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Opportunities and Barriers of Electrified and Automated Passenger Ferries in Gothenburg

A Pilot Study in ElectriCity– WP2

FREDRICK EKMAN
PONTUS WALLGREN

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1 INTRODUCTION & AIM

According to UN's sustainability goal 11, which relates to *"making cities and human settlements inclusive, safe, resilient and sustainable"* sustainable transport is a fundamental component. This is especially significant given that one quarter of energy-related global greenhouse gas emissions come from transport and are expected to further increase over the years to come (United Nations, 2015).

In line with the UN's sustainability goals, the city of Gothenburg has created an overarching goal with the intention to work towards sustainable development – socially, ecologically, and economically. The transportation system needs to contribute to this overarching goal by swiftly changing to more sustainable transportation (Göteborgs stad, 2023).

However, according to Gothenburg's Environmental Administration (Sw. Göteborgs miljöförvaltning), the climate goals follow-up for 2023 reveals that the work is progressing in the right direction, but too slowly. Therefore, more forceful actions are needed (Göteborgs stad, 2023). Some of the forceful actions needed include reducing the number of trips taken with motor vehicles such as privately owned cars. This transition can be facilitated by changing the type of modality used for travel. For example, instead of using privately owned cars, people can walk, cycle, or use public transport for personal mobility. Similarly, transitioning from heavy trucks to cargo bikes, railroad, and maritime solutions for logistics.

Effort has been put into changing mobility behaviours in favour of more sustainable transport means. For instance, the 'cycling program' created by the Traffic Committee in Gothenburg has the goal of increasing the number of trips done by cycling by 300% and that 75% of the Gothenburg population views Gothenburg as a 'cycle-friendly' city by the end of 2025 (baseline year 2011) (Trafikkontoret, 2022). Furthermore, there are also other more long-term sustainability goals related to cycling and other means of transportation. For instance, the goals are that 35% of all travels are conducted by means of cycling and/or walking, at least 55% of the motorized travels are conducted by means of public transport, and that at least 85% of the Gothenburg population perceive walking as an attractive way of getting around in the city by 2035 (Göteborgs stad, 2023).

However, according to the results of the half-time follow-up conducted in 2021 of the 'cycling program', there has only been a 57% increase in cycling - from 73,000 in 2011 to 115,000 in 2020. In terms of perceiving Gothenburg as a 'cycle-friendly' city, only 41% experience the city as a 'cycle-friendly' city. Therefore, instead of an increased positive perception of Gothenburg as a 'cycle-friendly' city, the perception has remained rather constant since the baseline year 2013 (i.e. 42%) (Trafikkontoret, 2022). Furthermore, in terms of the progression towards reaching the more long-term sustainability goals (by 2035), none have been met, and/or development is either unchanged or moving in the wrong direction (Göteborgs stad, 2023). Not following a positive rate of progression becomes even more problematic due to the projected increased population with an estimated 25,000 new private residences and 50,000 new workplaces built in the city of Gothenburg by 2035 (Trivector, 2021). Not meeting the sustainability goals related to transportation, i.e., not changing traveling habits in terms of transitioning to other more sustainable means of transportation, will cause the current transportation system to be insufficient, which in turn will lead to negative effects such as queues and accidents, to mention a few. Therefore, more needs to be done, and rather swiftly.

Two of the barriers that can be mitigated, increasing the potential for success in transitioning from less sustainable modes of transportation, such as commuting with privately owned cars to better options such as walking, cycling, and public transport, involve (a) creating solutions to facilitate crossing over the centrally located river, Göta Älv, and (b) creating a mobility solution that allows for accessibility despite parts of the city undergoing construction, thereby causing mobility challenges on land (Trafikkontoret, 2015, 2020; Trivector, 2021).

One mobility solution to these barriers is the increased use of ferries. A previous study by Trivector (2021) have identified several potential berths and routes that are relevant for future operation with manually operated ferries. These potential berths and routes are based on efficiency, economy and resources needed, i.e. number of ferries.

However, technological advancements have been made within the maritime sector. For instance, several companies have developed and continue to develop new types of ferries that are both electric and highly automated (Hyke, 2024; Tele2 IoT, 2023). Automation in maritime vessels are envisioned to enhance safety, improve environmental sustainability, increase efficiency and reduce cost (Goerlandt & Pulsifer, 2022).

Given these potential advancements, it raises the question: Are the current ferry traffic system including berths and routes optimal or can it be further enhanced by using electric and highly automated ferries and is this desired?

Thus, the aim of this pilot study is to create an understanding of the potential of introducing electric and highly automated ferries as a solution to increase possibilities to cross the river, Göta älv, as well as increase accessibility, both in terms of a testbed but also as a long-term mobility solution.

To support the aim, two research questions were formulated:

RQ1: Which berths and routes are most relevant for a testbed for electric and highly automated ferries?

and;

RQ2: Which are the possibilities and barriers for introducing electric and highly automated ferries in the format of a testbed and as a long-term mobility solution?

2 BACKGROUND

In this chapter, an overview of berths will be presented followed by a description of current routes and potential future routes identified in previous research.

2.1 OVERVIEW OF BERTHS & CURRENT FERRY TRAFFIC ROUTES

Ferries have been proposed as a complementary solution that can mitigate the expected increased use of Älvsborgsbron, Göta Älvsbron, and the soon to be built bridge between Hugo Hammars kaj and Packhuskajen (Trafikkontoret, 2020; Trivector, 2021) i.e. a bridge built solely for walking and cycling. Furthermore, ferries have also been presented as a viable solution to enhance the possibilities to cross the river Göta Älv and increase accessibility during periods of heavy and rapid city development that may interfere with landbound mobility.

Based on previous research, there are several existing berths, as well as potential but not yet existing berths that are relevant to consider. According to Trivector (2021), there are thirteen berths along both sides of the river Göta Älv that should be considered (see figure 1).

Figure 1 – Relevant existing and non-existing berths

All these berths have different characteristics and qualities important to consider when evaluating them as potential docking options for electric and highly automated ferries (see table 1).

Table 1 - Evaluation of berths (Trivector, 2021)

	Traveling potential	Land access	Connection to other public transport	Connection to bicycle lanes	Connection to continuous network of walking paths	Proximity to target points	Potential for social benefits
Ringön	1	4	1	3	2	1	2
Gullbergsvass	1	4	3	4	4	1	2
Frihamnen	3	4	1	3	2	2	2
Operan	3	4	4	4	4	3	2
Lundbystrand	3	4	1	3	4	2	2
Stenpiren	4	4	4	4	4	4	3
Lindholmen	4	4	3	4	4	4	3
Järntorget	3	4	4	4	4	3	3
Slottsberget	1	4	1	2	4	2	2
Stigberget	3	4	4	4	2	3	3
Eriksberg	3	4	3	3	4	3	2
Eriksberg V.	2	4	3	2	4	2	2
Klippan	2	4	3	4	4	2	3

2.1.1 BERTHS WITH LOW POTENTIAL

However, some of the berths are less relevant than others. According to Trivector (2021) both Gullbergsvass and Ringön (non-existing) berths are regarded as irrelevant until after 2035 due to their low ‘traveling potential’ i.e. expected to be few people travelling to or from these berths.

Eriksberg Västra (non-existing berth) and Slottsberget (existing) are also considered to have low potential as relevant berths due to low or no build-up of new infrastructure e.g. housing and industries, or due to being far from areas with settlements and therefore low traveling potential.

2.1.2 BERTHS WITH RATHER HIGH POTENTIAL

There are berths that have a rather high potential as relevant berths, namely Eriksberg (existing), Stigberget (non-existing), Klippan (existing), Frihamnen (non-existing) and Lundbystrand (Pumpgatan) (existing). These are rather relevant to consider since they are located centrally in the city and have close connection to networks of walkways and bicycle lanes (Eriksberg), lie in close connection to the planned 'Lindholmsförbindelsen[1]' (Stigberget), create possibilities of shortcuts (Klippan), create a value from an urban planning perspective (Frihamnen). At the same time they are only relevant if the bridge for cyclists and pedestrians between Hugo Hammars kaj and Packhuskajen would not be built–which it will be. However, the bridge is not planned to be finished until 2031 and therefore the berths could be relevant until that time.

2.1.3 BERTHS WITH HIGH POTENTIAL

The berths with the highest potential include Stenpiren (existing), Lindholmen (existing), Operan (existing) and Järntorget (non-existing but under development). These berths are highly relevant since they are centrally located with good connections to land based public transport and create a shortcut between the inner city of mainland Gothenburg and Lindholmen on the island of Hisingen (Stenpiren), lie in close proximity to schools, workplaces and have an increasing number of private housing (Lindholmen), are close to Nordstan[2] and the central station (Operan) and due to potential connections to the Metrobus system and for creating shortcuts to e.g. Lindholmen for cyclists (Järntorget).

As of now, the current public transport ferry traffic operating on Göta Älv in Gothenburg, uses diesel-electric hybrid ferries and seven berths.

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[1] The Lindholm Connection (Sw. Lindholmsförbindelsen) is a tramway tunnel planned in Gothenburg between Lindholmen and Linnéplatsen that goes via Stigberget.

[2] A shopping mall located in the innermost parts of the city of Gothenburg.

2.2 CURRENT PUBLIC TRANSPORT (FERRY) ROUTES

The current public transport routes operated by ferries in Gothenburg are routes 285, 286 and soon route 287.

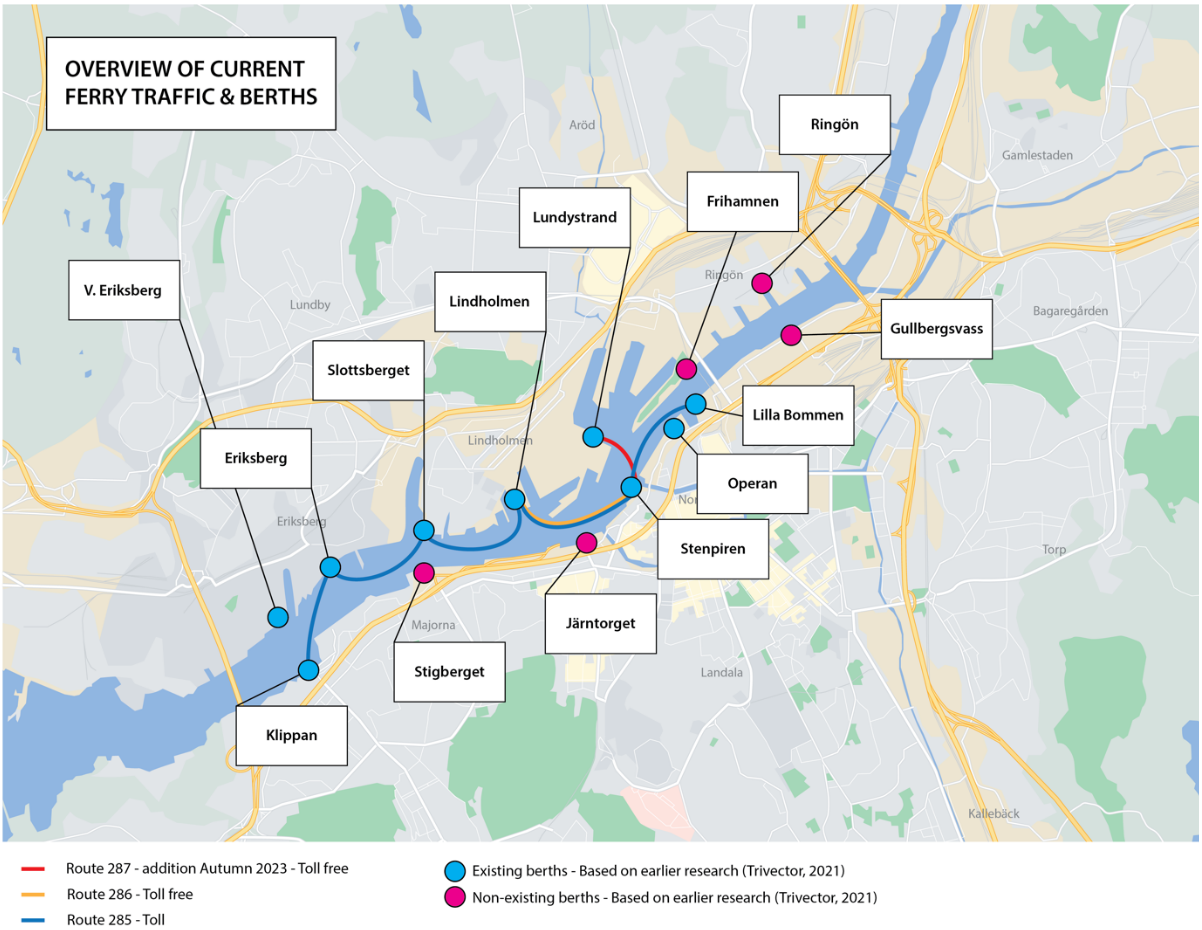

Figure 2 - Current ferry routes, 285, 286 and 287.

Route 285 (blue) goes between Lilla Bommen and Klippan via Stenpiren, Lindholmen, Slottsberget and Eriksberg (see figure 2). Route 286 (orange) goes between Lindholmen and Stenpiren and is a toll-free ferry route (see figure 2). Finally, route 287 (red) was planned to start to operate during the autumn of 2023 (which it has not yet due to delays) and to go between Lundbystrand and Stenpiren also as a toll-free ferry route (see figure 2).

Furthermore, the ferry routes being procured for the time-period 2025-2040 have removed Slottsberget's berth and Lilla Bommen's berth from route 285 (blue) (see figure 3).

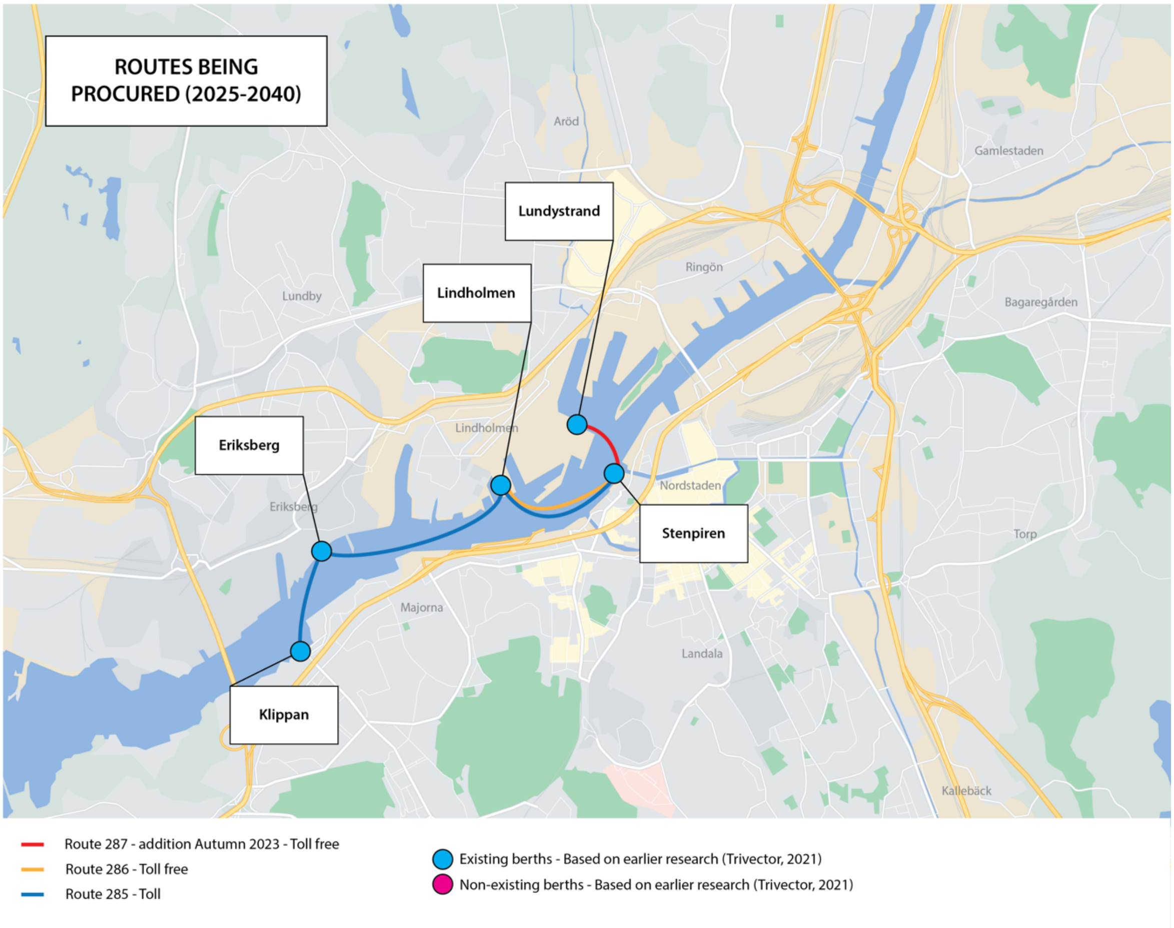

Figure 3 - Routes under procurement (route 285, 286 and 287).

However, removing berths and routes decreases the possibilities to be able to access different locations on either side of Göta Älv by ferry and contradicts other suggestions presented by Trivector (2021) whom suggests increasing the amount of required berths to have a robust and efficient traffic system that complements existing and planned bridges over Göta Älv.

2.3 SUGGESTED FUTURE PUBLIC TRANSPORT (FERRY) ROUTES

First and foremost, according to Trivector (2021) there are seven aspects that must be considered when considering ferry traffic routes in Gothenburg: (i) the biggest concentration of people traveling is found in the most eastern part between Älvsborgsbron and Hisingsbron, (ii) for public transport users who have a starting/ending point further away from the river, landbound public transport, e.g., busses and trams, often makes a better mobility solution, (iii) ferry traffic has the biggest potential when it creates shortcuts that offer similar and/or quicker traveling times than their landbound counterparts, e.g. bus or tram, (iv) ferries should primarily exist for travels across the river and not alongside the river, (v) view ferry traffic as a complement to landbound means of mobility, (vi) a route that travels across the river but also passes several berths along the way in a sick-sack pattern and hereby creating shortcuts, increases the potential for more passengers, and (vii) shuttle traffic, i.e. a ferry route only going back-and-forth between two berths on both sides of the river, often creates lower flexibility and increases total idle-time (Sw. 'reglertid') per distance travelled.

Furthermore, based on three scenarios describing the potential future of 2035 with respect to land use and traffic, several ferry traffic route systems were created. The three scenarios where: ‘Scenario 2014’ – where traffic and land use is according to the situation that prevailed in 2014, 'Scenario 2035 minimum' - traffic according to the year 2014, but where planned land use for the year 2035 is used as a starting point, and 'Scenario 2035 maximum' - planned land use for the year 2035 and application of the so-called fictitious line network planned for the year 2035[3] (Trivector, 2021; Västra Götalandsregionen, 2018).

The ferry traffic route systems were evaluated in relation to the three scenarios in terms of efficiency, economy and resources needed, i.e. the number of ferries. The ferry capacity was based on the size of today's ferries, i.e. Älvsnabbare (route 286): 298 passengers of which 80 can bring their bicycle, and Älvsnabbare (route 285): 448 passengers and bicycles if there are any leftover room available (Trivector, 2021).

Furthermore, based on these and other aspects, e.g. service frequency (Sw. 'turtäthet'), route distances, sailing time etcetera, several traffic route suggestions were created, of which one was deemed most relevant to consider from an efficiency perspective (see figure 4).

The suggested ferry traffic route system includes two routes (blue and purple route see figure 4).

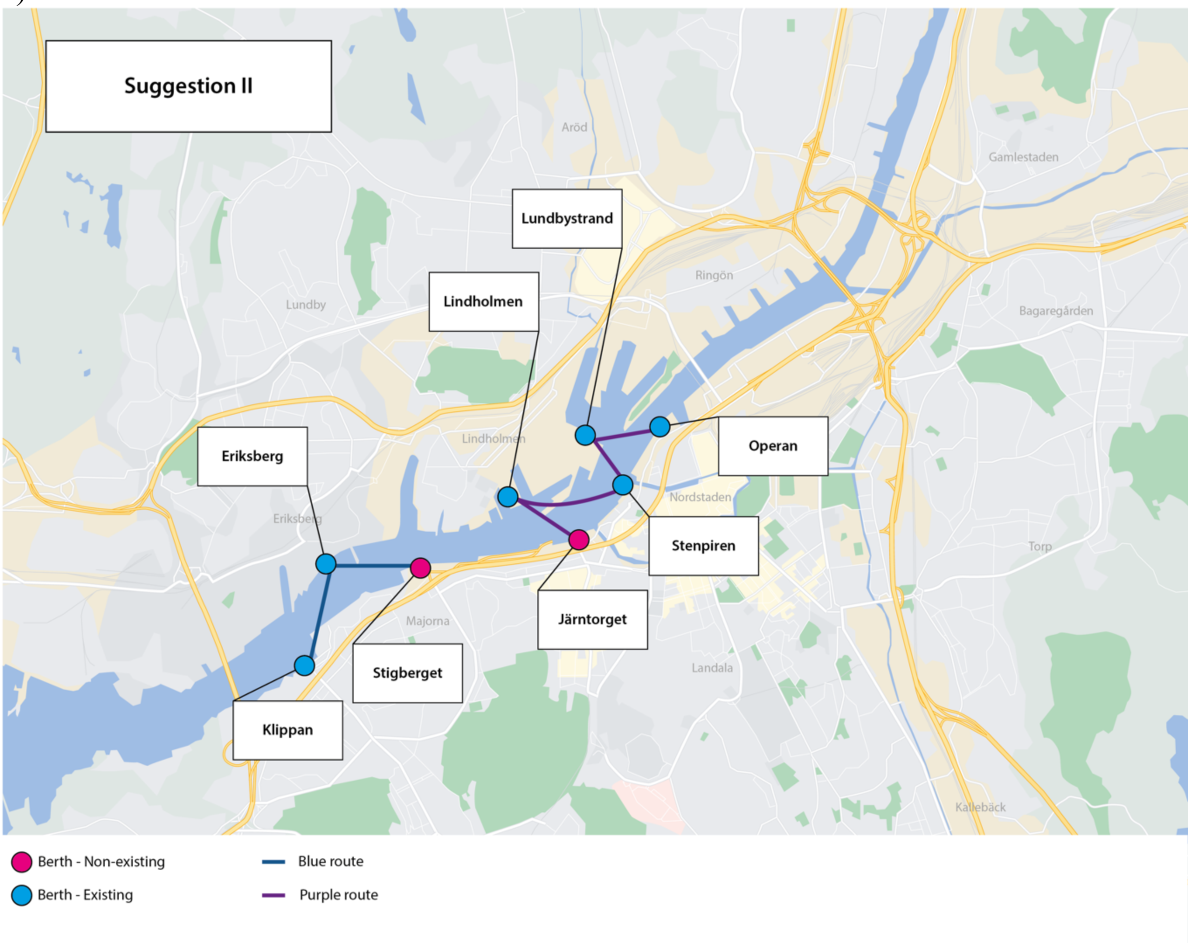

Figure 4 - Suggested future routes (Trivector, 2021)

One of the routes goes between Järntorget to Operan via Lindholmen, Stenpiren and Lundbystrand (purple route). The other route goes between Klippan and Stigberget via Eriksberg (blue route).

[3] The fictitious line network can be found in 'Målbild Koll2035' – Public transport program for traffic in Gothenburg, Mölndal, and Partille is a strategic planning document for the development of public transport.

The suggested ferry traffic route system can meet the mobility needs, keep a high level of service frequency (every 7.5 minutes) which applies to both routes (blue and purple). Finally, the suggested ferry traffic route system can also operate with only eight ferries if dimensioned as of today.

