Results of the survey- and interview study

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The island of Färingsö is located in the Stockholm archipelago and part of Ekerö municipality. Despite its relative proximity to Stockholm, Färingsö is characterised by a relatively low population density of 115,9 inhabitants per m2, in comparison to 374,6/m2 in the metropolitan area of Stockholm ((Statistiska centralbyrån, n.d.).
This low density brings with it particular challenges when it comes to creating an efficient and economically viable solution for public transport. The existing system - built around a set of local and regional bus lines on a fixed schedule – can only operate on a low frequency, due to the low population density and a lack of demand. Thus, an alternative system was conceptualised that is built around a central main line and a to the main line connected network of smaller, autonomous vehicles with an on-demand service. Passengers could request a ride, for example via a mobile app. They are then directed towards a certain location or stop at which the on-demand bus will pick them up.

Because the population is spread out, mostly along the coastal areas, a relatively high number of different bus lines is necessary to connect all inhabitants to the rest of the island or the mainland. The current solution consists of a network of six local bus lines. This smaller network is connected to the mainland and the Stockholm metropolitan area through one main line. However, because of the low population density, demand for the smaller local buses is low. Thus, in order to keep the system economically viable, the local buses are scheduled on a low frequency.

As part of analysing the feasibility and to better understand potential effects of future transport solutions on travellers' transport habits, we *focused on/scrutinised* a human-centric perspective. We were interested in how a potential service needs to be designed to be attractive for travellers in relation to the current transport system. Further data on travellers' transport preferences and viewpoints were therefore of interest.

As the basis for a specific design of the new solution, it was necessary to scrutinise people's acceptance regarding features and properties of the proposed new service. This included aspects such as wait times, number of changes, travel times or different modes of ride requests (e.g. via smartphone, website, call etc.). Furthermore, we wanted to understand any additional needs and attitudes. Goal of this study was to elicit necessary requirements for future transport solutions.
In detail, we wanted to scrutinise:

(1) What are the prevailing travel patterns of travellers in, from and to Färingsö?
(2) Which patterns and preferences can be observed in regard to key features and key specifications – journey duration, transfer frequency, waiting times, public transport accessibility and mode of ordering?
    a. How do current journeys differ between transport modes in relation to journey duration, transfer frequency and accessibility (e.g. distance to next stop)?

b. How does travel time, wait times, distance to stops, options for transfers affect people's acceptance of the proposed new transport services?
c. Which other factors are relevant for travellers when choosing their mode of transport?

(3) Which specific design recommendations ensue from the results of RQ1 and RQ2?
(4) Are there additional aspects that could affect the acceptance of the proposed service positively or negatively?

1. Methods

In this study we focused on all travellers, regardless of mode of transport – this includes travellers that are using public transport as well as those mainly relying on their car or those mixing different modes.

1.1 Survey

1.1.1 Survey Design

For the survey we focused on three topic areas: (1) Participants current usage of different transport modes, (2) Participants attitudes towards existing public transport and (3) participants attitudes towards a presented future scenario involving on-demand transport. In addition, we also gathered demographic data, such as age, gender, occupation, household size and income – both to check for statistical representativity as well as to compare data between different population groups.
For (1) we designed a simplified version of a passenger traveller survey, modelled after standard surveys in Sweden such as by Region Skåne[1]. There is a considerable risk in evaluating practices and routines through survey methods, since memory recall can easily be skewed by a variety of factors. Thus, participants were asked to focus on a particular day - the last day of travel – and prompted for a detailed account.
For (2) and (3) we identified x over-arching factors based on based on the project's scenario requirements and on first insights from the pilot interviews.
The resulting survey consisted of four different sections:

- Section (I): General demographics
- Section (II): Current transport habits
- Section (III): Attitudes towards current transport forms
- Section (IV): Attitudes towards the proposed transport service

On the last page, participants were asked if they would be willing to participate in an interview on the surveys topic and pointed towards a different site on which they could leave their name and contact details.

1.1.2 Sampling and dissemination

After an evaluation of potential risks and advantages, we used a convenience sampling method. Participants had to fulfil only one criterion – to have travelled to, from or within Färingsö within the last *3 weeks*. This was controlled through an initial question.
The survey was designed in electronic, using a web-based interface (reference). Producing a paper copy was deemed unfeasible, mostly due to its length and relative complexity. The risk of losing less digitally adverse participant groups was outweighed by the advantages of easier and broader dissemination and data handling.

[1] https://utveckling.skane.se/siteassets/publikationer/resvaneundersokning_2018.pdf

The link to the virtual survey was disseminated through digital channels, mostly through social media, but targeted to specific local groups on platforms such as *Facebook* and *Reddit.* Additionally, the survey was disseminated with the help of print material (posters and flyers) that contained the link in form of a QR-code, to facilitate access. Printed material was distributed on Färingsö at different transportation hubs, both to users of public transport (those waiting for busses) as well as car travellers (on different parking lots, directly attached to parked cars). Posters were also prominently displayed in two different cafes and on public notice board at different location throughout Färingsö.
Given the dissemination methods used, we have to assume that there is a certain bias towards a) people more familiar with the use of digital technologies b) people that are more active in the community, e.g., by participating in online groups.

1.2 Interviews

Main goal of the interviews was to gain information about people's attitudes and motivators for their choice of public transport. We also were interested to learn about potentially unknown factors that can lead to acceptance or rejection of different modes of transport. By triangulating results from the survey with the qualitative results of the interviews, we were able to learn more about the context of different travel behaviours and decision factors.

1.2.1 Interview design

The interviews were designed as semi-structured interviews and intended to last about 30 to 60 minutes. In preparation for the interviews an interview guide was created. Outgoing from our main interests in the project, the guide was structured around the following themes:

1. General information about participants occupation, age, household size, general activities, etc.
2. Current travel preferences, incl. travel choices for different journey types, such as commute, errands, hobbies etc but also preferences for journeys within or to and from Färingsö. Follow-up questions were asked regarding particular routines, habits, needs.
3. Attitudes towards the current system, incl. particular challenges or negative experiences but also positive aspects.
4. Attitudes towards potential new system and their general willingness to change travel habits.

The interview process was designed iteratively; thus, the interview guide was continuously updated, parallel to the on-going data analysis. If one or several participants brought up new aspects, we would add these to the guide to check for further occurrences.

1.2.2 Recruitment

Participants were recruited through two channels. A first round of respondents was recruited via a local Facebook-group. A second group was recruited via the survey (cf. 1.1.1). Our call for interview participants received a lot of interest, in total 36 people indicated their availability for an interview. However, in order to balance out age and gender among participants, we recruited 9 of them for interviews. An overview over these respondents can be found in Table 1.
This kind of sampling comes with the risk of over-representing certain population groups. In this case, many of those expressing interest in participating were female, between 40 and 59 years old and particularly active in the local community. Hence, in the later stages of recruiting we focused on recruiting male participants as well as participants from age groups.

Table 1: Overview over interview participants

	Occupation	Public transport use	Main mode of transport

P1	Female, 54	Employed	Within Färingsö, but rarely. Used to take public transport during her studies	Commutes by car to central Stockholm
P2	Female, 62	Employed	Commutes by bus to Stenhamra	Bus
P3	Female, 39	Employed	Few times when going out	Commutes by car to central Stockholm
P4 & P5	Female, 41 & Male 42	Employed	Almost never	Commute by car to central Stockholm
P6	Male, 54	Employed	Almost never	Commutes by car to central Stockholm
P7	Male, 28	Student	Commutes by public transport to university	Bus and Subway
P8	Male, 67	Retired	Never	Car

1.2.3 Interview set-up and process

P1, P2, P3, P4 and P5 were interviewed at their home in Färingsö. This kind of setup led to a higher degree of comfort for participants and these interviews took between 60 and 90 minutes.
Half of the interviews were conducted online via the software zoom. Participants were provided with a link. None of the participants showed any difficulties in using this kind of setup. These interviews varied in their duration from 30 to 45 minutes.
In the beginning of the interview participants were introduced to the project and informed about the purpose of the study and the use and storage of their data. They were also asked if they agreed to audio recording of the interview. At this point, participants were not yet made familiar with the concrete concept, this was introduced through the second half of the interview. In the beginning, participants were asked about their overall living situation, work, family, and other familiar topics in order to create a more relaxed atmosphere.
At the end of the interview, participants were encouraged to ask questions if they had any and also informed over some of the projects next stages.

1.2.4 Analysis

Interview recordings were partially transcribed and analysed with the help of thematic analysis, using a mix of pre-defined as well as emergent codes. Emerging themes were further clustered and related to quantitative data.

