needs and desirables the cabins should fulfill.

Participants:

Approximately 30 high school teenagers divided in two groups.

Supervisors:

2

Duration:

Approximately 20 minutes

The questions of interest brought up during the group discussions were as follows:

- What do you think of the cable railway idea?
- What are your expectations of the cable railway?
- What would you like to be able to do, when traveling with the cable railway?
- How do you think the cabin should be furnished?
- What is important for you when traveling with public transportation?

Appendix 9.

Focus group

To evaluate and further develop generated subconcepts, a focus group with a set of participants from multiple passenger groups were conducted inside the mock-up, furnished according to the layout of the subconcepts.

Props:

Mock-up

Chairs representing seats

Vertically standing bars representing handheld support

Bicycle

Documentation:

photos, and written text

Participants:

5

Supervisors:

2

Duration:

Approximately 45 minutes

The list of participant along with a declaration of which passenger groups they represented is presented in table F.

Table F. declaration of participants in the focus group.

Representing passenger group
Everyday commuter, bicyclist
Everyday commuter, bicyclist
Everyday commuter
Everyday commuter
Everyday commuter

The participants were asked to freely interact with each other and the mock-up representing subconcepts, thinking out loud and discussing subconcepts aspects. The supervisors asked open ended questions to trigger discussion on specific aspects on the following topics:

- Overall appearance of concepts
- Placement of seats
- Number of seats
- Physical support
- View
- Bicycle inside cabin
- Alternative designs
- Other Passenger groups inside cabin

When all topics above had been subjected in the discussion, the participants were allowed to make, evaluate and discuss adjustments to the subconcepts they thought could improve the subconcept.

The sequence was repeated for the remaining subconcepts.

Appendix 10.

Observations II

Visual identity of vehicle interior

Observations of the interior in Västtrafiks vehicles were conducted onboard their vehicles to study Västtrafiks visual identity concerning interior and furnishing. Table G lists the type of vehicles the observations were applied to. The observations focused on colors, materials, interior type (e.g. type of seats) and surfaces of the interior onboard the vehicles. Observations were documented in written text and through photos of the interior.

Table G. List of vehicles and models in which the interior was studied.

Public transportation vehicle	Identification/type
Buses	Buses occupying lines: 16, 17, 18, 19, 55, 60
Trams	M29, M31, M32
Ferries	Älvsnabbare

Appendix 11.

Consultation IV

Comprehensiveness of collected data

Consultation with cable railway project group member with insights in the development of public transportation vehicles at Västtrafik.

A consultative meeting (approximately 45 minutes) was conducted with members of the cable railway project management team holding great knowledge and insights in developing environments for public transportation. Focus was set on verifying and providing additional information to the gathered passenger insights and current behaviour.

Data and insights gathered so far in the project was presented to the project management member who assessed the overall level comprehensiveness. The gathered insights and information was discussed, based on the development of Västtrafiks upcoming and existing vehicles, ensuring that the information would cover the current standards and legislations of public transportation.

Appendix 12.

Affinity-diagram

To structure, compile and visualize the large amount of information gathered throughout the project, a affinity-diagram in line with Kaulio et al. (1999) was conducted.

Collected data was categorised, numbered and coded by color based upon origin simplifying tracing data back information to its source.

The data was individually documented in written text on post-its, structured and grouped together based upon affiliation. In turn, the groups were organized in according to affiliation in relation to other groups, creating an extensive structure of the gathered data.

Appendix 13.

Requirement list

The establishment of requirement list for the key design features for a good passenger experience was based upon an interpretation and examination of the data and insights gathered throughout the project. Based upon importance and relevance, the requirements were described in an objective manner, of what a concept for a cabin interior should provide and perform, allowing a binary and objective yes/no answer. If necessary, the fulfillment of the requirement was specified by defining a value of when the requirement is fulfilled.

Three types of requirements were created; Objective requirements, Subjective requirements and guidelines (named type I, II and III) described below.

Type I

Objective requirements with defined value of fulfillment which could be answered objectively with a yes/no.

Type II

Subjective requirements considered to be fulfilled when achieving a 85 % positive response from at least 85% of test participants, in accordance with Västtrafiks overall goal of 85 % passenger satisfaction by 2025 (Västtrafik, 2016).

Type III

“Unmeasurable” requirement with non-binary defined value of fulfillment. Therefore, defined only as guideline to be used proactively.

All requirements were compiled and structured into a list with categories developed in the affinity-diagram.

Description of type	Objective requirements (yes/no)		Fulfillment of requirement	Yes
	I	II		
II	Subjective requirements (must be fulfilled according to at least 85% of test participants)			Possibly
III	Guidelines			No
Category	Name	Requirement	Specification	Type
		<i>The concept should:</i>		
Flow	1.1	allow passengers to embark or disembark within 20 sec.	Up to 25 passengers at the same time.	I
	1.2	encourage passengers to place themselves out of the main flow.		I
	1.3	provide an easy access area for short journeys.	Out of the main flow.	I
	1.4	maintain the flow inside cabins, regardless of type of passengers traveling.		I
	1.5	enable passengers to embark and disembark without disturbing fellow passengers.		II
	1.6	counteract passengers' belongings being placed within the main flow.		III
	1.7	aim for enabling passengers to embark or disembark within 15 sec.	Up to 25 passengers at the same time.	III
	1.8	contribute to belongings not occupying space intended for passengers.		III
	1.9	encourage optimized use of the space while crowded.		III
	1.10	facilitate for bikers to lead their bike in an anti clockwise turn inside the cabin.		III
Accessibility	2.1	provide permanent seat.	For those who have difficulties sitting on foldable seats.	I
	2.2	have permanent seats and/or space to stand close to the door.		I
	2.3	provide an easily accessible open space of minimum 2x2 m.	Enable wheelchairs of class A-C to turn around freely.	I
	2.4	provide open spaces free from physical obstacles:		
	a	- even floor.		I
	b	- no protruding objects.		I
	2.5	provide continuous physical guidance from doors to closest seats.		I
	2.6	provide accessibility for at least two units at the same time:		
	a	- prams	Out of the open 2x2 m.	I
	b	- wheelchairs		I
	c	- bicycles		I
	d	- walkers		I
	2.7	have no objects fixed on the cabin floor.		I
	2.8	provide seat adjacent to areas suitable for prams, wheelchairs and walkers.		I
	2.9	have at least 10% of the seats on a height of 500 mm.	For impaired and elderly passengers.	I
2.10	provide a free height of 2,10 m inside the whole cabin	For the 99.99 %ile of men.	I	
2.11	allow all cabins to be identical.	The design should cover needs of all prioritized user groups.	I	
2.12	enable visually impaired passengers to easily understand the physical environment.		II	
2.13	provide all passengers with an equivalent experience.		II	
2.14	enable impaired passengers to locate a seat/space close to the door.		II	
2.15	enable passengers to pass by a parked pram, wheelchair, bicycle or walker.		III	
Personal space	3.1	provide seat separated from others.		I
	3.2	avoid placing passengers seated face to face.		I
	3.3	provide a barrier between back rest and main flow.		I
	3.4	provide sufficient space in front of seats.	At least 820 mm in front of backrest.	I