2.4 KEY TAKEAWAYS

The berths with the highest potential to be useful for passengers include Stenpiren, Lindholmen, Operan, and Järntorget (berth under development). The berths with high potential include Eriksberg, Stigberget, Klippan, Frihamnen and Lundbystrand. Finally, the berths with low potential during the current circumstances are Gullbergvass, Ringön, Eriksberg Västra and Slottsberget.

Furthermore, it seems as (i) the current routes, (ii) the routes currently under procurement and (iii) the routes identified to be efficient, economically sustainable and resource optimized, differ.

Regardless of routes chosen, it is nonetheless important to consider where there are concentrations of potential passengers, to create shortcuts for passengers, operate primarily transversely across rivers, operate via several berths to increase the potential of more passengers and avoid shuttle traffic. Finally, it also is important to consider whether or not the cost of infrastructure, e.g. more berths, are important or if traveling possibilities are more important.

3 METHOD

This chapter describes the activities and methods used to collect relevant data to be able to answer the two research questions:

RQ1: Which berths and routes are most relevant for a testbed for electric and highly automated ferries?

and;

RQ2: Which are the possibilities and barriers for introducing electric and highly automated ferries in the format of a testbed and as a long-term mobility solution?

3.1 RESEARCH ACTIVITIES

The activities included: **(i) a user study** with focus on experience, expectations, and acceptance of the current and future electric and highly automated ferry traffic, **(ii) interviews** with project stakeholders and experts, and finally **(iii) a co-creation workshop** including relevant project actors involved in the project as well as experts on mobility and logistics.

3.1.1 USER STUDY WITH FERRY PASSENGERS

The purpose of the user study was to get better insights into how passengers using the ferry traffic in Gothenburg experience and accept the current service, but also how they expect a potential electric and highly automated ferry traffic would be like and to what degree they expect to accept such a solution. The user study was conducted onboard on ferry route 286 and 285 in Gothenburg whilst travelling between the different berths along the route.

The user study used a mixed-method research approach, e.g. combining both questionnaires and interviews to be able to compare and/or relate the data sets to each other (Creswell, 2014). Secondly, by using both questionnaires and interviews it is possible to not only answer to what degree something is experienced and/or accepted but also 'why' something is experienced and/or accepted to what degree.

The data collection included five parts, of which four were questionnaire based: (i) background information including age, gender and how often the user study participant travels with ferries in Gothenburg (see appendix I), (ii) a multiple-choice questionnaire where the participant could choose how he or she wished the future ferry traffic service should be paid for, e.g. by subsidies or by the passenger or by other organizations etcetera (see appendix I), (iii) the SKAS acceptance scale adapted by Johansson et al. (2022) focusing on the participant's acceptance of the current ferry traffic in Gothenburg (see appendix II), (iv) the SKAS acceptance scale focusing on the participant's acceptance of the idea of a future ferry traffic in Gothenburg using electric and highly automated ferries (see appendix III), and (v) three interview questions focusing on a comparison between the current ferry traffic and a potential future ferry traffic using electric and highly automated ferries (see appendix IV).

Even though the user study was conducted on a ferry the two SKAS acceptance questionnaires also included images of the current ferry operating in Gothenburg (part iii – Appendix II) as well as an image of an electric and highly automated ferry (part iv –

Appendix III) developed by Hyke[4]. These two images functioned as 'mediating tools' (Karlsson, 1996), to further support understanding of the differences between current ferries and electric and highly automated ferries.

Finally, in the last part (part v – Appendix IV) including the three interview questions, probing techniques were applied, in terms of follow-up questions (Kelly et al., 2010) regarding relevant and interesting topics brought forward.

PARTICIPANTS
Fifty-five persons participated in the study. The participants (53% male and 47% female) were passengers travelling on route 285 (Älvsnabben) and route 286 (Älvsnabbare).

ANALYSIS
The analysis of the questionnaire data was conducted using simple statistics, e.g. calculating median values and totals. The interview data, that was collected by notes taken by the first author, was analysed using a thematic analysis (Braun & Clarke, 2006) to identify patterns and/or relevant themes in the discussion with the participants.

3.1.2 INTERVIEWS: PROJECT STAKEHOLDERS & EXPERTS

The purpose of the interviews with stakeholders and experts was twofold:

(i) Interviews with project stakeholders[5] had the purpose of identifying their needs and hopes as well as their perception of potential possibilities and barriers related to an electric and highly automated ferry testbed as well as possibilities and barriers related to a long-term electric and highly automated ferry traffic system.

The interview questions were inspired by questions found in a business model canvas (BMC) (Osterwalder & Pigneur, 2010) but with additional items, such as items related to project stakeholders' respective goals in relation to a joint endeavour of introducing and even long-term implementation of electric and highly automated ferries.

The main function of the questions in the BMC was to function as 'mediating tools' (Karlsson, 1996) to support and stimulate the participants to more easily reflect on what needs and hopes they had for their own organization in a joint endeavour. This, in turn, also supported the elicitation of their perception of potential possibilities and barriers related to such an endeavour.

(ii) Interviews with experts on mobility and/or logistics were conducted to further nuance important aspects first raised by project stakeholders. Therefore, the interviews with experts were quite exploratory in nature. In other words, interview questions were formulated and adapted to fit each interview depending on the scope of the specific interview. The scope of the interviews ranged from the experts' views on payment method for future ferry traffic, possible ferry routes (short- and long-term), inter- and intraorganizational aspects, berths and operational guidelines, regulations and what they believed would be the barriers and possibilities for electric and highly automated ferries.

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[4] An electric and highly automated ferry vessel developer in Norway (URL: hyke.no)
[5] Project stakeholders includes primarily stakeholders involved in the pilot project. However, other potential future stakeholder showing an interest in a testbed and/or long-term implementation of electric and highly automated ferries was also included and therefore also denoted as 'project stakeholders'.

PARTICIPANTS

The project stakeholders were nine representatives from different organizations, such as Älvstranden utveckling AB, Hyke, Källfelt Byggnads AB, PEAB, the City of Gothenburg, Styrsöbolaget AB and Västtrafik AB. The representatives included seven male and two females.

The experts were six representatives from different organizations such as RISE Research Institutes of Sweden AB (RISE), Region Stockholm, The City of Gothenburg including both Stadsbyggnadsförvaltningen and Stadsmiljöförvaltningen, Södahl & Partners AB and Cstrider AB. The representatives included five male and one female.

ANALYSIS

The analysis was conducted using a thematic analysis (Braun & Clarke, 2006) of both data sets together, i.e. analysing both project stakeholders and expert interview data together, to identify patterns or relevant themes.

3.1.3 CO-CREATION WORKSHOP

The purpose of the co-creation was threefold: (i) the main purposes were to ideate and evaluate berths and routes for a potential testbed as well as identify important but uncertain factors that must be considered for a potential long-term implementation of an electric and highly automated ferry traffic system, (ii) other purpose were to disseminate findings from the project and (iii) create a space for actors to meet and potentially create synergies moving forward.

The co-creation activity was divided into two parts. **The first part**–and most important–focused on ideating and evaluating berths and routes that can be involved in a potential testbed for electric and highly automated ferries. **The second part** focused on allowing the participants to identify factors that are important but at the same time uncertain and therefore must be considered when designing an electric and highly automated ferry traffic system as a service.

The first part's (Part I) focus lay on ideating possible berths and routes to be included in a potential testbed. The participants were divided into four groups with 3-4 individuals in each group. Each group were given several A3 papers with an illustration over the relevant part of the river Göta Älv. The illustration included all identified relevant berths for a potential testbed. Some of these berths already exist (blue) and others do not (pink) (see figure 5).

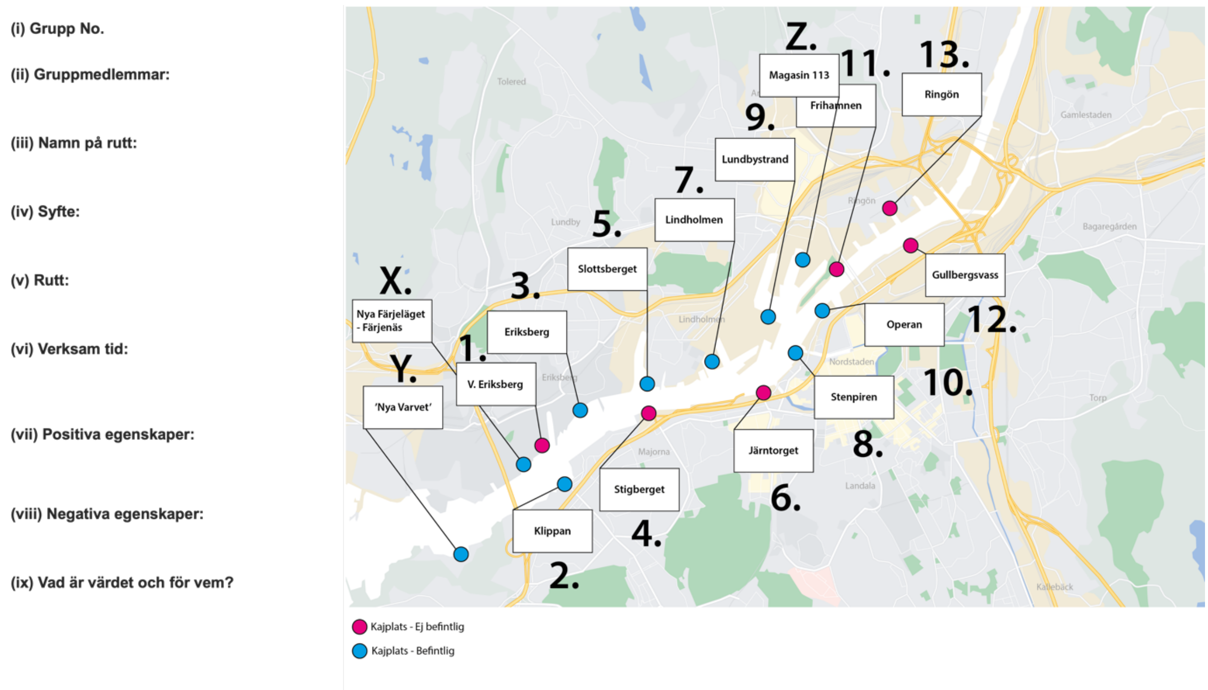


Figure 5 - Template for testbed ideation and evaluation.

Furthermore, each A3 paper with the illustration of the river and existing and non-existing berths included also a number of questions that each group had to answer. These aspects were: (i) which group they belonged to, (ii) which members belonged to that group, (iii) an optional name for the created testbed concept, (iv) the purpose of the concept, (v) between which berths the route should be implemented, (vi) time of operation, e.g. during summer or between 06.00 and 17.30, (vii) positive aspects of the concept, (viii) negative aspects of the concept and (ix) the expected value of the concept and whom the value is created for (see figure 5).

Furthermore, the groups were given 40 minutes to decide on berths and routes relevant for a testbed, after which, each group were to present their testbed concepts for the other three groups and the moderator (first author) of the co-creation workshop. Each group had ca 5 minutes to present their concepts.

Finally, after all groups had presented their concepts, each participant of the co-creation workshop received <u>one gold star</u> representing 2 points and <u>one silver star</u> representing 1 point. They were asked to give the respective stars to the two concepts they believed were most relevant as a testbed.

The first part of the co-creation workshop took ca two hours (including a presentation by the first author on potential berths and both possibilities and potential barriers to electric and highly automated ferries which took place before the participants got ideate and evaluate testbed concepts).

The second part (Part II) was inspired by 'STEEP' analysis using a 2x2 matrix (Rhydderch, 2017), i.e. accounting for social, technological, economic, environmental and political factors that drive or hinder change. The participants got to by themselves identify the most important and the same time most uncertain factors that must be considered for successful long-term implementation of electric and highly automated ferries, after which they got create scenarios based on these factors. The scenarios lay within a time horizon of between 10-30 years into the future.

Once again, the participants were divided into the same four groups with 3-4 individuals in each group. Each group were given a stack of post-it notes and got to, during five minutes, individually write for them important factors that must be considered if and when implementing electric and highly automated ferries as a long-term mobility service.

After the five minutes, each group collected all post-its and put them on a whiteboard where the moderator (first author) had created a chart where the y-axis represented the degree of importance and the x-axis the degree of uncertainty (see figure 6).

Figure 6 - Importance vs uncertainty.

After all post-its were placed on the y-and x-axis on the whiteboard, the moderator (first author) and another researcher analysed the post-its, located in the upper right corner (representing high importance and high uncertainty) (see figure 7) under ca five minutes to determine the two most frequent factors whilst the participants had a break. The two factors that occurred the most and that were deemed relevant and possible to create scenarios around was chosen.

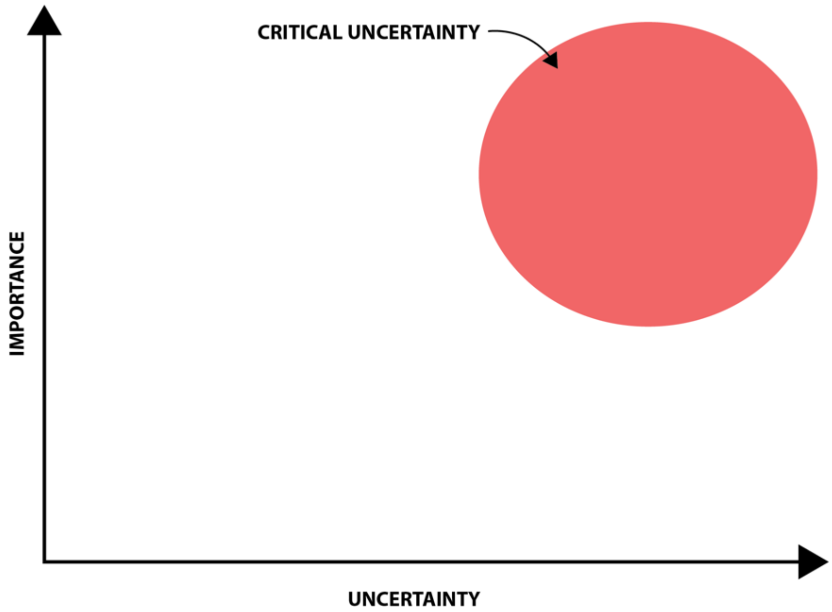


Figure 7 - Critical uncertainty.

After which the two themes that had been chosen were put into a 2x2 matrix (Rhydderch, 2017) that in turn made it possible to create four different concepts/scenarios (see figure 8).

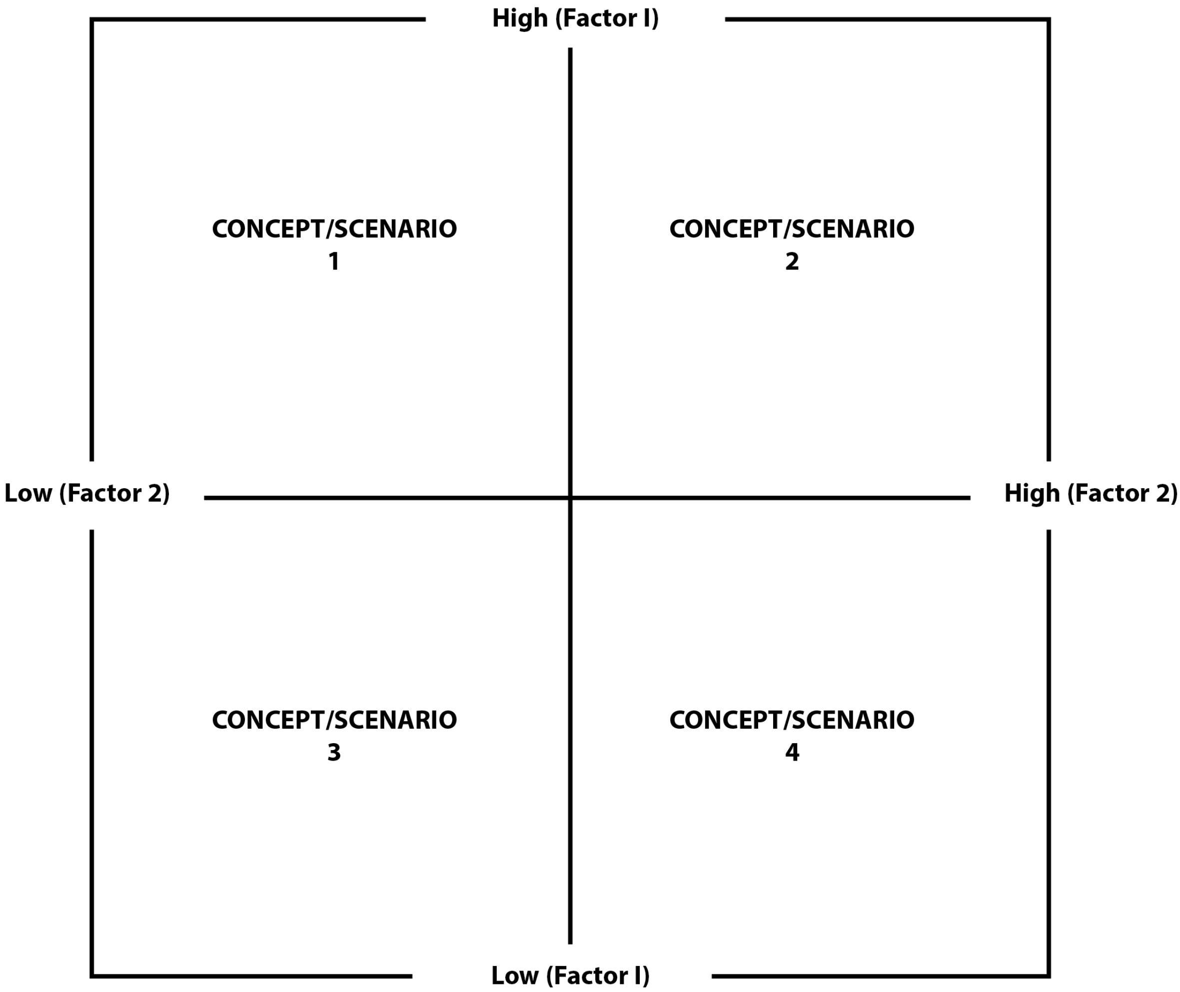


Figure 8 - 2x2 matrix.

The creation of the scenarios/concepts by each of the four groups partaking in the co-creation workshop was supported by a number of questions that they had to answer:

(i) The main purpose of the electric and highly automated ferry traffic system that they were to create in the scenario,
(ii) objectives with the system,
(iii) included elements in the system,
(iv) expected positive effects, and;
(v) expected barriers to reach those positive effects and potential solutions to those effects.

After the participants had create electric and highly automated ferry traffic systems as scenarios (one per group i.e. four systems in total) the groups got to present their future ferry traffic systems.

The second part of the co-creation workshop took ca 1.5 hours. Thus, the whole co-creation workshop took ca 3.5 hours.

PARTICIPANTS

The co-creation workshop included both project stakeholders and experts including expertise on mobility, logistics, the traffic system, public transport, land-and property, infrastructure, ferries, innovation, design and human factors. The project stakeholders and experts were in total 14 representatives from different organizations such as The City of Gothenburg, Södahl & Partners AB, Cstrider AB, Elof Hansson Fastigheter, Älvstranden Utveckling AB, Volvo Penta, Källfelt Byggnads AB, Västtrafik AB, Chalmers University of Technology. The representatives included eight male and six females.

ANALYSIS

The result of the first part (Part I) of the workshop was compiled by calculating the total points given each testbed concepts. For the second part (Part II) the analysis involved comparing relevant aspects identified in each of the scenarios to see if there were any common denominators that are relevant to consider for a future electric and highly automated ferry traffic solution.

4 FINDINGS

The findings presented is a compilation of the previous described activities: (i) project stakeholder interviews, (ii) expert interviews, (iii) a user study with ferry passengers as well as (iv) a co-creation workshop. All activities were conducted to be able to answer the two research questions:

RQ1: Which berths and routes are most relevant for a testbed for electric and highly automated ferries?

and;

RQ2: Which are the possibilities and barriers for introducing electric and highly automated ferries in the format of a testbed and as a long-term mobility solution?

This chapter is divided into four different sub-sections: 4.1. Ferry Passengers, 4.2. Project Stakeholders & Experts, 4.3. A Testbed for Electric and Highly Automated Ferries and 4.4. Long-Term Service Designs Considerations.

In the first sub-section (4.1. Ferry Passengers), focus will lie on the ferry passengers' experience of the current ferry traffic as well as on their expectations of electric and highly automated ferries.

The focus of the second sub-section (4.2. Project Stakeholders & Experts) will lie on the project stakeholders' and experts' view of the current ferry traffic and their expectation of an electric and highly automated ferry traffic.

In the third sub-section (4.3. Testbed for Electric and Highly Automated Ferries) findings from the first part of the co-creation workshop will be presented, where different ferry routes were considered and evaluated for the purpose of testing the potential of electric and highly automated ferries.

Finally, the fourth sub-section (4.4. Long-Term Service Design Considerations) presents findings from the second part of the co-creation workshop, where the most important but also most uncertain factors related to a future service design are described. These factors are then used as a basis for further ideation of four different scenarios. The scenarios are presented at the end of sub-section 4.4.

4.1 FERRY PASSENGERS

The ferry passengers' experience of the current ferry traffic as well as their expectations of electric and highly automated ferries were predominantly related to expected benefits but also concerns of introducing electric and highly automated ferries. These expected benefits and concerns were divided into three levels of abstraction based on their inherency: user experience level, ferry traffic level and societal level.

4.1.1 USER EXPERIENCE LEVEL

User experience level is here defined as the lowest level of abstraction and considers the passengers' experience of travelling with today's ferries and expectations of traveling with electric and highly automated ferries in the future.

Acceptance

First and foremost, based on the SKAS questionnaire, the fifty-five participants in the user study with ferry passengers were more accepting than not, towards the idea of electric and highly automated ferries. The participants generally believed that new technology will often be more environmentally sustainable during use than its predecessor, and that fully electric ferries are always more environmentally friendly than diesel-electric hybrids.

The biggest discrepancy between the current ferries and future electric and highly automated ferries can primarily be noted for item 1, 'Reliability', item 4, 'Comfort', and item 5, 'Safety' (see figure 9). In terms of reliability, many participants feared that there would be a lot of problems at the beginning of a possible implementation of electric and highly automated ferries. They thought that new technology often comes with unforeseen issues related to the reliability of the technology. However, they also believed that these issues would be corrected over time.

Regarding comfort, the participants believed that the current level of comfort could decrease due to electric and highly automated ferries reducing the amount of personnel onboard. This could lead to less accommodating behaviour towards the individual passenger. For instance, the captain often waits if he or she sees an individual that is a bit late, something that the participants did not believe a highly automated ferry would be able to do.

However, the biggest concern among the participants was the level of safety that can be ensured on a highly automated ferry. This related to both the actual operational safety and the level of interpersonal security involving other passengers that could be ensured with less personnel onboard. More specifically, participants thought that there would be a small difference in experience between travelling with today's diesel-electric and manually operated ferries and electric and highly automated ferries but that this would hold true only until an incident and/or accident would occur.

Nevertheless, in general, the participants were more positive than negative towards the idea of electric and highly automated ferries, even though they showed a lower level of acceptance towards the idea of electric and highly automated ferries compared to today's solution (see figure 9).