2. Survey Results

2.1 Overview over survey results

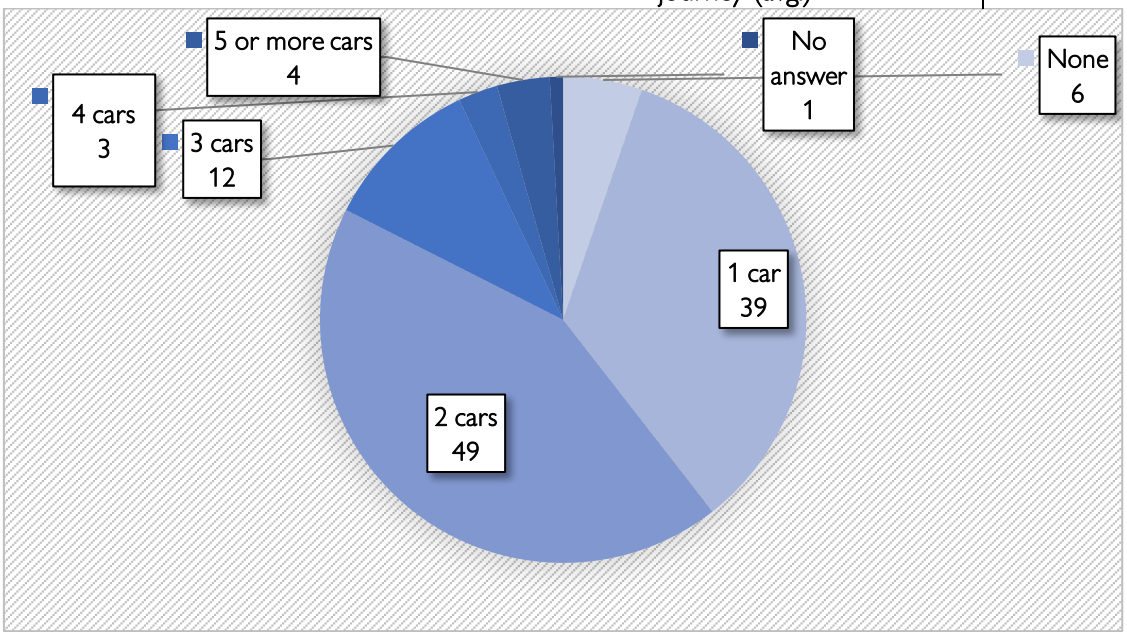
We received in total 114 answers to the survey. Table x shows an overview over some basic metrics such as age, gender, and income of respondents. As often the case in survey studies with convenience sampling, the responses were rather strongly weighted towards female respondents.
Average income Ekerö
Age groups in Ekerö

Table 2: Do you own or have access to a car?

Yes	No	No answer
103	10	1

Figure 1: How many cars are in your household?

Total number of journeys	184
Number of journeys per respondent (avg.)	1,6
Number of sections per journey (avg.)	2,34



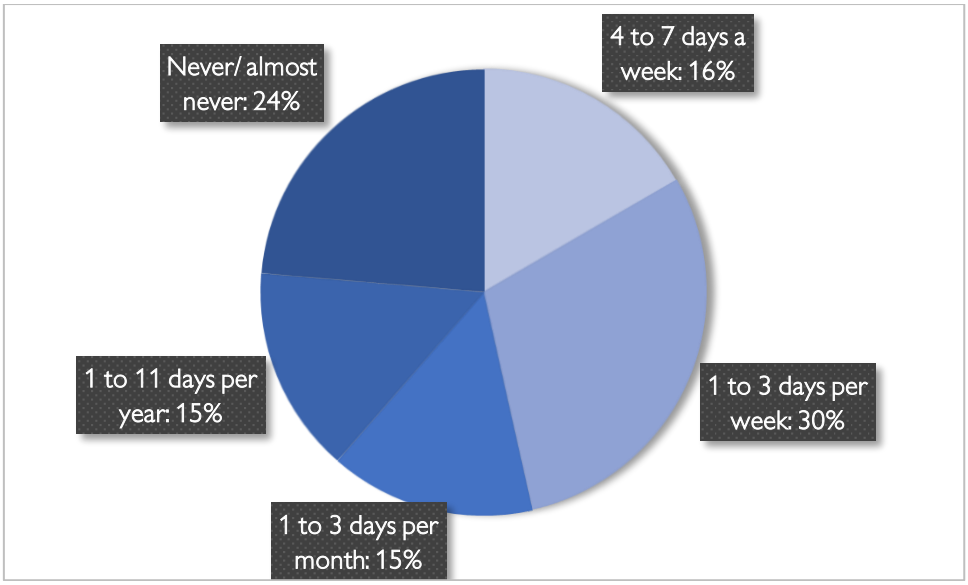


Figure 2: How often do you use public transport?

2.2 Travel habits

Table 3: Journeys and journey sections

In section II of the survey, respondents were asked to give information about their most recent day of travel by listing journeys (i.e., a complete journey from start to final destination) and journey sections (i.e., each part of the journey using a different mode of transport). For instance, someone who would take their car to work would report ***one*** journey from home to work and ***one*** journey section, since he did the whole journey by car.

Table 4: Journey destinations

In total, 184 journeys were reported with an average of 2,34 sections per journey. On average, each respondent reported 1,6 journeys (Median: 2). (See tab. 3)

76% of the reported journeys were either to or from Färingsö, i.e. were started or ended outside of Färingsö. 24% of the reported journeys were within Färingsö (Tab. 3).

	#	In %
Within Färingsö	45	24 %
To/From Färingsö	139	76 %

Journey types

Table 5: Journey types

We can divide these journeys into three categories: Car journeys (Journeys exclusively done by car), public transport journeys (exclusively via public transport) and hybrid journeys (involving both car and public transport). In the following we will use these three categories in our analysis. We will refer to travellers for each journey type as *"car travellers"*, *"public transport travellers"*, and *"hybrid travellers"*, respectively.

Journey types	#	In %
Car	78	42 %
Public transport	66	36 %
Hybrid	34	18 %

As shown in table 5, only 36% of all reported journeys were done solely by public transport, 60 % of journeys involved the use of a car, either as driver or as passenger.

Number of transfers (public transport and hybrid modes)

For public transport and hybrid journeys we can count the number of transfers for each journey. Public transport journeys include on average 0,92 changes (Median: 1) with the majority of journeys not involving any transfers (P = 0,41) and only 21% involving 2 or more transfers.

We also looked at the number of changes in hybrid journeys. Here we exclude the transfer from car to public transport and focus solely on changes between different public transport forms (e.g. from one bus to another). None of the reported hybrid journeys involved more than one transfer with a majority of the journeys involving no transfer. This might indicate that the car is used in order to avoid additional changes of public transport.

Number of transfers	0	1	2	3	Avg.
Public transport	23	27	10	3	1,03
Hybrid	22	12	0	0	0,35

Table 6: Number of transfers for public transport and hybrid journeys

Duration of journey

We asked respondents to give two different estimates for journey duration:

a) An estimate over the duration of their actual journey
b) An estimate for the duration of a hypothetical journey with other transport modes ("If you would have taken the car/public transport instead")

This results in 7 different *data points* (See also table 6)

- Durations for all three different journey times as reported.
- Estimate over duration of a hypothetical car journey (from both public transport and hybrid travellers)
- Estimate over duration of a hypothetical public transport journey (from both car travellers and hybrid travellers)

Table 7 shows an overview over results. There is a significant difference between actual journeys done by car and journeys done via public transport. Interestingly,

Table 7: Overview over reported travel time and estimate indicators

	Actual travel time	As estimated by car travellers	Estimated by public transport travellers	Estimated by hybrid travellers
Car journeys	*Actual duration reported by car travellers*	*Not applicable*	*Estimate duration for hypothetical car journey*	
Public transport journeys	*Actual duration reported by public transport travellers*	*Estimate for hypothetical public transport journey*	*Not applicable*	*Estimate for hypothetical public transport journey*
Hybrid journeys	*Actual duration reported by hybrid travellers*	*Not applicable*		

Table 8: Travel durations and estimates (Average in minutes, median (min)in brackets)

	Actual travel time	As estimated by car travellers	Estimated by public transport travellers	Estimated by hybrid travellers
Car journeys	41,9 (35)	---	42,8	46,5
Public transport journeys	77 (78)	78 (80)	---	90
Hybrid journeys	79 (75)	---	---	---

Distance to closest stop

Similarly, to the procedure for journey duration, we asked respondents to give us two different estimates:

a) Distance between their point of origin and destination and the closest stop. (Only for public transport and hybrid travellers)

b) An estimate over the distance between origin/destination and stop for a **hypothetical** public transport journey (only for car- and hybrid travellers).

