**RISE Viktoria // Drive Sweden // Autonomous Base Camp**

# Final Report:
## Feasibility Study on Autonomous Shuttle Solutions in Östersund


REGION
JÄMTLAND
HÄRJEDALEN

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# Prestudy overview

The city of Östersund has clear targets of being fossil free by 2030, as well as creating an attractive city environment with clean air and less congestion. New transportation solutions that facilitate the use of public transport to its citizens are therefore of great interest. There is a steady growth in the number of inhabitants, which will require functional and efficient transport solutions to create an attractive city with a high quality of life to its citizens, especially for the elderly and people with other mobility requirements.

Autonomous shuttles are a potential element in the design of the future transportation system. It could open new application areas so that public and private actors can offer efficient, convenient and clean mobility alternatives to the traditional, privately-owned car. With deployment of autonomous shuttles, Östersund municipality hopes to approach a future city with enhanced intermodality and increased public transport utility.

The initial idea to investigate autonomous shuttle services was sparked in relation to ongoing discussions of relocating Resecentrum in Östersund; from Gustav III's square in the city center to the railway station. The aim of the relocation is to promote cultural life at its current location, but also to maintain good public transport. However, as Resecentrum constitutes an important transport hub and commuter access to the city center, its movement is thought to create more demands on the transportation pathway between the railway station and the city center.

In addition to the specific case of relocating Resecentrum, there is also an evident curiosity in Östersund to test and evaluate new transport solutions to gain more competence within the field. Several use cases were therefore proposed initially to cover different perspectives regarding viability of the service and relevance to their users.

RISE Viktoria has worked together with Östersund municipality, Region Jämtland Härjedalen (Region J/H) and public transport operator Vy to perform this feasibility study where four proposed routes were discussed within the project team and through workshop exercises with other local and external stakeholders.

| | |
|---|---|
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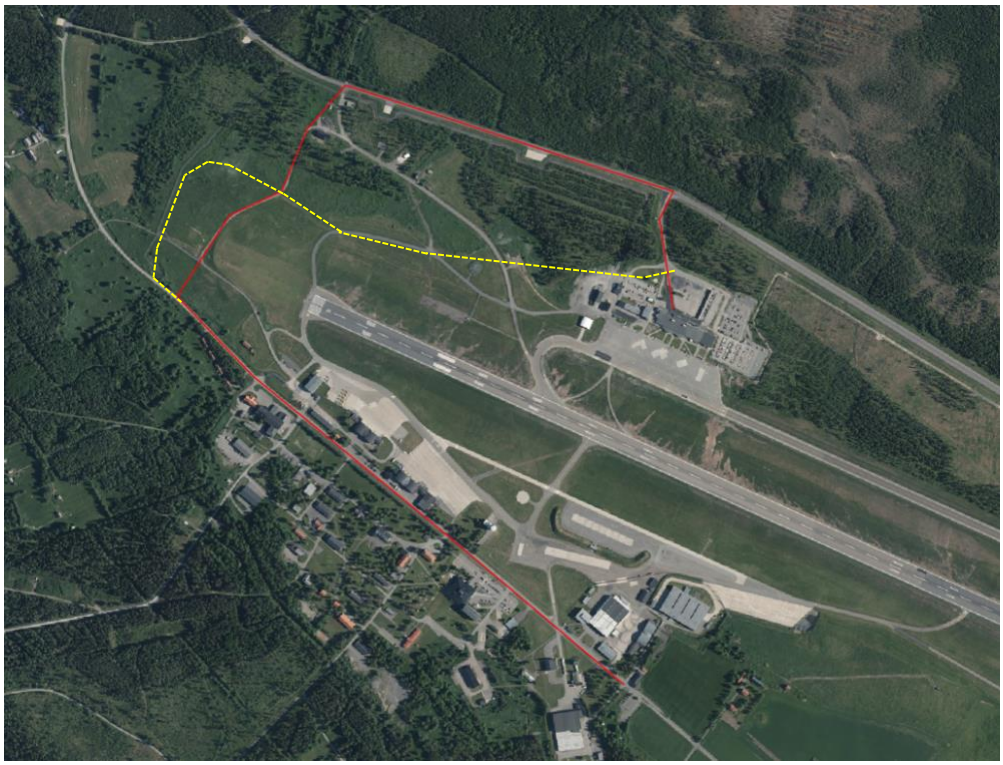
# Identifying the Feasibility of Autonomous Shuttles

## Proposed Routes

Four routes were produced as interesting for further examination as last-mile solutions with different use purposes within the city and close proximity of Östersund. Below follows a short description of each, but more details on road infrastructure is important to explore in a later stage to determine the shuttle service capability.