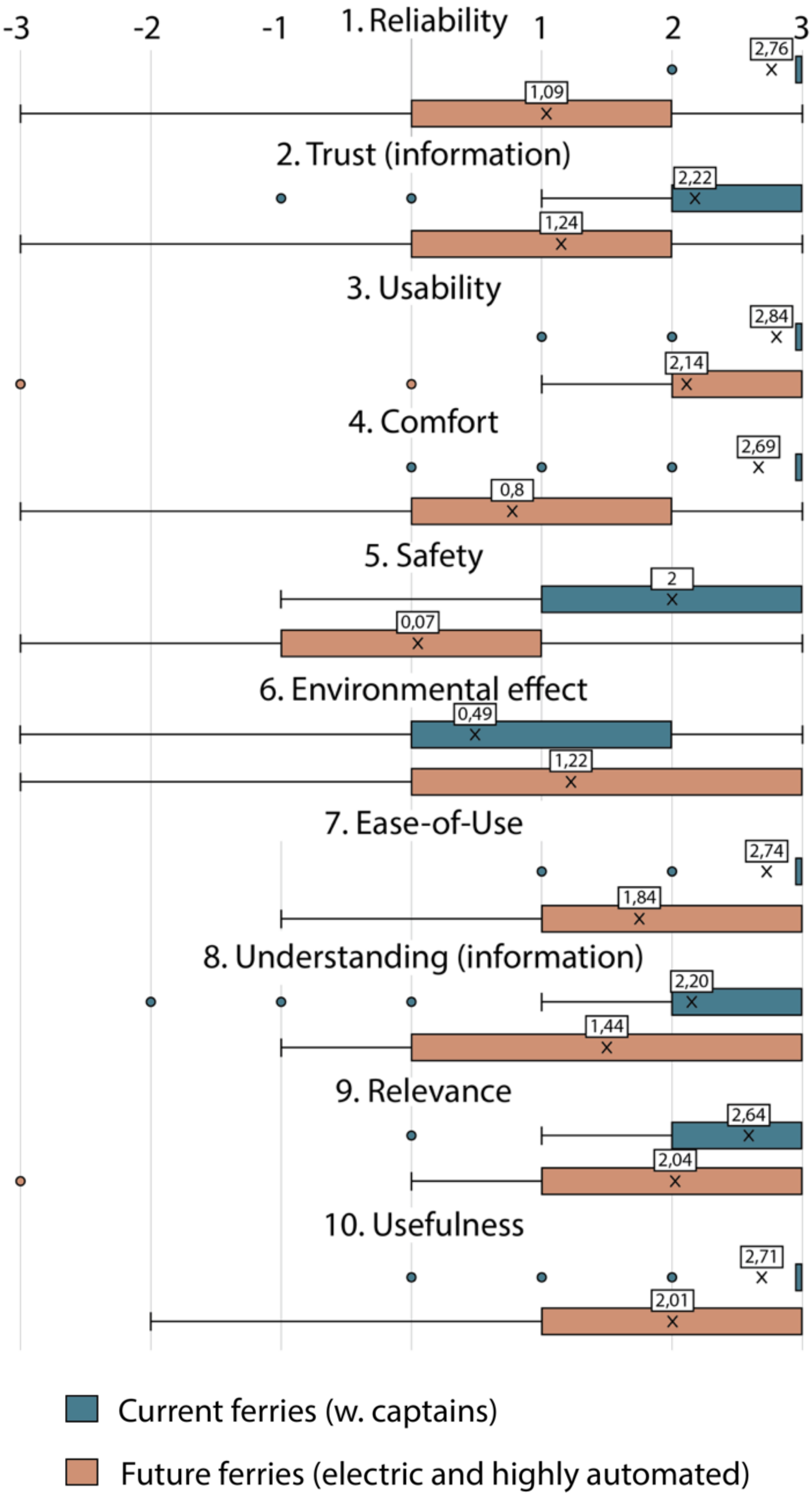


Figure 9 - Results of SKAS questionnaire.

User Experience and Pricing Concerns

In terms of user experience, many participants in the user study (as well as other experts and stakeholders), thought that the current pricing of 35 SEK for people only travelling across the Göta Älv is too expensive. This was especially true for people on bicycles. The price of 35 SEK to travel long distances for the time period of 90 minutes (the time-window for a single ticket) may be a valid cost. However, it seems that 35 SEK to just cross the river once within a commuting context is not. Therefore, there is a need to further explore what a reasonable cost might be to travel short distances with electric and highly automated ferries for these users/travel categories.

Participants' Views on Travel Costs

When the participants were asked to rate how, in their opinion, future ferry traffic should be financed, they believed that the ferry traffic should primarily be 'free of charge' as line 286 and 287 is today. Specifically, of the fifty-five participants, 60% wanted the ferry use to be 'free', i.e., subsidized through taxes; 22% preferred paying for the trips themselves via a public transport subscription as often done today via Västtrafik; and 11% wanted a combination of funding, with organizations such as companies covering half of the travel expenses alongside subsidies from the region (see figure 10).

The Importance of Smooth Transitions

The explanation for the rating may not solely be a matter of cost (although this is a big part). It also seems to be a matter of how smooth the embarking / disembarking transitions are. In other words, subsidies from the region are highly valued not only because they render the ferry service seemingly free at the point of use, but also because it is just a matter of 'hop-on' and 'hop-off', creating smooth transitions between different modes of transport during travelling. If payment is required during the travel this may disrupt the users' flow whilst 'en-route'. As of now, the experience resembles that of using a bridge – smooth transitions travelling onto and off the bridge. This is also part of the explanation for why approximately 22% preferred paying for travelling via subscriptions – it is smooth and does not interfere with travelling.

The Need for a Smooth Service Design

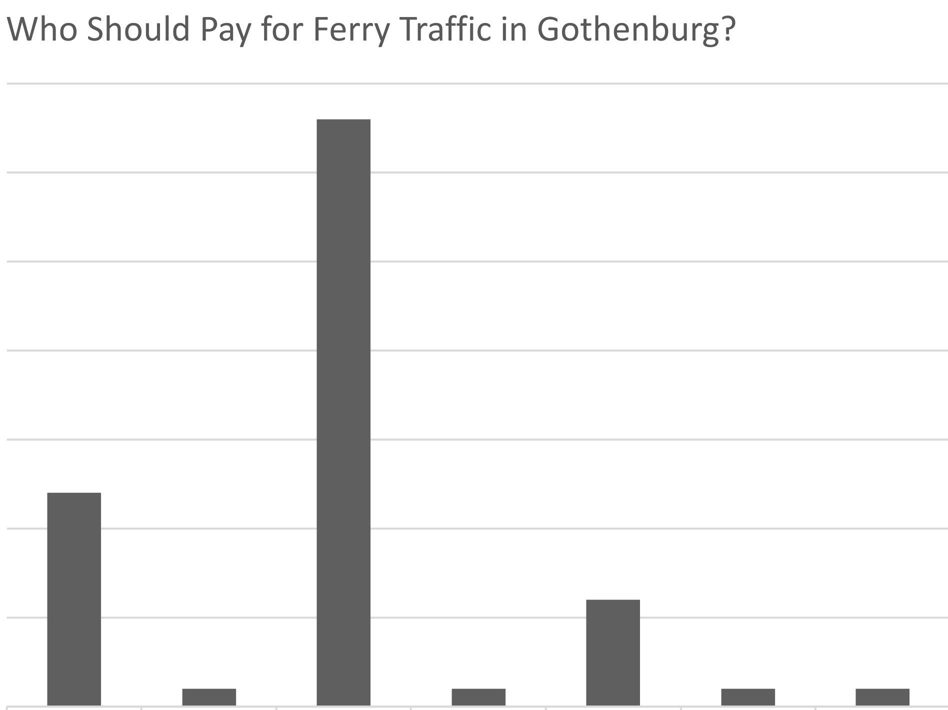
Another explanation for the ratings is that no one wants to lose something that is appreciated for an alternative that could be less beneficial, e.g., more issues or a less positive experience in general. Therefore, if changing the service design, it needs to allow for smooth transitions, i.e., no payments or similar that disturb the user while travelling – minimizing the need for the task of paying whilst en-route.

Organizations' Role in Ferry Traffic Costs

However, 11% of the participants responding to the questionnaire thought that organizations, together with subsidies, would be the best way of paying for the ferry traffic in Gothenburg in the future. They believed that since organizations such as companies benefitted from having ferries sailing to their location, economically, by making them more attractive, but also allowed their employees to more easily commute to-and-from work. If so, they should also be responsible for parts of the cost for the ferry traffic.

Conclusion

Thus, the current pricing of 35 SEK for people only travelling across the Göta Älv should be further investigated. Even though a minority of the participants felt that organizations should be partly responsible for the cost of having ferries, especially if they benefited, this matter should be further explored within the context of the future of the ferry traffic in Gothenburg.



	The Passenger - Should be included in the public transportation cost?	The Passenger - Should pay per trip (buy individual tickets - outside of other public transportation)?	Subsidized through tax funds – for example, line 286 – Älvsnabbare (free for the passenger).	Organizations, such as companies, pay the entire cost of all ferry traffic to/from their land/business (free for the passenger)?	Organizations, such as companies, pay a part of the cost of all ferry traffic to/from their land/business and part is subsidized by the region (free for the passenger)	Organizations, such as companies, pay a part of the cost of all ferry traffic to/from their land/business and part is paid by the passenger?	Organizations, such as companies, pay a part of the cost of all ferry traffic to/from their land/business and part is paid by the passenger and by subsidies by the region?
No.of Respondents	12	1	33	1	6	1	1

Figure 10 – Participant opinion of how future ferry traffic should be financed

Maritime Safety & Interpersonal Security

Responsibility & Information

In general, the participants believed that the experience of travelling with manually operated diesel-electric hybrids and highly automated electric ferries would be quite similar until a potential incident or accident occurs. They expressed concerns about who would be responsible in such situations, such as, a fire or someone falling overboard while traveling with an unmanned ferry. This concern extended to the safety of travelling with highly automated ferries and the need for information about what to expect. Passengers need clear instructions on what to do and when to act if an incident or accident occurs.

The Role of Authority Figures
Similarly, some participants expressed concerns about being alone with other passengers, without an 'authority figure' present. Female participants, in particular, mentioned the unease of travelling alone with other people without any authority figure who could act as a deterrent or intervene if necessary. Several participants viewed the crew members on board not only as operators responsible for the ferry but also as authority figures whose presence creates a sense of security and safety.

Conclusion
There is a need for solutions that consider potential incidents and accidents and provide clear information for passengers. Furthermore, having an 'attendant' onboard could ensure safety if incidents or accidents occur. This authority figure could not only mitigate the risk of interpersonal conflicts between passengers but also create a perception of safety and security. If an attendant is not a feasible solution, a technical solution that embodies these functions should be considered.

THE DECKHAND
In relation to the removal of the deckhand onboard, which many expected that the introduction of electric and highly automated ferries would contribute to, a couple of participants mentioned that they felt this would be an unfortunate development.

Familiarity & Social Interaction
They felt it was pleasant to see the familiar faces of the deckhands on the ferries every morning or afternoon when commuting to or from work. Therefore, they were concerned that introducing electric and fully automated could lead to the deckhand being removed which in turn would decrease the familiarity and general positive experience that one gets from having deckhands onboard the ferries.

Conclusion
Thus, it seems as though the deckhand not only adds to the perception of maritime safety and interpersonal security, but they also assist in creating positive experiences whilst travelling with the ferries.

DOCKING (DRIVING) BEHAVIOUR
There were also concerns among the participants' regarding to what degree future and highly automated ferries could accommodate to individual needs compared to today's solution where a captain is controlling the ferries.

Accommodating & Considerate Behaviour
One of two primary examples was (i) whether or not highly automated ferries will be able to wait a few minutes for an individual (or several) who have not yet boarded the ferry. This since several participants experienced that captains often waited for them when they were running a bit late. This behaviour was experienced as highly positive and desirable. The second example, even more important, was (ii) whether highly automated ferries would be able to consider people with disabilities due to age and/or sickness. Similar to the first example, this primarily related to accommodating behaviour for people who need the extra time to board or disembark the ferry.

Conclusion
Thus, highly automated ferries need to include solutions that allow for varying passenger needs related when boarding and/or disembarking the ferry e.g. being late for the embarkment and/or due to disabilities.

REDUCTION OF NOISE
Finally, many participants also felt that since highly automated ferries will be electric, they expected them to be quieter which was viewed as something positive from a travel experience standpoint.

Conclusion
Thus, there is a wish that electric and highly automated ferries provide a more comfortable sound environment for the passengers.

4.1.2 FERRY TRAFFIC LEVEL

Ferry Traffic level is here defined as the intermediary level of abstraction and considers the passengers' experience of today's ferry traffic system and expectations of the ferry traffic system in the future – a future including electric and highly automated ferries.

AUTOMATION AS AN ENABLER
Within the term 'Automation as an Enabler' several needs are incapsulated. These includes needs related to: (i) Ferry Berths, (ii) Reliable Operation, (iii) Travel Purposes, (iv) Seamless Use and (v) Automation & Unemployment.

Ferry Berths
In terms of ferry berths, it was found that the participants expected and hoped that the introduction of electric and highly automated ferries would change the ferry traffic system for the better by making it possible to increase the amount of ferry berths along Göta Älv (in proximity to Gothenburg) to make it more convenient to cross the river.

Reliable Operation
Furthermore, in terms of reliable operation, it was found that the participants expected electric and highly automated ferries to enable higher levels of punctuality and predictability. They believed that this would lead to more consistent performance over time, meaning that the ferries would adhere to the timetable more accurately and encounter fewer issues. An explanation as to why the participants believed that electric and highly automated ferries would be able to enable higher levels of reliability is due to the passengers believing that with fewer people involved in the operation of the ferries, fewer errors would occur–e.g., due to sickness or mistakes while operating the ferry–i.e., less human factor issues. Furthermore,

they believed that the information would be more exact and predictable, e.g. information about estimated departure and arriving times would better align with the ferry's actual departure and arrival.

However, these benefits will not, according to several participants, be realised until after the initial introduction phase. In other words, several participants believed that initially, there could potentially be more issues in comparison to the current solution due to technical, operational and organizational issues. These issues included increased operational unpredictability and more ferries being out of service due to technical issues, operational issues due to mixed-traffic, i.e., manual and automated maritime vessels sharing the same space which requires to be mitigated as well as organizational issues such as not having the technical expertise needed locally, and therefore a reliance on outsourced technical expertise which could lead to both economic and sustainability consequences. This was seen as highly unfavourable by the participants, e.g., the need to fly in technical experts as soon as there are issues with modern electric and highly automated ferries.

Travel Purpose

Regarding travel purposes it was found that the current traffic system could be improved which many hoped that an electric and highly automated ferry traffic system would enable by allowing more travel purposes being met. The participants felt that as of now the ferry traffic system mainly caters for commuting needs but not leisure travel needs such as evening activities to the same extent. Therefore, several participants wanted a ferry traffic system that did not only account for commuting to and from work but also for leisure activities during evenings, nights, and weekends.

Seamless Use

Many of the participants' comments also related to wanting a ferry traffic system that was more seamless. In other words, they wanted a ferry traffic system that allowed ferry passengers to just hop-on and hop-off, more or less wherever and whenever they wanted across the length of Göta Älv in proximity to Gothenburg. This would decrease both the distance and the time required to reach or wait for a ferry.

Additionally, a few participants also expressed that electric and highly automated ferries could enable on-demand services to optimize the ferry traffic. In other words, the participants believed that electric and highly automated ferries could employ AI systems to adapt to changing travel demands. Thereby the ferry traffic system could be optimized to ensure that ferries did not operate empty.

Automation & Unemployment

There were concerns among some of the participants that introducing electric and highly automated ferries would lead to unemployment for deckhand as well as captains. This was seen as something negative since the participants felt bad for the people that potentially could lose a job and/or opportunity for a job.

Conclusion

Thus, there is a belief and hope for electric and highly automated ferries to enable more possibilities to be able to cross the river, more reliable (punctual and predictable over time) ferry operation but also more exact and predictable information. However, there is also a concern that during the introduction phase these potential benefits might be overshadowed by technical, operational and organizational issues. Therefore, there is a need to mitigate introductory issues since they could lead to negative experiences. Secondly, there seems to be a need for an electric and highly automated ferry traffic system to operate continuously, all day and night throughout the week. However, this issue must be further investigated. Third, there were also concerns related to unemployment/less job opportunities due to introducing higher levels of automation within the ferry traffic system. A solution that might mitigate this issue is to show the actual consequences, including both positive and negative, to further support a nuanced discourse of what might happen if electric and highly automated ferries would be introduced. Finally, there seems to exist a need to further decrease experienced interruptions whilst traveling and improve connectivity between travel routes within the ferry traffic system in Gothenburg. This could be solved, e.g., with more berths along both sides of Göta Älv.

4.1.3 SOCIETAL LEVEL

Societal level is here defined as the highest level of abstraction and considers the passengers' expectations of the effect on our society if electric and highly automated ferries is implemented.

THE DOMINO EFFECT

Within the theme the 'domino effect' lies expected benefits on a societal level.

Electric and Highly Automated Ferries: A Catalyst for Technological Progress

According to one participant, one expected benefit that can lead to other benefits is that the introduction of electric and highly automated ferries will lead to more technological advancements which in turn creates a need for further technological advancements. This 'domino effect' was deemed as something positive according to the participant since it increases the speed of which we evolve and become more sophisticated.

Job Opportunities Stemming from Technological Advancements

Furthermore, these advancements could, according to another participant, in turn lead to more job opportunities for engineers but also increase the potential for marketing of Gothenburg as an innovative and technological strong city which in turn could lead to other potential benefits.

Conclusion

Thus, there is a possibility for several and different types of benefits when introducing new technology. For instance, electric and highly automated ferries may not only increase the potential for more user-centric and sustainable mobility solutions but can also act as a catalyst for further technological progress. However, there might also be exacerbating effects long-term that is more difficult to anticipate. Even though potentially difficult to anticipate they still needs to be, as far as possible, considered already from the beginning of a potential introduction of electric and highly automated ferries.

A DYSTOPIC FUTURE

However, some participants saw the use of electric and highly automated ferries as one more technological step in the wrong direction, a step that drives us further from how we are supposed to live.

The Impact of Automation on Socio-Economic Disparity and Social Cohesion

According to one participant, a step in the wrong direction includes relying more upon technological solutions and less on humans which in turn creates a more asocial society that we are not supposed to live in. Other participants perceived automation in general as being a negative solution in relation to having an open society. The participants perceived automation as a tool to increase profit which in turn increases the distance between socio-economic classes within the society. In other words, automation was a way to guard profit interests in a society built upon hierarchical structures such as socio-economic classes and further increase the distance between the classes making the rich richer and the poor poorer.

Conclusion

Thus, it is important to be transparent about the potential effects of introducing new technology, including both positive and negative consequences, as a way of fostering a correct understanding. This understanding may, in turn, assist people in establishing appropriate levels of trust in the organizations behind the technology, as well as in the new technology itself. Finally, having appropriate levels of trust in an organization and/or technology may then support people in more readily accepting the introduced technology.

4.2 PROJECT STAKEHOLDERS & EXPERTS

The views of project stakeholders and experts concerned aspects related to electric and highly automated ferries that are important to consider. These aspects were divided into eight themes: (i) 'Sustainability is Key', (ii) 'Revenue Potential via Marketing and Mobility' and (iii) 'Mobility as a Service (MaaS), (iv) Interorganizational issues, (v) Intra-organizational issues, (vi) Risk, (vii) Waterborne Transport & the Maritime Market, and (viii) the Procurement Process.

(i) SUSTAINABILITY IS KEY

The theme 'Sustainability is Key' relates to the project stakeholders', primarily ferry developers', public transport representatives' and experts' on shipping, view on sustainability in relation to electric and highly automatic ferries.

Sustainable & User-Centric

According to some of the project stakeholders but also a few experts, it was important to show that the ferry traffic could become more sustainable and user-centred for public transport users as a step towards the goal of further decreasing the need for using privately owned cars.

To do so, the ferry traffic system must enable travel benefits for the users by e.g. more ferry traffic berths, more departures per unit of time, creating shortcuts to cross the river (in comparison to public transport busses and/or trams and/or privately owned cars that have to travel longer distances and cross one of the two bridges available) as well as by creating a ferry traffic system that only uses electric propulsion systems to become more ecologically sustainable.

Sustainable & User-Centric Ferry Traffic yield lasting results

By creating a ferry traffic system that is more ecologically sustainable and more enabling for the users, i.e., a more user-centred ferry traffic system, it was believed that the overall sustainability of the traffic system would increase by reducing CO_2 and particle emissions by decreasing the number of cars within the city and decreasing the number of queues as an added benefit.

A Paradigm Shift: from Local to Global

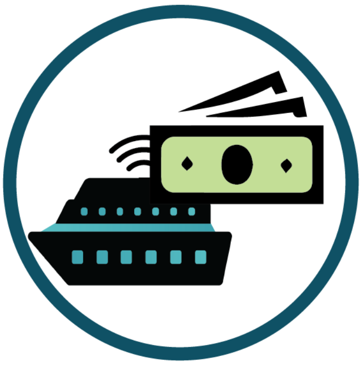
However, to be able to make the ferry traffic more sustainable and user-centred and reap the benefits, there must be an economy in new mobility solutions related to the ferry traffic. According to project stakeholders and experts, this requires a change regarding how the maritime industry is currently approaching the design, manufacturing, and operation. Currently, they often only create one-off solutions or small-scale productions for a specific purpose, such as a local wharf designing and manufacturing a few ferries for one particular mobility service in one specific location. Such a location often has specific demands, such as docking heights. Therefore, some of the project stakeholders but also experts mentioned the need for resource optimization by changing the approach.

Incremental Optimization

Resource optimization relates to four aspects: (i) optimize the manufacturing of ferries to not only create one-off solutions for one specific market (e.g. ferry traffic in Gothenburg) but solutions that, e.g., fit different locations (such as cities) and ferry berths, (ii) instead of small scale production of ferries, focus on mass production of ferries (similar to the car industry) to be able to lower the cost, (iii) automate the operating functions of ferries to reduce labour cost and increase efficient operation, and (iv) create ferry traffic systems that not only have one purpose but instead create value by being used for different purposes i.e. value-stacking. An example of value-stacking could be using ferries for commuting purposes but also for leisure and/or experience-related purposes such as tourism.

Conclusion

Thus, there is a demand for optimization related to the way we approach the design, manufacturing and operation of ferries. In addition, there is a need to identify business models that include value-stacking revenue streams to be profitable and, by this, further increase potential system optimization, e.g., by using the ferry traffic for more than just commuting to/from work.



(ii) REVENUE POTENTIAL VIA MARKETING AND MOBILITY

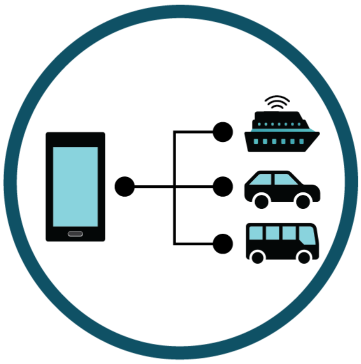
The theme of 'Revenue Potential via Marketing and Mobility' relates to the project stakeholders', primarily land-property and business owners', view on what electric and highly automatic ferries can enable for their business.

Potential Short-Term Benefits

The short-term revenue potential includes: (i) opportunities for partaking in commercial campaigns in relation to an introduction of electric and highly automated ferry traffic systems that, in turn, can increase the interest for a specific area of land and/or business. It is also important for some of the project stakeholders to be viewed as an actor associated, in one way or another, with innovation, which being part of an introduction of electric and highly automated ferries enables. Second, (ii) the potential of automation to establish more berths, which in turn could increase the potential for flows of consumers to different areas in the city, which in turn could increase the potential of revenue for businesses, e.g., hotels and stores etcetera.

Potential Long-Term Benefits
The long-term revenue potential includes: (i) opportunities associated with land and property management. Continuously being part of introducing new solutions and the mere fact of being seen in media assist land and property owners to show to their customers as well as others that they are, indeed, managing land and property by increasing the value through increasing the attractiveness of that specific land and/or property. Second, (ii) closely related to management is the importance of showing a land and/or property's development potential by further increasing possibilities of transport to and or from that specific land or property. Hereby one increases the potential for certain land areas to grow and become a location of interest and commerce.