For the analysis we only analysed those estimates that related to a stop in Färingsö.

Results are shown in table 8. They show that there is a considerable distance between the reported actual distances to the next stop compared to the estimates given by car and hybrid travellers. This applied in particular to journeys that start on Färingsö. This might be an indicator for the car being used as a "Last-mile"- solution for those residents that live further away from the next bus stop. It is less apparent why there is a difference between start stops and end stops.

Table 9: Indicated distances to next bus stop/journey

	Actual distance to stop	As estimated by car travellers	Estimated by public transport travellers	Estimated by hybrid travellers
Public transport journeys - start	428	950	---	725
Public transport journeys - end	462	518	---	473
Hybrid journeys	Omitted*	---	---	---

* Estimates for hybrid journeys were omitted since a majority of the start and end destinations in Färingsö were reached by car.

Travel time of day

As part of the passenger survey, we asked participants to indicate, which time of the day the journey started. Main travel times lay between 6 and 8 am and 4 and 5 pm, indicating rush hour during these times (See Fig. 3). In Figure 4 we divided and compared public transport and car journey times. There are no public transport journeys reported before 6 am, most likely due to the bus schedule.

Furthermore, car journeys have a more even spread throughout the day, while public transport journeys tend to happen around particular times, especially in the morning. This might indicate less flexibility for public transport journeys, possibly due the bus schedules' limitations.

Figure 3: Journey start time

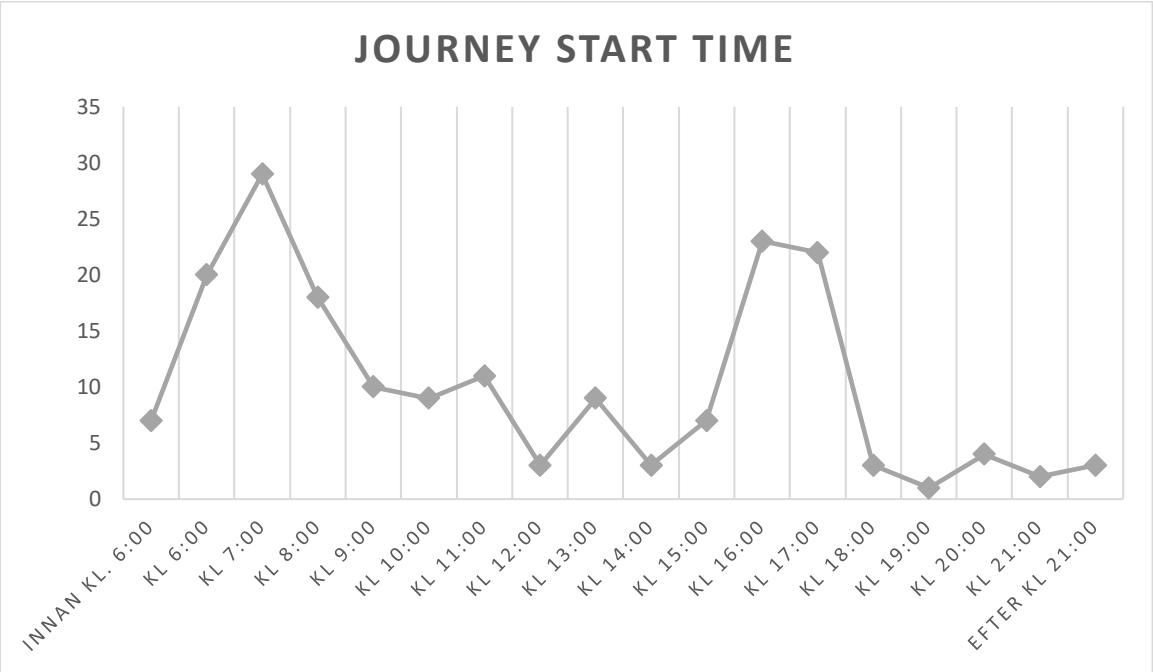


Figure 4: Departure times for car and public transport journeys

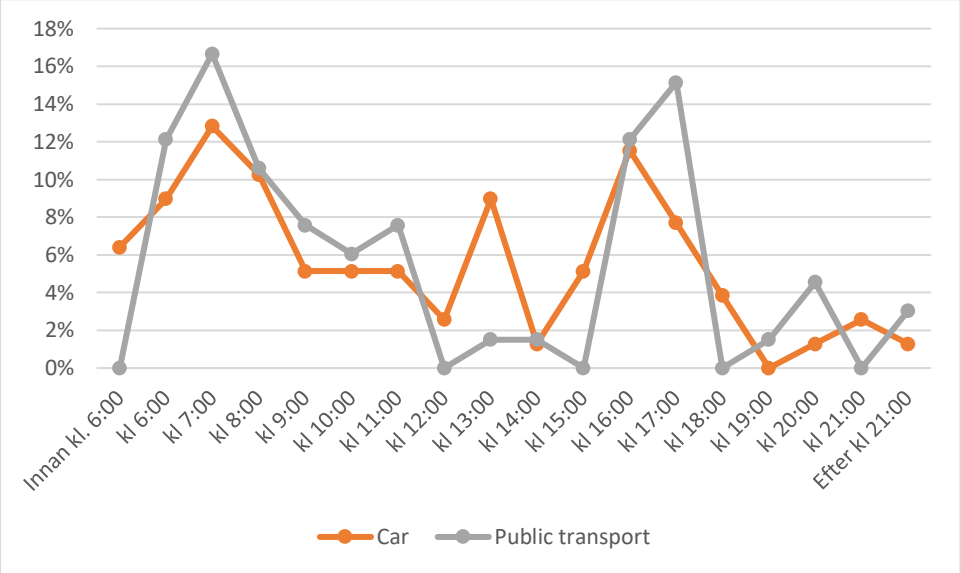


Figure 5: Departure time and travel time (min) for public transport journeys

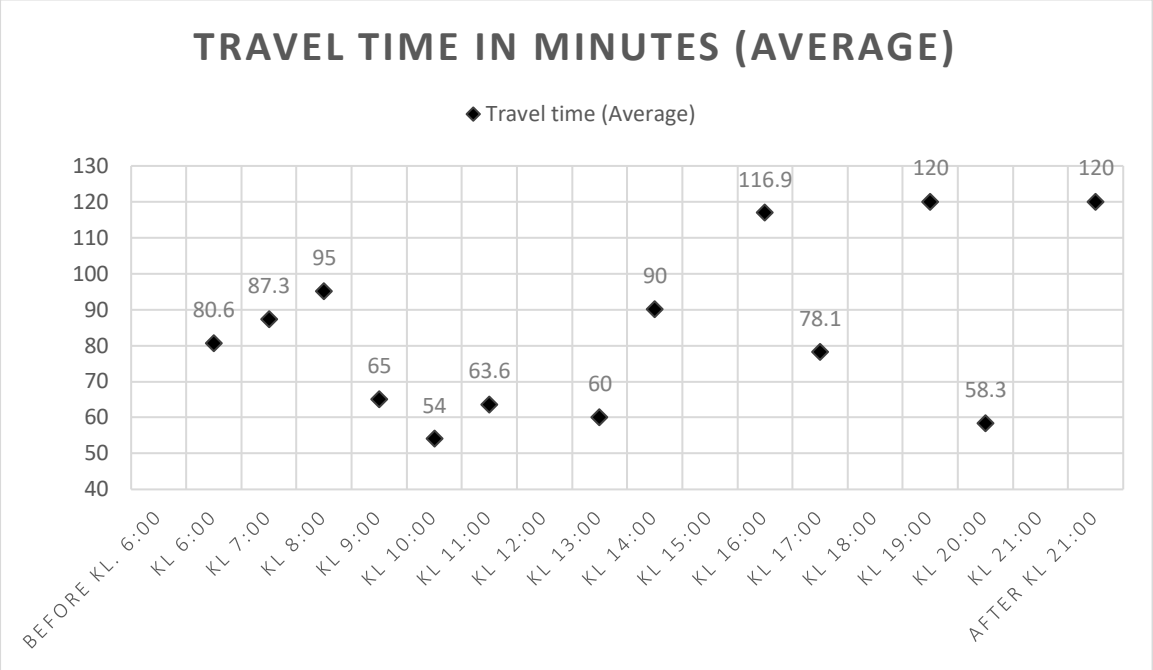


Table 10: Average number of changes per departure time

Departure time	Average number of changes	Number of changes – public transport only
6am	0,83	1
7am	0,44	0,64
8am	0,7	0,71
9am	0,28	0,4
10am	1,4	1,75
11am	1,43	1,8
Noon	0,4	n.a.
1pm	1	1
2pm	1	1
3pm	0,67	n.a.
4pm	1,08	1,63
5pm	0,47	0,6
6pm	n.a.	n.a.
7pm	2	2

8pm	0,67	0,67
9pm	n.a	n.a.
After 9pm	2,5	2,5

2.4 Attitudes towards the introduced scenario

2.4.1 Traveller groups

As part of the analysis process, we identified four different groups according to their general travel habits and preferences. We used three indicators: (1) Participants travel data from part 1 of the survey (detailed passenger survey). (2) QX (How often do you use public transport?) (3) QY (If you were free from restrictions, which mode of transport would you choose?).
With the help of these indicators, respondents were divided into the following four groups:

Group 1: Public transport users

Travellers in this group were already using public transport and would prefer to use it in the future. This group's attitudes were of great importance, since any new solution should not deter existing public transport users.