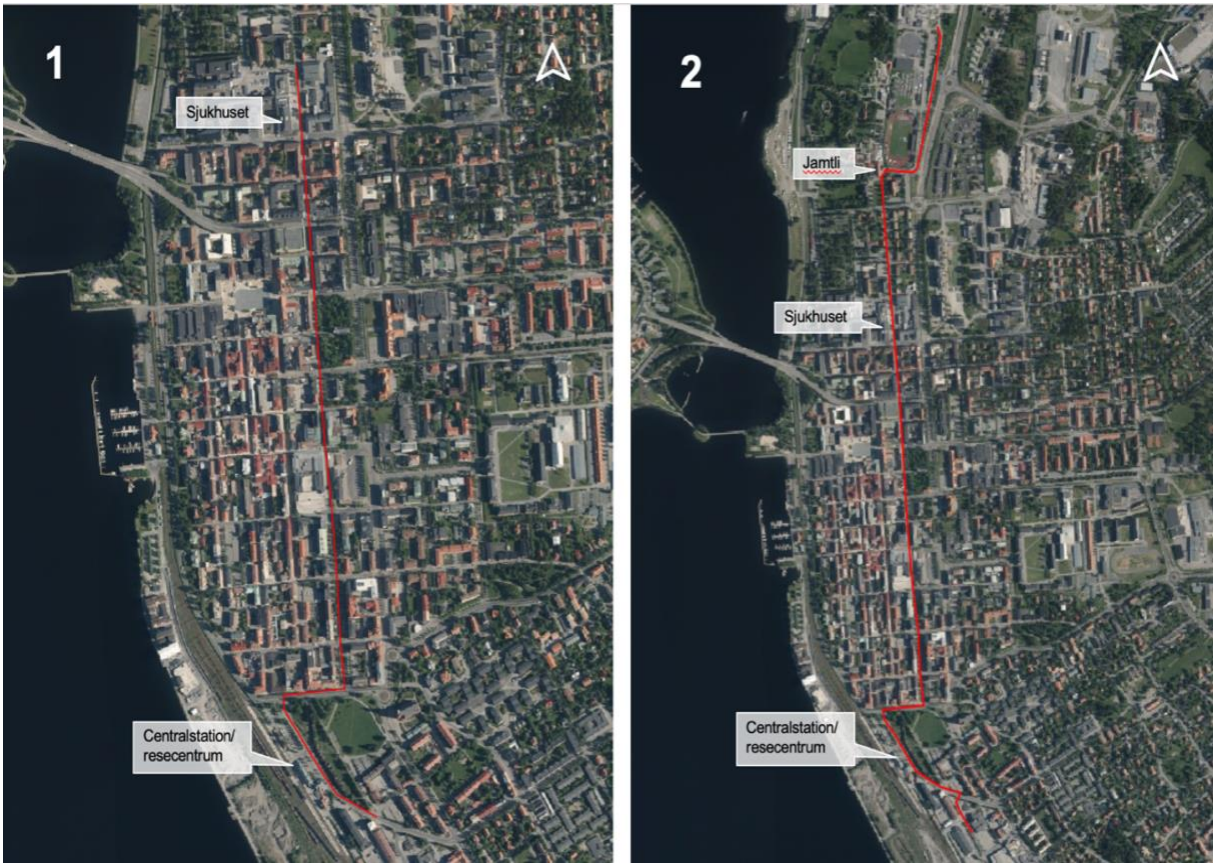
### Airport

Targets for the *Airport* case is to link the Åre Östersund Airport with Frösö Park Hotel and its associated work area. Besides the airport terminal and the hotel, the route would also continue until Frösö Park Arena. Passengers staying at the hotel or going to conferences at the arena could use this as an alternative to regular flight coaches. Furthermore, Frösö Park is planned to become a new residential area which could substantially increase the transportation demand in the area. The route is approximately 3 kilometers one way but could possibly be shortened in the future due to ongoing discussions on building a new road (yellow dotted line). A major part of the road is yet not asphalted which it will have to be in order to operate a shuttle service.



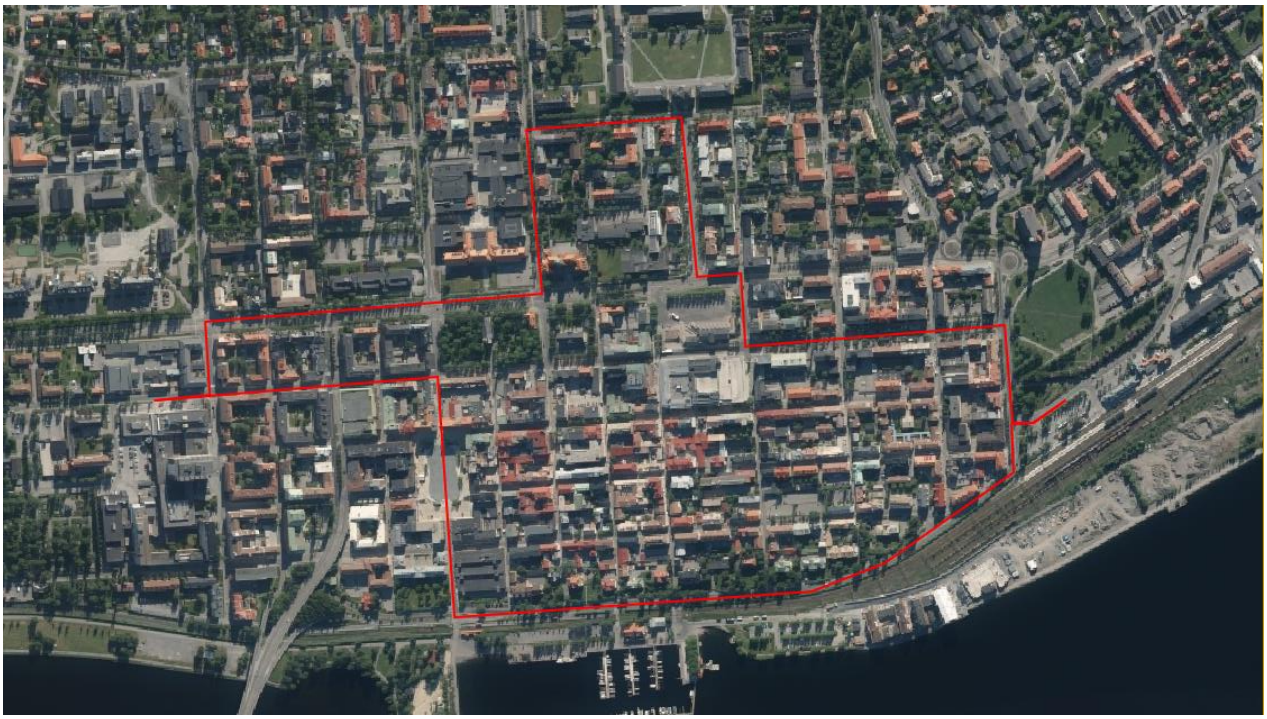
## Central Passage

Targets for the *Central Passage* is to partly relieve the current public transport in the city center, but also to create a clear connection between Östersund central station (railway station) and the hospital where an alternative is to prolong this route even further to cover Jamtli museum and car retailers (Berners) in the northern parts of the city. Another alternative is to continue this route south to cover Bangårdsgatan and a parking space at the city entrance. Several stops along the route is considered, like Gustav III square, Kyrkparken and Jämtkraft. The route length varies between 1.6–2.6 kilometers one way depending on given alternatives and route extensions.