3.5	provide support, to prevent falling, for all passengers without having them to interfere with others' personal space.		II
3.6	counteract passengers feeling observed.		II
3.7	enable the passengers to see the entire cabin.		II
3.8	provide enough space for standing passengers' to maintain their personal space		II
3.9	provide enough space around seated passengers' to maintain their personal space.		II
3.10	allow passengers to keep supervision over their company at all times.	For example children or care recipients.	II
3.11	provide maximum number of seats possible, while maintaining comfort for non seated passengers.	Total cabin capacity must remain at 25 passengers.	III
Physical support			
4.1	provide support for the back while seated.		I
4.2	have seats on a height of 450 mm.		I
4.3	provide physical aid while standing or moving around inside cabin.		I
4.4	admit the passengers to get supported from their hands.	For the 0,01 %ile of women-99,99 %ile of men.	I
4.5	provide support that is fixed while in use.		I
4.6	have clearly visible supports.	High contrasting colors.	I
4.7	provide continuous support from the doors to different kind of positions in the cabin.	Open space, standing and seated.	I
4.8	provide support for changing position from standing to seated and reversed.		I
4.9	allow passengers to sit and lean with an erected back.	Take notice of the walls' convex shape and placement of handrails.	I
4.10	provide various resting opportunities:		
a	- sit down.		I
b	- stand up.		I
c	- lean while standing.		III
4.11	facilitate for the passengers to find appropriate support at all times.		II
4.12	provide possibilities for the passengers to have a steady journey, regardless of position inside the cabin.	Preferably a variation of supports.	II
4.13	provide support where the passengers do not need to use hands.		III
Added value			
5.1	allow passengers to sit in the direction of travel.		I
5.2	provide opportunity to sit next to a fellow passenger.	Also when one or both are wheelchair users etc.	I
5.3	allow wheelchairs, walkers and prams/strollers to be placed in the direction of travel.		I
5.4	enable children to look at the view without bringing their feet on to the seat.		I
5.5	counteract that passengers place feet at surfaces intended for sitting.		I
5.6	be perceived as clean.		II
5.7	be perceived as spacious.	Both while empty and while loaded.	II
5.8	avoid excessive twisting of torso to reach a view.		III
5.9	allow people to get a full vertical panoramic view.		III
5.10	admit wet umbrellas to be kept on a distance from passengers.		III
5.11	allow passengers to stretch out, if cabin is not crowded.		III
5.12	enable all passengers to find a view both while standing and seated, regardless of placement.		III
5.13	enable view in all four directions of the cabin.	Forward, backwards, right and left.	III
5.14	provide support for crutches while not used.		III
5.15	admit passengers to bring large or odd sized baggage.	If cabin is not crowded.	III
5.16	admit passengers belongings to be placed off the cabin's floor.		III
5.17	provide possibility to fasten bicycles.		III

Appendix 14.

Establishment of vision

As a way to structure and organize a common direction of further work, a vision containing the essence of a satisfying result was developed.

The aim was to highlight and mediate the essence of a desirable passenger experience inside the cabins.

The establishment of the vision benefited from the recently established affinity diagram where all gathered data had been processed and structured. Several frequent upcoming data when establishing the affinity-diagram was compiled into a list of essential components, suitable for good passenger experience. The data was thereafter, in several iterative stages structured into a vision, consisting of shorter explanatory text, describing a good passenger experience. The established vision is presented in Result chapter on page 62 and 79.

Appendix 15.

Consultation V

Recommendations for establishing requirement list

Consultation with a Ph.D. Student in Human-Machine Systems for the Department of Product and Production Development at Chalmers University of Technology.

The consultation focus was set on obtaining information, verify quality and comprehensiveness of requirements and to receive recommendations of requirement list structure for how the requirement list could be objectively and correctly presented.

Appendix 16.

Consultation VI

Cable railway project management team

Consultation for aligning visions for public transportation

A consultative meeting was conducted with two members of cable railway project management team at Västtrafik (project group manager and member of the cable railway project management group with insights in the development of public transportation vehicles).

The consultation was an activity conducted in order to verify and align the overall approach that had been developed so far, enclosed by the established vision and requirement list.

Each deliverable was presented and processed separately through discussions of comprehensiveness and alignment with existing ideas and visions. The discussion covered the visual on a detailed level while the requirement list primarily covered category level.

Appendix 17.

Co-design workshop I

The workshops were conducted separately for each participant from the passenger groups, adjacent to the conducted interview.

The purpose of the workshop was to make the users generate, express their needs and expectations by individually supervised creative interaction with trigger material and generative tools such as props and mock-up. Thereby creating a shared design language of visual and direct communication. The aim was that the participants would contribute to the development process with their own experience, complement the data from their interviews and hopefully discovering both needs and solutions based on tacit knowledge which otherwise would not have been mentioned.