Group 2: Aspiring public transport users

This group consisted of people that would like to use public transport more often but are in practice mostly resorting to the use of the car. This group's preferences are considered of importance, since they might indicate opportunities for increasing the amount of public transport users with the help of a new system.

2.4.2 Decision factors:

QX asked respondents about factors that affected their choice of transport, asking them to indicate each factors importance on a scale from 1 to 4. While almost all factors were evaluated as somewhat important, four factors stood out: Timeliness, travel duration, wait times when changing, and bus routes. Graph x shows the relative number of respondents that regarded each issue as "very important". Apparently, any factors relating to time are rated of high importance, while lower rated issues are relating to bus stops, their location and comfort.

Table 11: Overview over decision factor ratings

Rating	Duration of journey	Timeliness of busses	Possibility for transfers	Transfer wait time	Comfort on buses	Sustainability & Environment	Ticket costs	Bus routing	Bus stop locations	Bus stops condition and comfort
Not at all important	0	0	0	1	3	9	2	0	1	11

Somewhat unimportant	1	2	12	1	35	27	24	2	13	57
Somewhat important	21	16	43	19	60	39	57	26	58	37
Very important	92	96	59	93	16	39	31	86	42	9

Figure 6: Decision factors - relative frequency of 'very important' - public transport users

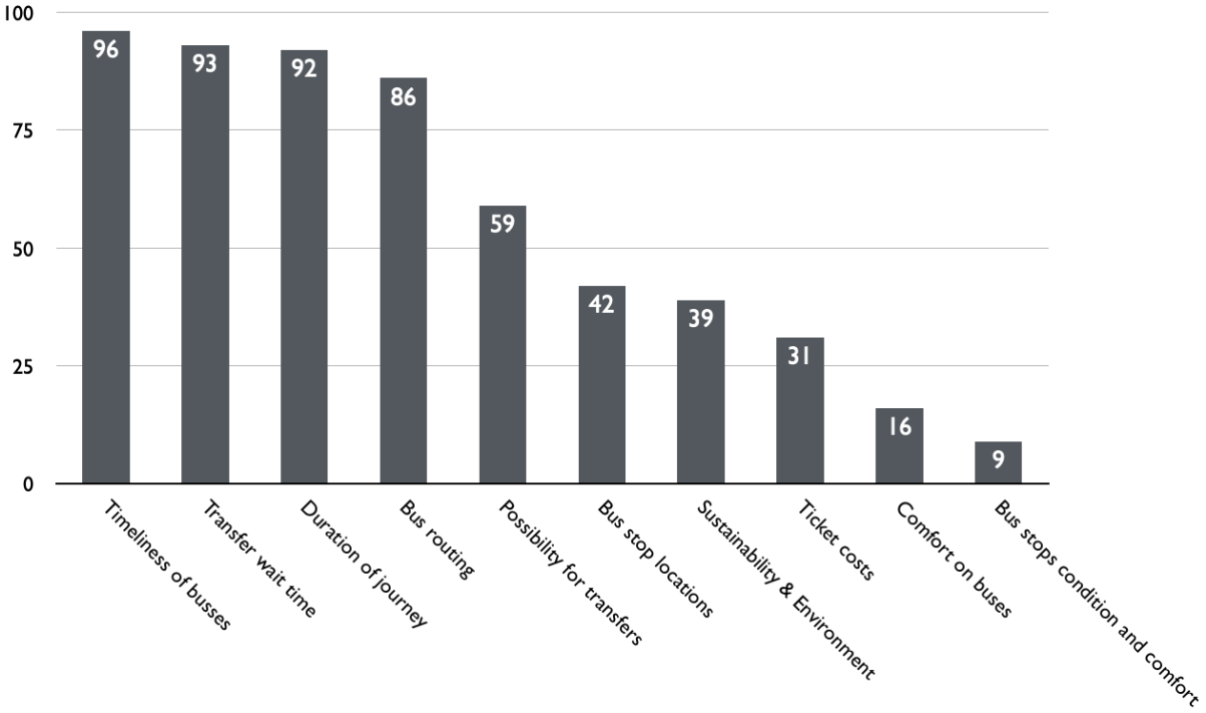
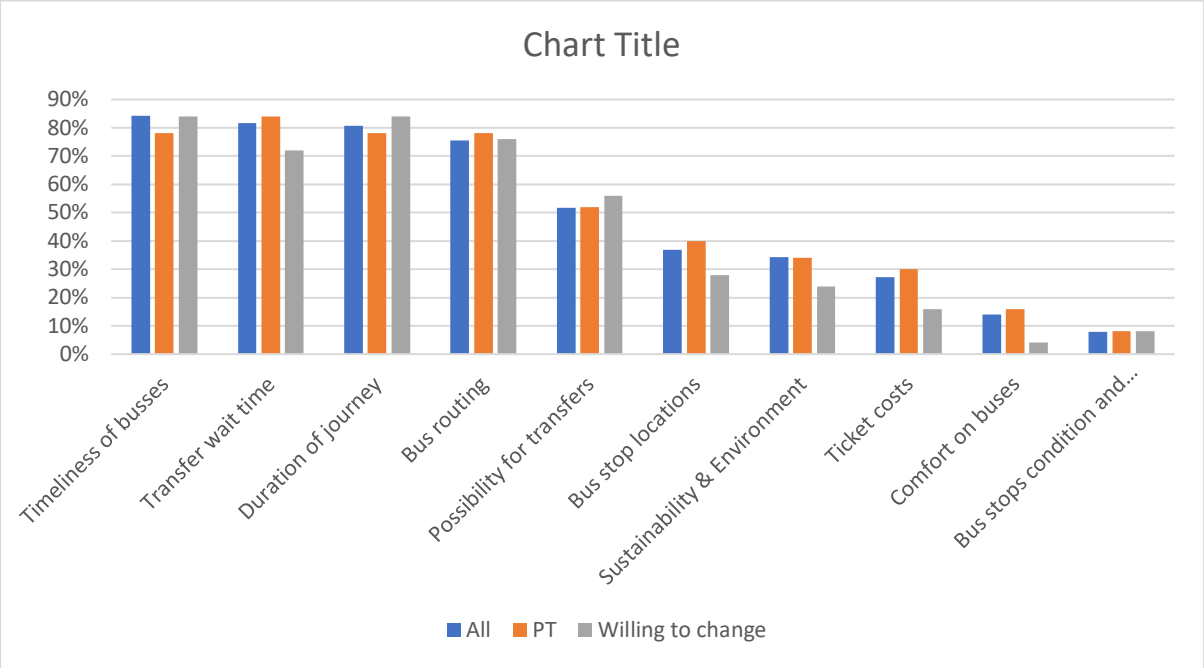


Table 12: Decision factors for Public transport users and potential users

	Duration of journey	**Timeliness of busses**	**Possibility for transfers**	**Transfer wait time**	**Comfort on buses**	**Sustainability & Environment**	**Ticket costs**	**Bus routing**	**Bus stop locations**	**Bus stops condition and comfort**
Public transport users	3,74	3,84	3,76	3,78	3,4	3,24	2,9	3,06	2,74	2,26
Open to change	3,84	3,68	3,84	3,76	3,44	3,12	2,8	2,84	2,64	2,52
All	3,76	3,73	3,39	3,84	2,73	2,92	3,06	3,78	3,24	2,24

Figure 7: Decision factors - rel. frequency of rated 'very important' by different user groups



2.5 Attitudes towards future scenario

In the last section, respondents were asked about their opinions on a proposed service that was explained with the help of a detailed scenario. We focused on some particular factors that were vital for any further decision within the implementation.
In the following we present an overview.

