PART II

A PERSONAL RAPID TRANSIT SYSTEM

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6.1 Transportation and current action

As much of today’s literature suggests, a shift in public transit is one of several needed actions to change people’s direct and indirect demand of oil. The shift has to be appealing to those who see today’s public transit as slow, non-reliable, inconvenient, and expensive, but none the least to those who see the car as the primary mode of transportation. Thus, a new transit system has to be quick, environmentally friendly, reliable, convenient, and cheap - hence what people demand and the opposite of today’s public transit. A new transit system should attract people who already use public transportation as well as the people who rather take the car for work. But are there any systems that can take on this challenge? The following quote from an article by Anthony Perl, professor of urban studies and political science, may suggest that such a system might exist (Literary review of Canada, 2007, pg. 21).

There is also the possibility of introducing a new local transport mode that would approach the convenience of conventional automobiles while approximating the energy efficiency of public transit.

Investing in new transit systems is often expensive but if there are profits to be made from this in the long term both economically and environmentally – this should be further explored. At the moment lobby groups have formed communities that work together in the challenge to minimize the car market share, its influence and impact on urban planning. Feasibility studies, practical small-scale tests and simulations have been performed by multiple organisations since the first time the concept of PRT (Personal Rapid Transit system) was introduced in the late 1960’s. From the planner’s perspective, the important question is how these new transit systems can be implemented in the built environment.

6.2 Problematization and secondary question

Visual encroachment in urban planning is vital when discussing elevated architecture which comes with a Personal Rapid Transit system. These new environments need to be designed with care both for the users in terms of security and liveliness as well as for the general public using the city and the urban environment. It is also important how these new transit solutions are introduced and if a suitable order can be identified to implement them in different urban environments to gain acceptance from the public. Within the field of urban planning one should study if there are any general design guidelines that can secure an attractive urban environment. Basic planning ideas and solutions should be explored, because if not implemented with caution; we may have future problems with alienation within our urban environments. Problems of safety and security can become evident because sightlines and viewable connections between different levels of the urban space are vital. These issues with implementing elevated architecture in the urban environment leads up to my secondary question:

How can a PRT system be made useable and an attractive component in the urban space?

6.3 Disposition

These subjects and the secondary question will be studied and presented in three different parts: First, a study on a theory on elevated architecture, public transit demand, the PRT system, and examples of current PRT projects. Secondly, an analysis and proposal discussion on the public space and elevated architecture, the Toronto transit case, phasing strategies, and a discussion on the Toronto urban environment. Thirdly, the proposal on the Toronto waterfront consisting of a comprehensive study, design guidelines, and a detailed study on a PRT station at the waterfront. Within the work of this thesis the design guidelines will be presented in this individual part, and the comprehensive and detailed study will appear in our common proposal for Cherry Beach.

6.4 Assessment of sources

Finding materials to this study has not been difficult but the problem with the sources is that most of them come from the same groups and as it is business for these companies that deal with new technology, one has to be aware of the aspect of economic profit as well as the character of lobbyism. Also, a lot of the sources are rather contemporary as it is closely tied to current technology. Jan Gehl is a well-known author and thinker within the field of urban planning, and especially his emphasise on the qualities of urban space. Theories on the urban space and differentiated levels have been brought in the thesis in order to challenge the PRT system’s urban space qualities.
7. Transportation history, trends, and planning

7.1 New solutions of public transportation

Transportation issues have always been of great importance for building a community or a city, although the first small villages with short distances didn’t require long journeys. As time has passed, every community and city has grown in a way that the transportation issue have become more important. In fact, the evolution of technology has in most of the cases actually been the propelling force behind city development. New technical solutions have driven and determined the tasks of the planner and the architect, as the train and rail business did for the industrial age of the 18th and 19th century, and of course as the car did for most of our cities after WWII during the 20th century, and still does. Hence, contradictory to the history, our generation have grown up with fairly consistent transportation modes as the car, the bus and the train. New transit modes have been introduced when the existing ones no longer are able to perform the task (Värmdö Kommun, 2006, pg. 24). The development of canals, railway, asphalt and motorways varies over time. As the diagram describes, the knowledge of a new transportation system have been around at least about 30 years before it is actually put into practise. This has also happened when the existing transportation system have been on its peak.