Props:

Mock-up

Chairs that represent seats

Brought personal belongings such as bicycles or handbags.

Documentation:

Audio recordings, photos of the activity

Participants:

8

Supervisors:

1-2

Duration:

Approximately 10-30 minutes depending on participants commitment and number of generated ideas.

The list in table H declare which passenger groups each participant represented during the co-design workshop I.

Table H. Participants from passenger groups during co-design session I.

	Representing passenger groups
1	bicyclist, everyday commuter
2	everyday commuter
3	everyday commuter
4	physically impaired, senior citizen
5	physically impaired, senior citizen
6	physically impaired, senior citizen
7	wheelchair
8	physically impaired

After a short presentation of project and the cable railway prerequisites, the participant was asked to furnishing a layout in the mock-up with the props appropriately for their use of their own passenger group. Thereby generating ideas based upon specific needs of the passenger group. When conducting the task the participant was asked to motivate his/her action and choice of layout.

During the session the supervisors asked open-ended questions about the created layouts in a semi-structured manner. The idea was to trigger further ideation and to steer the participants to reflect upon and discuss the ideas on a deeper level. Supervisors would also implement parts of or whole designs of previous participants to evaluate and challenge the participants to design for other passenger groups.

Commonly/frequently asked questions during the sessions were:

- How would this layout affect your cable railway trip?
- How do you think this layout would affect other passenger groups?
- How would (rearrangement of the layout) affect your trip?
- What would be the best layout if you traveled;
 - Alone?
 - In a larger group of people?
- How would your needs alter if you traveled for longer period of time;
 - 4 minutes
 - 12 minutes

Appendix 18.

Brainstorming session I

These brainstorm sessions were a generative substitute for participants whom for various reasons were unable to conduct the co-design workshop I.

Documentation:

Audio recordings and written text.

Participants:

6

The list in table I declare which passenger groups each participant represented during the co-design workshop I.

Supervisors:

1-2

Duration:

10-15 minutes

Table I. participants from passenger groups during co-design session I.

Representing passenger groups
visually impaired
visually impaired
family with children, everyday commuter
everyday commuter
everyday commuter
everyday commuter, pregnant

Brainstorming session were conducted individually in adjacent to a conducted interview for all participants. Focus was set on generating ideas based upon the needs of the prioritized passenger group the participant represented. The sessions followed the structure of brainstorming founded upon on following topics:

- How would the cabin interior be designed to meet you needs?
- How would the seats be positioned?
- How can the cabin be designed so that everyone inside can enjoy the view?
- How can the comfort be increased inside the cabin while traveling?

Appendix 19.

Brainwriting session

The brainwriting was conducted by the project members. To include all passenger groups in the designs, new ideas were merged together with ideas generated in previous methods.

Tools:

Pen and paper

Participants:

2

Duration:

40 minutes (4x10 minutes)

In total, four sessions were conducted focusing on the following two topics:

- Inclusive layout of cabin interior for all passenger groups
- Specific cabin design solutions for passengers with visual and physical impairments, compatible with the needs for other passenger groups.

Informal evaluation

To evaluate and narrow the number of concepts generated during the brainwriting session into a smaller number, an informal evaluation of the ideas was conducted.

Each idea was individually assessed by the project members. Based upon assessed feasibility, overall potential and fulfillment of needs of the passenger groups' concepts were deemed as interesting in further development of cabin interior design.

Appendix 20.

Brainstorming session II

A Brainstorming session with the project members was conducted to generate ideas based upon the emerged insights and feedback from the focus group.

Tools:

Pen and paper

Participants:

2

Duration:

Approximately 20 minutes

The session covered two questions, which were discussed and generated throughout the whole session without a predefined structure but followed the overall framework of a brainstorming session. The questions were the following:

- How can accessibility for bicycles, prams and wheelchairs increase inside the cabin, without reducing the number of seats?
- How can we create more seats, without reducing the accessible areas for wheelchairs and bicycles etcetera?

The result was evaluated adjacent to the session through informal evaluation, based upon the requirement list and feedback from gathered from the focus group.

Appendix 21.

Testing cabin concepts

To evaluate the selected subconcepts, usability tests were conducted to compare and evaluate critical aspects of cabin performance in line with passenger experience for passenger groups without specific needs. The qualitative and quantitative output related to passenger experience was to be used for assessing most suitable concept.

The capacity and scenario test were open participatory observations of 25 participants integrating with furnished mock-ups according to concept layouts. The participants were asked to act as they would normally do in public transportation for a trip lasting between 10-15 minutes. The tests were afterwards followed up by a short reflective focus group session.

Table J presents the number of participants from each prioritized passenger group participating in the usability tests.

Table J. Participants of the capacity and scenario tests from each passenger group.

Prioritized passenger groups represented	Number of participants
Everyday commuter	18
Family with children	4
Senior Citizens	3

Mock-up setup

For the usability tests the Mock-up was furnished according to the concept layouts visualize concept designs. To do so the mock-up was furnished with chairs and vertical bars. To indicate a direction of travel a illustration of the cable railway was projected in front of the mock-up, as illustrated in figure D. Sound and motion from the tests were documented through an overhead video camera, installed over the mock-up.

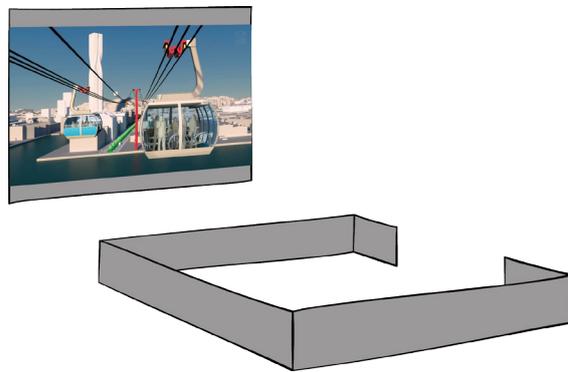


Figure D. The picture that was displayed on a projector screen to indicate the direction of travel.