Conclusion
Thus, there is a need for land-, property- and business owners, in general, to be able to be part of new mobility solutions such as the introduction of electric and highly automated ferries since it is in their interest both from a marketing perspective and from a financial point of view. If land-, property- and business owners can create new berths at locations with commerce but also at locations not yet established whilst at the same time be able to market themselves via an introduction of electric and highly automated ferries, there is a possibility for an economic symbiosis between electric and highly automated ferry manufacturers and private business actors such as land-and property owners to finance an introduction together. This will, in turn, also create benefits for most mobility users by creating new travel possibilities to and from areas not supported today.



(iii) MOBILITY AS A SERVICE (MAAS)

MaaS: A User-Centric Paradigm
The theme of 'Mobility as a Service' relates to the project stakeholders', primarily electric and highly automated ferry manufacturers', ferry traffic operators', mobility service providers' and maritime logistics experts' view on what electric and highly automatic ferries can enable for mobility (but also logistics).

According to some of the interviewees, from the project stakeholders but also the expert group, a potential electric and highly automated ferry traffic system must be designed around the idea of Mobility as a Service (MaaS). MaaS is *"…a user-centric, intelligent mobility distribution model in which all mobility service providers' offerings are aggregated by a sole* *mobility provider, the MaaS provider, and supplied to users through a single digital platform*" (Kamargianni & Goulding, 2018).

In Gothenburg, Västtrafik AB is the sole mobility provider that offers different modes of transport such as busses, ferries, trams and trains, to their customers via a travel planner application. Therefore, the public transport system in Gothenburg already offers MaaS in which a potential electric and highly automated ferry traffic system could be included.

Beyond Multimodal MaaS: Elevating the Service

However, according to the interviewees, the service offered cannot only be a multimodal MaaS solution but must offer more. A couple of the interviewees saw that electric and highly automated ferries had the potential to increase mobility possibilities by adding 'On-Demand' services to the multimodal MaaS solution provided already today.

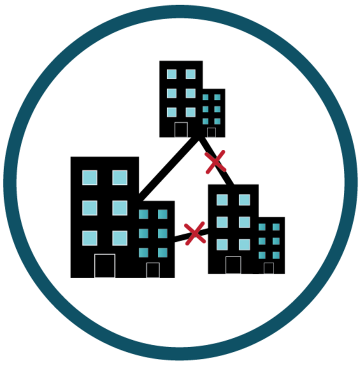
For example, one of the interviewees (representing a land- and property owner company) perceived that electric and highly automated ferries could not only be used as a mode of transport for commuting but could offer more arrivals and departures as well as create more connections along both sides of the river, this to further the possibilities to travel across the river (something more or less all interviewees agreed upon). This, in turn, could increase the possibilities of adding On-Demand capabilities to the mobility service. Having On-Demand capabilities could, according to the interviewee, lead to using electric and highly automated ferries not only for commuting but for different events e.g. meetings (or to travel to and from different events) which could add to a more vibrant river, in turn leading to the river becoming a bigger part of the city. This would, in turn, further the connection to the cultural heritage of Gothenburg as a port city.

Electric & Highly Automated Ferries: A Part of Future MaaS & Logistics?

Interestingly, several of the project actors and experts observed that electric and highly automated ferries could be used for more than mobility. A maritime logistic expert spotted the possibilities of using the river not only for mobility but also for logistics as well as transportation of waste as a way to decrease the number of vehicles currently negotiating for space in the streets. This is a function that electric and highly automated ferries could support. However, whether or not a multipurpose ferry traffic system has potential in the future, the main thing to consider is that all types of different traffic modalities, e.g. busses, trams, trains, e-scooters and car-sharing solutions, are considered from the beginning. In other words, that a top-down approach is considered so as to not create sub-optimal transport solutions for mobility as well as logistics.

Conclusion

Thus, it seems that there are many possibilities related to electric and highly automated ferries. These possibilities include enabling more arrivals and departures, creating more connections along both sides of the river, and being used for more than just commuting. For instance, they could be part of events and/or assist event visitors in travelling to and from events more easily. In addition, these ferries could serve as a complement to other services, such as a transport service for businesses or hotels, or as an addition to transport services like the air-port buses which are additions to the national and international travelling service. In the long term, these ferries could also be used for more than just mobility, such as logistics and transportation of waste. However, for this to be successful, a top-down approach is necessary where all different types of traffic modalities are considered together as a whole. This would require a systems perspective approach to both mobility and logistics.



(iv) INTERORGANIZATIONAL ISSUES

Interorganizational issues relate to issues that hinder a possible introduction and implementation of electric and highly automated ferries due to 'responsibility and support' issues.

Responsibility & Support

According to several of the project stakeholders, it is difficult to understand who is and who should be responsible for the possible introduction of electric and highly automated ferries short-term, e.g. via a testbed, but also who should be responsible if and when electric and highly automated ferries were to be implemented as a long-term solution to mobility.

Responsibility due to Being Trustworthy

Many project stakeholders did, however, feel that City of Gothenburg should be the organization responsible for leading such an endeavour since many of the project stakeholders seem to trust the organization to be able to make rational decisions based on the residents of Gothenburg's mobility needs, but also committed to see an electric and highly automated ferry system implementation through, if there were to be any issues.

Perceived Lack of Competence

Finally, business-, property- and landowners as well as international ferry manufacturers, experienced that there was a lack of public authority competence related to laws and regulations but also that laws and regulations were not applicable due to being e.g. outdated. This is something that must considered when having the intention of creating a testbed for new mobility solutions such as electric and highly automated ferries.

Conclusion

Thus, there is a wish that actors, such as the City of Gothenburg, take the lead and long-term responsibility for new mobility solutions since they are deemed trustworthy. There also seems to be a lack of support related to information about laws and regulations associated with introducing new mobility solutions, e.g. electric and highly automated ferries. Therefore, there seems to be a need for increasing agency competence related to new technology within the mobility sector. This is important to further increase the potential for rapid changes to more quickly reach goals set up by Västra Götaland Regionen (VGR), e.g. sustainability goals.

(v) INTRAORGANIZATIONAL ISSUES

Intraorganizational issues relate primarily to two issues: 'different priorities within an organization' and 'the credibility of the endeavour'.

Different priorities

Economy Top Priority

According to a project stakeholder representing a land- and property owner, there are often different priorities within the organization which in turn affect what resources will be spent and on what. The organization's own economy is often the top priority. Therefore, it is difficult for organizations to put in the efforts and resources needed into being a part of realizing e.g. a testbed of a new mobility solution without any clear guarantees.

Level of Credibility of the Endeavor

Credibility

To receive internal funding and be able to place the resources needed into an endeavour such as being part of supporting the creation of a testbed for electric and highly automated ferries, the endeavour needs to have high levels of credibility. By credibility is here meant that the endeavour will in the short-term and/or long-term increase the potential for benefits for the organization.

Credibility via Marketing & Mobility

These benefits include increased recognition as well as mobility possibilities for the involved organizations e.g. routes going to and from the involved organization's land-, property- and/or business. Routes that are beneficial for the organization. Which in turn can, as mentioned before, increase revenue via marketing but primarily via mobility.

Verify Credibility

Therefore, it seems as if it is sometimes difficult to be able to put resources, in time and money, into new, untested and unverified solutions due to different priorities within organizations. However, if the endeavour includes a level of credibility, such as showing potential for increased revenue either short-term and/or long-term via marketing and/or mobility, there is a higher chance of retrieving the funding needed for the endeavour in terms of being part of a testbed for electric and highly automated ferries or even be part of launching a long-term implementation of electric and highly automated ferries.

Conclusion

Thus, to create a partnership for a possible joint effort in introducing a testbed and even implementing electric and highly automated ferries long-term, it is highly important to illustrate the potential benefits from a marketing standpoint but primarily the mobility benefits for the involved organizations supporting an endeavour such as having a testbed that includes berths and routes that are relevant for the involved organizations.

(vi) RISK

In terms of the barrier risk, there are primarily two issues: 'the burden of new technology' and 'manually operated versus automated technology'.

The Burden of New Technology

Safety Concerns

Perhaps the biggest concern was that electric and highly automated ferries pose a risk towards maritime safety due to e.g. expectations that without a captain onboard, there are potential risks if something were to happen, e.g. a fire and/or a system malfunction. However, there were also concerns, as mentioned more in-depth by the ferry passengers (see section 4.1. Ferry Passengers) about passengers' interpersonal security.

Economic Risks: High Investment Costs

Furthermore, there are also economic risks involved with investing in new technologies, especially in the maritime business, due to e.g. the already high investment costs in comparison to other public transport vehicles –15-20 times more than a bus, according to one expert. Therefore, it is of uttermost importance to receive support from agencies in terms of economic support but also support in terms of competence related to new technologies within the maritime sector which, according to one expert, is still lacking within different agencies.

Regulatory Hurdles

There are also issues related to current laws and regulations, according to some of the experts. The absence of laws and regulations for unmanned and automated maritime vessels is an issue that is considered one of the major barriers and that, instead of assisting, are hindering the possibilities for a paradigm shift in the maritime market (Lokrantz & Jönsson, 2019). This is a shift that could support in creating more sustainable (and even safer) ferries and ships but also would assist in creating more efficient operations.

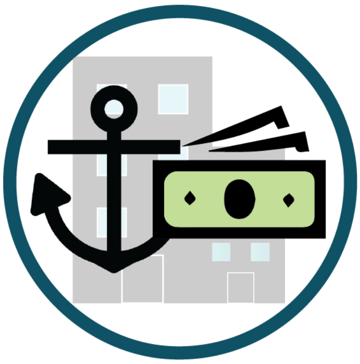
An example of a barrier related to efficient operation is the current speed limits which are defined to mitigate negative effects such as waves or swells caused by boats and ships. There is new technology such as hydrofoil technology that reduces such waves and swells. However, the laws and regulations are still based on standard boat hulls and therefore speed limits are defined based on that even though new technologies can mitigate these issues to a significant extent. Therefore, laws and regulations need to be updated and based on what new technology can offer.

Conclusion
Thus, there is a need to further investigate how to ensure maritime safety and experienced and actual interpersonal security with less and/or no staffing on-board, increase the possibilities for economic support but also support regarding how to go about when wanting to introduce new mobility solutions within the maritime sector and finally, a need for laws and regulations to be looked over so as to be up-to-date in relation to the current context and new technology.

Manually Operated versus Automated Technology
Surpassing Baseline
Another risk or rather concern that was mentioned was the potential issue of electric and automated ferries not reaching, even less surpassing, the current level of maritime safety, security, comfort, sustainability, efficiency and overall utility. These are fundamental aspects to consider, otherwise the expected success of electric and highly automated ferries might not happen.

Conclusion
Thus, there is a demand for electric and highly automated ferries and the surrounding system to reach or preferably surpass the level of maritime safety, security, comfort, sustainability, efficiency and overall utility offered by the current ferry traffic system.

(vii) WATERBORNE MOBILITY & THE MARITIME MARKET
In terms of the barrier 'Waterborne Mobility & The Maritime Market', there are primarily two issues: A local market endeavour and relative energy consumption.



A Local Market Endeavor
The domain of ferry design, manufacturing, and operation predominantly exists within local markets.

Local Shipyards and Custom Ferries
Project stakeholders and experts experienced that ferry-related endeavours primarily unfold at local shipyards. These shipyards engage in the design and manufacture of a limited number of ferries, often tailored to specific—and predominantly local—requirements. The local context drives the need for custom solutions.

Unstandardized Infrastructure and Docking Challenges
The issue of this specificity lies in the unstandardized nature of infrastructure, particularly piers and docking solutions. Unlike standardized transport hubs, ferry berths exhibit significant variability. Varying docking heights, water depths, and spatial constraints necessitate custom designs for each location e.g. city.

The "One-Off" Approach
The consequence of this specificity and infrastructure diversity is the prevalence of custom "one-off" ferries. Each vessel is designed and manufactured to fit specific docking conditions, passenger capacities, and operational needs. While this approach ensures optimal functionality, it comes at a cost—both in terms of design complexity and manufacturing expenses.

Cost and Limited Export Potential
The custom nature of these ferries renders them expensive. Their attractiveness lies primarily within the local market, where their tailored features align with specific demands. However, this specificity paradoxically limits their export potential. Unlike the bus market, ferry exports remain limited.

Conclusion
Thus, there appears to be a need for either standardization in terms of piers and docking solutions or ferries that are adaptable to fit different piers and docking solutions. Secondly, there is a need for ferries that are standardized in the sense that they can be used not only for a local market but for many different places and purposes. This demands a shift in how the design, manufacturing and operation are approached – taking it from a local endeavour to a global one. This, in turn, can lead to reduced costs of ferries of the future.

Relative Energy Consumption
According to project stakeholders and experts, such as representatives from Västtrafik AB and Region Stockholm, ferry traffic is 4-5 times less efficient than landbound public transport vehicles such as busses due to a ferry's water resistance. However, this is not a nuanced depiction of the situation.

Optimizing Ferry Traffic: Right-Sizing for Efficiency
First, according to other project stakeholders and experts, e.g. ferry developer representatives, the current ferry traffic in Gothenburg has a utilization rate of under 20% i.e. below 20 passengers per transported person kilometre. This is low considering that the current ferries, which can take up to 300 passengers, often run almost completely empty (below 60 passengers on average). Therefore, it is important to adapt the sizes of the ferries to the actual mobility needs to increase the utilization rate and thus minimize the waste of resources.

Ferries vs. Landbound Mobility: A Fuel Efficiency Perspective
Secondly, there is another issue related to the comparison between ferries and landbound modes of mobility such as busses and/or trams. Ferries have the potential to travel shorter distances to reach different destinations due to the possibility, under the right circumstances, to travel across rivers whilst busses and trams often need to travel longer distances as they have to drive around the river or via bridges to reach a destination.

According to one of the project stakeholders, a representative from a local ferry manufacturer, by decreasing the size of ferries, having them fully electric and by the mere fact that ferries can travel across rivers, leading to shorter person kilometres travelled, it is possible to increase the average fuel efficiency per passenger-kilometre (MJ/pkm) to a high degree and by this substantially decrease emissions.

Conclusion
Thus, first there needs to be a standardization or at least consensus on how to calculate the efficiency of different vehicle types that are aimed to be used within mobility e.g. public transport. This to be able to realistically be able to compare different modes of transport and to be able to draw valid and reliable conclusions. Secondly, it is highly important that the ferry traffic also is based on travel needs i.e. adapt to the number and flow of people traveling. For example, on-demand solutions that allows to only travel to and from places where it is known that there are potential passengers. But also, that the performance-oriented procurement process considers user related variables that can be measured, monitored and evaluated e.g. user satisfaction and/or adoption but also variables related to the regional goals e.g. sustainability goals such as energy efficiency and emissions produced etcetera.

(viii) THE PROCUREMENT OF FERRY TRAFFIC
Finally, in terms of the barrier 'the Procurement of Ferry Traffic' there are three issues 'Procurement Information Transparency', 'Catch 22 Due to Interplay Between Organizations', and 'Contract Period'.

Procurement Information Transparency
Information Accessibility
According to several of the project stakeholders it was difficult to understand where to receive the information regarding how to go about getting one's travel needs met. In other words, how can a local organization provide mobility possibilities for their potential customers and/or how can an external e.g. ferry manufacturer find the information necessary to be part of the procurement process?

Needs Being Heeded
This related to how to go about getting information but also how to be heeded by the organization responsible for the procurement of public transport. According to some of the project actors it was difficult to be heard by organization such as primarily Västtrafik AB but also to a certain degree the City of Gothenburg (who is involved with e.g. planning infrastructure and do their own evaluations regarding when and where certain public transport possibilities likely needs to be deployed). For instance, PEAB have an interest in a route to Magasin 113 and Källfelt Byggnads AB has an interest in a route going to Nya Varvet but also Nya Färjeläget (Färjenäs) and Stenpiren. Källfelt Byggnads AB has even gone as far as creating their own ferry route between Stenpiren and Nya Varvet. A route which they operate during the summer with their own acquired ferry. Something they have been doing the last couple of years due to not getting any support from Västtrafik AB.

Therefore, it seems as if different organizations such as local businesses that have mobility needs have a hard time understanding how to go about being part of the procurement process (and how that procurement process is conducted) but also getting heard from the responsible organizations behind different mobility solutions in Gothenburg.

Conclusion
Thus, it is important to more openly share information to local and external stakeholders how the procurement process is conducted as well as how to go about being part of the process. This, by for instance deploying specific organizational functions responsible for communicating and assisting new potential actors on the market. Whether they may be manufacturers, traffic operators or local business owners that has mobility needs not yet fulfilled.

Catch 22 Due to Interplay Between Organizations
If information was found and an organization - in need of mobility solutions e.g. a ferry route to their business, reached the correct representative from the responsible organizations there were still quite difficult barriers to push through due to a *catch 22* issue. The issue is an effect due to the interplay between the City of Gothenburg and Västtrafik AB.

Three Interlinked Organizations
According to an expert representing the City of Gothenburg there are except traffic operators and public transport manufacturers three, highly interlinked organizations involved in the procurement process: Västra Götaland Regionen, Västtrafik AB but also the City of Gothenburg (see figure 11).

First, the owner – Västra Götalands Regionen who has different strategies and goals e.g. create a robust and cohesive region that are equal and open and that are fossil-free and circular (Götalandsregionen, 2021). They hand over requirements based on those strategies to Västtrafik AB (see figure 11).

Västtrafik AB the regional public transport organization owned by Västra Götalands Regionen are then responsible for executing and ensuring that strategies and goals are met in terms of public transport (see figure 11).

Furthermore, Västtrafik AB then send out tender documents with specific requirements to the open market and different traffic operators e.g. ferry-, tram- and/or bus- operators can choose to apply. If a traffic operator wins a contract, they are responsible for procuring vehicles from different companies e.g. ferry-, tram- and/or bus- manufacturers (see figure 12). However, the catch 22 issue is created from the interplay with the fifth organization indirectly involved in the traffic system, namely the City of Gothenburg and Västtrafik AB (see figure 11).

The City of Gothenburg also has strategies and goals and are responsible for planning and executing infrastructural changes to the city e.g. develop new areas. Which often takes a lot more time than to create new public transport routes regardless of these routes relates to land- or water. Given the gradual development of new areas, there arises a need for the city to deploy mobility services, even before these areas are fully completed. This need originates from residents, workers, and individuals with an interest in the developing region. However, Västtrafik AB, driven by revenue per public transport user, tends to be hesitant in deploying public transport solutions to areas that are not yet financially viable.

Conclusion
Thus, addressing mobility needs remains crucial, not only in the short term but also from a long-term perspective. By providing mobility options even though the short-term revenue potential is low, the value of new areas can increase and become more attractive for stakeholders e.g. organizations such as global co-operations. Which in turn can, in the long-term generate value through other revenue streams. Therefore, it is even more important to be open for new actors on the market, that in turn can, more quickly, generate value by already having potentially more sustainable and cheaper mobility solutions to mitigate short-term losses.

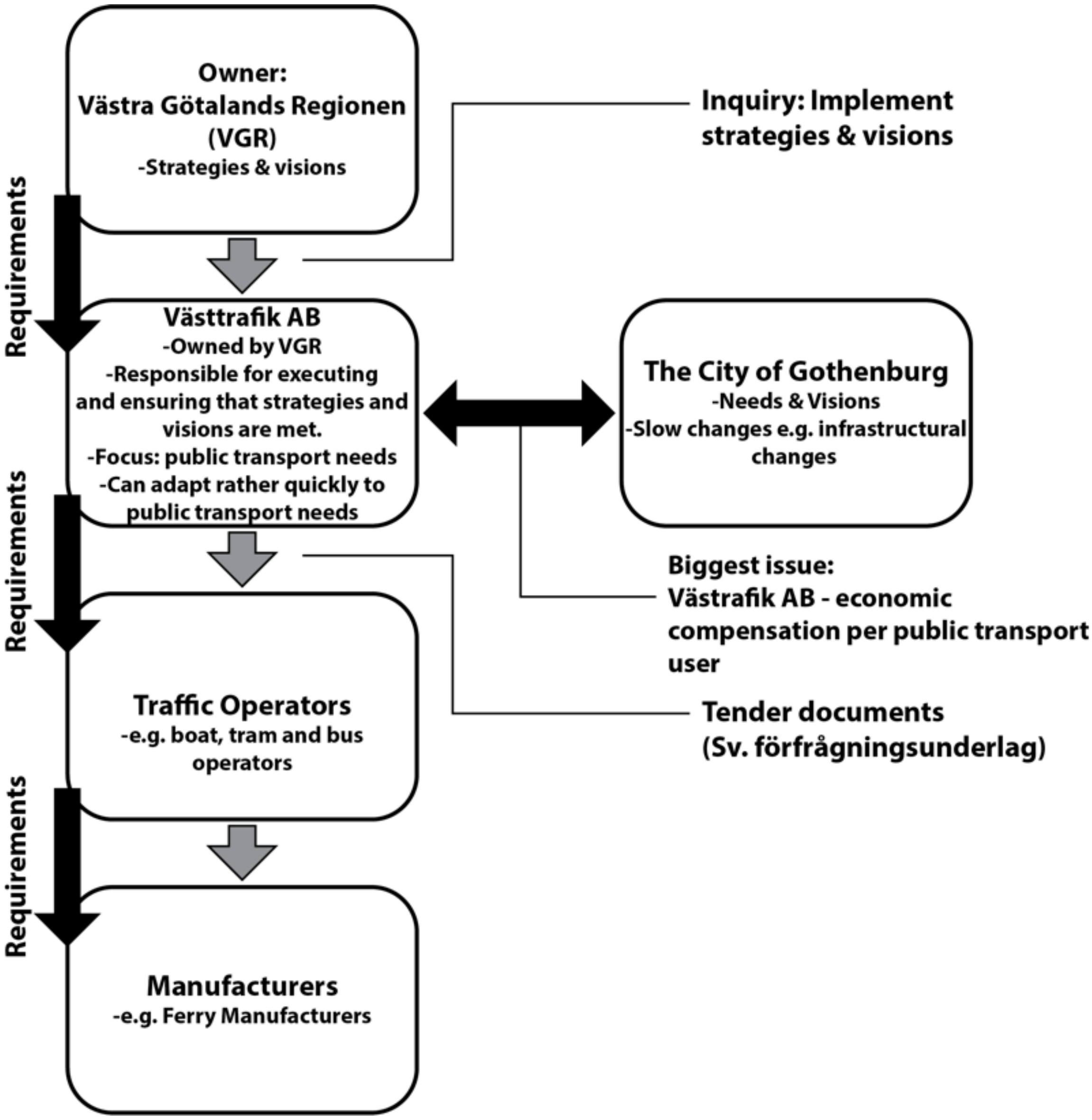


Figure 11 - Composition of organizations and the procurement process

Procurement Contract Length and Lock-In Effects in the Ferry Industry
The procurement process for transportation infrastructure projects involves many considerations, and one critical aspect relates to the length of procurement contracts. In this context, stakeholders often grapple with the perceived length of these contracts, which can significantly impact project outcomes.

The Length of Procurement Contracts

Project stakeholders frequently expressed concerns about the extended duration of procurement contracts. These apprehensions stem from the belief that protracted contract periods may hinder flexibility and limit the ability to adapt to changing circumstances e.g. hinder a swift change from diesel-electric hybrid ferries to fully electric ferries to be able to quickly adapt to stricter sustainability goals.

The Need for Long-Term Instalment Terms

Despite reservations about lengthy contracts, practical considerations demand a nuanced approach. The acquisition of ferries, with its substantial upfront costs, demands a pragmatic solution. To facilitate the financial burden on traffic operators, instalment terms spanning up to 15 years are often deemed necessary. These extended payment schedules allow operators to gradually redeem their debt to ferry manufacturers.