7.2 Consumer requirements of public transit: Sweden and Europe

The car has held back development of public transit since it can offer individual trips and because there hasn’t been any feasible and affordable new technology available in the transit sector. Although a lot of money has been spent on improving existing public transit, the market share has stagnated since the 1950s. In the box (lower right) the relationship between the car and public transit have been described regarding their market share in Sweden since the 1950s when the car was introduced in Sweden. As the market share of public transit have stagnated during the last 50 years in Sweden and the usage of cars has increased, some people argue that this is solely because of an increase in wealth of the public. Hence more people can afford to buy a car and don’t have to use public transit, which they don’t find useful compared to the freedom of a car.

As stated above and similar to most of other countries in Europe, public transit market share has stagnated during the last 50 years in Sweden, as the use of cars have risen dramatically. In a survey done by the European Union the majority of EU citizens named the car as their mode of transport (51%). The second most popular mode of transportation for daily activities is public transport (21%), followed by walking (15%) (European Commission, 2007, pg. 9). In the same survey citizens were also asked what improvements in the service of public transportation they demanded in order to choose public transit instead of the car. The two most important improvements required by the citizens were better schedule (29%) and better connections to regular destinations (28%). Regarding better schedule the Swedes had a higher percentage (31%) compared with the average European (29%), and the Swedes also valued better connection to regular destinations higher (30%) than the average European (28%). No major differences were found between the Swedes and the average European regarding improvements of public transportation but interestingly when it comes to security of public transit the Swedes valued that to only 2% while the average European valued this matter to 6%.

7.3 Consumer requirements of public transit: Toronto

Public transit in Toronto consists of buses, subway, trains streetcars, and regional trains that connect Toronto with surrounding municipalities. The TTC (Toronto Transit Commission) is the agency
in charge of Toronto’s public transportation, i.e. investments and operation. During the 1990s provincial funding were cut back for the TTC but it is currently being restored to some extent, and existing public transit is being revitalized as streetcar lines are extended and new vehicles are introduced. The quote below displays.

There is a growing expectation that transit in general, and the TTC in particular, must take on an increased role in providing travel for people in Toronto if the city is to grow and thrive economically and in an environmentally-sustainable way. Each level of government has recently announced plans and policy initiatives, that highlight the need for greater use of transit in urban areas – the City with its Official Plan, the Province of Ontario with its “Smart Growth Council” and “Gridlock Subcommittee”, and the Government of Canada with its approval of the Kyoto Accord (Toronto Transit Commission, 2003, p. E1)

Public transit in Toronto has a tough challenge to attract people from car usage as the average auto occupancy is declining from 1.22 to 1.08 persons per car and peak period traffic conditions is now extending to 3 hours (Toronto Transit Commission, 2005). The transit market share has slowly declined between 1986 and 2001. According to the TTC Growth Strategy the percentage of Torontonians using public transit in 1986 was 25% and in 2001 the figure was 21%. The difference is greater during peak periods of the day as it was 31% in 1986 and 24% in 2001 (Toronto Transit Commission, 2005). The TTC have asked people what reasons they have for not using public transit and the most common answers were transit too slow/trip too long (27%), car faster (25%), poor connections/wait too long (19%), car more convenient (17%), and poor/in frequent service (16%) (Toronto Transit Commission, 2005). Thus, according to the survey Torontonians want a more fast and reliable transit service that is competitive with the car.

7.4 Toronto planning documents
In our research of Toronto and the Port Lands we have found several planning documents that are used when planning and phasing the development at the Port Lands. According to our individual themes of the thesis we have studied these documents to see what they say about our chosen subjects, and regarding public transit one can extract some statements on what the city wants.

Toronto By-law
The City of Toronto By-Law (No. 346-2003) is the planning document that regulates development in the central part of Toronto and is an extension of the Toronto Official plan. It focuses on a certain area of the city regarding development of land on a more comprehensive level. The By-Law maps out the important questions like for example structures of transit and roads, as well as guidelines for parks etc. It deals mainly with the waterfront, including the Port Lands, and contains principles and policies of urban planning. A few of these policies deals with rights-of-way for buses and streetcars in order to be more efficient. Another policy states that “union station will be developed to maximize its capacity as a transportation centre and restore its historic grandeur” (By-Law, 2003, pg. 4). Union station is today Toronto’s main node for public transit and is used to connect many of the adjacent communities in the more central parts of the city. One of the principles in the By-Law discusses the priority for sustainable modes of transportation (Toronto By-law, 2003, pg. 8):

A sustainable transportation system that gives priority to transit, cycling, walking and water transport and reduces the need for car use will form the basis for transportation planning in the Central waterfront. Future travel demand will be mainly met by non-auto means. Road capacity will be added only to meet local traffic needs.