2.5.1 Preferred modes of ordering

Table 12 indicates that the majority of respondents would be willing to order the service through an application. The least popular option was to order via an automated phone service.

Table 13: Accepted order modes

People accepting to order through…		
	#	In %
Call service	22	19,3 %
Automated call service	3	2,6 %
Web interface	35	30,7 %
Mobile App	100	87,7 %

2.5.2 Pre-order time

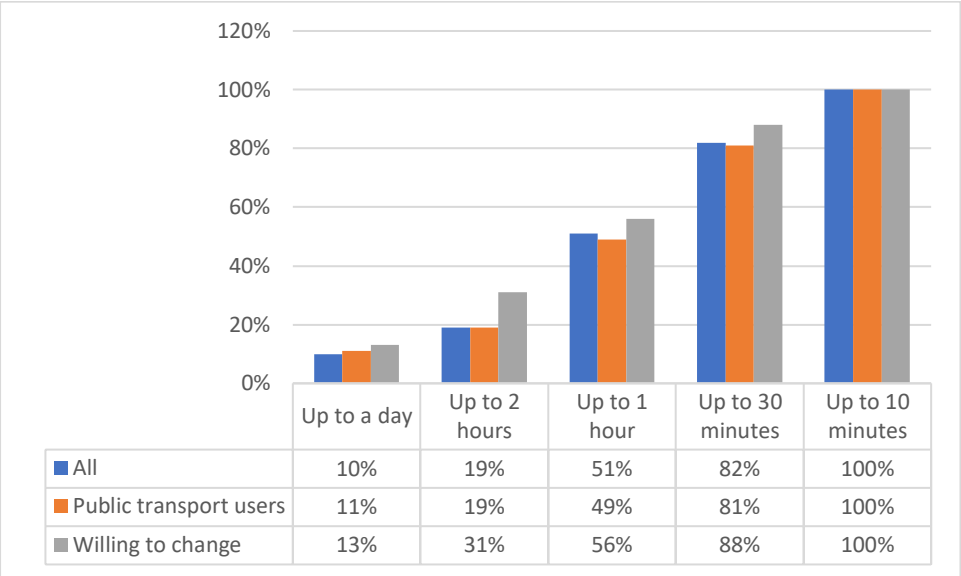
In QX, respondents were asked to indicate how long in advance they would be willing to book such a service. For instance, the answer "up to 5 minutes" would indicate that the respondent is willing to book a bus ride up to 5 minutes before the intended start of the journey. Table 13 shows the number of answers for each accepted wait time, as well as the accumulated number of answers. It shows that a large majority of users would be willing to order up to 30 minutes in advance. This number drops significantly for a longer pre-booking time of up to an hour. Only a small number of respondents (19,3 %) would be willing to book up to 2 hours in advance.

Table 14: Accepted pre-booking time

Accepted max. time for pre-booking	Frequency	Acc. frequency	Acc. frequency in %
Up to a day	11	11	10,1 %
Up to 2 hours	10	21	19,3 %
Up to 1 hour	35	56	51,4 %
Up to 30 minutes	33	89	81,7 %
Up to 10 minutes	20	109	100 %

We compare the overall preference of respondents with the preferences of the two focused user groups – existing public transport users and those open to change (cf. Section 2.4.1) - as shown in figure 8. There is no significant difference between these groups, even though those 'open to change' show a slightly greater flexibility. In this group, 31% are willing to pre-book for up to 2 hours in advance.

Figure 8: Accepted pre-order times by user groups



	Up to a day	Up to 2 hours	Up to 1 hour	Up to 30 minutes	Up to 10 minutes
All	10%	19%	51%	82%	100%
Public transport users	11%	19%	49%	81%	100%
Willing to change	13%	31%	56%	88%	100%

2.5.3 Wait time during transfer

Table 15: Accepted transfer wait times

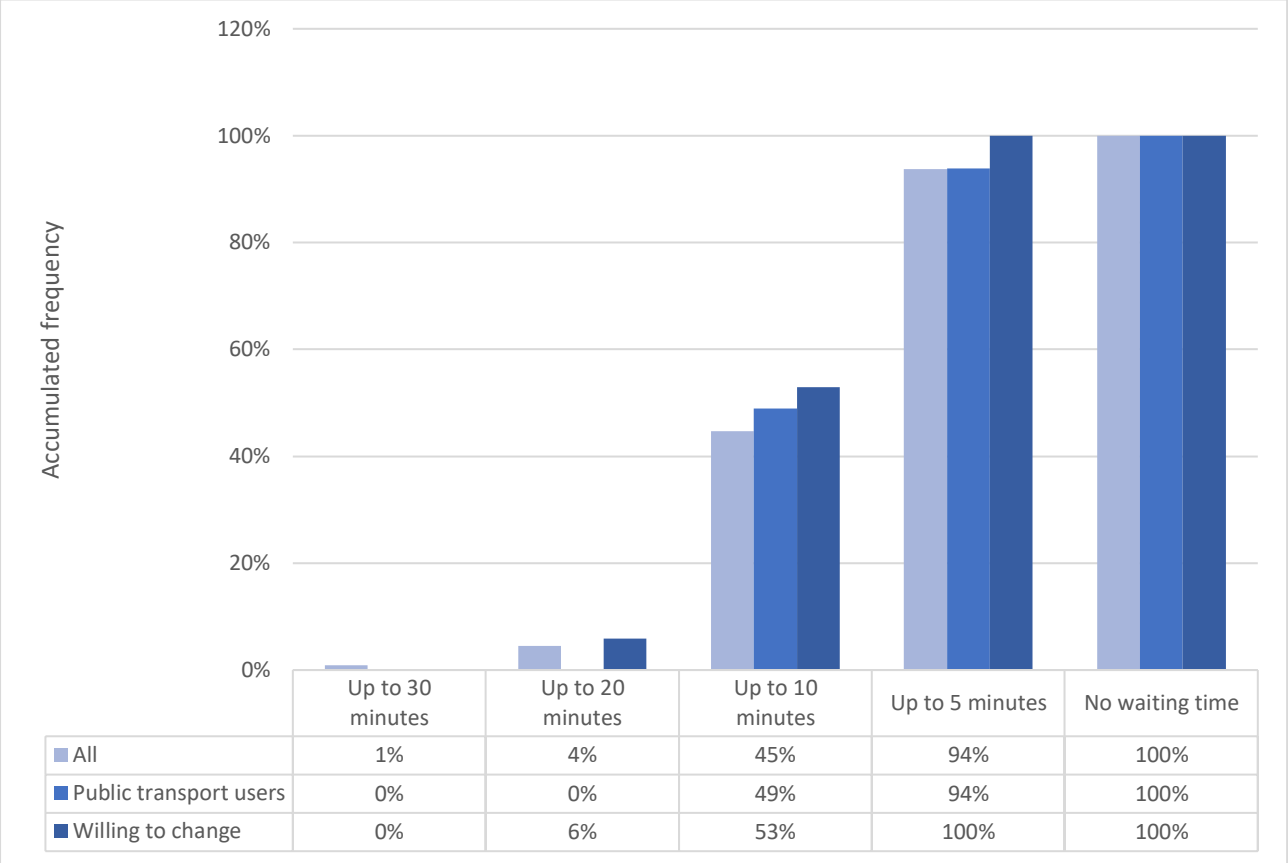
Transfer wait time	# of answers	Acc answers	Acc. in %
No answer	2	11	10,1 %
Up to 30 minutes	1	1	0,9 %
Up to 20 minutes	4	5	4,5 %
Up to 10 minutes	45	50	44,6 %
Up to 5 minutes	55	105	93,8 %
Less than 5 minutes	7	112	100,0 %

Another important factor was the accepted transfer waiting time. Transfer waiting time describes the amount of time a traveller will have to wait at a transfer point before being able to continue their journey. For instance, a passenger might take a so-called flexbus that brings him to a transfer bus stop where he will have to wait a certain time for the main line bus to arrive. If a respondent indicates a 5-minute transfer wait time, they would be willing to wait for up to 5 minutes for the connecting bus.

Table 14 shows an overview over respondents answers as well as accumulated answers. While a large majority of respondents are willing to wait for up to 5 minutes, only 44,6 % would accept a wait time up to 10 minutes.