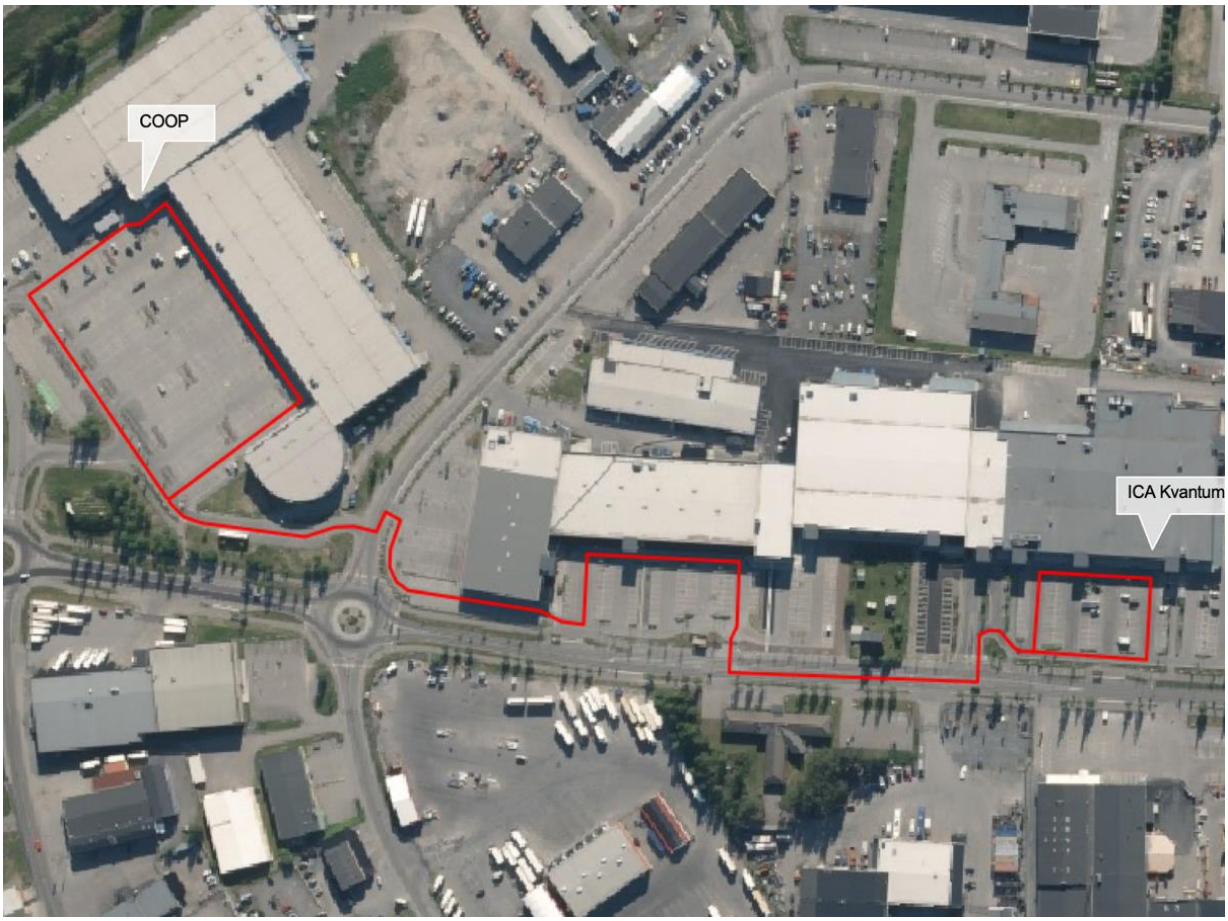
## Central Loop

Targets for the *Central Loop* is like the central passage to relieve the current public transport in the city center. However, beyond connecting to the hospital, this route also prioritizes to carry passengers from the central station to Mittuniversitetet and Jämtlands Gymnasium. The total length of this loop is approximately 3.8 kilometers.



## Lillänge

Targets of *Lillänge* is to relieve the public transport and facilitate mobility within the shopping area. Instead of expanding current bus services to operate closer to the stores, autonomous shuttles could offer an "extended arm" to these services or an alternative to driving private vehicles between stores in the area. The route is proposed to operate between ICA Kvantum and COOP along several of the existing parking lots, a total route length of approximately 1.2 kilometers one way.




In order to develop these four propositions further and discuss which one(s) that are motivated to proceed with, a co-creational workshop exercise was conducted to involve more stakeholders and gain new perspectives.

# User Perspectives & Viability Analysis

A workshop was arranged where each route was discussed amongst local and external actors, including Östersund municipality, Region J/H, public transport operator, public transport agency, service providers, vehicle industry, insurance company and more.

Both user perspective and viability of the alternatives were assessed, including possibilities/gains, potential risks and the opportunity to propose changes or additions that would make the respective solutions more feasible. Each group was then asked to present their choice of most interesting case based on these perspectives. A following joint exercise was also performed where every individual was allowed to change her/his mind according to different statements. See **Appendix 1 & 2** for detailed results and discussions.

After concluding workshop results, the *Central Passage* and *Central Loop* cases were chosen as most interesting and relevant to proceed with due to the outcome of performed exercises and succeeding discussions with the project partners. Both routes were seen as valuable to the citizens of Östersund and offers viable options to create services that gives good brand exposure with high environmental impact without being too expensive in relation to presumed usage. Even though results from the joint workshop exercise showed that the Central Loop was least preferred, further analysis of the Lillänge case turned out to demand a lot of road infrastructure changes and the Airport case is thought to be less motivated as flight coaches already exists and the number of travelers is low.

## Central Passage

Alternative route 1 from the Central Passage option with an extension north to Berners (car retailer) was chosen as most interesting of the two propositions, running between the railway station and Berners (car retailer). Beside the scope of this study, there are ongoing discussions to relocate Resecentrum (a central hub for city bus traffic) to the railway stations. An autonomous shuttle service could become a viable mobility alternative for passengers going from this new Resecentrum, for visitors to the hospital or Jamtli museum, or for those that work in the Berners area. Berners could also be a possible location for the shuttle bus garage and/or charging of the vehicles. Some parts of the route are located at existing bus streets along Kyrkgatan, which could be utilized for shuttles instead (or a mix of the two if the shuttle service should be a complement to the existing public transport). Some roads between the crossing Kyrkgatan-Färjemansgatan and Jamtli museum are narrower. The narrowest part is measured to 6.6 meters including parked cars.


Main elements of the proposed route:

- 3 left turns
- 2 intersections with traffic light
- 30–50km/h (mostly 30–40km/h)
- 5.2km round trip
- Estimated one-way route time: 13 minutes (assuming average operational speed of 12.5km/h)

Feedback from Autonomous Shuttle Provider:

Some parts of the trajectory have no buildings (between Jamtli and Berners) and will require navigation support to operate without problems. GPS-measurements of the total length might be enough to determine the required amount of support. The speed limit seems to be 40 km/h on parts of the route which might be challenging as other vehicles likely will overtake the shuttles, creating risky situations. A suggestion is to reduce the speed limits of some roads to facilitate shuttle operation. Road width does not seem to be a problem along this route for shuttle vehicles to operate. The narrowest part is 6,6 meters wide including parked vehicles, which might be challenging during winter with snow banks, but it has to be further analyzed. At least two vehicles will be required to maintain good service.

## Central Loop

This route is motivated as an option to also enable service for passengers going to Mittuniversitetet and Jämtland gymnasium. During the workshop exercises, an alternative modification was presented as a "vertical elevator" running from Västra station via the hospital and onwards to the university (see yellow dotted line). That alternative could offer a complement to the existing public transport where passengers use shuttles to travel up/down the city center and can easily change to buses going in the horizontal direction at Kyrkgatan. The original proposition is analyzed within this study, but the alternative route could be addressed during a later stage if it turns out to be interesting.

Main elements of the proposed (original) route:

- 7 left turns
- 4 intersection with traffic lights
- 30–50km/h
- 3.8km round trip
- Estimated round-trip route time: 19 minutes (assuming average operational speed of 12.5km/h)

<u>Feedback from Autonomous Shuttle Provider:</u>

There are nearly no queues, a lot of parking spaces, few bicycles and a lot of space in the streets. Many of the streets have speed limits of 40-50km/h and hence autonomous shuttles driving in 20km/h will not be any success. They will become challenging for other traffic to handle and result in worsened traffic flows.

The *Central Passage* case was chosen as the most relevant and viable option to proceed with detailed service design and cost calculations since its less problematic in terms of handling other road users and make a difference rather than aggravating the general traffic flow.