Capacity test

The capacity test was a test conducted to gather information of how passengers may experience a fully loaded cabin with 25 passengers. The focus of the capacity test was to gather qualitative and quantitative data of the following aspects:

- Obtain information, whether it was possible to accommodate 25 persons with the concepts or not.
- Obtain indications of time consumption to board and disembark 25 participants.
- Obtain indications of how the cabin layout affects the time it takes to board and disembark participants.
- Obtain indications of the level of crowding inside the cabin during maximum load.
- Obtain indications of how participants perceived the experience of a fully loaded cabin.

Test sequence

The participants were asked to interact as they would normally do in public transports during trips between 10-15 minutes.

1. Upon a given signal all participants would gather mock-up in no particular order.
2. As all participants were gathered inside short open ended question regarding their experience was asked:
 - How does it feel?
 - Is this an acceptable situation for traveling four minutes?
3. Upon a given signal all participants would disembark the mock-up in no particular order.
4. Time consumption for boarding and disembarking, as well as comments, discussion and movements inside the mock-up were documented. The capacity test was repeated for all concepts.

Scenario test

The scenario test consisted of a made up scenario, mimicking the intended sequence for boarding and disembarking at four stations, based upon given instructions. The focus was to test how cabin concept would perform in multi-station cabin railway systems with passengers boarding already half-full cabins.

The purpose of the scenario test was to cover the following aspects of the concepts:

- Obtain data of participants' moving patterns (flow) within the cabins.
- Obtain data regarding which spaces would be most attractive
- Obtain data considering how participants would interact when boarding an already half full cabin.
- To see if there were any unpredicted behaviour among participants previously in the process.

Participants received individual instructions when to board and disembark as shown in table K. The distribution of instructions were random with exception for the family of four which were all given instruction D.

Table K. List of the variation of instructions given to participants during the test second sub-test. The asterisk indicate that the participants disembarked after the test had ended.

Variation of Instruction	Number of Participant, with instruction	Instruction to board cabin	Instruction to disembark cabin
A	7	Station 1	Station 3
B	6	Station 1	Station 4
C	3	Station 2	Station 3
D	4	Station 2	*
E	5	Station 3	*

Test sequence:

1. The cabin arrives to station 1.
2. On a given signal, all participants with instructions to board station 1 board the concept in position of their own choice.
3. The cabin leaves station 1 and arrives to station 2.
4. On a given signal all participants with instructions to disembark at station 2 disembark.
5. On a given signal, all participants with instructions to board station 2 board the concept in position of their own choice.
6. The cabin leaves station 2 and arrives to station 3.
7. On a given signal all participants with instructions to disembark at station 3 disembark.
8. On a given signal all participants with instructions to board at station 3, would board the concept in position of their own choice.
9. The cabin leaves station 3 and arrives to station 4.
10. On a given signal all participants with instructions to disembark at station 4, would disembark.
11. The test is completed, participants still onboard the concept disembark.

The scenario and movement of participants in and out of the cabin is described in table L, listing the number of participants that disembarked and boarded at each station during the test.

After participants boarded at the stations, test leaders asked open ended questions about their experiences in order to start smaller discussion and to make the participants to reflect upon their positions and experience.

The reason for not all remaining participants disembarked at the fourth and final station was to create the possibility of more interference between seated passengers, that would stay on board and others that would disembark.

Table L. Listing the number of participants disembarking and boarding for each station during the test.

Station	Participants disembarking	Participants inside cabin after disembarking	Participants boarding	Participants inside cabin after boarding
1	-	-	13	13
2	-	13	7	20
3	10	10	5	15
4	6	9	-	-

Focus group

Both the capacity and scenario test were followed up by shorter focus group collecting qualitative data regarding overall passenger experience, design pros and cons, and most suitable concept.

For this, the participants were split up in two equally sized groups. The topics discussed were:

- Was there room for everyone?
- Were you satisfied with your position inside the cabin?
- What do you think of the concept in relation to others?
- What can be improved?

Analysis of usability tests

The data collected through the conduction of usability tests were both qualitative and quantitative. The following text defines which aspects and data that was analyzed and the method for analyzing.

Accommodating 25 passengers

Based upon ocular inspection of recordings from the overhead camera of the capacity test, the analysis would define whether 25 passengers could physically fit inside the concept. The aspect was binary defined (yes/no) and did not take qualitative data into consideration such as the participants comments or the content of the discussion.

Time consumption for boarding and disembarking 25 passengers

Based upon ocular inspection of the recordings of the capacity test. The time consumption was defined as the time it took from the first to the last of the 25 participants to board respectively disembark the mock-up. The data was rounded up to full seconds.

Attractive spots

Based upon ocular inspection of the recordings from both the capacity and scenario test, the most attractive seats/position were, based upon which spots were occupied first during the tests. The least attractive spots were defined by being picked last or not at all. The quantitative data from the tests was also backed up by qualitative data such as related comments from participants collected, both during and after the tests had been conducted. The analysis explored which places that were the most popular and how they were oriented inside the mock-up.

Crowding

Based upon ocular inspections of the recordings from the capacity and scenario tests, the analysis would define the level of crowding inside the mock-up. The estimation was made based upon how and how much the participants spread out inside the mock-up and how close they placed themselves in relation to each other. The level of crowding was estimated relative to the reference test and other concepts tested.

Perception of crowding

The perception of crowding inside of the concepts was based upon the qualitative feedback from participants in adjacent to the tests relative to other concepts.

Flow

Based upon ocular inspections of the scenario tests, but also the capacity test, the flow inside the mock-up of a concept was estimated based upon participants' moving patterns. Movements inside the cabin was marked and listed on a piece of paper with a figure of an overhead view of a cabin. The figure divided the cabin in 36 equally sized squares, as shown in figure E.

The analysis of flow inside the cabin was based upon all sequences of the scenarios, with the exception of the final disembarking, as this was not considered as representative. The squares were color coded based upon how many times they were crossed during the test.