Hence, the document states the development of transit that tackles the car dependency and a network of pedestrian and bicycle lanes that is given priority. As can be seen below the By-Law Central waterfront secondary plan, a transit network has been laid out in the Port Lands with links to the adjacent communities such as the East Bayfront district as well as the West Don Lands. The link to Union station and Bremner Boulevard is also evident in the transit plan.

Toronto Sustainability framework
The Toronto Sustainability framework was prepared by the Toronto Waterfront Revitalization Corporation in 2005 and deals with sustainability at the waterfront. The report presents a Sustainability action plan which deals with different subjects, where transportation is one of them. The report states that currently the Port Lands area is poorly served by transit. It points out that the main initiatives to increase public transit ridership are to convert travel lanes to bus-only rights-of-way lanes, to increase fuel taxes, road tolls, increased parking costs, and to plan for more dense development. It proposes restricting opportunities for parking on-site, designating car-free zones, opportunities for car pooling, mixed use, and bike paths and pedestrian linkages as suitable actions to create more sustainable transportation.
8. A new transportation system - PRT

8.1 Functionality

A podcar (used in a PRT system) is a small vehicle mainly for 4-6 persons that runs on or under a guideway directly to a destination chosen by the passenger with no stops on the way. Since the guideway in most cases is elevated above ground the podcar never suffers from congestion and runs independently from other traffic systems. The main idea of the podcar is for the trip to be individual, like taking a taxi or the car but still travelling by public transit, or by some called para transit. It has been described by some as a horizontal elevator, you just choose the destination by a single push on a button and then quietly ride the podcar to the destination.

8.1.1 Different modes

There are several modes of pods going directly on the guideway (on tracks or on rubber wheels), hanging underneath, or a dual mode which consists of a car that can run both on the street and on a guideway. The latter one can dock on the guideway which is then on ground level, followed by an incline and then the car runs on the guideway elevated off the ground.

8.1.2 Propulsion and monitoring

Most of the PRT systems are driven by electricity and the pods are often powered through the track with lineside conductors. A linear induction motor on the podcar with stationary conductive rail for propulsion and braking is a common solution but there are also rotary motors. A computerised system keeps track of all the pods in the system and can direct vacant pods to stations where they are needed. According to computer simulations 30% of the pods are running around the network empty and the rest of the pods are transporting passengers (Oral source, Tegnér, 2007).

8.1.3 Track layout

As mentioned above, the system avoids congestion because of its elevation over regular traffic and the track pattern that is laid out consists of several loops that are connected to each other. Density is very important because PRT probably works best in more spread out areas where there is an obvious difficulty to arrange a common transit corridor, although PRT can handle most demand of public transit even in more densely populated urban environments. Thus it is important to adjust the new PRT network after the different functions of the chosen area, and as Tegnér (Oral source, Tegnér, 2007) puts it “the PRT guideway network are built in loops around residential areas, business areas, hospital areas, terminals, university campus areas, shopping malls etc. and if possible straight through the area”. Because the podcar can only transport about four people per vehicle there is a need for a lot of them. Most PRT systems can have a headway of three seconds which means the distance in time the pods have to have between them. Compared to regular line-haul transit systems, which generally have headway of three minutes, this is an advantage of the PRT system. Stations are most likely to be designed on the same height from the ground as the guideway and offline of the network. This means pods can pass by on the regular network while the other pods can stop on the offline track to pick up passengers; hence gains in travel time for the system. Distances between 250-500 meters between stations are most suitable as the walking distance to these shouldn’t be too long. But from an economic point of view, elevated and sometimes expensive stations too close to each other are not desired. As mentioned earlier stations can also be attached to buildings or even inside indoor malls which means accessibility for physically impaired persons is increased.
9. Comparison of PRT and LRT

9.1 Capacity

Passenger capacity is crucial for any public transit system and because podcars are smaller and carry less passengers per vehicle the PRT system need a high frequency and shorter headway (distance in time between the podcars).