We also compared the accepted transfer wait time between different traveller groups. Similar to the pre-order wait time (cf. section 2.5.3), those 'open to change' show a slightly higher tolerance: 53% of this group would be willing to wait for up to 10 minutes. (cf. figure 9)

Figure 9: Accepted transfer wait-time by user groups



2.5.4 Number of transfers

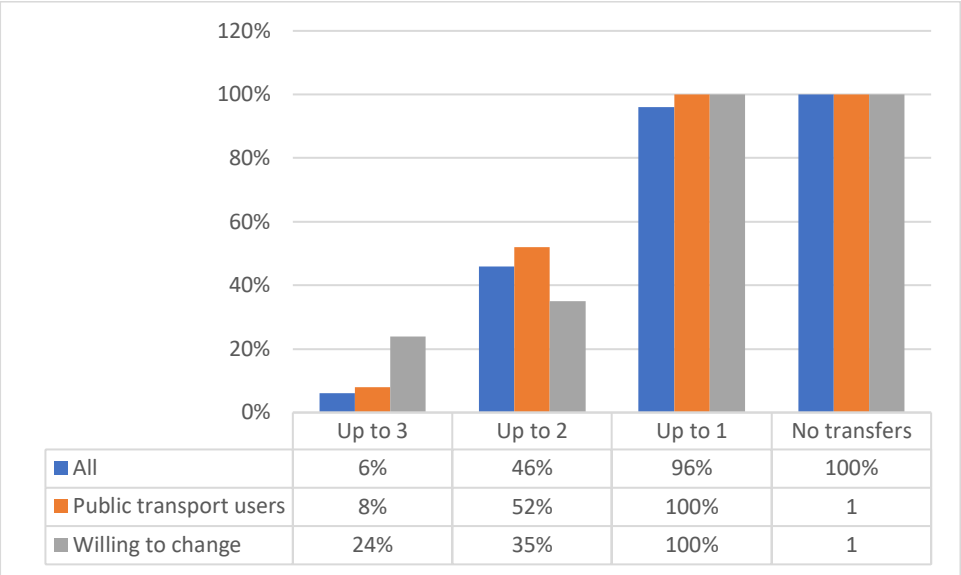
We asked respondents about the number of transfers they would find acceptable for each journey. Table 15 shows the results. 96,4% of respondents would be willing to transfer ones per journey. Only 45,5% would accept up to two transfers.

Figure 10 shows a comparison between different user groups. Public transport users are slightly more willing to accept up to two transfers, while 24% of those 'open to change' are even willing to accept up to three transfers.

Table 16: Accepted number of transfers

Number of transfers	# of transfers	Accu-mulated	Accumu-lated in %
Up to 3	7	7	6,4 %
Up to 2	43	50	45,5 %
Up to 1	56	106	96,4 %
No transfers	4	110	100,0 %

Figure 10: Accepted number of transfers by user group



2.5.5 Distance to bus stop

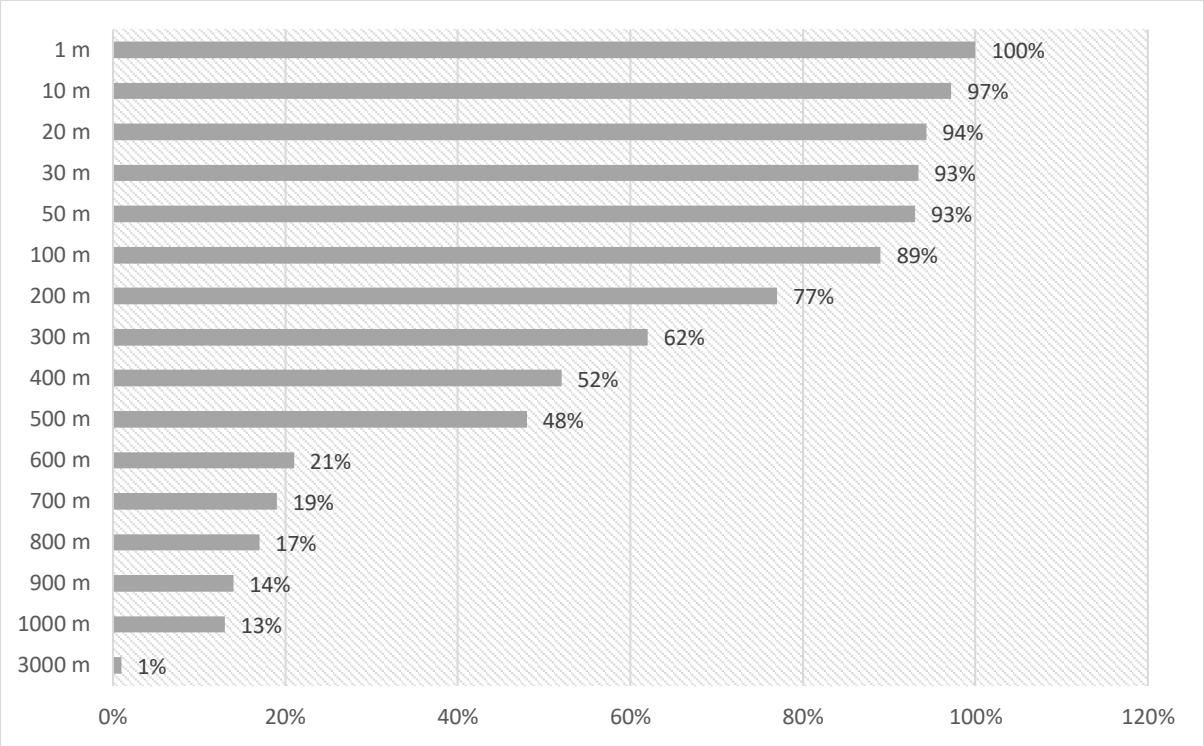
Respondents were also asked about their preferences regarding the distance to the next bus stop, i.e. the length between their point of departure and the closest bus access point. Table 16 and figure 11 show respondents' preferences, with a fairly large spread between 0 and 500m. Only 20,8% of respondents would accept a stop further than 500m away.

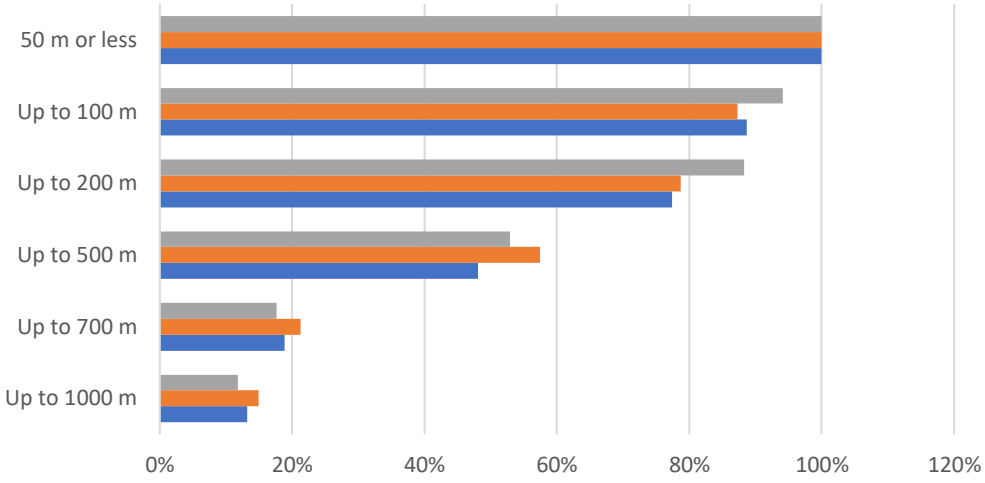
Table 17: Accepted distance to stop

Distance to stop (in m)	# of answers	Accumulated # of answers	Accumulated in %
3000	1	1	0,9 %
1000	13	14	13,2 %
900	1	15	14,2 %
800	3	18	17,0 %
700	2	20	18,9 %
600	2	22	20,8 %
500	29	51	48,1 %
400	5	56	52,8 %
300	10	66	62,3 %
250	1	67	63,2 %
200	15	82	77,4 %
150	3	85	80,2 %

100	9	94	88,7 %
50	4	98	92,5 %
30	1	99	93,4 %
20	1	100	94,3 %
10	3	103	97,2 %
1	2	105	99,1 %
0	1	106	100,0 %

Figure 11: Accepted distance to stop





	Up to 1000 m	Up to 700 m	Up to 500 m	Up to 200 m	Up to 100 m	50 m or less
Open to change	12%	18%	53%	88%	94%	100%
Public transport users	15%	21%	57%	79%	87%	100%
All	13%	19%	48%	77%	89%	100%

3. Qualitative results

In the following section we report on the qualitative observations that resulted from both the interviews as well as the qualitative parts of the survey. The data has been structured around different themes that emerged through the analysis. Our observations are exemplified with direct quotes, names and places have been anonymised.