- Orange level 1 (≥ 9)
- Orange level 2 (6-8)
- Orange level 3 (3-5)
- Orange level 4 (1-2)
- White (unused area)

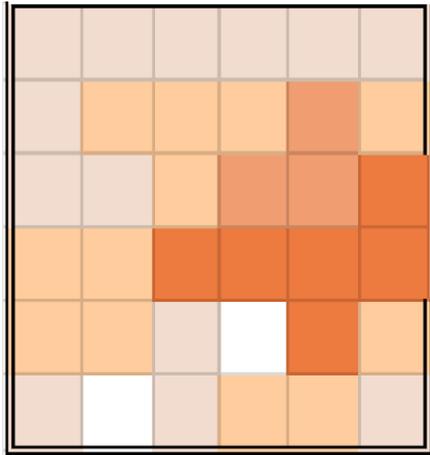


Figure E. Example of mapping the flow inside the cabin during the scenario test.

The squares were also marked with a number, defining the specific number of times the area was crossed during the tests.

Squares marked with (x) indicate permanent seats.

Squares marked with (!) indicates a space occupied by other participants.

Appendix 22.

Co-design workshop II

The co-design workshop II was conducted primarily to evaluate, but also to further develop, adapt and discuss needs and expectations on the developed subconcepts so far by interaction with the mock-up.

Through the co-design workshop the aim was to develop a design that would fulfill the needs of wheelchair users and enhance passenger experience, more than just fulfilling basic needs. By using the mock-up, one created a shared design language of physical and direct communication.

Props:

Mock-up

Chairs that represent seats

Brought personal wheelchair
(Class B electrical wheelchair)

Documentation:

Audio and video recordings,
photos of the activity

Participant:

Wheelchair user with substantial experience and insights of wheelchair accessibility in public transportation in Västra Götaland.

Supervisors:

2

Duration:

Approximately 45 minutes

After a shorter presentation of project, cable railway prerequisites and the developed subconcepts, the participant was asked to interact inside the mock-up, which had been furnished according to the layout of the subconcepts. The participant was then asked to think out loud about the layout. At the same time the supervisors would ask open-ended questions in a semi-structured manner, to trigger discussions on a deeper level. The participant was also asked to perform smaller tasks, to evaluate aspects of accessibility.

When the participant had obtained the overall idea of a subconcept layout, he was encouraged to generate modifications of the layout to better fit wheelchair users needs. The participant was then asked to evaluate the modifications through interaction. At the same time the supervisors would ask open ended questions to further investigate the modification of the layout.

When all concepts had been evaluated and modified, the participant was asked to estimate and motivate which of the concepts that would have the most potential for providing the best passenger experience.

During the session the concepts were discussed with focus upon:

- Number of wheelchairs to fit inside the cabin
- Maneuvering wheelchairs of different types and classes inside the cabin
- Comparison and estimations of the concepts potential, based upon accessibility.
- Overall potential for a good passenger experience inside cabin.

Analysis of usability co-design workshop II

Wheelchair accessibility

Based upon qualitative data collected and ocular inspections of the recordings from the co-design workshop II, wheelchair accessibility was estimated relative to other subconcepts.

Aspects taken under considerations were:

- The number wheelchairs that could fit inside the cabin.
- Maneuvering wheelchairs of different types inside the cabin.
- Wheelchair placement inside the cabin.

Overall potential for good passenger experience for wheelchair users

Based upon qualitative data such as discussions and comments during the co-design workshop II, the potential for good passenger experience of the subconcepts were estimated relative to each other. Aspect taken under consideration were:

- Number wheelchairs that could fit inside the cabin.
- Maneuvering wheelchairs of different types inside the cabin.
- Wheelchair placement inside the cabin.
- Overall Passenger experience inside cabin

Appendix 23.

Consultation VII

Expert in public transportation design

To verify and align the design of the final concept, the expert in public transportation design was contacted.

The overall design of the final concept was communicated through simple illustrations of the overall layout along with quick sketches on paper. Based upon the visual material and complementary information gathered in the project process, the overall potential of the concept was assessed.

Recommendations provided in general originates from and relies on existing UN regulations for construction of coaches and buses called *UN Regulation No. 107*

Discussions, reflections and recommendations of measurements and other relevant for detail development material, in line with existing public transportation standards were discussed throughout the consultation and is presented below.

Physical supports

Aspects that covered physical supports was focused on armrests.

Armrests comes with pros and cons. They provide good support for passengers, but are in the way when getting into the seats for passengers that does not use them. Foldable armrests could therefore be an alternative, but at the same time are likely to break and malfunction.

Handrails and vertical bars

Slings are somewhat of a last resort solution. Does not provide as much support as a permanent support and can be in the way of other passengers.

Leaning supports

Leaning supports can be seen as a good compromise between space efficiency and comfort.

A design that combines leaning supports and foldable seats could be a successful approach for increasing the potential passenger comfort, as they allow more passengers to sit in low to medium number of passengers are on-board the cabin.

Sitting areas

Aspects that covered sitting areas was focused on ergonomics of such equipment.

Recommended angle of backrests is 18 degrees. The angle does not have to be continuous and can therefore have a steeper angle in the lower back support. An example of such design with measurements is shown in figure F.

Minimum size of area for sitting is 400x400 mm as shown in figure G

Recommended height for standard seats is 450 mm as shown in figure H

Recommended height for seats designated for elderly and physically impaired is 500 mm (as shown in figure H) and should make up for about 10 percent of the sitting areas.

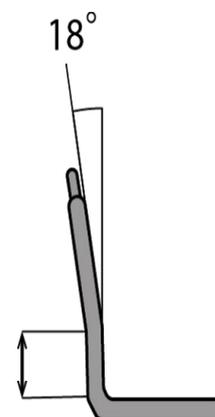


Figure F. Recommended angle for backrests.

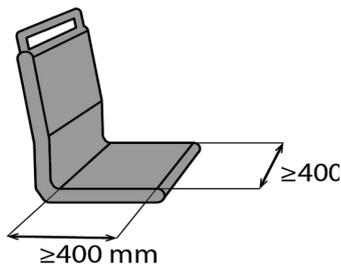


Figure G. Minimum size of sitting areas.