Lock-In Effects and Trade-Off

However, the consequences of protracted contract periods extend beyond financial arrangements. When specific route and ferry requirements are established at the contract's outset, it introduces the risk of lock-in effects. Lock-in occurs when an organization becomes overly reliant on a single solution, inhibiting flexibility and limiting alternative options (Lundell et al., 2021). In the context of transportation infrastructure, this translates to being "stuck" with a particular technology or service provider for an extended period.

The Importance of Flexibility and Adaptability

To achieve global sustainability goals, flexibility becomes more important than ever before. The ability to swiftly adapt to emerging technologies or alternative transport modalities is crucial. While long-term contracts may address immediate financial needs, they must be balanced with the imperative of remaining open to innovative solutions. The dynamic nature of the transportation sector demands agility, ensuring that we do not compromise our ability to embrace better alternatives as they arise.

Conclusion

Thus, while addressing financial realities through extended instalment terms is essential, project planners must carefully navigate the trade-offs. Achieving a balance between financial prudence and long-term adaptability is critical for sustainable and a resilient transportation system.

4.3 A TESTBED FOR ELECTRIC AND HIGHLY AUTOMATED FERRIES

The current section encompasses the findings from part I of the co-creation workshop where different ferry routes were considered and evaluated for the purpose of testing electric and highly automated ferries.

Furthermore, the routes are based on the number of berths, both berths that exist and are in use and berths that do not yet exist (see figure 12). The berths included functioned as a base from which the co-creation participants could create routes. The berths are results from earlier research (Trivector, 2021) but also identified from interviews with project stakeholders. The routes presented in figure 12 are current and/or decided routes (but not yet implemented due to construction delays e.g. route 287). The numbered berths were identified in earlier research and the ones indicated by letters are identified as potential berths based on the interviews with stakeholders.

Thus, figure 12 shows existing and non-existing berths (but still potential berths in the future), the current ferry routes but also routes that are to be implemented but not yet due to construction delays i.e. route 287.

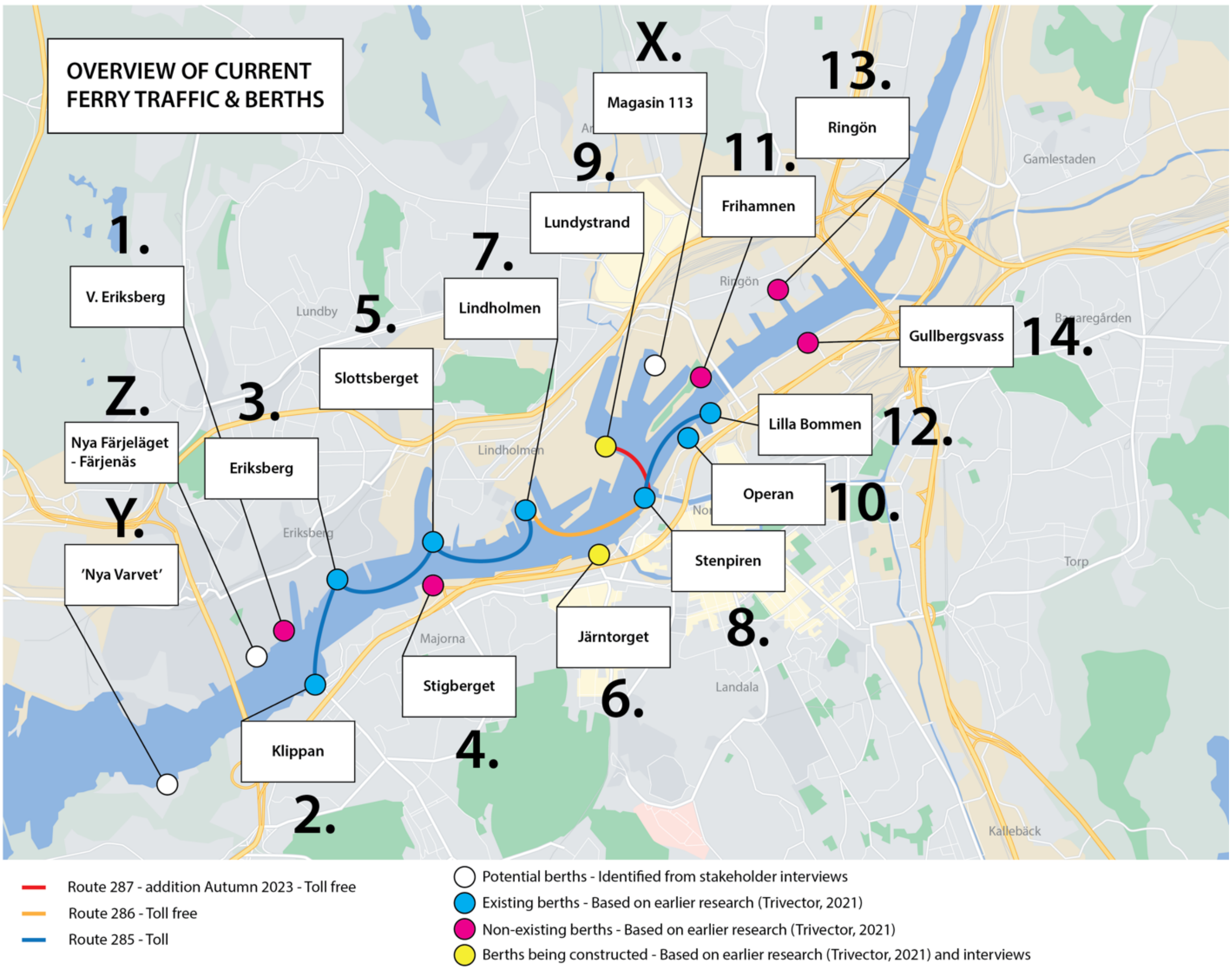


Figure 12 - All possible berths for a potential testbed.

4.3.1 CONCEPTS

Based on the overview of current ferry traffic and berths (see figure 12 above), the project stakeholders as well as mobility and logistic experts co-created, according to them relevant routes for a testbed with electric and highly automated ferries and together as a whole group evaluated which of the concepts had the highest potential. 11 concepts were created.

Concept 1

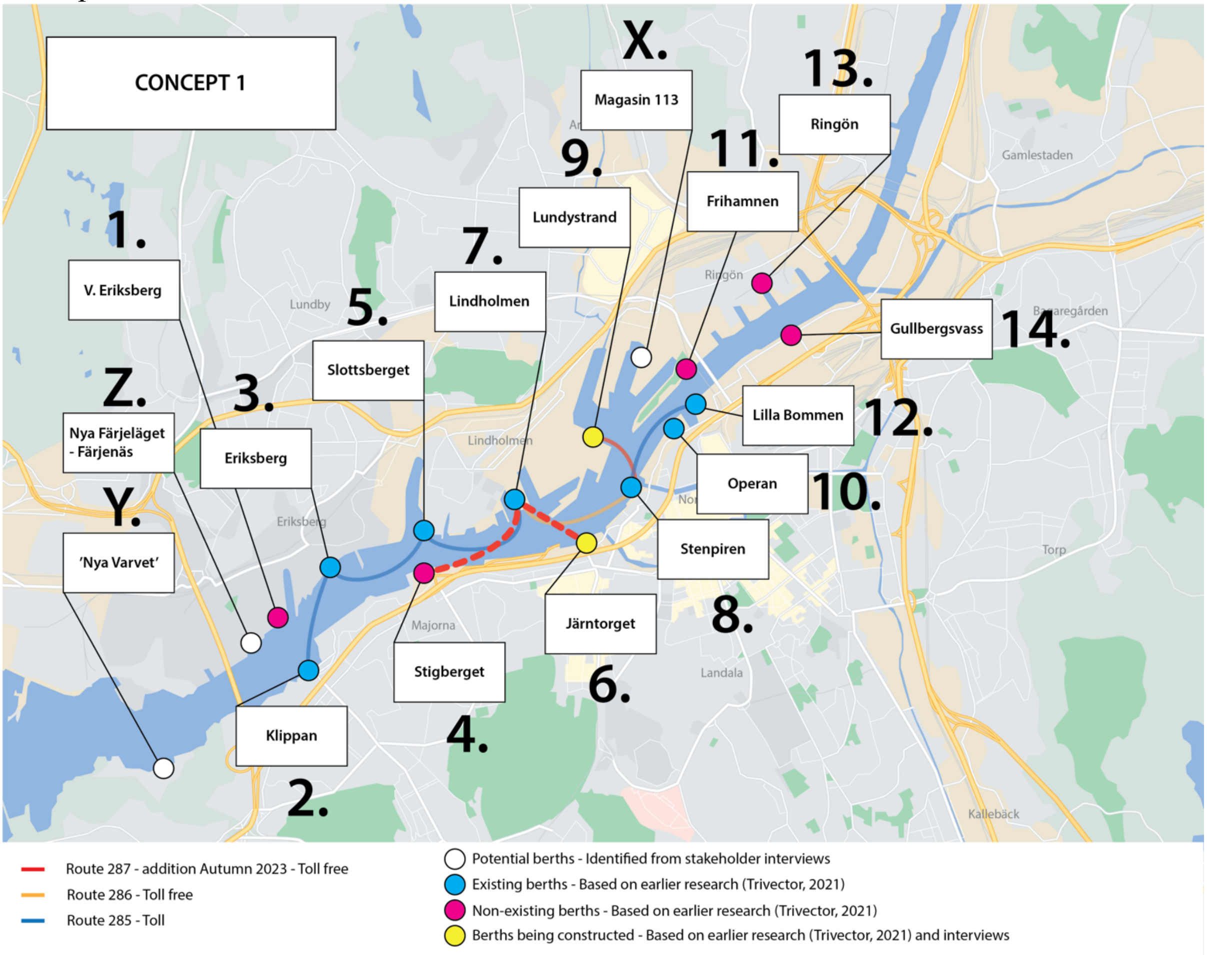


Figure 13 - Concept 1

Route
Stigberget - Lindholmen – Järntorget

Purpose
The purpose of concept 1 is to create a quick and relevant crossing over Göta Älv between three berths where there already is a known high passenger base, i.e. a large share of Gothenburg's population must cross Göta Älv between these three berths. The route is to be used as both a commuting route (to and from work) but also as a route to different 'after-work' activities. Finally, when necessary, the route could also be used for on-demand services, e.g. during an increased need for transport across the river such as in the case of an event.

Time of Operation
06.00-22.00 weekdays + On-demand capabilities (when needed)

Positive Aspects
Quickly being able to cross Göta Älv. Connections to cultural life. Utilizes existing flows. Complements current routes i.e. route 286 and 285. Supports property development on the south side of Göta Älv.

Negative Aspects
Increases the number of ferries at Lindholmen, which in turn could lead to congestion. Access to Södra Älvstranden due to changes regarding who is the lessee of the land.

What is the Value and for Whom?
Quicker commuting and increased possibilities to be able to cross the river and thus decreasing the distance between different destinations on mainland Gothenburg and the island of Hisingen. Creates a mobility solution that adheres not only to commuting needs but also to support experience related travel i.e. being able to travel to and/from concerts, events and nightlife.

Concept 2

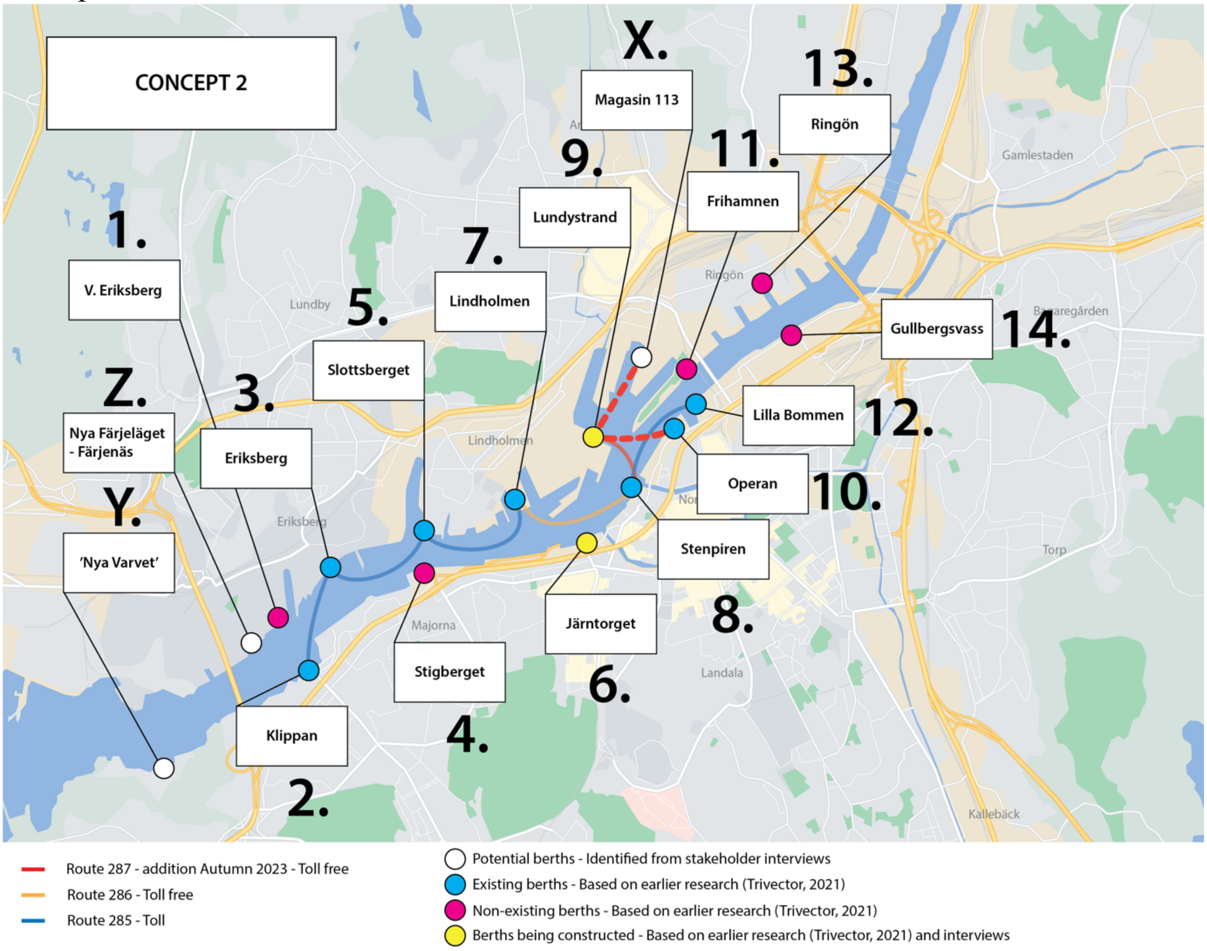


Figure 14 - Concept 2

Route
Operan – Lundbystrand – Magasin 113

Purpose
The purpose of concept 2 is to connect Västlänken[6] with Lindholmen and Frihamnen.

Time of Operation
06.00-22.00 (including weekends)

Positive Aspects
Supports centrally located flows as well as supports city development at Lundbystrand and Frihamnen. There is already charging infrastructure at Lundbystrand that can be used. Complements route 287. It also connects to Västlänken.

Negative Aspects
Less information regarding potential passenger flows between Lundbystrand and Magasin 113 i.e. uncertain travel occupancy.

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[6] Västlänken, a new railway tunnel underneath the city of Gothenburg, that enables seamless commuter and regional trains. With three new stations, travel becomes quicker and simpler with less transfers.

What is the Value and for Whom?

Creates a quick crossing for commuters and assists visitors of Gothenburg arriving via Västlänken to more easily reach different locations on Hisingen island. Creates a mobility solution not only for commuting needs but also supports nightlife (e.g. at Frihamnen there are Magasin 113 which for instance arranges concerts and Smyrna Church, both attract bigger groups of people). Could potentially also create a temporary mobility solution for employees at Polestar AB. However, their relocation will not take place until 2028.

Concept 3

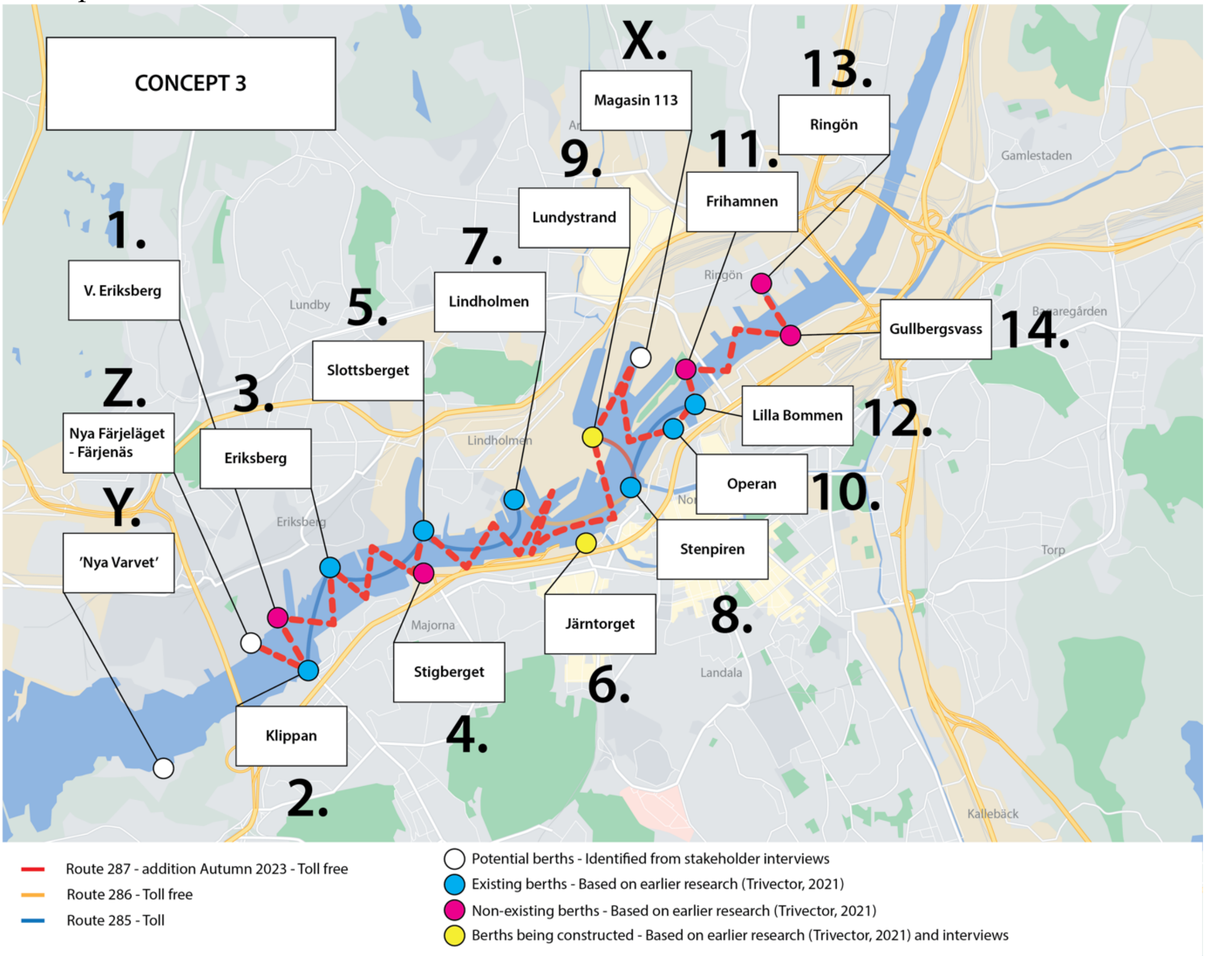


Figure 15 - Concept 3

Route
Where there is a need - alongside both sides of Göta Älv (in the city of Gothenburg)

Purpose
The purpose of concept 3 is to create high levels of flexibility using 'free-floating traffic' on-demand services. Dimensioned by small and moveable cost-effective berths along both sides of Göta Älv. Showing that electric and highly automated ferries can be a more flexible solution compared to today's solution with fixed berths.

Time of Operation
On-Demand 24/7

Positive Aspects
Based on current travel needs and has the function as a 'virtual bridge' that can exist everywhere someone needs it. Highly flexible and does not need expensive infrastructural changes.

Negative Aspects
The perception of risk of standing alone e.g. in the night, waiting for a ferry alongside Göta Älv as well as travel alone or with only a few others in a small electric and highly automated ferry. Can lead to many sub-optimal sized electric and highly automated ferries taking up

space in the river. May disturb or be disturbed by the current ferry traffic i.e. route 285, 286 and 287.

What is the Value and for Whom?
Cheap infrastructural costs and flexible for someone who wants to be able to travel wherever and whenever. In terms of a test bed it shows the flexibility electric and highly automated ferries could enable.

Concept 4

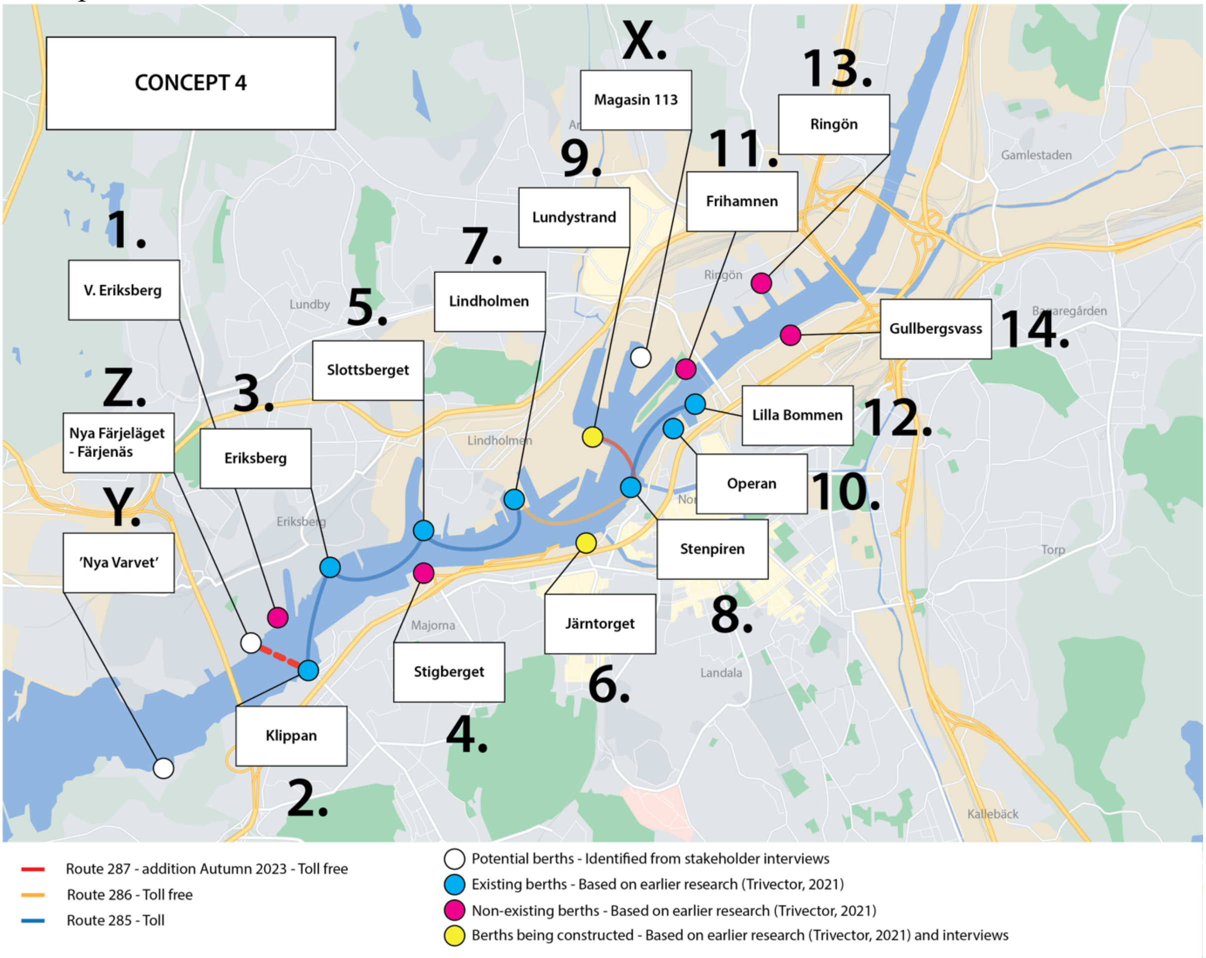


Figure 16 - Concept 4

Purpose
The purpose of concept 4 is to create a ferry traffic route for pedestrians and cyclists.