All interview respondents were rather critical of the current public transport solution, with the large majority using cars for their everyday commute. We identified x critical aspects that emerged throughout the interviews.

3.1 Choice of transport mode

All interview respondents had invested some thought into the choice of transport, especially when it came to the daily commute. Because all, but two, respondents were working outside of Färingsö, their way to work took a considering part of their time. Overall, all respondents recognised that living in Färingsö came with certain trade-offs when it came to mobility and flexibility, due to its comparatively remote location.

3.1.1 Choice between car, public transport and other forms of transport

The car was the main choice of transport for most respondents and none of them could imagine being able to manage without a car. This dependency was met with different strategies, such as the one reported by P1:

> *Q: So how many people in the house drive a car? I saw quite a few cars parked in the front…?*
> *A: It's just my husband and me […]. You know, the cars are so unreliable, like last week we just got one from repair and I know that the Volvo probably is going to have an issue again soon. So, we just have three cars, in case one of them breaks. Because we cannot rely on public transport. (P1)*

6 out of 8 respondents lived in a household with two or more cars. P4 and P5 explained that when purchasing their car, the need for durability was the main criterium for their choice of car brand, together with the availability of reliable and fast repair service.

> *"P4: It's important to bring the car to a licensed service place. Also, because of the rental…*
> *P5: …yeah, I remember, last time I brought the car in and then it turned out they had no rental car available until the next day, […] so I just went away with my car and came back the next day." (P4/P5)*

Many of the residents are also missing a functioning bike network. Because the main roads in Färingsö are having a generous speed limit and lack pedestrian or cycle lanes, cycling is considered not save enough. One of the survey respondents expresses their frustration:

> *"It's so frustrating, because it's such a short distance (ca. 5km) and since it's a busy road with sparse street lights it's not possible to bike or walk." (Survey respondent)*

Several of the interviewed people mention similar concerns and many express their desire for cleaner forms of transport.
Indeed, throughout the interviews it became apparent that there is a very high degree of civic engagement paired with concerns about the environment and sustainability among many of Färingsö's residents. Many of the interviewed respondents actively chose to move to Färingsö in order to be closer to nature, while still in commuting distance to central Stockholm. Hence, the fact that they felt reliant on their cars as main form of public transport was seen with concern as the following quote from P1 shows:

> *"Q: When you take the car, how does that work for you?*
>
> *A: It feels bad […] it just feels like I am driving around in this thing that spreads all the dirt and poison into nature. I love living in nature, so it feels just wrong with the car." (P2)*

3.5 Importance of predictability

Despite this desire for more sustainable traffic solutions, driving is seen by most as unavoidable, due to a perceived lack of reliability of existing public transport solutions. P1 was one of the interview respondents who had lived in Färingsö for several decades and had previously made use of public transport frequently:

> *"I used to take the bus all the time during my studies. I would take the No. X and then change and then the T-bana goes to my work.*
> *Q: Why do you not do that anymore?*
> *A: Now since I work it's just too unreliable and takes too much time. By car it only takes me 30 minutes but by bus it's one and a half hours if I am lucky." (P1)*

In P1's case, public transport was practical as long as her schedule was fairly flexible, but as soon as she was met with the demands of her workplace, public transport became too unreliable.
For some respondents, the car gives them a sense of control over their own schedule, since it is is not bound to a particular timetable:

> *"If I take my car, I know before 6 the roads are empty. So, I can get up early and get ahead of the traffic. That doesn't work with the bus."(P6)*

The need for flexibility also affects the choice of other alternatives. P4 and P5 often coordinate with other parents in the neighbourhood on picking up their children from school and after-school activities. This kind of car-pooling does not seem to be a viable option for their commute:

"Q: How about car pooling? Like driving together with someone else in the car?

P4: I wouldn't want to do that. No, I think that just becomes so complicated. Sometimes someone is sick or maybe you have to go earlier or later. No, no…" (P4)

3.2 Attitudes towards existing public transport services

Respondents from both interviews as well as the survey express a high degree of discontent with the currently available public transport services. This is certainly due to a certain degree of sampling bias – those who feel unhappy are more likely to volunteer in order to voice their discontent. Yet, most of the issues brought up are similar across the different respondents and shine a light on factors that influence acceptance.

3.2.1 Bus routes and network

Throughout the last decades, the bus network in Färingsö has changed multiple times with multiple changes in transport providers. Most of the interviewed residents were very aware of these changes and the challenges that the existing geography and road network provided.

One of the more recent changes that sparked a lot of discontent, was the re-routing of bus no. 176. Previously, this line would connect Stenhamra directly with the Metro-stop at Brommaplan. But with a recent schedule change, the bus now takes a detour via neighbouring town Ekerö, which adds (*how many minutes?)* to the schedule. One of the questionnaire participants writes:

"As long as the bus goes via Ekerö, I am taking the car. I am damn tired of the detour via Ekerö." (Survey respondent)

3.2.2 Frequency and Duration

Q: If you could have the ideal situation, how would your ideal public transport network look like?
A: What I would want is a bus that brings me from here to Svanhagen, or maybe Brommaplan, that comes every hour… or maybe even every half an hour. Throughout whole day. (P3)

Where I live there are fantastic connections. There's a direct bus from my home to Brommaplan. The only reason I take the car instead of the bus is that traffic is so infrequent. In the evenings and weekends there are no direct busses and it's often in a frequency of every two hours from Svanhagen to Svartsjö. (Survey response)

3.2.3 Transfers

Travellers that don't travel from Stenhamra or Svanhagen but live or work further north on the island, usually have to transfer in Svanhagen or Stenhamra. X different bus routes connect the different parts of the island with each other. One of the more important one for commuters leads via the main road to a smaller village in the north where the buses drive a loop around and then return to Svanhagen. Many of the interviewed travelers, like in the example below, prefer to avoid the additional transfer.

"Interviewer: You said the No. 318, that is our favourite. Why?
A: Because it goes all the way to Brommaplan. So, I don't need to change. But it only goes in the morning and evening a few times. And if you need to commute at other times, you need to take the slower bus." (P 1)

In this example, P8 has her own strategy for minimising transfers. Others interviewed, were combining car and bus in order to not have to transfer between two buses. It becomes very apparent that taking public transport requires a certain amount of planning. P7 regularly uses public transport in order to get into central Stockholm. The transfer in Svanhagen is a major issue of concern for him:

> *So when I go home and I need to take the 176 to Svanhagen and I need to decide, do I take the one now or the one in 20 minutes. So if I take the one in 20 minutes, maybe I am lucky and it will be in time. Or not, then I will miss the 317 and that one goes only once an hour or less. So if there is any traffic I am stuck at Svanhagen for an hour or so. Or if I take the one earlier and that one is in time, then I will have to wait again for the 317. So it's always this… I always have to decide, everyday. And I always end up waiting anyway (P7)*

One major reason for many of the transfer struggles was a reported lack of coordination between different bus lines. P 5 explains:

> *"One thing that changed a few years back, I think they got a new company and they just don't coordinate anymore. So many times when the No 176 was late […] and you miss the connection and then you have to wait there at Svanhagen. In the winter it can be very cold." (P2)*

How such a coordination could look like was described by one of the survey respondents:

> *"You cannot trust that the buses will come. Before, since 1970 and after, overall everything worked as it should and the bus drivers had information about other buses, they could call them if you needed to reach a connecting bus. Today, you cannot get any information and many departures are cancelled or massively delayed. I really feel bad for the children that have to commute to school in the city." (Survey response)*

3.3.4 Information

Another important aspect of traveling is the processes of finding and using information needed for planning the journey. For the car journey, information consists usually of possible routes as well as the traffic situation. P6, who usually takes his car to work, explains this as follows:

> *[takes his mobile phone] Here, when I want to go to work, I can go to google maps and it shows me right here, the traffic and everything. So, I know, this time here, this is going to be the time I will be there. And when I go to here [clicks on public transport field], I know already, this is not the right time. I know, that bus will be late and then I cannot change so fast here. It should be better for public transport, shouldn't it? (P6)*

P6 shows frustration with the information available on public transport; at least the one shown to him on the app google maps. But other means of information come with flaws, as well. P7 commutes almost daily by bus and uses the app "SL" by the local public transport service provider. For him, the app is vital on his daily commute, especially in situations when it becomes stressful:

> *"It's so stressful, you sit on the bus and constantly check the app and the traffic, you hope that you will make it. And then you get off and the 317 just drives away in front of your nose" (P7)*

The situation P7 describes is re-occurring throughout the interviews. The main bus line, No. 176, runs on a higher frequent schedule, with departures every 10 or 20 minutes. The connecting bus lines on Färingsö however, have a much lower frequency. Thus, passengers rely on bus 176 to reach the transfer stop on time, because when missing the connecting bus, they will be forced to wait often for an hour. Hence, having reliable information about bus times is very important. In this context, the bus company that currently runs the local lines on Färingsö is seen as untrustworthy, as one of the survey respondents expresses:

> *At the moment, buses are run by a company that mismanages and cheats a lot. But if you could trust that the buses run in the first place and keep to the timetables, much more people would take the bus. (survey response)*

This quote highlights the connection between information in form of timetables and the perceived reliability of the system. Information is vital in order to plan and hence be able to rely on the public transport system.