9.1.1 Line capacity

As the general headway for most PRT systems are three seconds or less the system is competitive to regular manual-driven line-haul transit systems which generally have a headway of three minutes. The table (upper, right) shows typical transit systems in Stockholm and their seating capacity besides the PRT system (calculating with 100% occupancy in the podcar with four seated passengers). Here the podcar has a higher seating capacity (9,600 passengers) than traditional LRT (4,680 passengers), even compared with the metro (7,560 passengers). But it should be noted that the metro also has capacity for standing passengers and that the podcar in this case has a maximum occupancy with 4 seated passengers as can be seen in the same table. As one cannot calculate with a maximum seated capacity of a podcar, a problem occurs for the PRT system although economic incentives for ride-sharing can be implemented. But regarding the capacity the podcar can actually compete with the car and regular line-haul transit, i.e. buses and streetcars, although not with subways and commuter trains as these systems can accommodate more passengers with more standing passengers.

9.1.2 Station capacity

The crucial part for implementing a PRT system regarding capacity is about designing the podcar station. During peak hours they have to have enough available podcars and berths at the station for the demand. Computer simulations for a podcar network at Flemingsberg in the Municipality of Huddinge in Metropolitan Stockholm shows that there would be a need for two podcar stations to take care of the passenger loads from a commuter rail station (WSP, pg. 19, 2007). This statement shows the emphasis that has to be on designing podcar stations and to make correct calculations and prognosis for a future podcar network. The table below from the same report illustrates what passenger capacity can be reached for a podcar station and how many berths per station are needed. The table (below, right) shows that passenger capacity is also dependant on how many people that use the podcar by themselves and how many people ride-share.

9.2 Costs

As with most of public transit systems, with a PRT system comes a great deal of initial costs and as a new system often requires a lot of users/passengers there is a need for a proportionally extensive network. As there hasn’t been any practical experience of costs for a PRT system implementation of such a new system can be argued, but since the 1960’s a lot of cost-benefit analysis and cost calculations on PRT systems has been produced. As new systems are introduced they are often hand-made, especially regarding PRT systems, which makes them expensive compared to regular batch production which cuts the costs remarkably.

9.2.1 Capital costs

According to a calculation done on the capital costs for different PRT developers the average cost per track-kilometre corresponds to approximately 65 million SEK (WSP, 2007, pg.31). By comparing the capital costs of PRT systems with other public transit systems one finds that PRT is highly competitive with ground transportation, i.e. buses, and much cheaper compared with LRT (Light Rail Transit) systems, i.e. streetcars. The table on the next page presents these differences in capital costs.

9.2.2 Operational costs

When discussing costs it is also important to look at the operational costs for the systems, but
since there aren’t any practical experience from a PRT system, calculation of these costs should be evaluated carefully although it is interesting to note the advantage of the PRT system compared to regular transit systems such as buses and streetcars. The table to the right presents data on comparisons of operational and maintenance costs in Euros per passenger kilometre. The cuts in costs for the PRT system comes from the system’s energy efficiency and the absence of drivers’ salaries which stands for a great deal of the operational costs for all transit systems. About two thirds of the operational costs for bus traffic constitutes of salaries for bus drivers, which are increased annually by 3% (Värmdö Kommun, 2007, pg.29.).

9.3 Travel time
Since an elevated PRT system avoids traffic congestion there are a lot of gains in time compared to buses and streetcars. The podcar can maintain a high average cruising speed. This sort of benefits are presented in a study by WSP who have compared travel time (door-to-door) for three different transit modes; bus, light rail transit, and personal rapid transit. Their conclusion is that the podcar mode offers a door-to-door speed which is twice as fast as the existing public transit modes.

9.4 Safety and Security
Many people die every year in traffic accidents. In 2007, 469 people died on the Swedish road system (Electronic source, www.ntf.se). Many accidents occur because of the human factor. Because of the elevation from ground level of the PRT system this means it avoids the risk of accidents with other traffic or pedestrians. The absence of drivers also reduces the risk of accidents. One of the early systems, in Morgantown in the US, has completed 110 million passenger-miles without serious injury (Electronic source: Wikipedia, 2008). Hence, an automated system such as the PRT system could actually cut down the Swedish death rate dramatically. But besides the factor of safety it is also important to make these new systems secure for passengers. Because of lack of drivers there is a risk for harassment from one passenger to another, thus there is an obvious need for camera-monitored and well-lit vehicles, and viewable stations. If stations and vehicles can be kept clean and welcoming then people will also use them to a greater extent.