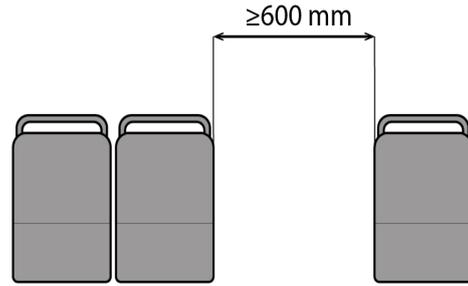


Figure J. Recommended minimum distance for passages in between seats and other objects.

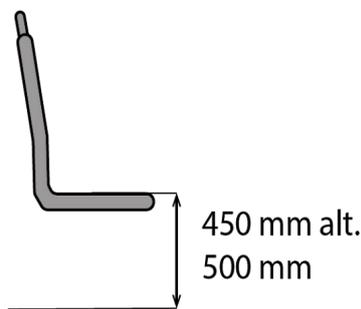


Figure H. Recommended heights for sitting areas.

Recommended seat pitch (distance between rows of seats) is at least 820 mm measured from one point of the seat to the point on the seat in front, as shown in figure I.

Recommended minimum distance for passages eg. between seats is 600 mm as shown in figure J.

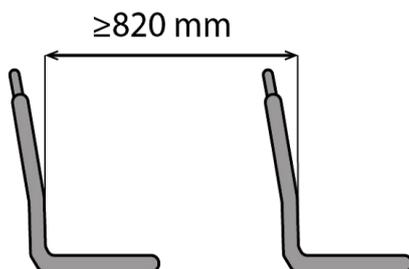


Figure I. recommended seat pitch

Placement

Areas for sitting where passengers are facing each other should be avoided, as it is often experienced as uncomfortable and easily intervenes with personal space.

The aspect of weight adjustment when it comes to placement of chairs inside the cabin should not be a problem. The placement of chairs does not guarantee the weight distribution inside the cabin anyway. This aspect should therefore not be of any major concern of the development.

Seats are due to traditions a preferred choice for sitting over benches in Swedish public transportation. In other nations, such as the UK, benches are a much more common sight in public transportation and therefore more accepted among passengers. Seats are therefore to prefer for Gothenburg's cable railway. However, if benches somehow would be the better alternative of the two, the level of innovation of the cable railway in public transportation might result in a greater acceptance among passengers than in other vehicles.

Other

- Reflective surfaces should be avoided
- Protruding objects should be marked with contrasting colors

Appendix 24.

Verification of final concept with requirement list

The final concept was finally evaluated and verified through the established requirement list by two the project group.

The fulfillment of the set requirements was determined based upon insights gathered throughout the project, as well as the results of conducted. The fulfillment of requirements was documented according to table M.

Table M. system for marking fulfillment level of requirements.

Green marker	Fulfilled requirement
Yellow marker	Possibly fulfilled requirement
Red marker	Unfulfilled requirement

Fulfillment of subjective requirements (type II) were assessed based upon the insights and results gathered throughout the project. Even though no test participants were contacted for the assessment, the fulfillment of each separate subjective requirement was assessed based upon a reasonable outcome, in line with the insights gathered in the project.

Yellow marker indicating “possibly fulfilled” meant a lack of data which resulted in that the requirement could not be confirmed as objectively fulfilled.

Appendix 25.

Consultation IX

Cable railway project management team

Consultation with two members of the project management group at Västtrafik (project group manager and project management member with insights in the development of public transportation vehicles).

The focus of the consultation was to present and verify the overall result and project deliverables with project management.

Each deliverable was presented and discussed separately. The final concept was visualized through vectorised illustrations of both overall concept as well as detailed illustrations of concept functions.

Appendix 26.

Results from tests

Time consumption boarding disembarking

Table N lists the time required for each sub concept in both maximum capacity and scenario tests.

Attractive spots

Figure K show the passenger placement over time inside the sub concepts during the scenario test before and after boarding and disembarking.

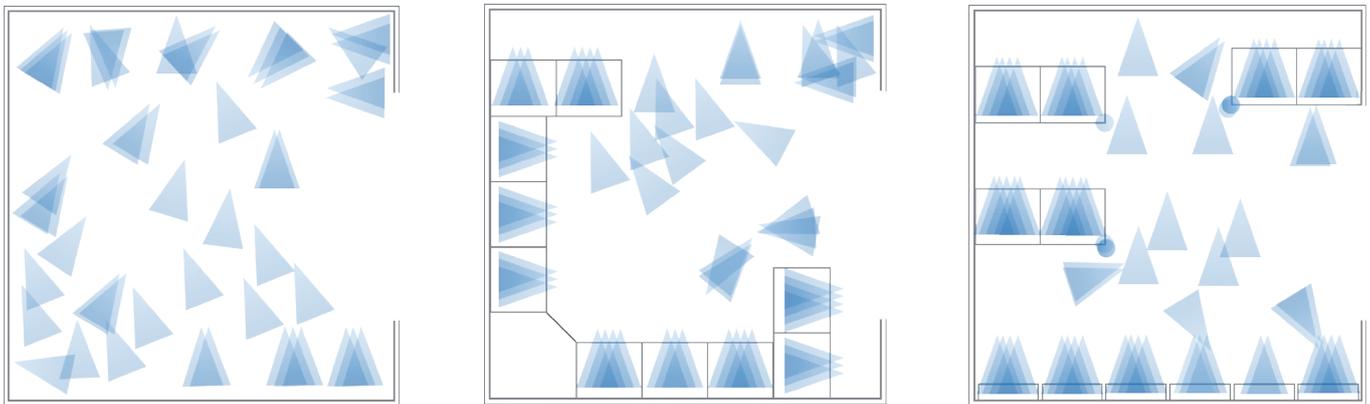


Figure K. Illustrations of summary of passenger placements inside cabin during scenario tests before and after boarding and disembarking stations (from the left; subconcept 1, subconcept 2, subconcept 3).