# Service Specifications – Central Passage

Travelling between the railway station and Berners takes about 6 minutes by car or 14 minutes with current public transport[1], so in order to offer a favorable alternative to the citizens, visitors and guests, we recommend that the shuttle service at least not exceeds 20 minutes per one-way trip. This is thought to be acceptable for people that are used riding with public transport, especially if the shuttle service is tailored to operate with adaption to incoming trains or regional buses. However, it is harder to motivate private car owners to change to shuttles unless these can use dedicated roads when congestion is higher in the city during rush hours. Another solution is to offer low ticket prices and prizeworthy parking spaces in close proximity to the railway station or Berners so that car owners see cost benefits with using shuttle transit as a last-mile option. As Östersund will see an increased number of inhabitants in the future, autonomous shuttles might be the solution to create a more attractive city environment with less cars, but only if the service and its business model is proven reliable to customers.

## Included Stops

The proposed route is currently trafficked by city buses and hence the shuttles could use the existing bus stops with some additional stop at Berners. An initial idea is that both services share the same route to increase accessibility, though some bus lines could potentially be replaced in the future if the shuttle service turn out to be appreciated enough to be scaled up and offer higher passenger capacity. The existing bus stops are suitable for shuttle vehicles as well according to a provider of autonomous shuttles.

## Garage and Charging Spots

No locations for shuttle shelter or charging has been determined. Berners, Jämtkraft or Jamtli are potential stakeholders that might see value in offering these facilities. There are municipal charging spots located at the railway station (22kW or 3.7kW) that might be possible to use. Moreover, there are existing charging possibilities at Jämtkraft and Jamtli.

[1] maps.google.com/maps

### Operating hours and frequency of service

A weekly schedule was proposed with inputs from the public transport agency in Region J/H. This schedule will be used as basis for cost calculations from the autonomous shuttle provider, who can also suggest modifications to better suit the operational parameters of their vehicles.

| | |
|---|---|
| *Weekdays:* | Operating between 06:00 – 22:30<br>06:00 – 18:00; every 15th minute (4x per hour)<br>18:00 – 22:30; every 30th minute (2x per hour) |
| *Saturdays:* | 10:00 – 17:00; every 30th minute (2x per hour) |
| Sundays: | 10:00 – 16:00; every 30th minute (2x per hour) |

# Shuttle Provider Assessment

Recommendations and cost estimations for deploying a shuttle pilot in Östersund has been provided by Applied Autonomy, a Norwegian company that delivers knowledge, solutions and services for autonomous transportation.

Their main recommendations and takeaways for Östersund is presented in the table below. Another major consideration is whether Östersund should implement the complete trajectory or not to begin with. For instance, in Kongsberg, Norway, a collaboration between EasyMile, Kongsberg Municipality, Applied Autonomy, Nettbuss, the Norweigan Public Roads Administration and Brakar initiated a stepwise implementation of autonomous shuttles last year (2018)[2] to support a good communication with the citizens. Quoting Olav Madland from Applied Autonomy; *It is important to tell the citizens that this new service is a pilot project with completely new technology. They will be disappointed if they think they get mature ISO certified vehicles running fast without an operator. Stepwise implementation is just to make the project a success, not a fault. Risk assessments can be done for the chosen trajectory as a whole but apply for permission to DOT (Transportstyrelsen) for each phase.*

As a suggestion, Östersund could start stepwise implementation by choosing only one half of the trajectory as first/last-mile transportation between the railway station and the city center, or between Berners and the city center. This would decrease initial costs and offer a possibility for Östersund to analyze whether the service is appreciated by its citizens and if an extension by the other half is a relevant next step.

[2] https://easymile.com/pilot-project-of-autonomous-bus-service-underway-in-kongsberg/

| Risks | Reasons why | Tasks |
|---|---|---|
| Speed limits at 40km/h and above | Will not be possible to get permission to implement shuttles driving in those speeds. DOT in Norway accept trajectories with higher speeds, but policies have to be verified for Sweden.<br><br>Moreover, speeds above 40km/h increase the probability of other vehicles overtaking the shuttles and creating risky situations. | Reduce speed limits to at least 30km/h along the trajectory. Some parts of the chosen route have 40km/h.<br><br>(However, the current average speeds in the city in around 20km/h) |
| Reduce unnecessary stops | Better performance of the vehicles | - Keep snow banks out of the trajectory<br>- Improve the line during winter season. |
| Lack in navigation due to missing support | The bus needs assets for navigation support | Install navigation plates at some parts of the route |
| Reduced parking due to the space need for the vehicles | The bus needs space to drive | The chosen trajectory seems to be ok |
| Bus stops not prepared | People need to easily get on and off the vehicle | The chosen trajectory seems to be ok |
| Need of many shuttle vehicles due to long operation hours every day. No time for charging. | The costs will be very high for the vehicles and their operation | Reduce the operation times. Maximum driving is 14 hours in summer time, and half that time during winter due to use of AC. |

The proposed time schedule has been used for cost estimations, but it will be hard to motivate with reasonable amounts of vehicles due to charging times. Every 15$^{th}$ minutes during weekdays between 06:00 – 22:30 seems not to be possible with the relatively long trajectory of the *Central Passage.*

# Estimated Service Costs

Two different setups have been simulated to offer alternative next steps. The first setup (**Setup 1**) is for 2 shuttles whereas the other (**Setup 2**) analyze the additional costs of adding a 3$^{rd}$ shuttle for more capable system. The costs are given in SEK and is based on a 9 months pilot along the *Central Passage* including both project setup and operation.

A lot of the costs are related to reimbursements to the vehicle hosts as well as renting the shuttle vehicles. To reduce the costs of running a 9 months pilot in Östersund, it is therefore recommended to oversee the proposed time schedule and discuss whether three vehicles are actually required to manage the service that Östersund wants. A reduced number of operating hours would decrease the costs for vehicle host reimbursements and possibly also the number of shuttles needed to manage operations; which would significantly lower the investments for Östersund if they decide to proceed with a pilot. Consequently, below results can be viewed as a

"worst-case-scenario" regarding investments in running a pilot along this route. However, some additional costs might appear as no estimations for possible navigation support required or other uncertainties have been provided.

## Setup 1 – Costs

| | Quantity | Cost Project phase | Cost Operation | |
|---|---|---|---|---|
| Documentation to apply for pilot permits (SAR report) | 1 long route | 165,000 | | |
| Project lead and follow-up | 70 hours | 55,000 | | |
| Signage along route, inform public and transport of vehicles | | 440,000 | | |
| Setup simple application to show real time location and included stops | 2 shuttles | 110,000 | | |
| Training operators to control the vehicles | 6 persons | 165,000 | | |
| Adapt shuttles to the chosen route | 2 shuttles | 388,388 | | |
| Documentation of routines for different actors | | 35,750 | | |
| Renting shuttle vehicles including software, service and insurances – weekdays | 2 shuttles for 9 months. (based on proposed time schedule) | | 2,970,000 | |
| Renting shuttle vehicles including software, service and insurances – weekend days | 2 shuttles for 9 months. (based on proposed time schedule) | | | |
| Reimbursements to vehicle hosts | 2 shuttles 9 months. (based on proposed time schedule) | | 2,200,320 | |
| Cleaning and maintenance of vehicles | 2 shuttles for 9 months | | 161,280 | |
| Renting garage spot | 2 shuttles for 9 months | | [TBD] | |
| IT-integration of the shuttle service with the public transport system, data collection for ordering transport | 2 shuttles for 9 months | | 63,360 | |
| Control center service | 2 shuttles for 9 months | | 198,000 | |
| SUM | | 1,359,138 | 5,592,960 | 6,952,098 SEK |