4. Analysis and Implications

For the analysis, we use quantitative survey data in order to show the specifications for the key parameters – as specified in RQ1 and RQ2. We contextualise these results by integrating qualitative data from the interview study to highlight particular pain points and resulting design recommendations.

4.1 Current travel habits

RQ1a was formulated as following:
RQ1: What are the prevailing travel patterns of travellers in, from and to Färingsö?

The data shows that under the current conditions, travellers rely to a large extent on their cars. Only 36% of all reported journeys are public transport journeys. The data also shows that car journeys are in many aspects more convenient, i.e., they take less time and offer a higher flexibility.
Yet, the fact that 36% of the recorded journeys are done via public transport and that 46% of travellers indicate that public transport would be their preferred mode, shows that there is a large potential for increasing the amount of public transport journeys on Färingsö.
However, the gap between public transport and car journeys in regard to many important aspects – e.g. waiting time, travel time, required walking distances – indicates that there is a need for an overhaul of existing public transport services in order to make it attractive.
In the following we want to describe travellers most important decision factors and give recommendations for how an on-demand travel model should accommodate travellers' preferences.

4.2 Key parameters

In the following we want to focus on specifying key parameters for the proposed service.
RQ2: Which patterns and preferences can be observed in regard to key features and key specifications – journey duration, transfer frequency, waiting times, public transport accessibility and mode of ordering?

a. How do current journeys differ between transport modes in relation to journey duration, transfer frequency and accessibility (e.g. distance to next stop)?
b. How does travel time, wait times, distance to stops, options for transfers affect people's acceptance of the proposed new transport services?

The results of the survey serve as indication for some of these parameters for the design of the service. These parameters should be seen as complementing technological challenges but also demonstrate some important factors for maximising user acceptance.

Mode of ordering

For ordering rides, a mobile phone application seems to be the most accepted form. This could possibly be complemented by a web-interface for those who are reluctant to download an app or do not have access to a smartphone. Considering the low acceptance for ordering via phone call, establishing such a service might not be economically viable.

Pre-order time

Over 80% of respondents are willing to wait for up to 30 minutes for the bus after ordering. Thus, this should be the overall target when developing the service. Of course, any further reduction in pre-order time will potentially increase acceptance.

Number of transfers

While almost all respondents are willing to transfer once, only a small number would accept more transfers than that. Existing public transport users are slightly more tolerant, more than half of them would accept up to 2 transfers. Results from the survey also show that the majority of current public transport users only transfers once. This aligns with some of the observations in the interviews that indicate that people avoid having to transfer.

Transfer wait-time

While a large number of respondents would accept a transfer wait-time of up to 5 minutes, the acceptance drops considerably for transfer wait-times of 10 minutes or longer. Hence, transfer wait-times longer than 5 minutes should be avoided if possible.

Distance to bus stop

A distance of up to 200 m to the bus stop was acceptable for 77% of respondents and 300m was still acceptable for 62%. Distances of 500m and above would not be accepted by a majority of respondents. Existing public-transport users and the group 'open to change' were slightly more flexible.

When reporting their journeys, public transport users estimated on average a distance to the stop of 428m/468m to their bus stop. For car and hybrid journeys the distance was indicated to be over 700m. Thus, the upper limit for this parameter should be set to 450m as to not discourage existing public transport users. Overall, it is proposed that the service should be designed to aim for a distance of 200m or less between point of departure and pick-up point to increase attractiveness for all user groups.

3.2 Design challenges and recommendations

Apart from these parameters, some observations that emerged from this study point towards some areas that might provide some additional challenges.

Predictability and control

The most important decision factors according to the survey results mostly relate to the aspect of time. Travelers want busses that are on time, don't take too long to reach the destination and allow for a quick transfer to other busses. This aligns with the qualitative results that indicate that the busses delay and inconvenient buss transfers are the biggest challenge when taking public transport.

Observations from the interviews also show that traveller's discontent is not necessarily due to the length of the journey or wait times in themselves, but rather to the high fluctuance and the unreliability of schedules. Especially current and former public transport commuters emphasise the challenge of having to deal with last-minute changes and delays. In contrast, the car is perceived as controllable. Despite frequent traffic jams, the car offers travellers a much greater reliability.

In addition, interview respondents also express the need to make changes to their journey last minute, for instance when asked to pick up a child from school or when stopping by the supermarket on the way home.

For the design of the proposed service this means that reliability and control have to be a priority. Travellers should feel as though they are in control of their journey and that they are able to adjust their journey if necessary.

Different design elements in the interface might be helpful in increasing the travellers' sense of predictability and control:

- Information about the system status (e.g. number of buses running) and potential disruptions (e.g. weather warnings, earlier disruptions)
- Maps and the possibility to see and follow buses on the map.
- Options for adjusting certain details, for instance preferred transfer stops or multi-stop routes.

Transfers

One of the key parameters for the design of the service is the number of transfers required for each journey. Qualitative data shows that in the current situation, respondents are not content with transfers, mostly due to bad coordination between different bus lines and unreliable schedules that lead to increased wait times. This might be one of the reasons why the majority of respondents would not accept more than one transfer within their journey.

This leads to a particular challenge for the design: Within all current scenarios, all travellers that want to travel to locations not reached by the main line would have to change at least twice: Between the flex-buss and the main line as well as between the main line and the line that brings them to their final destination. This might lead to a lower acceptance, especially from those travellers that are already able to reach their destination with only one change (for instance, by taking a direct bus from Stenhamra to Brommaplan). There are some design implications related to this particular challenge:

- The main-line route should be planned in a way as to maximise the amount of stops directly connected to Brommaplan. As an indicator, current traffic data can be used for determining the most frequently used stops, both along the current main line (176) as well as along current minor lines.
- Transfers between the flex line and the main line should be made as effortless as possible, for instance by minimising transfer wait-time.
- Another possible way of minimising the experienced disruption through transfer is by providing adequate information through the app interface, for instance about the current bus locations or alternative ways of reaching the destination.

The decision factor "transition to other modes of transport" is rated as slightly less important to many travellers. From the interview data we learn that existing connection to the subway network (T-bana) is functioning well for travellers. Hence, the required transfers that will be part of the new service might be compensated by other benefits.

Conclusion

The main aim of this empirical study was to scrutinise the feasibility of establishing an autonomous on-demand bus service on Färingsö. Furthermore, the aim was to gain indicators for some of the key parameters of the service that would facilitate user acceptance. For this purpose, quantitative and qualitative data was collected through an online survey as well as an interview study. Based on the results we could show that while acceptance and use of the existing public transport service is low, there is a lot of potential for acceptance of a service that utilises on-demand service.

To ensure that such a service would improve travel for both existing and potential new public transport travellers, we could highlight specifications for key parameters such as the following (see also Table 17):

- The service should primarily be reachable with the help of a mobile app.
- The distance to the closest access point should not be more than 450m.
- The service should be available to order up to 30 minutes in advance or less.
- There should be a maximum of 2 transfers per journey.
- The wait time when transferring should not be longer than 10 minutes.

Table 18: Results for key parameters

PARAMETER	IDEAL CONDITION	MINIMUM CONDITION
Order mode	Mobile app and web interface	Mobile app
Pre-order wait time	10 minutes	30 minutes
Number of transfers	1 transfer	2 transfers
Transfer wait-time	5 minutes	10 minutes
Distance to pick up	200m	450m

Furthermore, qualitative data indicated that the design of the service should address two major challenges: It should be designed for a maximum of transparency and predictability and allow a maximum of control to the user. Key design elements here are a wide access to information, such as vehicle positions and network capacity.
Another major design challenge is to minimise the disruption of journey through transfers. Since the proposed service will potentially require more transfers, these have to be designed as effortless as possible, i.e. through minimising transfer wait times and information about delays and travel alternatives.

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