Route
Klippan – Nya Färjeläget (Färjenäs)

Time of Operation
06.00-22.00 everyday

Positive Aspects
Can create a high frequency of departures/arrivals. Färjenäs is difficult to reach by car and therefore dominated by cyclists and pedestrians. The route could relieve walkways and bicycle lanes in the surrounding area. Another positive aspect is that this route can support the increased development near Klippan. Fits well with current routes and complements route 285.

Negative Aspects
There is uncertainty regarding travel occupancy, and the route is also weather dependent both in terms of the level of interest travelling between the two berths outside of the summer season as well as due to weather conditions i.e. drift ice during wintertime that could make it difficult to test electric and highly automated ferries.

What is the Value and for Whom?

The primary value is that of a positive travel experience crossing the river for pedestrians and cyclists for commuting and experience related events. For instance visiting Färjenäs, one of the oldest parts of Gothenburg, that has events such as festivals, coffee shops and nature related activities and sceneries.

Concept 5

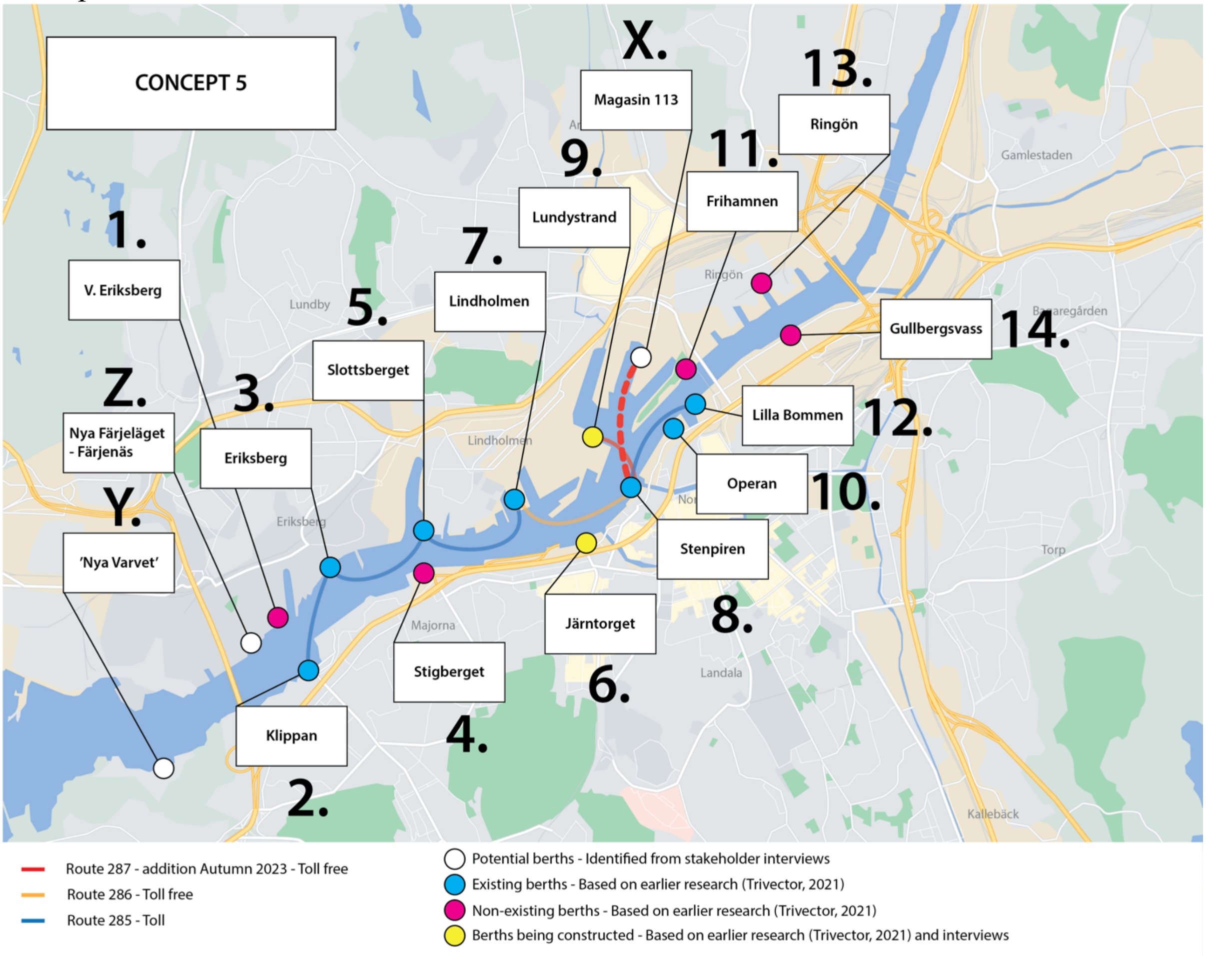


Figure 17 - Concept 5

Purpose
The purpose of concept 5 is to create a ferry traffic route for commuting, tourism and for experience related events e.g. taking the ferry to a concert, being part of showing the city of Gothenburg from the river or to be used for a night out.

Route
Stenpiren – Magasin 113

Time of Operation
06.00-22.00 everyday (April-October)

Positive Aspects
Possibilities for high frequency of departures/arrivals. Complements current routes 285, 286 and 287. Supports centrally located flows as well as supports city development at Frihamnen.

Negative Aspects
There is an uncertain travel occupancy.

What is the Value and for Whom?
The value lies in the different mobility types the route can offer since it should focus on commuting, tourism i.e. get the view of Gothenburg from the river whilst traveling as well as

experienced related mobility i.e. travel to and from concerts, nightlife and miscellaneous events.

Concept 6

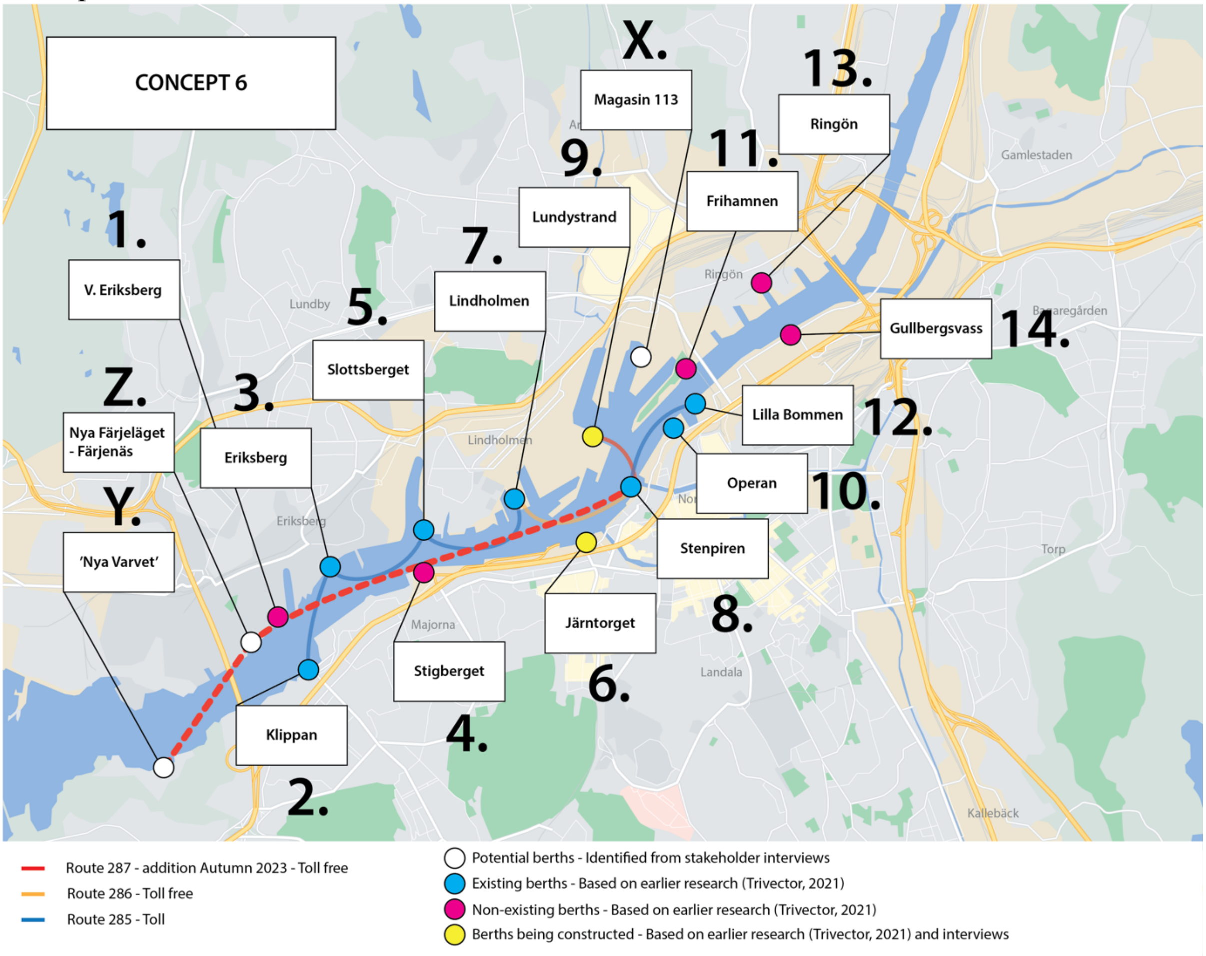


Figure 18 - Concept 6

Purpose
The purpose of concept 6 is to create a ferry traffic route for both commuting and for experience related events e.g. taking the ferry to a concert or for a night out.

Route
Stenpiren – Nya Färjeläget (Färjenäs) – Nya Varvet

Time of Operation
11.00-21.00 everyday (May-September)

Positive Aspects
There is a known passenger need.
Complements current routes 285, 286 and 287. Supports businesses e.g. hotels at Nya Varvet.
Experience and tourism related mobility, i.e. being able to see the city of Gothenburg from the river, travel to and from events.

Negative Aspects
Rather low frequency of departures/arrivals. Travel occupancy is uncertain.

What is the Value and for Whom?
The value lies in the different mobility types the route can offer since it should focus on, commuting, local tourism i.e. get a view of Gothenburg from the river whilst traveling as well as experienced related mobility i.e. travel to and from concerts, nightlife and miscellaneous events.

Concept 7

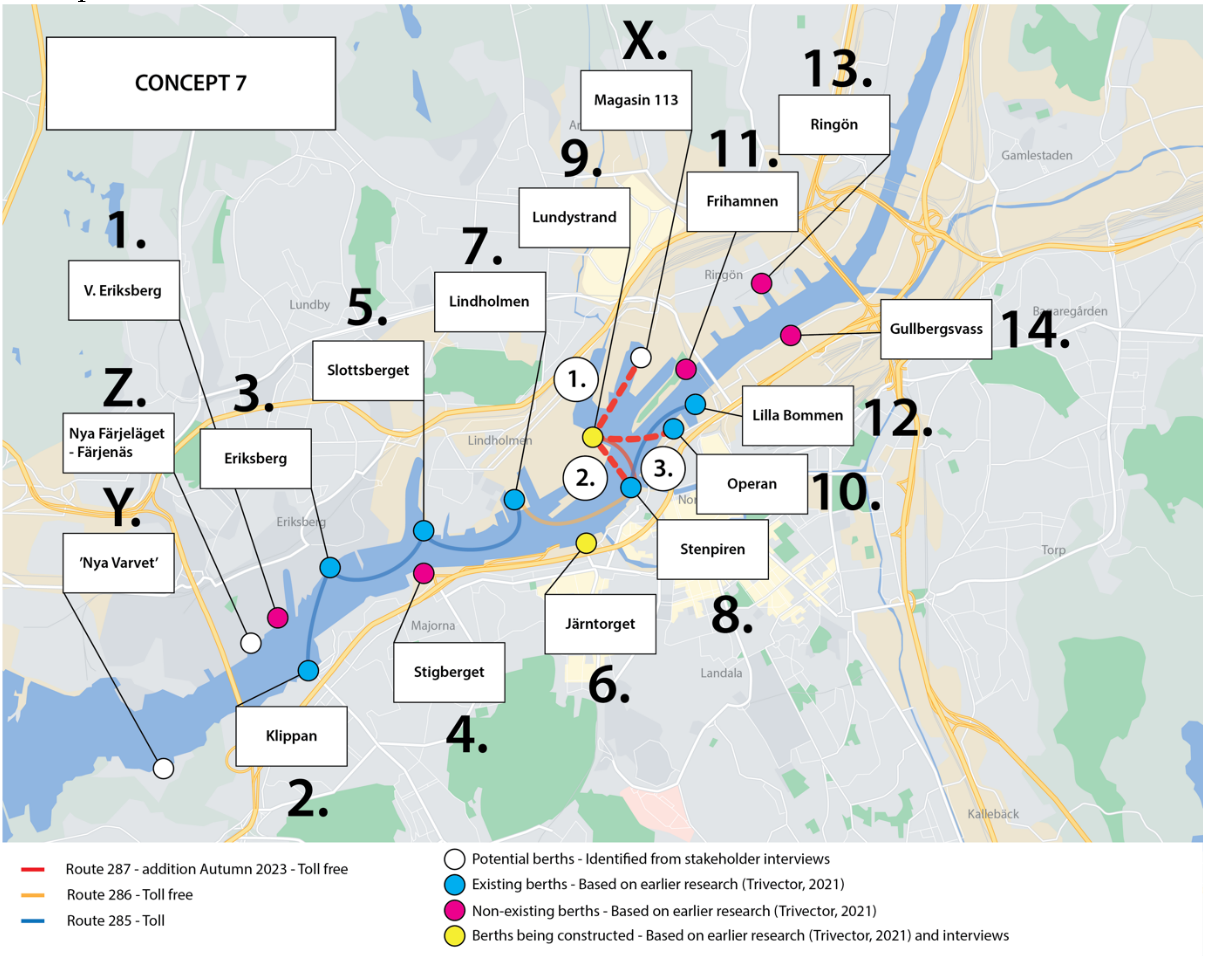


Figure 19 - Concept 7

Purpose

The purpose of concept 7 is to allow for a gradual implementation, starting with covering short distances in rather protected locations e.g. between Lundbystrand and Magasin 113. This in turn would lessen the demands on what electric and highly automated ferry should be able to do as well as mitigate potential maritime risks. The maritime risks that would be greater if crossing Göta Älv e.g. due to the need of accounting for other traffic etcetera.

Route

1. Lundbystrand – Magasin 113
2. Magasin 113 – Lundbystrand – Stenpiren
3. Magasin 113 – Lundbystrand - Operan

Time of Operation

Primarily summertime. However, this depends on on implementation phase. In other words, in the later stages it may be possible to increase the operating time.

Positive Aspects

Maritime safety and flexibility. Complements route 287 (phase 1. and phase 2. of the gradual implementation). There is already charging infrastructure at Lundbystrand that can be used. Finally, it also connects to Västlänken.

Negative Aspects

May need expensive infrastructural additions at Lundbystrand and Magasin 113. However, since automation may enable the use of smaller ferries this, in turn, would allow for cheaper, smaller and more flexible berth solutions. Berths that can be moved depending on the need e.g. move depending on which phase the testbed currently is in.

What is the Value and for Whom?

The value lies in the flexibility and the gradual implementation. But also, in. the latter phases it is possible to add mobility solutions for passengers that want to go to concerts and other events e.g. at Magasin 113 but also other places in the Frihamnen area.

Concept 8

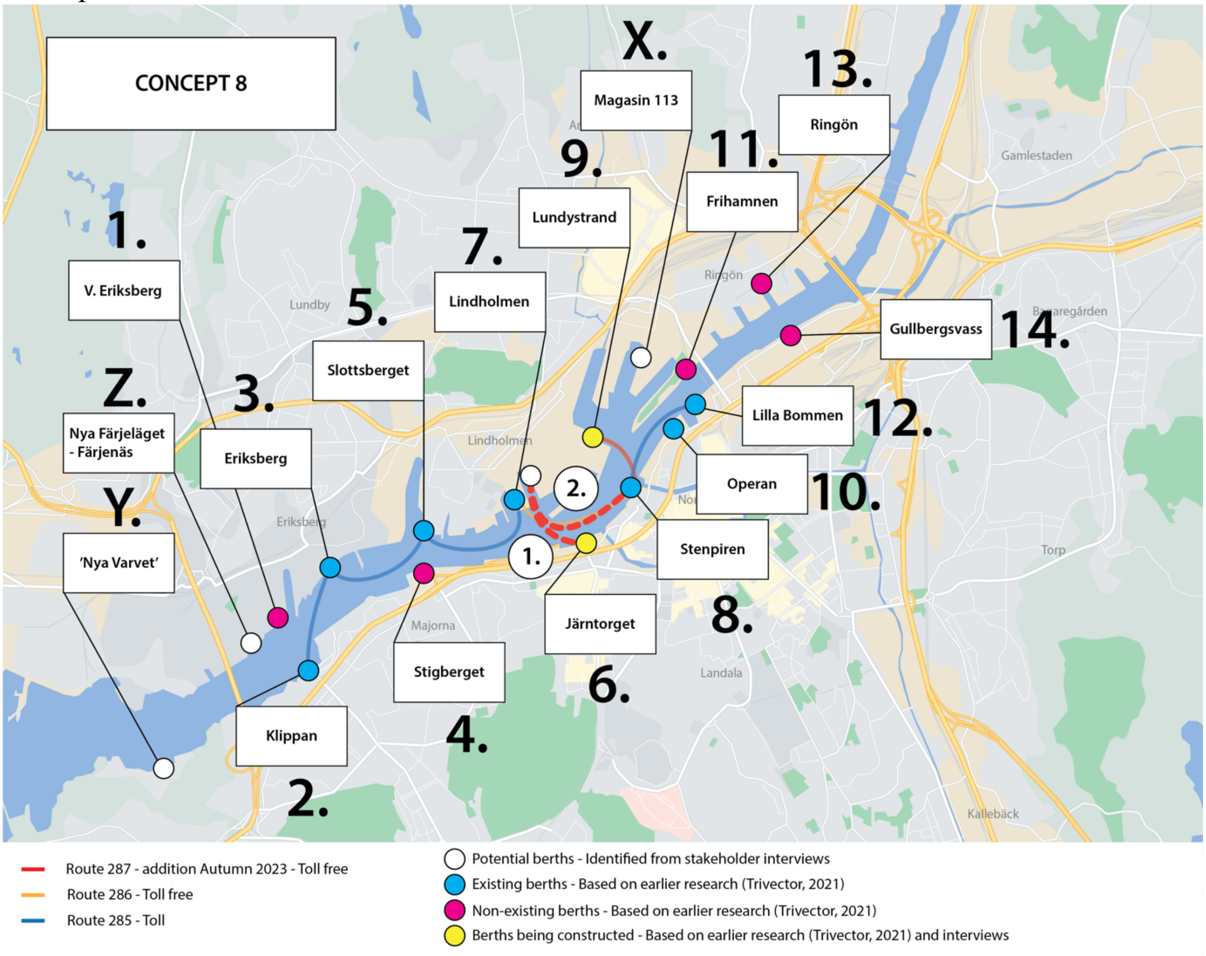


Figure 20 - Concept 8

Purpose

The purpose of concept 8 is to combine the testbed with other maritime mobility-, logistic- and (on water) living endeavours e.g. Gothenburg floating lab.

Route

1. Easternmost Lindholmen pool[7]– Järntorget
2. Easternmost Lindholmen pool – Stenpiren

Time of Operation

Primarily summertime. However, this depends on implementation phase, in the later stages it may be possible to increase the operating time.

Positive Aspects

Connects to other logistic-, mobility- and aquatic living initiatives. Mitigates docking issues by having its own berth.

Negative Aspects

[7] A new berth to reduce the number of vessels that docks at Lindholmen berth

The rather high number of vessels in that area could potentially increase the level of risk. Finally, at some point e.g. in a later phase of the testbed it is important to test the electric and highly automated ferries in more difficult areas.

What is the Value and for Whom?

The testbed could be a valuable complement to maritime mobility, logistics, and aquatic living initiatives. It has the potential to attract the necessary attention for new funding to further create innovative maritime solutions. These solutions could positively impact sustainability, for example, by reducing the number of privately owned cars and optimizing Gothenburg's mobility and logistics systems, while also reconnecting with the city's heritage as a port city.

Concept 9

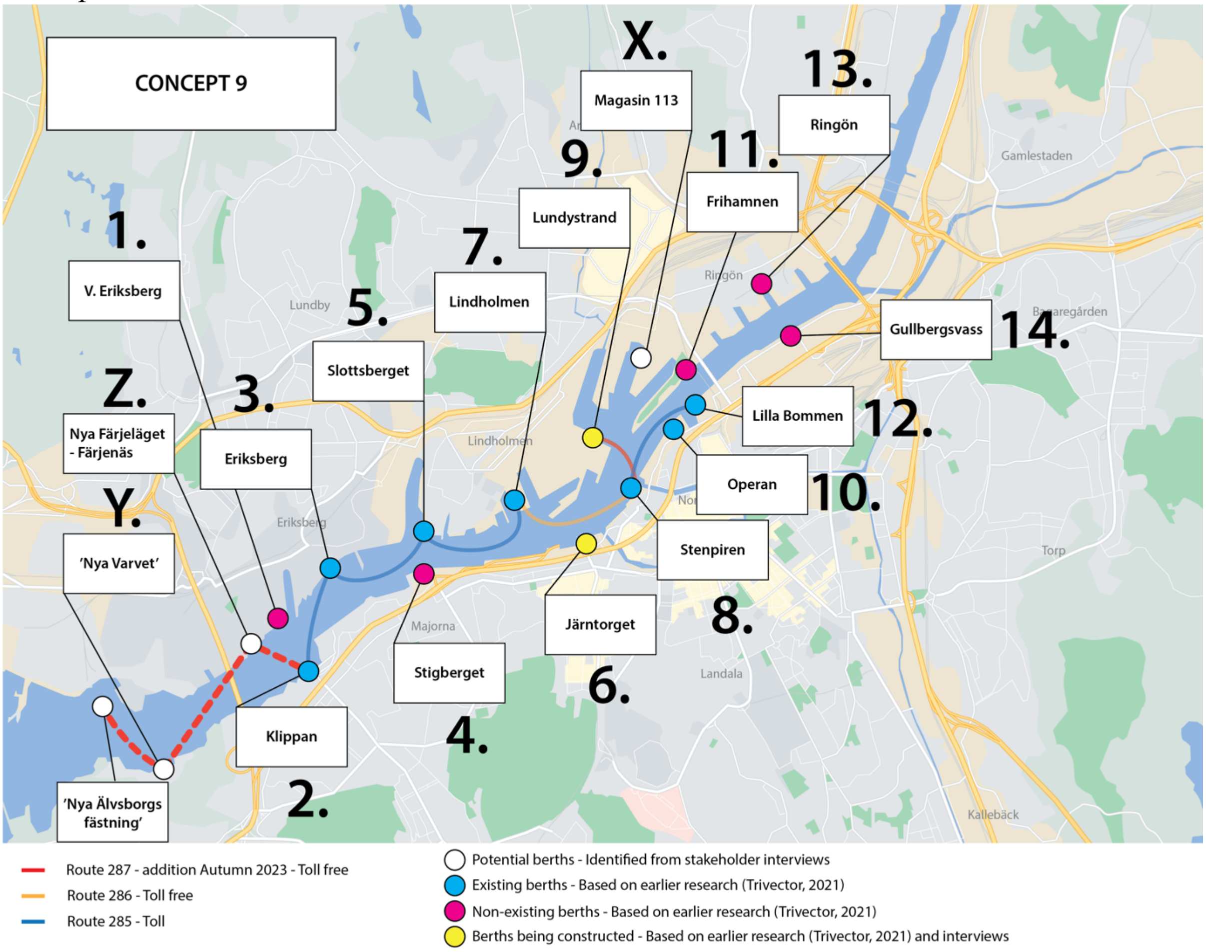


Figure 21 - Concept 9

Purpose
The purpose of concept 9 is to create a route that complements current ferry route 285 with a route for tourism by allowing tourists to visit 'Nya Älvsborgs fästning' whilst at the same time be able to partake in nightlife e.g. restaurants and hotels at Klippan and 'Nya Varvet', as well as culture-historical events at Nya Färjeläget (Färjenäs).