## Setup 2 – Costs

| | Quantity | Cost<br>Project phase | Cost<br>Operation | |
|---|---|---|---|---|
| Documentation to apply for pilot permits (SAR report) | 1 long route | 165,000 | | |
| Project lead and follow-up | 70 hours | 55,000 | | |
| Signage along route, inform public and transport of vehicles | | 440,000 | | |
| Setup simple application to show real time location and included stops | 2 shuttles | 110,000 | | |
| Training operators to control the vehicles | 9 persons | 247,500 | | |
| Adapt shuttles to the chosen route | 3 shuttles | 499,356 | | |
| Documentation of routines for different actors | | 35,750 | | |
| Renting shuttle vehicles including software, service and insurances – weekdays | 3 shuttles for 9 months. (based on proposed time schedule) | | 4,455,000 | |
| Renting shuttle vehicles including software, service and insurances – weekend days | 3 shuttles for 9 months. (based on proposed time schedule) | | | |
| Reimbursements to vehicle hosts | 3 shuttles 9 months. (based on proposed time schedule) | | 3,300,480 | |
| Cleaning and maintenance of vehicles | 3 shuttles for 9 months | | 241,920 | |
| Renting garage spot | 3 shuttles for 9 months | | [TBD] | |
| IT-integration of the shuttle service with the public transport system, data collection for ordering transport | 3 shuttles for 9 months | | 95,040 | |
| Control center service | 3 shuttles for 9 months | | 297,000 | |
| SUM | | 1,552,606 | 8,389,440 | 9,942,046 SEK |

In addition to the total costs, Applied Autonomy recommend counting on 15% extra costs for uncertainty.

# Analysis

This feasibility study was tasked with investigating the viability and relevance of autonomous shuttles as a new mobility option that can facilitate the use of shared transport in Östersund. Our conclusion is that the current technology is capable of running the chosen route (Central Passage), and that this inner-city service has the potential to offer high public utilization. However, it is important to consider whether the estimated cost of service and gained benefits are worthwhile an actual investment;

1. What are the exact issues and solutions that travelers already in the area see for increased transit use? How can we adopt as much as user perspective in designing a better experience for them?
2. How does this service compare to existing public transport alternatives regarding costs per ride delivered? Is it motivated within the operational parameters of autonomous shuttles to see this as an option regarding overall travel times and comfort for users?
3. What are the potential gains in environmental impact compared to the use of private vehicles?

To make steps forward the first question requires either a new survey and qualitative interviews, or access to the detailed survey answers rather than descriptive statistics. The latter questions can be analyzed using estimations and calculations based on proposed service costs and knowledge of autonomous shuttle properties.

## 1. Questionnaire

The objective of the proposed questionnaire is to find more detailed and updated origin destination data and to find the qualitative judgements, attitudes, motivations, etc. for not using transit and the willingness to change and under what conditions. If focused on only the latter part, the number of respondents can be smaller because we have lower demands on representativeness of the sample. No matter the number of respondents, measures should be taken to take representativeness into account, from an inclusion standpoint. If a large-scale survey is planned, make sure to include a smaller qualitative investigation with more depth to complement the survey.

Example of Questions:

***Demography***

Age: Gender: Occupation:

Living situation: Access to car (Y/N):

***Current transport behavior***

1. Where do you typically travel in Östersund – in your daily life or when visiting?
2. What factors are most important in regard to your transport behavior?
3. How did you get here today?
4. Are you familiar with any possibilities to get here using public transport?

***Future attitude***

1. Are you likely to travel between A and B?
2. What are your needs concerning going from A to B?
3. Can you see yourself going from A to B using a shuttle service if it was available?
4. How would a shuttle connection between A and B potentially make any difference to you?
5. What would make or break that kind of service?
6. What are your wishes/demands for starting to use that service?
7. Further comments

# 2. Rides Delivered & Cost Per Ride

Considering a weekly schedule as proposed earlier, some simple calculations can be done regarding number of private vehicle trips prevented as well as the potential cost/value of those prevented trips, based on three scenarios: maximum capacity (100%), reasonable capacity (75%), and half or low capacity (50%).

| **COST PER TRIP (based on 9 months pilot investment)** | | | | | | |
|---|---|---|---|---|---|---|
| *Shuttle passenger capacity* | No. vehicle trips prevented per departure | No. vehicle trips prevented per day (weekday) | No. vehicle trips prevented per day (weekends) | No. vehicle trips prevented per week | Total vehicle trips prevented during pilot (9 months) | Cost per vehicle trip prevented |
| 50% | 7 | 798 | 196 | 994 | 38766 | 179,3 SEK |
| 75% | 10 | 1140 | 280 | 1420 | 55380 | 125,5 SEK |
| 100% | 14 | 1596 | 392 | 1988 | 77532 | 89,7 SEK |

The cost for a single-ticket on the city buses in Östersund is 30 SEK[3] and hence it will be important to design a shuttle service where travelers can pay the same (or less) amount in order to run a viable business model. With the combined investment and operational cost estimation of 6,952,098 SEK for the *Central Passage* case, it is evident that additional funding is needed to match the ticket prices for existing bus traffic. These calculations can be updated if Östersund decides to proceed with a long-term integration of autonomous shuttle services as opposed to a 9 months pilot, where they might improve the business model further to include more frequent departures and funding from other stakeholders or initiatives.

# 3. Potential Emission Reduction

By using electric autonomous shuttles, sourcing clean energy, there is potential to reduce local $CO_2$ emissions through the reduction of privately driven vehicles. However, to reach those benefits, it is crucial to design a service where car owners get clear incentives and see the gains of changing to first/last-mile shuttle transport. Good connections to existing public transport and parking spaces are therefore important parameters that should be considered before starting services that aim to gild the local transport ecosystem. Considering the *Central Passage* case, easy calculations show that a replacement of private car trips with shared autonomous shuttles can theoretically reduce local $CO_2$ emissions in Östersund with 28 – 56 metric tons during a pilot

[3] https://www.nettbuss.se/globalassets/tidtabeller-ostersund/sbo_prislista_buss.pdf

test depending on the passenger capacity of each shuttle. See assumptions and calculations below.

*Assumptions:*
Diesel emissions: 2,81 [kg $CO_2$/l][4]
Fuel consumption: 0,5 [l/10km][5]

Route length (return trip): 5.2 km

| **$CO_2$ EMISSION REDUCTIONS (based on 9 months pilot)** | | | |
|---|---|---|---|
| *Shuttle passenger capacity* | No. vehicle trips prevented per departure | Total vehicle trips prevented during pilot (9 months) | Emission reductions during pilot [tons of $CO_2$] |
| 50% | 7 | 38766 | 28,3 |
| 75% | 10 | 55380 | 40,5 |
| 100% | 14 | 77532 | 56,6 |

It is important to consider these numbers as theoretical estimations. They are built on the assumption that all 50 – 100% of the passenger capacities are people using the shuttle service as a substitute of using their private (diesel driven) vehicle. Some might use the shuttles instead of walking or biking for instance, which would not result in any emission reductions.