Table N. Time required for 25 test participants to board and disembark the cabin.

(Seconds)	Sub concept 1	Sub concept 2	Sub concept 3
25 persons, in	25	27	32*
25 persons, out	16	24	21
Station 1, in	11	13	14
Station 2, in	9	12	12
Station 3, out	11	7	13
Station 3, in	5	8	6
Station 4, out	5	9	10

Crowding

Figure L show Illustrations of placement of passengers inside cabin during maximum capacity tests with declaration of sequence of entry for all three sub concepts.

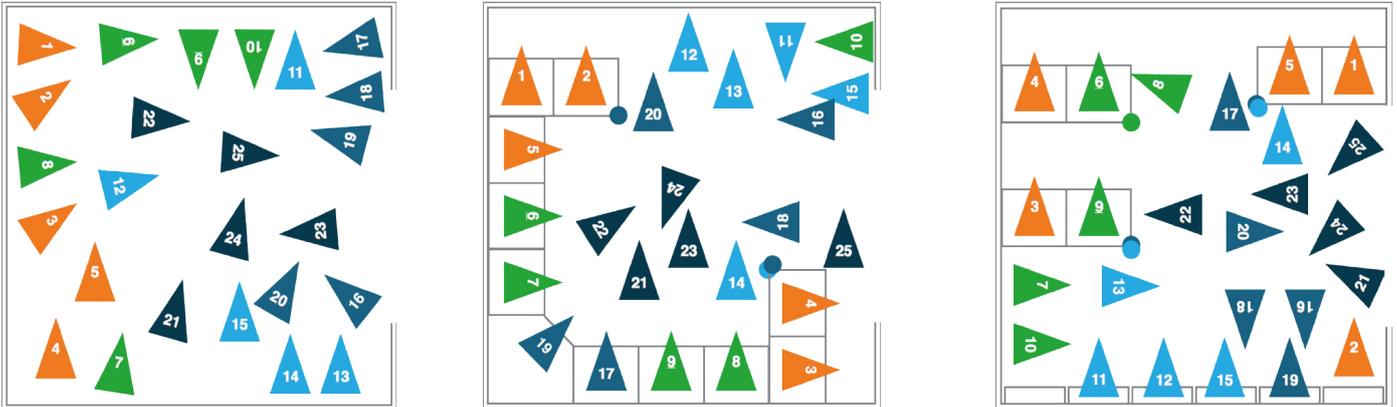


Figure L. Passenger placement inside sub concept and declaration of sequence of entry of passengers. (from the left: subconcept 1, subconcept 2, subconcept 3)

Quotes from capacity and scenario tests

subconcept 1

“It feel as if here is enough space for everyone”

“It is an wide door, which is nice, as two persons can go inside the cabin at the same time”

subconcept 2

“I was lucky to get a good seat, with much leg room”

“In the corner, every other seat was occupied, and i think that so will be the case in reality as well, and then I think that it gets a bit harder to choose which place to stand/seat, when every other seat on a row is occupied i mean. In those cases I think that I rather stand up during the travel”

“A good spot in a cable railway for me is when you can look outside, and that was better now when people were sitting down”

“It was easier to find a place with good view now (relative to subconcept 1)”

“It should be turned right, in the direction of travel (the seats)”

“The seat in the corner was not optimal”

“You have to know the ones you’re seated next to, because you sit very tight (regarding the seat in the corner)”

“There is more room with 25 passengers in the cabin than there are on busses and trams when it is crowded”

“Smooth to move in and out”

“It’s a very open plan, that’s probably why it’s so easy, nothing gets in your way”

“It’s not as easy to get out of there as it is from other places of the cabin (regarding the seat in the corner)”

“I wanted a seat, and I got one”

“Although I had to take my children into consideration, but my husband took care of them (related to previous comment)”

“I experienced that it was more space with this solution than the empty one, since people ended up in different levels”

“It felt more spacious with seats than without”

“I was seated in the front and there I had lots of space! It didn’t feel tight at all”

“I think it becomes a more relaxed atmosphere in the cabin when people are seated”

“It is nice that you have the possibility to sit down”

“The pair of seats were the most attractive”

“The seats in the front are really the best”

“It felt like it was a handrail missing to the right in the front. There was just a very large empty area without anything”

“I think you want to sit down and look outside in the direction of travel”

“Think of the physically impaired that can’t stand up for long durations of time”

“Will there be different cabins? like an all standing cabin and a cabin full of seats?”

“I think that one will reduce the capacity if all the cabins are adapted to passengers with impairments”

subconcept 3

“It felt good”

“It was rather crowded”

“I thought this one was better (than subconcept 1 and 2). The seats were better placed and you had a better view forward”

“It looked much more spacious in this last one”

“There is more open spaces (relative to sub concept 2)”

“Since you can fold the seats down, depending on how many passengers there are you can chose weather to sit or stand”

“I think it was a little bit harder, I hesitated for a while when I entered the cabin. and it was not as easy to get to the position that you wanted (in relation to sub concept 1 and 2)”

“I think this was better. The seats was better oriented and one could look in the direction of travel and so forth”

“I ended up in the middle of the cabin. It felt like it was rather crowded but that is no difference from today’s situation on the trams”

“It was good that there were three handrails to hold on to”

“It was easy to reach the vertical bars”

“It felt more spacious having foldable seats”

“This cabin looked like it was a lot more spacious than the last one (sub concept 2)”

“I thought it was a bit odd to sit in the back when others stand in front of you. You sit right towards the open space with a lot of strangers right in front of you”

“It feels like if someone brings a bicycle, they will place it there. And then one might avoid to sit in those seats (the foldable seats)”

“When i was standing in the previous cabin (sub concept 2) I felt like i lacked something to hold on to”

“I don’t know how much the cabin will swing once it is up in the air, but even if it is not that bad, one would feel rather... vulnerable, just by standing without support”

“I grabbed onto a vertical bar, but it would have been nice to grab onto something in the ceiling as well”

“The daily shape and state of mood would determine if i would want to stand or sit down”

Flow

Movements inside sub concepts during scenario tests shown in figure M.