Route
Klippan – Nya Färjeläget (Färjenäs) – Nya Varvet – Nya Älvsborgs Fästning.

Time of Operation
Summertime

Positive Aspects
Complements route 285. Does not create any interaction issues with other ferry routes. Adds to mobility possibilities in the most western part of Göta Älv (in close proximity to Gothenburg city).

Negative Aspects
Rather low frequency of departures/arrivals. There is uncertainty re travel occupancy. Weather dependent both in terms of the level of interest travelling between the berths outside

of the summer season as well as due to weather conditions i.e. drift ice during winter that could make it difficult to test electric and highly automated ferries.

What is the Value and for Whom?

Brings value both to residents of Gothenburg but also tourists by creating a complementary ferry route that shows many positive sides of Gothenburg e.g. nightlife, Gothenburg as a port city, historical buildings and other businesses such as hotels and restaurants.

Concept 10

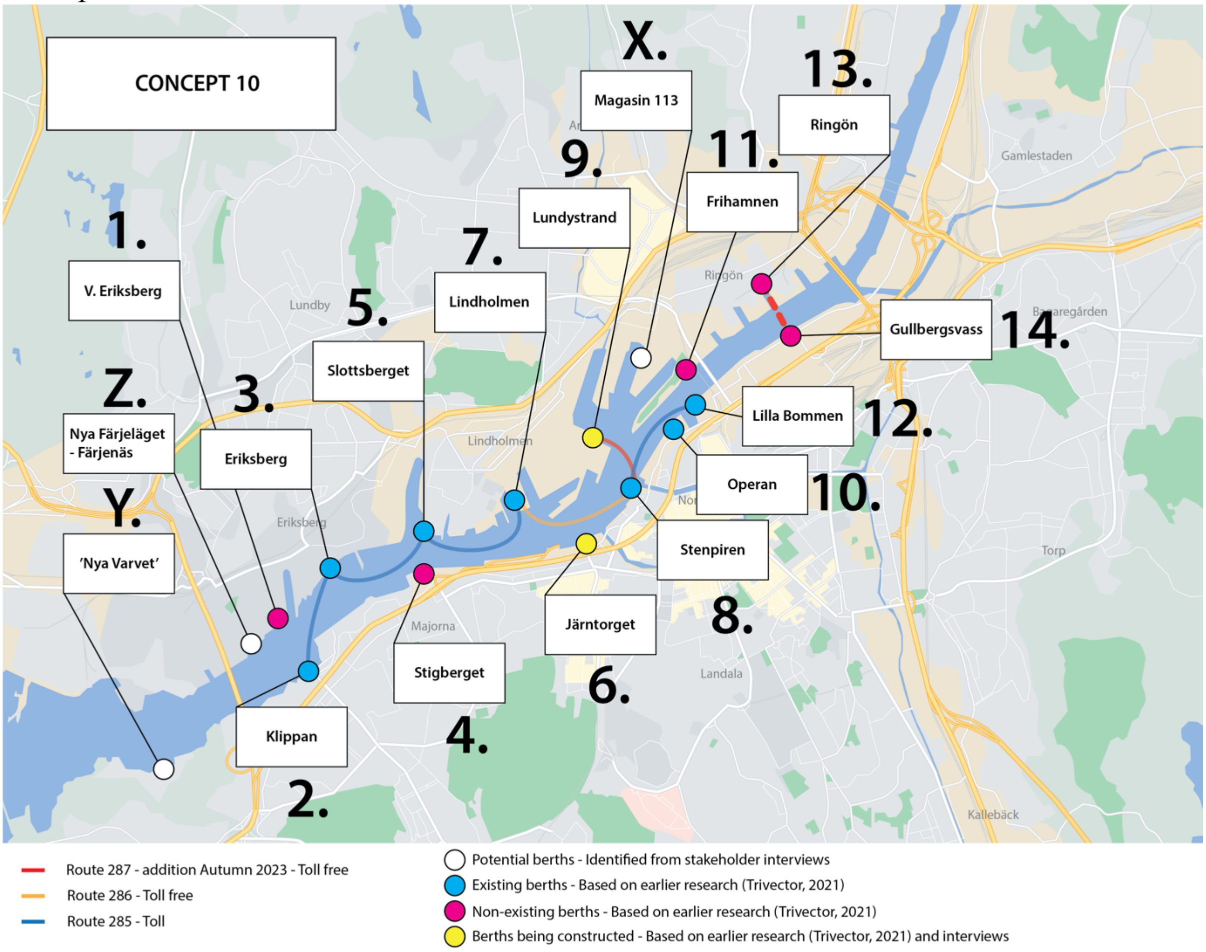


Figure 22 - Concept 10

Purpose

The purpose of concept 10 is to create a route that supports the establishments of new organizations and businesses at Ringön e.g. breweries, pubs, nightlife and generally local culture.

Route

Gullbergsvass – Ringön

Time of Operation

Not specified.

Positive Aspects

Does not create any interaction issues with other ferry routes. Adds to mobility possibilities in the eastern most part of Göta Älv (in close proximity to Gothenburg city). Connects Hisingen island to mainland Gothenburg.

Negative Aspects

High frequency of departures/arrivals. There is an uncertain travel occupancy. Not as weather dependent as more eastern located routes.

What is the Value and for Whom?

Brings value both to local organizations and businesses at Ringön as well as for citizens of Gothenburg wanting to partake in e.g. nightlife at Ringön.

Concept 11

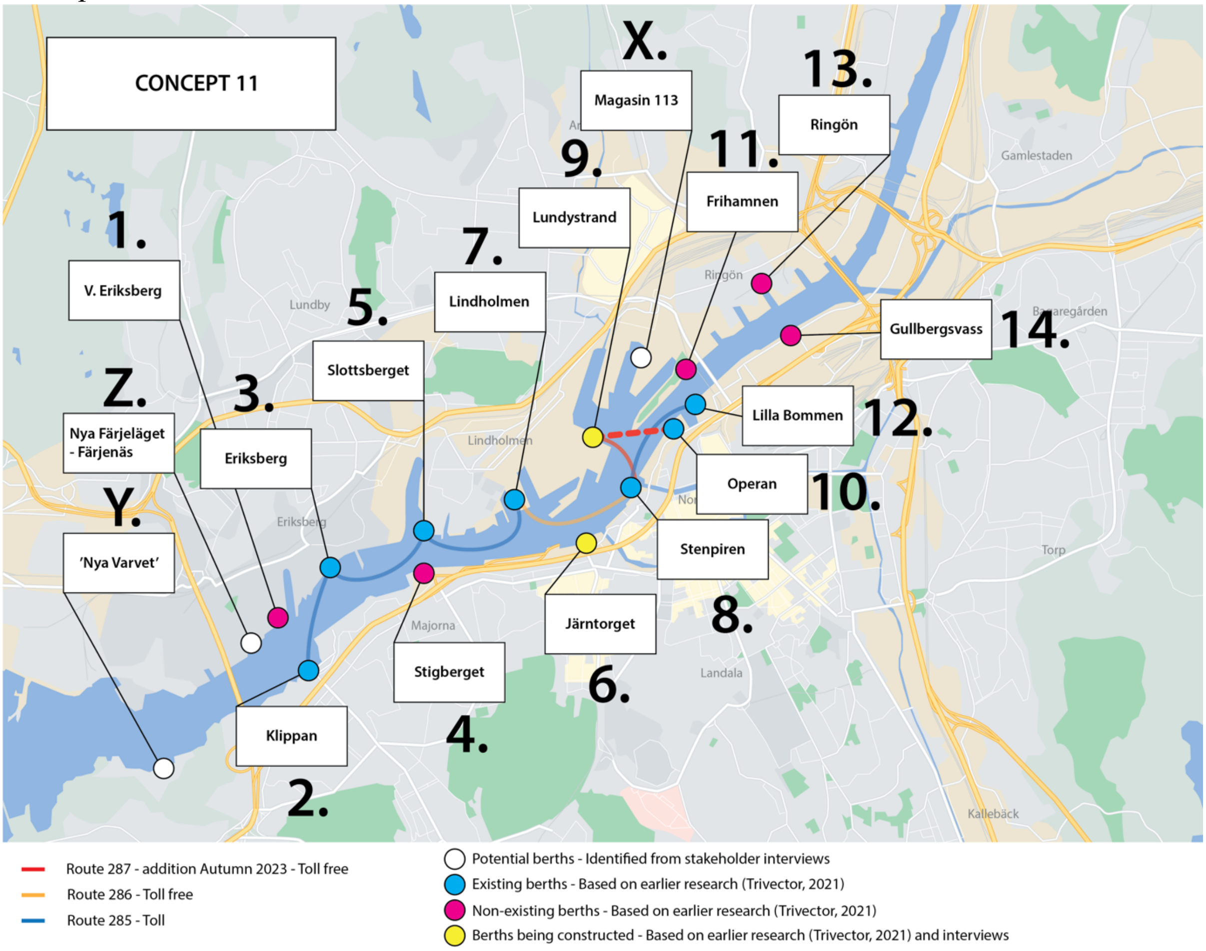


Figure 23 - Concept 11

Purpose
The purpose of concept 11 is to create a route that supports the establishments of new organizations and businesses at Ringön e.g. breweries, pubs, nightlife and generally local culture.

Route
Lundbystrand – Operan

Time of Operation
Not specified.

Positive Aspects
Possibilities for high frequency of departures/arrivals. Complements route 287. Connects to Västlänken and other public transport modalities. Supports centrally located flows as well as supports city development at Frihamnen. Connects Hisingen island to mainland Gothenburg.

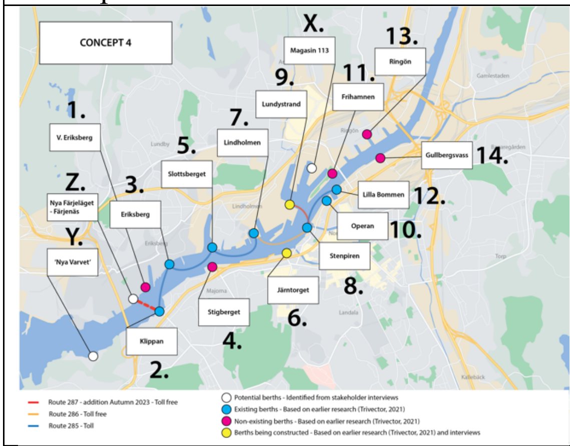
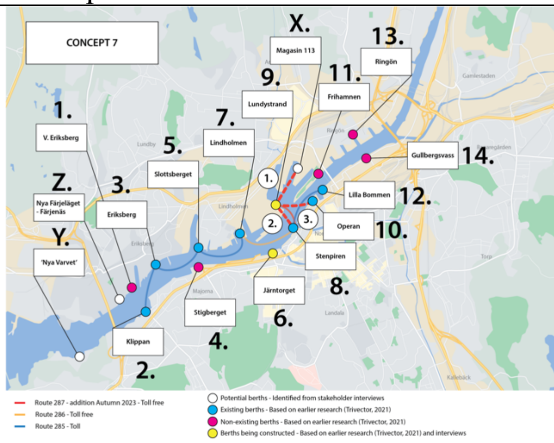
Negative Aspects

No 'operating' berth at Operan. May also create issues if public transport users believe the route is a standard route and the route is unreliable due to being part of a testbed (can be mitigated via information to the public).

What is the Value and for Whom?
Quicker commuting and increases the possibilities to be able to cross the river and thus decreasing the distance between different destination on mainland Gothenburg and the island of Hisingen.

4.3.2 CONCEPT EVALUATION

After the co-creation, the project stakeholders as well as mobility and logistic experts evaluated which of the co-created routes was deemed as having the highest potential as a testbed route. Only, the top two concepts are considered and will be presented. Finally, gold stars are worth 2 points and silver stars are worth 1 point.

<table>
<tr><td>Concept 4</td><td>Concept 7</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>★★★★</td><td>★★</td></tr>
<tr><td>★★★</td><td>★★★</td></tr>
<tr><td>Total: 11 points</td><td>Total: 7 points</td></tr>
<tr><td>Summary:
The purpose of concept 4 is to create a ferry traffic route for pedestrians and cyclists.

Route
Klippan – Nya Färjeläget (Färjenäs)

Time of Operation
06.00-22.00 everyday

Positive Aspects
Can create a high frequency of departures/arrivals. Nya färjeläget (Färjenäs) is difficult to reach by car and therefore there are dominated by cyclists and pedestrians. The route could assist by relieving walkways and bicycle lanes in the surrounding area. Another aspect that also is positive is that this route can support the increased development near Klippan.
Fits well with current routes and complements route 285.

Negative Aspects</td><td>Summary:
The purpose of concept 7 is to allow for a gradual implementation. This, by starting with short distances in rather protected locations e.g. starting between Lundbystrand and Magasin 113. This in turn would lessen the demands on what electric and highly automated ferry should be able to do as well as mitigate potential maritime risks. Maritime risks that would be greater if crossing Göta Älv e.g. due to the need of accounting for other traffic etcetera.

Route
1. Lundbystrand – Magasin 113
2. Magasin 113 – Lundbystrand – Stenpiren
3. Magasin 113 – Lundbystrand – Operan

Time of Operation
Primarily summertime. However, this also depends in which implementation phase that we are in. In other words, in the later</td></tr>
</table>

There is an uncertain travel occupancy, and the route is also weather dependent both in terms of the level of interest travelling between the two berths outside of the summer season as well as due to weather conditions i.e. drift ice during winter times that could make it difficult to test electric and highly automated ferries. **What is the Value and for Whom?** The primary value is that of a travel experience over the river for pedestrians and cyclists for commuting and experience related events. For instance, visiting Färjenäs one of the oldest parts of Gothenburg that have events such as festivals, coffee shops and nature related activities and sceneries.	stages it may be possible to increase the operating time. **Positive Aspects** Maritime safety and flexibility. Complements route 287 (phase 1. and phase 2. of the gradual implementation). There is already charging infrastructure at Lundbystrand that can be used. Finally, it also connects to Västlänken. **Negative Aspects** May need expensive infrastructural additions at Lundbystrand and Magasin 113. However, since automation may enable the possibilities to use smaller ferries this in turn would allow for cheaper, smaller and more flexible berth solutions. Berths that can be moved depending on the need e.g. move depending on which phase the testbed currently is in. **What is the Value and for Whom?** The value lies in the flexibility and the gradual implementation. But also, in. the latter phases it is possible to also add mobility solutions for passengers that wants to go to concerts and other events e.g. at Magasin 113 but also other places in the Frihamnen area.

4.3.3 DISCUSSION & CONCLUSION

First and foremost, concept 4 was by far the most appreciated and interesting route according to the participants in the co-creation workshop. Concept 4 is also one route that is highly interesting based on future mobility needs in Gothenburg. According to the city of Gothenburg's master plan, i.e. a comprehensive plan outlining the long-term development and land use of a municipality or region, there is an interest in expanding the current ferry routes with a route crossing Göta Älv between Klippan and Nya Färjeläget (Färjenäs) before 2035 (*Göteborgs översiktsplan*, 2024) (see figure 24). In addition, and it also complements the current route 285 as well as the future route 285 (see section 2.2. Current Public Transport (Ferry) Routes).

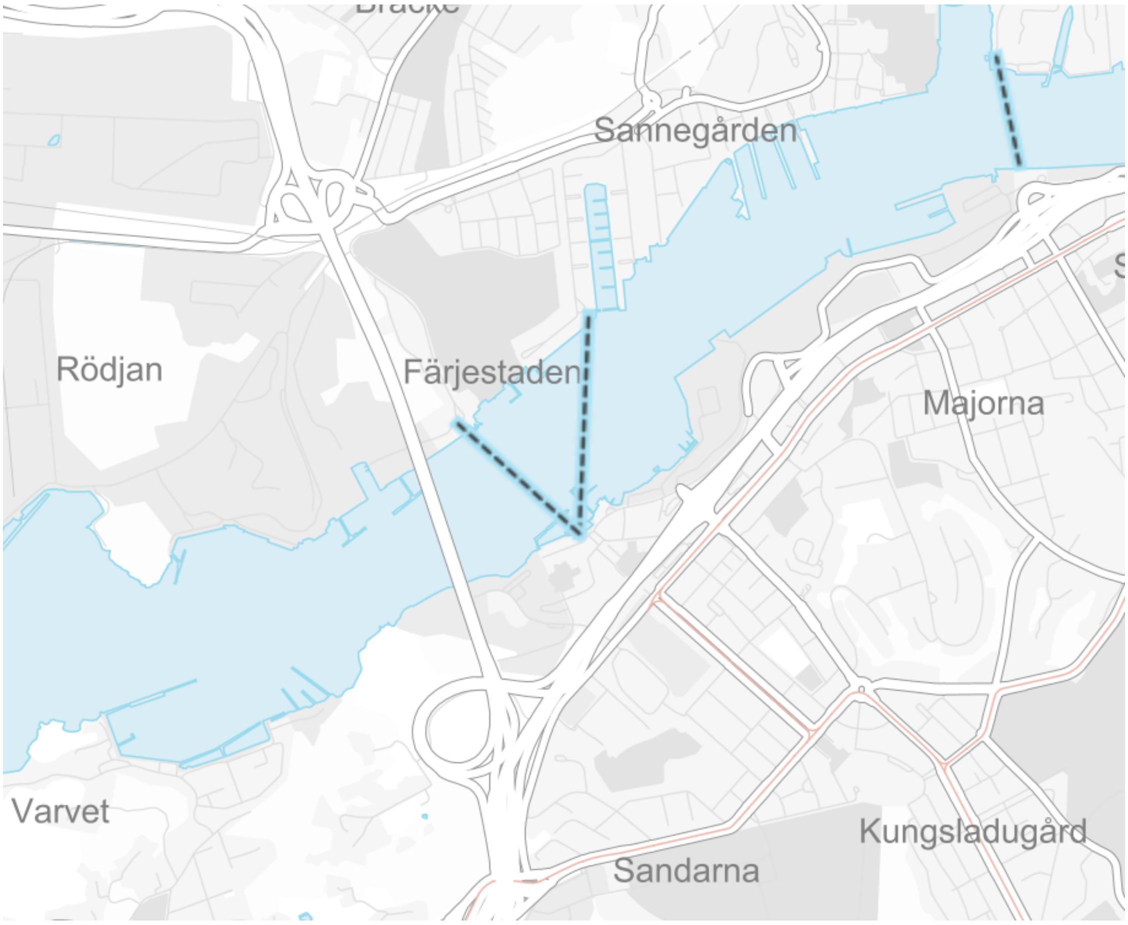


Figure 24 - Gothenburg Master plan (Sw. 'Göteborgs översiktsplan').

Furthermore, Klippan is a key berth today, with many passengers and a significant cultural environment. There is no berth at 'Västra Eriksberg', but there used to be a ferry berth in 'Färjenäsparken', a park that could be a destination for pedestrians and cyclists. Both Klippan and 'Västra Eriksberg' are close to different public transport modes, which will be further strengthened for Klippan in the future. Klippan, with high potential as a berth, will be a future transit hub linking the metro bus at Jaegerdorffsplatsen and the current tram stop.

Furthermore, according to the report by Trivector (2021), Klippan has a good connection to both pedestrian boardwalks as well as bicycle lanes which could further support the argument for a testbed route for electric and highly automated ferries between Klippan and Nya

Färjeläget (Färjenäs), even though the travel occupancy is lower than in the more centrally located berths, e.g. Stenpiren or Lindholmen.

Finally, the biggest issue related to a test bed route between Klippan and Nya Färjeläget (Färjenäs) is the susceptibility to weather conditions and other maritime vessels travelling along Göta Älv. This is something that needs to be considered before introducing electric and highly automated ferries in the format of a testbed.

Therefore, the idea behind concept 7 is fundamental regardless of testbed route chosen, i.e. a gradual implementation by starting with short distances in rather protected locations, e.g. starting between Lundbystrand and Magasin 113. This, in turn, would lessen the demand on the capabilities of electric and highly automated ferries as well as mitigate potential maritime risks.

Thus, a testbed with electric and highly automated ferries should be introduced in a gradual fashion based on the maturity of the technology by testing electric and highly automated ferries areas that are protected e.g. from weather or other traffic, such as between Lundbystrand and Magasin 113. After testing the technology, e.g. performance related aspects, the testbed can move and encompass new routes, e.g. between Klippan and Nya Färjeläget (Färjenäs). Preferably during summertime due to a potentially higher travel occupancy and less risks as the weather is better, e.g. no drift ice etc.

By doing so, the solution does not only mitigate possible risks such as technical failures in the beginning of the implementation which in turn could affect passengers' acceptance towards the novel technology but could also show the most important aspects of what electric and highly automated ferries potentially could enable – traffic system flexibility – being able to change routes and even purpose of the ferries depending on the need. Therefore, it is highly important for a testbed that the electric and highly automated ferries are introduced together with simple and perhaps even moveable berth solutions to allow flexibility which in turn could lead to increased accessibility and a resilient traffic system in general – there are seldom queues or other obstacles on the waterways.

4.4 LONG-TERM SERVICE DESIGN CONSIDERATIONS

This section presents the findings from part II of the co-creation workshop. The purpose of the second part of the co-creation workshop was to allow the participants themselves identify and create scenarios around the most important, but at the same time most uncertain, factors for a successful service design– a service design for the future that encompasses electric and highly automated ferries.

4.4.1 FACTORS & SERVICE DESIGN SYSTEMS

In the second part (Part II) the co-creation workshop participants got to, amongst each other, first (i) identify and define the most important, but at the same time most uncertain factors that are key for a successful electric and highly automated ferry service design in the long-term. After this, (ii) each of the four groups in the co-creation workshop got to ideate around four scenarios. These were scenarios based on the, according to the participants', the two most important but at the same time most uncertain factors.

(i) Factors that Drive and/or Hinder a Potential Long-Term Implementation of Electric and Highly Automated Ferries

Identified Factors – Flexibility & Standardization

The identified factors ranged from the uncertainty and importance of being able to ensure: maritime safety, financing of electric and highly automated ferries, fully functioning technology, being able to create a service design that is 100% safe for passengers regardless if it relates to maritime safety or interpersonal security, the uncertainty and importance of being able to create a service design that is cost efficient, being able to create the needed cooperation between actors responsible for a mobility service based on electric and highly automated ferries so it can succeed as well as the uncertainty and importance of a clear and concise political will in Gothenburg so as to be able to succeed in introducing and sustaining a long-term implementation of electric and highly automated ferries as a service.