# Next Steps and Financial Sources?

A suggestion is that Östersund starts discussing a shuttle service from a broader societal perspective as user needs and behaviors have to be analyzed further to create a service that is both viable and relevant. Alternatives are to do a shorter pilot test (9 months) to learn and build decisions for next steps on that outcome, or to pursue a longer pilot that includes development and additional projects. RISE as a research institute could assist Östersund in a procurement process to finalize the budgeting agreements with potential operators, selecting an operator, and helping the operator, municipality and consortium file for all the necessary permits.

[4] https://www.miljofordon.se/bilar/miljoepaaverkan/

[5] https://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Bransleanvandning-for-bensin--och-dieselbilar/?visuallyDisabledSeries=4f4129a2802bacf4

A different approach forward is to investigate the introduction of an on-demand feeder service to approach a solution that has not yet been tested in Sweden. This service could however be comparable with accessibility-adapted solutions in the current transport system, like *Flexlinjen* in Gothenburg, a bookable bus service operating in limited areas to facilitate public transport for more people (e.g. as an alternative to "färdtjänst"). According to a document from the City of Gothenburg[6], the cost for Flexlinjen is about 30 million SEK per year and management cost per travel is around 110 SEK; which is comparable the cost per vehicle trip prevented in this study. Typical locations for on-demand service are located at Frösö (red marking of potential residential area), where autonomous shuttles could serve as feeders to public transport going to the city center. This could decrease the need of private vehicles as well as facilitating movement for elderly and people with movement disabilities in the area. Further work is required to estimate the relevance and viability of this option (which area to serve, how to optimize pick-up of passengers along a route, where to connect with bus traffic etc.), but a functional solution with on-demand service can have good societal and environmental impact. And as it has not been tested in Sweden yet, the possibilities for funding is higher.


There are several different funding opportunities for autonomous shuttle services, such as Vinnova's "Innovations for a digitalized and automated transport system for people and goods"[7], Energimyndighetens "Bidra till att skapa ett transporteffektivt samhälle"[8] as well as the Viable Cities project[9], which is looking for demonstration sites in digitalization and new services. Östersund should have good communication with potential local stakeholders that might be

[6] http://tiny.cc/uu1j8y

[7] https://www.vinnova.se/en/calls-for-proposals/Strategic-Innovation-Programme-Drive-Sweden/smart-mobility/

[8] http://www.energimyndigheten.se/utlysningar/bidra-till-att-skapa-ett-transporteffektivt-samhalle2/

[9] http://www.energimyndigheten.se/utlysningar/viable-cities-utlysning/

interested in participating in a future shuttle pilot, which could generate some financial support. However, a plan to integrate this service with the public transport system will probably be required to create that interest where different actors see their long-term value and possible business strategies.

# Appendix 1

## Group exercise – Workshop 2019-05-20

This is a summary of the group exercises that were performed during the workshop. All user and viability comments and thoughts are statements combined from each of the 5 groups.

### Case 1 – Airport

#### User perspectives

Travelers or airport/airline staff staying at Hotel Frösö Park are considered possible users for this case. A self-driving shuttle service could be used for airport–hotel return trips, or possibly replace airport coaches to regular traffic if connected to the public transport network. Frequent departures with timetables taking delayed flights into account is important to make this an option for users, they should not have to spend time waiting for a shuttle at the airport terminal. Anyhow, the shuttles will have to run on narrow gravel roads to reduce total route length and some changes are possibly required for the service to function properly. There are currently plans to asphalt a new road between the airport and Frösö Park which could ease deployment of shuttles. Ticket prices for the shuttle service should be low to attract more users.

#### Viability perspectives

*Possibilities*

The route itself is simple to start with, and a new road will be created during this year which will further shorten the distance (and hence also travel time) of each trip, to approximately 2.5 kilometers. As these roads are less occupied compared to city Centre alternatives, the risk of shuttles halting or interfering with other traffic is low. There are known garages nearby for rent to store the vehicles, and a residential area may be developed at Frösö Park in the future to which the shuttle service could preferably be extended.

*Risks*

This case was considered not very interesting due to uneven and mostly low passenger flows. As planes arrive, the capacity requirements of the shuttle service are highly dependent on whether their passengers are going to Frösö Park Hotel or not. Initial costs to cover the possibility of high capacity and prepare a new road to shorten route distance can thus risk too extensive initial investments in relation to trips delivered. As the route is close to the airport, there is also higher risk for drifting snow which could affect the operational ability of the shuttles.

*Service details & route changes*
The shuttle service could become more beneficial if the scope is expanded to also connect seamlessly with bus line 3 between Frösö Park and Östersund city. Frequent shuttle departures could eventually make the current airport coaches redundant. A shortened route from building the new road as well as few stops (Airport terminal, Frösö Park Hotel, Conference building) is important to increase attractiveness, but more research of traveler/visitor transport patterns is necessary. At least one shuttle is needed. Actors like Frösö Park, Swedavia and Stadsbussarna should be involved to make this a viable transport option.

## Case 2 – Central Passage

### User perspectives

The joint opinion is that this alternative would be suitable for many different users and that it would increase the availability for user categories like elderly without cars, children and people with reduced mobility. To make the service as attractive as possible, it should cover local shopping, work areas, ease hospital visits and connect seamlessly with the train station and Resecentrum at frequent departure rates. Shuttle access to a city entrance parking lot could facilitate private car owners to utilize the service as well. All in all, the service should also include simple apps or payment methods and beneficial ticket prices to attract this great variety of potential users. Further analysis of traffic flows along this route is required to determine whether the shuttles will come to a lot of stops along the way due to temporary obstacles, which could lead to slow operation.

### Viability perspectives

*Possibilities*
Both alternatives offer good visibility and PR for self-driving shuttle pilots, though alternative 1 is probably easier to implement at first. On the other hand, alternative 2 could provide parking and charging station opportunities at Berners. A larger investment in shuttle fleet is needed due to many possible user groups, but a high degree of usage is still thought to make this a relevant option. Kyrkgatan is an attractive route for passenger transport since it is a bus street today.

*Risks*
Since parts of the route is already attractive for other modes of transport (cars, public transport), there are risks with shuttles slowing down traffic and interfering with the existing flow. There are many intersections where the shuttles could have a hard time interacting with other traffic. Moreover, the route has to be analyzed whether snow-plowing and deicing is sufficient for self-driving operation.