The squares are color coded based upon the number of times participants moved inside that area during the test.

The color coding follow the following pattern:

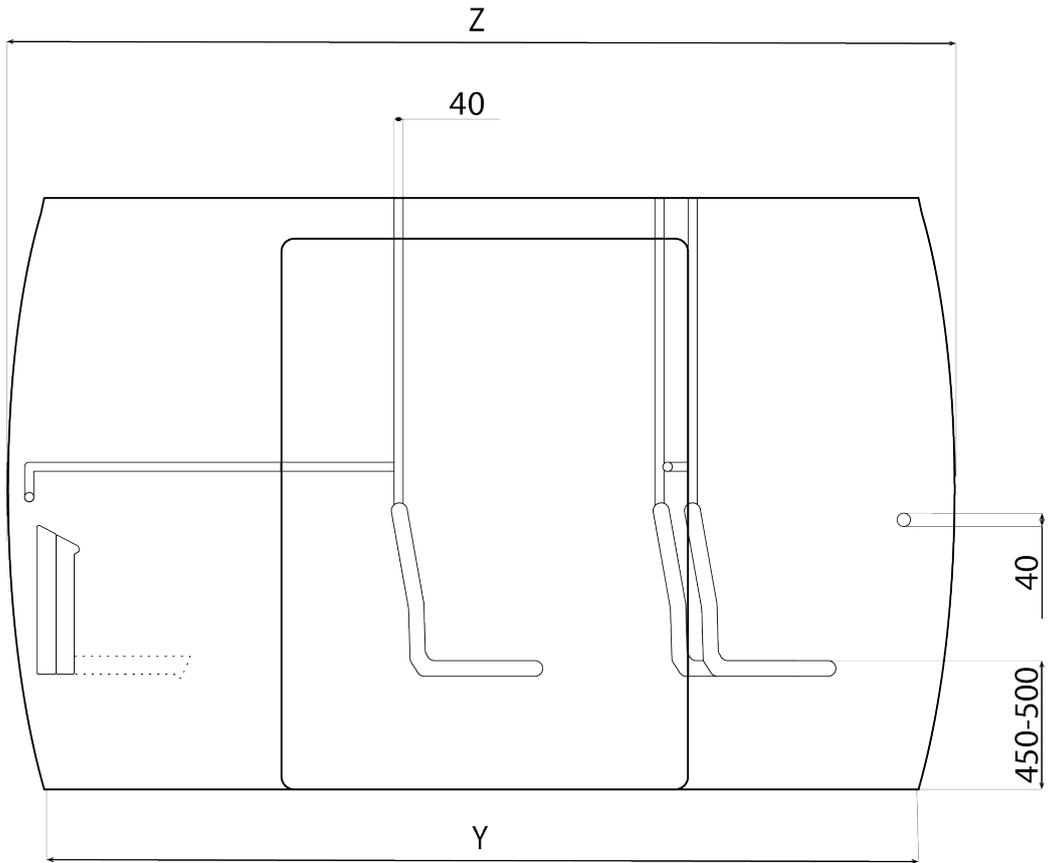
Orange level 1 (≥ 9)	
Orange level 2 (6-8)	
Orange level 3 (3-5)	
Orange level 4 (1-2)	
White (unused area)	

Squares marked with (x) indicate permanent seats.

Squares marked with (!) indicate a space already occupied by a participant.

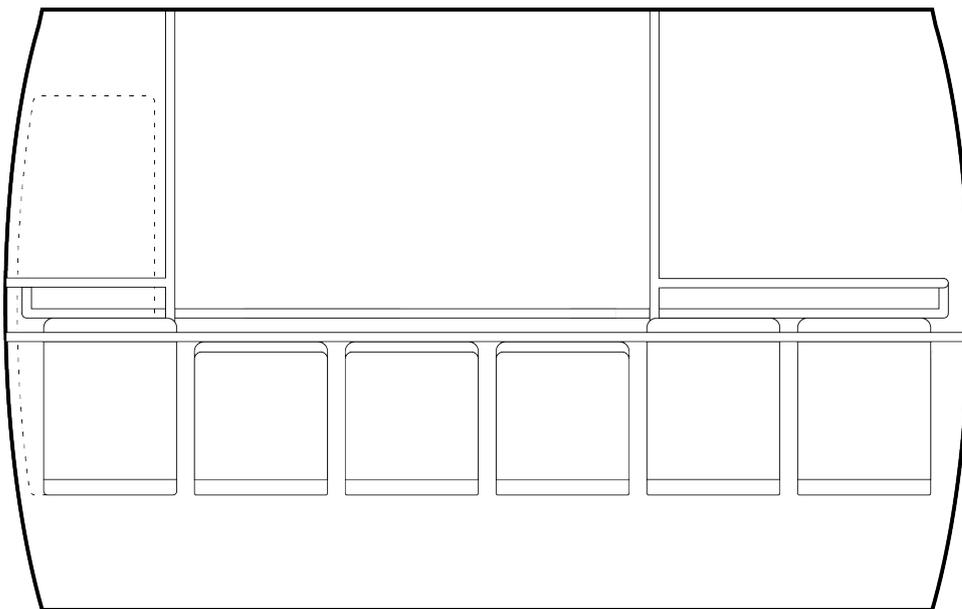
	sub concept 1	sub concept 2	sub concept 3
Summary disembarking boarding station 1-4			
disembarking station 1	-	-	-
boarding station 1			
disembarking station 2	-	-	-
boarding station 2			
disembarking station 3			
boarding station 3			
disembarking station 4			
boarding station 4	-	-	-
disembarking test ended			

Figure M. Illustrations of movements inside sub concepts during scenario tests.



[mm]

Figure O. Right side view with measurements of cabin interior details.



[mm]

Figure P. View from in front of cabin interior details.