However, two additional factors stood out as being the most important whilst at the same time the most uncertain how to reach. These two factors related to the level of flexibility and the level of standardization. The factor 'flexibility' related primarily to what degree infrastructure, locations of berths and planning could become more flexible to assist electric and highly automated ferries to enable a more 'needs-driven' and seamless ferry traffic system service design. The factor 'standardization' related to what degree it was possible to create standardizations related to infrastructure, laws and regulations related to infrastructure, e.g. building permits for infrastructure as well as maritime automation, whilst at the same time keep a high level of flexibility.

(ii) Service Design Systems

Four Electric and Highly Automated Ferry Traffic Service Design Systems

Based on the identified factors that were considered most important but at the same time most uncertain, the participants in the co-creation workshop were to create four different service design systems. The groups were assigned to create a service design system based on one of four different combinations of the two factors flexibility and standardization (see figure 25).

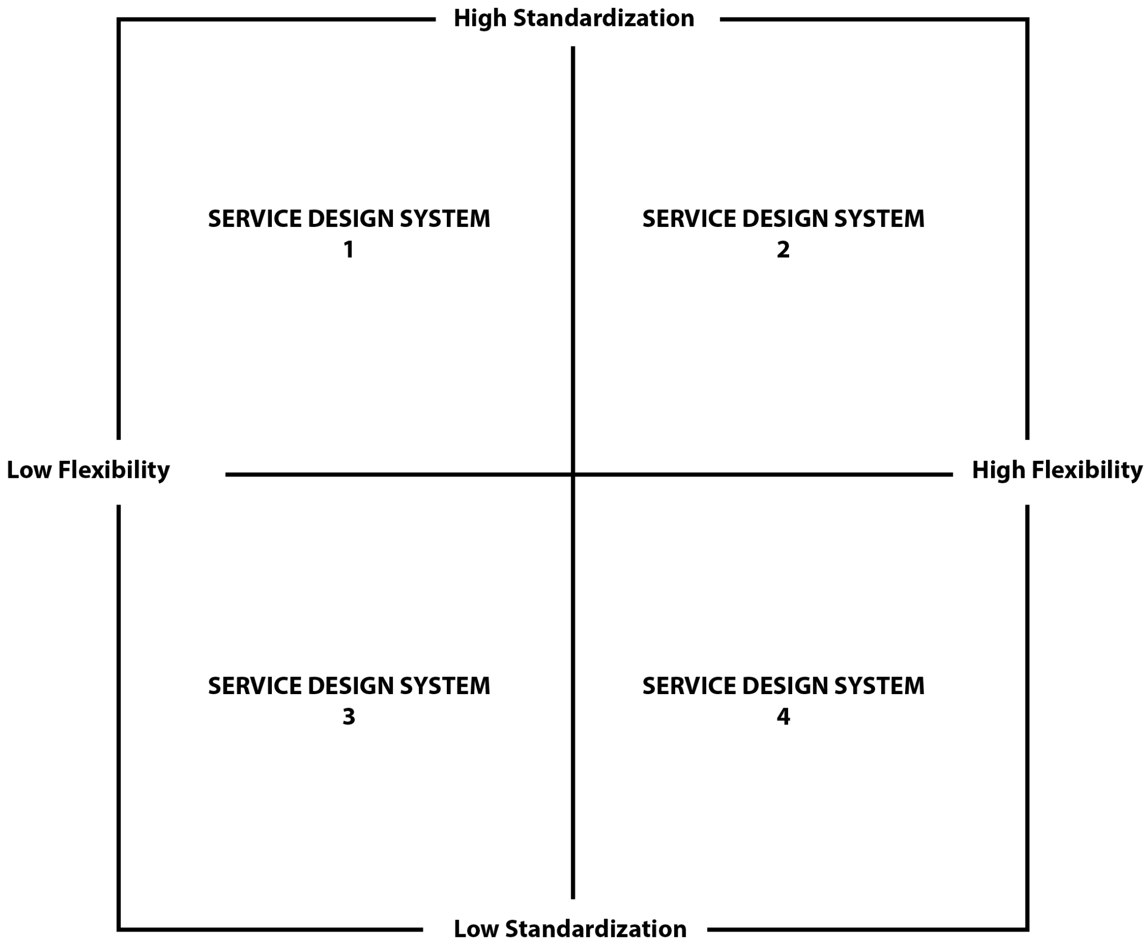


Figure 25 - 2x2 matrix.

Service Design System 1
Considers high standardization and low flexibility.

Main purpose of the system:
The main purpose of the system is to only focus on mobility, i.e. transport of people from point A to point B only in locations where there is a possibility for a high travel occupancy such as between Stenpiren and Lindholmen, the two most attractive berths in the city of Gothenburg. Two berths that are standardized.

Objectives of the system:
The objectives are to demonstrate and test different levels of automation, docking and electric charging.

Description of the Service Design System:
The group co-creating the system based on low flexibility and high standardization saw many similarities with a cable ferry solution, i.e. a ferry being led over a body of water such as a river via cables linked to each bank. The ferry would only travel back and forth between two berths and programmed to follow a predetermined route which was deemed as inflexible. The high level of standardization lies within the design of the berths which includes both docking- and charging solutions.

Interacting Elements included in the System:
Electric and automated ferries, berth and pier automatic identification system (AIS) and traffic system, i.e. Västtrafik's public transport system.

Expected Positive Effects:
An expected positive effect is a possibility to have a high traffic flow whilst at the same time optimize energy consumption. The system was also expected to be able to become a part of the overall traffic system, e.g. a part of the public transport system.

Expected Barriers & Possible Solutions to those Barriers:
There was primarily one barrier which related to the amount of space available for a testbed ferry at Stenpiren and Lindholmen, especially if the ferries were to be bigger (smaller ferries allow for more flexibility due to their size).

The presented solutions was a standardized berth with specific docking spots for each of the docking vessels, i.e. a specific docking spot for the electric and highly automated ferry travelling between Stenpiren and Lindholmen.

Service Design System 2
Considers high standardization and high flexibility.

Main purpose of the system:
The main purpose of the system is to have simple, sustainable, and efficient mobility, logistic and waste transports crossing Göta Älv– as one piece of the city of Gothenburg's transport puzzle.

Objectives of the system:
The objective is to bring the central parts of the city together by integrating land from approximately two kilometres west of 'Nya-Varvet', all the way to approximately two kilometres east of 'Ringön/Gullbergsvass' via transport routes, i.e. both mobility and logistic routes. This as a way of creating one homogenous and central part of Gothenburg city.

Description of the Service Design System
The service design system includes electric and fully automated vessels to be used for mobility, i.e. ferries but also for transportation of smaller goods, i.e. logistics as well as vessels for transportation of waste from different areas of the city. The vessels follow a pre-determined time-table but can also be used for on-demand services within either the mobility, logistic and/or waste transportation sector depending on the need.

The electric and fully automated vessels are accompanied by several and different sized traffic nodes along each side of the river. Some function as intermodal mobility nodes that allow mobility users to change from one modality to another e.g. bus to ferry. These nodes are placed in strategic places along the city and throughout the city to allow public transport users to be able to travel seamlessly within the whole city, using different types of transport modalities.

Furthermore, some nodes also function as logistic hubs in which goods and parcels are further consolidated and then transported 'the last-mile' to the destination on land via sustainable means of transportation. Other berths function as intermodal waste nodes in which waste are consolidated and change transport modality.

Therefore, the whole mobility system, e.g. public transport system including busses, trams, ferries as well as bicycles, e-scooters, pedestrians, cars and trucks, are considered together with the logistic system as well as waste transportation system. In other words, the mobility-, logistic- and waste transportation system has been planned strategically and deployed together in a top-down approach to reduce the number of vehicles such as trucks and privately owned cars in the city, thereby creating a city that is more attractive for citizens, visitors as well as for local organizations.

Interacting Elements included in the System:
The main elements included in the system is fully automated vessels, e.g. ferries that can be used for not only mobility but also logistics and waste transportation. The vessels need to support mobility users e.g. include chairs etcetera but also allow space for bicycles and e-scooters as well as space and accommodation for goods and parcels as well as space and accommodation for waste.

Expected Positive Effects:
The expected positive effects include less pollution, and more travelling within the city using more sustainable modes of transport; a more vibrant city where the river is once again a big part of the daily life of Gothenburg; less demands on the roads with less queues as a result.; and increased accessibility to mobility (but also logistic- and waste management services). Finally, the number of destinations within Gothenburg are predicted to increase as well and therefore also the number of nodes.

Expected Barriers & Possible Solutions to those Barriers:
The expected barriers were several. One of the barriers were the cost of creating such a complex system that accounts for all types of transport within a city. Secondly, there were concerns regarding how one should be able to create revenue from such a system.

However, a solution is to be able to increase the volume of ferries and by this decrease the cost. Another equally important solution is to have many organisations interested in cooperating in such an endeavour. However, to do so it is important to create consensus regarding what the common goal is. One step in the right direction for reaching consensus is that involved organizations together identify key performance indicators (KPI) and decide together on how to measure them.

Finally, other barriers that need to be mitigated are less than optimal berths (that need restoration and updates to account for future solutions) and finally, the currently allowed low speed in the river. This needs to be increased to create a more efficient and therefore more valuable use of the river.

Service Design System 3
Considers low standardization and low flexibility.

Main purpose of the system:
The main purpose of the system is transport people across or along Göta Älv in a sustainable fashion.

Objectives of the system:
The objective is to create a system that is reliable, robust, emission-free and cost-effective.

Description of the Service Design System
The group co-creating the system based on low flexibility and low standardization, saw many similarities with the current ferry traffic system in Gothenburg (and public transport services in Gothenburg in general).

Interacting Elements included in the System:
Such a system is based on long procurement contracts, fixed time-tables, a few but larger intermodal nodes and bigger but fewer passenger ferries designed for the specific location and purpose.

Expected Positive Effects:
However, some positive effects are possible with an inflexible and unstandardized system and that is there is expertise on that particular system, the system is predictable, and it is possible to have concentrated efforts towards one goal and/or one issue, e.g. having few berths allows concentrated efforts on them and their surround environment.

Expected Barriers & Possible Solutions to those Barriers:
The expected barriers for such a system included limited technological advancements and limited city development. One solution to overcome 'limited technological advancements' is to procure mass-produced ferries with standardized sizes and technical solutions. By this, mitigating expensive one-off solutions and being able to more quickly adapt to new and perhaps more sustainable solutions.

A solution to overcome 'limited city development' is to allow for moveable piers that can be moved based on new needs, i.e. a more on-demand type service that could assist in transporting people to areas with less mobility possibilities, e.g. a new area, or as a solution for events, i.e. when there are predictions of many people going to one area such as during festivals or similar.

Service Design System 4
Considers low standardization and high flexibility.

Main purpose of the system:
The main purpose if to provide an on-demand service for public transport users such as pedestrians and for people with portable modes of transport, e.g. foldable scooters and foldable bikes but also for cyclists. However, the on-demand service is only used outside of peak-hours. During peak-hours the service follows pre-determined schedules and routes.

Furthermore, the on-demand service is location-based i.e. the passenger can wait by the shoreline with, e.g. a phone that gives a signal to the ferry that he or she is waiting to be picked up, i.e. a demand-responsive solution using GPS. Then the ferry goes wherever the person wants it to go. The on-demand service is always online, i.e. demand-responsive 24/7 as long as it is outside of peak-hours.

However, the electric and highly automated ferries also have a secondary purpose i.e. to, when not transporting passengers, also transport goods and waste, primarily during the nights.

Finally, the idea of the concept is to make all transportation modes, including ferries, taxis, and buses, available on-demand and responsive to user needs, during off-peak hours. As soon as a passenger boards a ferry, land-based transportation systems are alerted. They know when and where the passenger will disembark the ferry, ensuring an automated bus is ready and waiting for the passenger to transfer. This seamless transition enhances the efficiency of the transportation network as well as creates a high levels of user satisfaction.

Objectives of the system:
The objective is to create a service that is fossil-free and environmentally sustainable and that the solution is created and implemented by the traffic operator. The service also needs to be, for the user, experienced as seamless, i.e. including seamless and a fully automated paying solution.

Interacting Elements included in the System:
A fully automated ferry and a bus and the interaction between the two.

Expected Positive Effects:
Expected positive effects are passengers experiencing accessibility and ease-of-use of the public transport system as well as an increased market share for ‘sustainable mobility’.

Expected Barriers & Possible Solutions to those Barriers:
One expected barrier relates to conflicts between this new type of solution and current manually operated traffic. For instance, the potential issues of having technical systems that need to account for manually operated vessels and vice versa.

4.4.2 DISCUSSION & CONCLUSION

Based on the four combinations – high standardization, high flexibility; high standardization, low flexibility; low standardization, high flexibility, and; low standardization and low flexibility, four concepts were created by the participants in the co-creation workshop.

One group recognized that a low level of standardization and low level of flexibility had similarities with the current system ferry traffic system in Gothenburg. For example, low standardization due to custom docking solutions and ferries designed and manufactured for the sole purpose of being used between specific berths at Göta Äl or ow levels of flexibility due to long procurement contracts and fixed time-tables and specific berths which can hinder the potential of greater customer satisfaction as well as quick system changes if needed e.g. quickly change to other types of energy sources due to lock-in effects (Lundell et al., 2021) or temporarily change routes due to changes in need, e.g. construction sites or events affecting landbound traffic .

Even though there are some positive benefits with a low level of standardization and low level of flexibility, e.g. a high local competence and a predictable system, some benefits may be missed according to some of the participants. Such benefits include reducing cost through procurement of standardized ferries and docking solutions as well as increased customer satisfaction through a more flexible system.

Furthermore, it seemed as high levels of flexibility and standardization were deemed as the most positive system with expected positive effects such as reduced emissions, increased accessibility, more sustainable trips, increased accessibility with new destination points in the city etcetera.

However, high levels of both flexibility and standardization may not be viable for all purposes. In other words, in terms of laws and regulations an electric and highly automated ferry traffic solution needs to follow standardized laws and regulations, e.g. regarding maritime safety, but may not need standardization in terms of what each customer wants to use it for, e.g. public transport and/or private event traffic. Therefore, it is fundamental to consider what should have high or low levels of standardization and high or low levels of flexibility respectively and to explore and consider this already whilst testing electric and highly automated ferries in a testbed format.

Regardless of the level of standardization and flexibility, they are key factors to consider to fully use the potential of automation which in turn could lead to value stacking, increased user satisfaction, increased resilient traffic system and hopefully also resource optimization, e.g. by being able to use the electric and highly automated ferry traffic system for more than just public transport in the way we are used to.

5 ANSWERING RQs & CONCLUDING REMARKS

In the final section of the report the research questions and aim will be briefly discussed and answered.

5.1 ANSWERING RESEARCH QUESTIONS

The aim of this pilot study was to create an understanding of the potential of introducing electric and highly automated ferries as a solution to increase possibilities to cross the river, Göta älv, as well as increase accessibility, both in terms of a testbed but also as a long-term mobility solution. To support the aim, two research questions were formulated: *Which berths and routes are most relevant for a testbed for electric and highly automated ferries? (RQ1),* and *which are the possibilities and barriers for introducing electric and highly automated ferries in the format of a testbed and long-term mobility solution? (RQ2).*

5.1.1 ANSWERING RESEARCH QUESTIONS I

A testbed should gradually implement electric and highly automated ferries based on technology maturity:

(i) If technological maturity of an electric and highly automated ferry only permits testing and evaluating technical capabilities, traffic routes should be created in enclosed areas with minimal traffic, such as between Lundbystrand and Magasin 113. This minimizes risks due to technical failures, weather conditions, and interactions with other vessels.

(ii) If the goal is to evaluate the benefits of electric and highly automated ferries while marketing the endeavour, it's better to establish traffic on routes with higher mobility and commercial value, like the route between Nya Färjeläget (Färjenäs) and Stenpiren.

However, the primary aim of the testbed should be to demonstrate the potential benefits of electric and highly automated ferries, focusing on the potential for ferry traffic system flexibility (in addition to increased sustainability) compared to the current ferry traffic system.

These findings align with Johansson et al. (2023) who conducted a study on passengers' experiences and expectations of automated buses. Their findings suggested that passengers expect automation to enhance mobility accessibility and flexibility, among other aspects, something that was deemed highly positive.

Thus, a testbed should illustrate the flexibility that electric and highly automated ferries could provide, potentially creating a more accessible and resilient traffic system. Consequently, a testbed for electric and highly automated ferries should be capable of changing locations and routes based on needs.

5.1.2 ANSWERING RESEARCH QUESTIONS II

In terms of the second research question (RQ2) the possibilities that can increase the potential for realizing electric and highly automated ferries, include:

(i) Focus on showing sustainability benefits of electric and highly automated ferries,

(ii) Allow actors innvolved in a potential endeavour of introducing and implementing electric and highly automated ferries to benefit from electric and highly automated ferries by being able to market themselves in relation to such an endeavour- and allow them to have access to mobility possibilities,

(iii) Incorporate a potential electric and highly automated ferry traffic service into a MaaS solution,

(iv) Allow for smooth transitions between ferries and other transport modalities, i.e. seamless payments and boarding/disembarking,

(v) Show on high levels of automation-enabled flexibility to increase accessibility as well as traffic system resilience, and;

(vi) Finally, add increased value by allowing the electric and highly automated ferries to be used for different purposes, e.g. 24/7 traffic every day of the week if there is a need, on-demand services, as a complement to other services, e.g. hotels and other mobility services, and further down the line also consider logistic and perhaps even waste transportation services.

However, if these options are of interest they need to be considered already from the beginning through a top-down approach where all traffic modalities including other public transport modalities are included as well in order to mitigate any sub-optimal effects.

In terms of barriers that can hinder the potential for realizing electric and highly automated ferries, includes:

(i) If the cost for the individual passenger is too high it can the decrease the potential users' acceptance and thus become a barrier. However, if reasonable priced in relation to what the service offers it can act as a possibility in favour for electric and highly automated ferries.

(ii) Lack of (updated) laws and regulations for automated vessels and lack of agency competence in relation to new mobility technology,

(iii) Lack of interest from important actors due to other priorities or failure to see the relevance of introducing and implementing electric and highly automated ferries,

(iv) Potential risk with new technology, e.g. technical failures, not creating any added benefits compared to current ferries, maritime safety and interpersonal security,

(v) Unstandardized infrastructure could potentially create difficult and costly solutions in terms of electric and highly automated ferry docking,

(vi) Failing to increase number of berths, low frequency of departures/arrivals and perhaps most importantly, does not create shortcuts for users,

(vii) Different approaches are used to calculate and compare operating efficiency, both among actors and between different types of public transport modalities, and;

(viii) Finally, long-term procurement contracts that can hinder the process by prolonging a potential shift to electric and highly automated ferries which potentially could hinder or extend the timeframe for reaching sustainability goals.

Thus, there are both possibilities and barriers related to a successful introduction and long-term implementation of electric and highly automated ferries. Regardless, electric and highly automated ferries could potentially lead to an increased sustainable mobility system whilst at the same time increase both accessibility and traffic system resilience by presenting a flexible mobility option.

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APPENDIX I

Ålder:	Kön:
☐ 18-30 år ☐ 31-40 år ☐ 41-50 år ☐ 51-60 år ☐ 61-70 år ☐ > 70 år	☐ Man ☐ Kvinna ☐ Annat

Efterföljande fem frågor gäller de senaste två åren.

	Aldrig	Några gånger per år	Några gånger i månaden	Någon till några gånger i veckan	Nästan varje dag
Hur ofta reser du med färjor?	☐	☐	☐	☐	☐

Vem bör stå för kostnaden av färjetrafiken i framtiden? (Välj endast ett alternativ)

Resenären – Bör ingå i kollektivtrafikkostnaden? ☐

Resenären – Bör betalas per resa (köpa enskilda biljetter – utanför övrig kollektivtrafik)? ☐

Subventionerat via skattemedel – Gratis för resenären (Tex. linje 286 – Älvsnabbare)? ☐

Bolag står för hela kostnaden av all färjetrafik till/från deras mark/verksamhet (Gratis för resenären)? ☐

Bolag står för en del kostnaden av all färjetrafiken till/från deras mark/verksamhet och **resten subventioneras av regionen** (Gratis för resenären)? ☐

Bolag står för en del av kostnaden av all färjetrafik till och från deras mark/verksamhet och **resten betalas av resenären?** ☐

Bolag står för en del kostnaden av all färjetrafik till och från deras mark/verksamhet och **resten betalas av resenären och subventioner från regionen?** ☐

APPENDIX II

DAGENS RESANDE

Foto: Västtrafik - (https://www.vasttrafik.se/info/alvsnabben-och-alvsnabbare/)

<u>Hur upplever du</u> som resenär:

1. Färjetrafiken...

... fungerar pålitligt ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... krånglar mycket

2. Färjetrafiken ger information och agerar på ett sätt som...

... går att lita på ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... inte går att lita på

3. För att resa över älven är färjetrafiken...

... användbart ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... oanvändbart

4. När jag använder färjetrafiken blir resandet...

... bekvämare ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... obekvämare

5. När jag använder färjetrafiken blir resandet...

... säkrare ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... farligare

6. När jag använder färjetrafiken får resandet ...

... mindre miljöpåverkan ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... större miljöpåverkan

7. Att använda färjetrafiken är ...

... lätt ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... svårt

8. Att förstå informationen som färjetrafiken ger är...

... lätt ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... svårt

9. Att uppfylla det behov som färjetrafiken försöker fylla är...

... relevant ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... irrelevant

10. För resor mellan 'fastlandet' och Hisingen är färjetrafiken ...

... ändamålsenligt ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... inte ändamålsenligt

APPENDIX III

EN MÖJLIG FRAMTID FÖR RESANDE ÖVER GÖTA ÄLV

Illustration: Hyke (https://shipsmonthly.com/news/hyke-and-remota-team-up-for-electric-and-autonomous-ferries/)

<u>Vad tror du</u> som resenär om en möjlig framtid där färjorna (tex linje 285-286) är förarlösa (automatiserade)?:

1. Förarlös färjetrafik kommer att…

… fungera pålitligt ☐ ☐ ☐ ☐ ☐ ☐ ☐ … krångla mycket

2. Förarlös färjetrafik kommer att ge information och agera på ett sätt som…

… går att lita på ☐ ☐ ☐ ☐ ☐ ☐ ☐ … inte går att lita på

3. För att resa över älven kommer förarlös färjetrafik att vara…

… användbart ☐ ☐ ☐ ☐ ☐ ☐ ☐ … oanvändbart

4. När jag kommer att använda förarlös färjetrafik blir resandet…

… bekvämare ☐ ☐ ☐ ☐ ☐ ☐ ☐ … obekvämare

5. När jag kommer att använda förarlös färjetrafik blir mitt resande…

… säkrare ☐ ☐ ☐ ☐ ☐ ☐ ☐ … farligare

6. När jag kommer att använda förarlös färjetrafik får mitt resande …

… mindre miljöpåverkan ☐ ☐ ☐ ☐ ☐ ☐ ☐ … större miljöpåverkan

7. Att använda förarlös färjetrafik kommer att vara …

… lätt ☐ ☐ ☐ ☐ ☐ ☐ ☐ … svårt

8. Att förstå informationen som förarlös färjetrafik kommer att ge kommer att vara…

… lätt ☐ ☐ ☐ ☐ ☐ ☐ ☐ … svårt

9. Att uppfylla det behov som förarlös färjetrafik kommer att försöka fylla är…

… relevant ☐ ☐ ☐ ☐ ☐ ☐ ☐ … irrelevant

10. För resor mellan 'fastlandet' och Hisingen är förarlös färjetrafiken…

… ändamålsenligt ☐ ☐ ☐ ☐ ☐ ☐ ☐ … inte ändamålsenligt

APPENDIX IV

Hur skulle det påverka att ha förarlösa färjor gentemot dagens färjetrafik?

Varför?

Vilka möjligheter ser du med automatiserade färjor som inte finns med dagens färjetrafik?

Varför?

Vilka problem ser du med automatiserade färjor som inte finns med dagens färjetrafik?

Varför?

Övrigt?

Tack!