*Service details & route changes*

There are some propositions of adjustments that could make this case more viable and relevant to more users. As Kyrkgatan is already occupied by a lot of other traffic, it could be interesting to re-route the shuttle service to Storgatan instead. One proposition is to extend the northern part of the route to ICA Maxi (an extra addition of some 1.2-1.7 kilometers depending on given alternatives). Another proposition is to extend the southern part of the route to Bangårdsgatan (about 300-500 meters extra) to reach a garage and good charging possibilities. Otherwise, there is a need to investigate available depots and charging locations. At least one shuttle in each direction is preferable, and it should be few stops in the city center to minimize travel times (relevant stops are Centralstationen, Mittpunkten, Kyrkparken, Sjukhuset & Jamtli). Other questions arise whether the shuttles could utilize parking spaces outside the city and if the service could be combined with upcoming construction periods in the city center. More user research of visitors/tourists is required to find out more about their transport behaviors and needs.

Länstrafiken, Regionbussarna, Region J/H, Destination Östersund, Östersund kommun, event organizers at Jamtli/Östersund Arena and shop/property owners are actors that could be involved in this case.

## Case 3 – "Central Loop"

### User perspectives

User groups are similar to the previous case ("Central Passage") with the addition of students at Mittuniversitetet and commuters from Västra station. The route is long and should be corrected to become a feasible option, possibly by combining with the previous case. The service should be adapted to work/study hours and integrated with the public transport network as well as offering beneficial ticket prices to attract the intended user groups.

### Viability perspectives

*Possibilities*

A joint opinion is that the route is relevant, but with some changes to prioritize access to Mittuniversitetet and getting past the elevation of Östersund city (a "vertical elevator"). As a suggestion, one part of the loop is erased to create a more attractive and less time demanding route for the users. Beyond students at Mittuniversitetet, this shuttle service could give value to other specific user groups like elderly and hospital visitors that gain from being transported up the hilly city environment.

*Risks*

This route covers many streets where some currently involve a lot of traffic or other temporary obstacles like parking on both sides (Rådhusgatan, Gröngatan, Regementsgatan, Strandgatan). An issue is therefore whether it risks slowing down other traffic and public transport. Also, the loop is quite long (3.9 kilometers) and risk users not seeing is as a beneficial way of transport. Moreover, it is important to analyze whether these streets are wide enough for self-driving shuttles (about 6 meters width requirement to fit one shuttle in each direction). More user research is needed to determine which parts that are relevant and which that are redundant.

*Service details & route changes*
If the route should be used as proposed initially, at least 1-2 shuttles should operate in each direction (clockwise and anti-clockwise) to help decrease travel times. An alternative route to prioritize the "vertical elevator" theory is to cut the loop in half and cover the hospital, university and gymnasium. This approach would create less problems from interfering with other traffic and public transport.

Östersunds kommun, Region J/H, Sjukhuset, Jämtkraft, Jernhusen, Berners, Mittuniversitetet, Biblioteket, shop and property owners are actors that could see value in being involved in this use-case.

## Case 4 – Lillänge

### User perspectives

Visitors and customers to Lillänge Shopping Centre are considered as most important users to this case. Furthermore, a good connection with the existing public transport network could facilitate access for single households without a car. Elderly and people with reduced mobility can easier move between shops, while others could use shuttle transport instead of moving their car short distances within the Lillänge area. Frequent departures, lots of stops and low ticket prices (lower than using your private car) are important measures to make this a viable option.

### Viability perspectives

*Possibilities*
Most of the participants thought this route is possible to operate. By some, it was discussed as the most promising to reduce private car usage in its area whereas other cases are more aimed as complements or replacements of existing public transport. The route is short and should therefore not require many shuttles.

*Risks*
As an extensive part of the route consists of parking lots, there is a risk of tardy shuttle operation due to a lot of other car and pedestrian movement. Also, as the route debouch just above a

roundabout at Hagavägen, the shuttle might face even more difficulties to operate without delays. One part of the route is private ground and might result in some hassle. Other concerns were "Who would want to pay for the ride?" and "What problem does it solve?". It is unclear whether car owners would use this service instead of just moving their car to the next store since they might drive home afterwards anyway and do not want to ride with a shuttle back to where they initially parked. Lastly, some discussed the fact that politicians in Östersund generally prioritize to invest in a better city center, rather than areas in its outskirts.

*Service details & route changes*

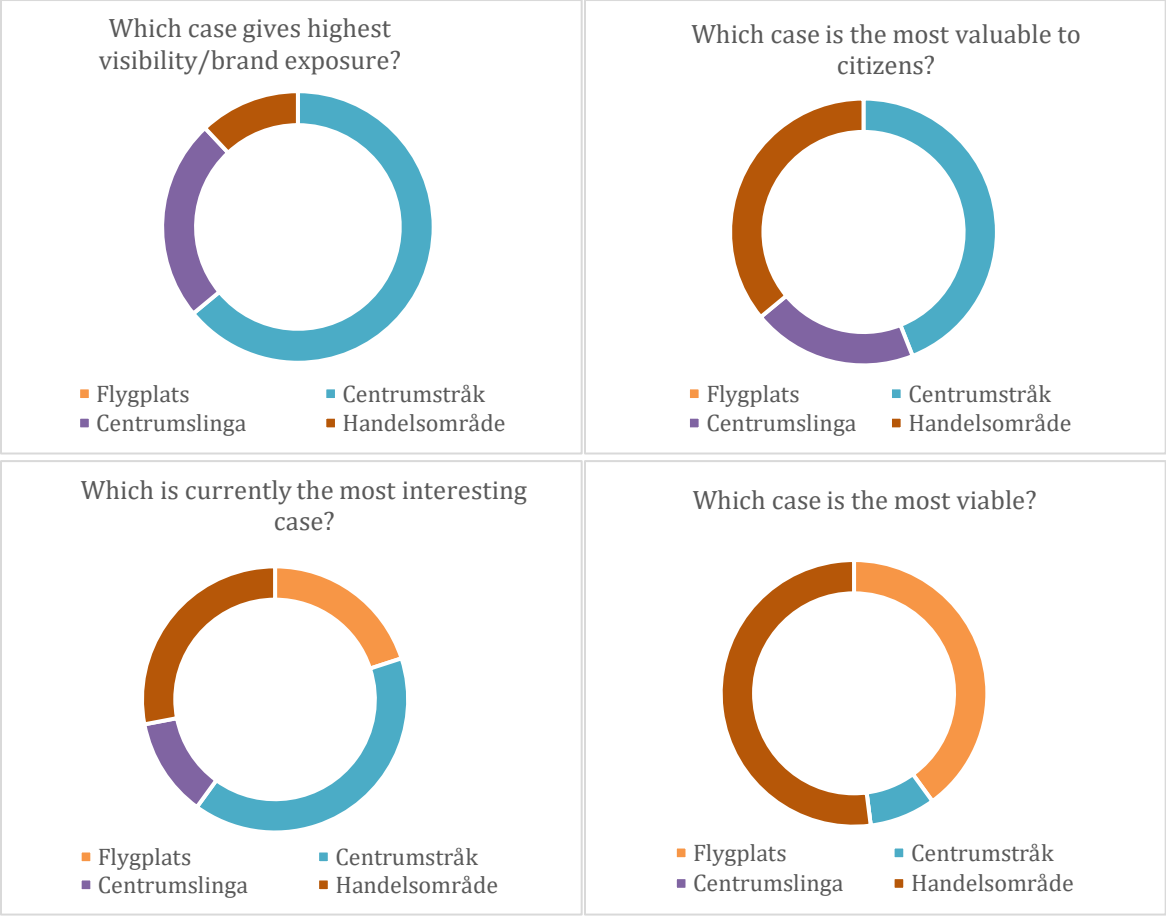
The route needs to become smoother and we should discuss how to avoid the "big road". A proposition is to follow the buildings all the way to become a more attractive alternative to potential users (see map). As the route is currently short, it should be enough with 2 shuttles, but if the service become more popular (and the route is extended to other stores), more shuttles could be needed for capacity reasons. To make this case more attractive to others than just those who drove their car to Lillänge, stops and timetables should be extended to also connect with city bus and region bus stops in the close proximity. There is a garage and culvert underneath ICA which could be included as part of the route to avoid the issue of private ground if it becomes a problem.

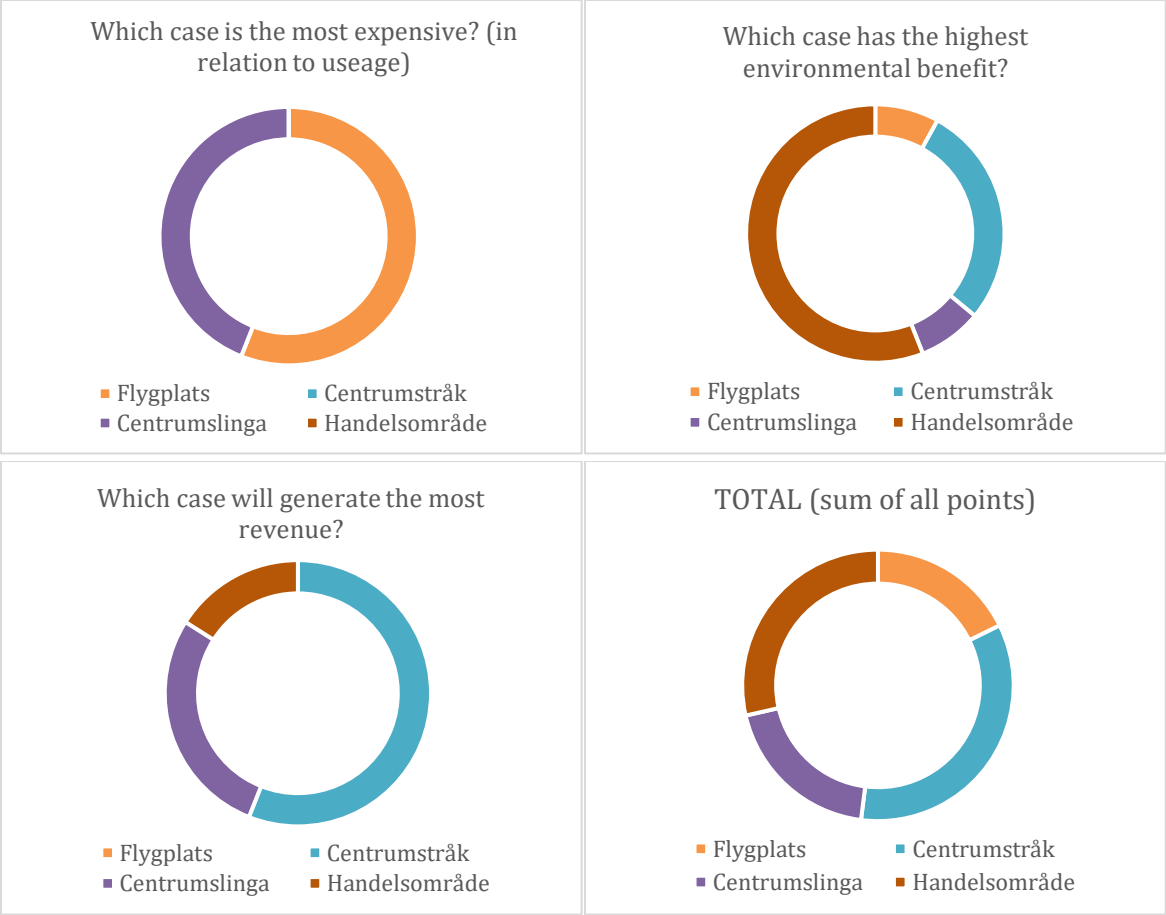
Shop owners are crucial actors to get involved in this case as co-financers. Some discussed that it might be favorable to let these shop owners develop the service themselves to see its values and potential to increase customer numbers. If the route is extended to involve connection with other public transport, actors like Östersunds kommun, Stadsbussarna and Region J/H should preferably be involved.

# Appendix 2

## Joint discussion – Workshop 2019-05-20

Each group discussed all 4 use-cases and presented which one they together chose as most interesting from a user and viability perspective. Each participant was allowed to change their mind after listening to the other groups. Below are results from a follow-up exercise where every individual chose which use-case they thought was best related to the question.






***Case 2 "Central Passage"*** seems like the most attractive case, although difficult to carry out. In comparison, the participants perceived it to create the highest potential value for the citizens, and at the same time gives high visibility/ brand exposure. It is not seen as very expensive in comparison to the others. It also fits the strategy to enhance the city center and may be part of a temporary solution when Resecentrum is moved.

*Risk, question marks:* There is a lot of complexity involved regarding interference with other modes of transport (public transport, cars, delivery…). Question marks are raised linked to snow/ice and whether the streets are wide enough and whether there are too many cars parked on the selected streets. Shop keepers in the city center may not appreciate that parking spots are taken away (even though the shuttle, when running properly, may bring just as many or more customers to the shops).

***Case 4 "Lillänge"*** is also seen as attractive because it solves a real problem (congestion) and is the one that creates the most environmental value (reducing cars). It is relatively easy to put into place since no extra infrastructure is necessary. Finding place for depots/charging is relatively easy compared to the city center. It is the only one that really addresses reduced use of cars, the

other cases are more about complementing public transport (which indirectly would reduce car usage by making public transport more attractive).

***Case 1 "Airport":*** This case was dismissed by many of the groups as uninteresting since it has a lower number of potential users, the value created is not as high as the other ones (even questionable according to some groups), and it entails some infrastructure costs that make the initial investment higher than the other ones. It is perceived as "most expensive, least value to users, least visibility, low environmental benefit, least possibility to generate an income". The main benefit is that it would be relatively easy to carry out (apart from preparing the road and putting up signs/posts for the lidar). Frösö Park may also be developed to a large residential area which could open up for some other future services.

***Case 3 "Central Loop":*** It was the least interesting case, judged by the voting. It was liked by many but seen as too long. This was the one that had the most suggested changes. "It doesn't work, but with this change/condition… it would". Together with the airport, it is perceived as the most expensive. It was seen as creating value to the citizens, but not as much as the Central Passage. In every "positive" aspect, the Central Passage beat the Central Loop.