9.5 Energy efficiency
The energy use is rather different when comparing existing public transit with podcars. It is all about the weight of the vehicle that determines how much energy is needed for propulsion and braking. The vehicles as well as the absence of starts and stops for the vehicle. Regarding energy efficiency there are two aspects that matter when comparing PRT and regular public transit - the average load factor and the elimination of starting and stopping. The average load factor is decided by how often the vehicle is running with a full load and how often the vehicle is running empty. A higher load factor leads to better energy efficiency which is something constructors aim for which means lower costs for the investor. Regarding this, the PRT system has an advantage compared with buses and streetcars which are heavier than podcars and also have to have well-planned operating schedules in order to reach maximum passenger occupancy. This means the traffic planners to a greater extent have to plan and forecast people’s travel patterns in order for the transit to be energy efficient - a problem that the PRT system doesn’t suffer from to the same extent. This consequently leads to longer waiting times for buses and streetcars.
10. Example study

10.1 General examples

10.1.1 Uppsala, Sweden
In Uppsala there has been a lot of activity in the recent years towards a more sustainable development, and just recently a PRT company has built the first test track in Sweden in order to test the system’s quality during winter conditions. This has affected the politicians of the city and an external consultant together with the city planning office is currently producing a feasibility study on how a system like this would work in the Uppsala context. The study area is an industrial community which contains an external shopping centre, and how it could be connected to the city with a PRT system. This part of the city has been chosen mainly because the amount of commuters, workers, and customers travelling to and from the area as well as “a conventional bus system hardly can be turned into an attractive public transit in this area” (Oral source, Engström, Uppsala Municipality). The study has been financed partly through an EU project fund called City Mobile and it is focused on economic and functional issues, and less on fitting the PRT system into the urban space. The study is to be finalised in 2008.

10.1.2 Karlskrona, Sweden
Another quite opposite example is the city of Karlskrona in the southeast of Sweden. The old and naval city founded in 1688 has a lot of old and preserved buildings and is also on Unesco’s World Heritage List. This means implementing an elevated transit system might not be an easy task to accomplish. The politicians in power have initiated a discussion on how a PRT system could fit in the urban context of the city and are considering inviting a PRT company to build a test track. According to Roger Poka, a politician of the Green Party in Karlskrona, one way of implementing a PRT system could be to initially implement it in less sensitive urban environments which would then lead to a broader acceptance from the public to implement it in the rest of the city (Oral source, Poka, 2008).

10.1.3 Värmdö, Sweden
The politicians in Värmdö are very interested in implementing a PRT system. Being a municipality part of the Stockholm archipelago with residents spread out on the countryside, it is difficult to provide people with efficient public transit. Studies done by the municipality of Värmdö shows a network which covers the whole municipality as well as detailed studies for PRT stations on key locations. Simulations have also been done, as well as mapping of travel statistics for the municipality.

10.1.4 London Heathrow, United Kingdom
A current and almost finished project is the PRT system at Heathrow Airport, London England. It is supposed to be ready for public use in late 2008. This system is supposed to connect a new terminal with the car parks at the airport. A new network of up to 18 driverless pods will ferry people between the main terminal and its car parks, where each pod will be controlled by an internal computer and onboard sensor systems (Electronic source, The Guardian, 2007).

10.1.5 Masdar (Abu Dhabi), United Arab Emirates
Another current project is the development of Masdar just outside of Abu Dhabi in the United Arab Emirates, where a whole new carbon free, six million square meter city is being planned for with public transit consisting of PRT and LRT systems. Supposed to be finished at 2015, the basic idea is for it to have absolutely no cars within the city and not producing any waste, with solar energy fields as its major provider of energy. With no cars evident in the urban environment there is more space for pedestrians and transportation of the public is carried out internally by small podcars, and externally by a LRT system which will connect the new city with Abu Dhabi, Raha Beach, and the airport.
10.2 Major example

10.2.1 Gävle, Sweden
In 1994 the city planning office of Gävle municipality, with several consultants, performed a study on how a PRT system could be implemented in the context of the city of Gävle. The aim of the study was to design and visualize a PRT guideway, stations, and pods which comply with the urban architecture in central parts of the city; a middle-sized Swedish city (Gävle Kommun, 1994). The study is limited to describing an elevated type of PRT system, which also creates the biggest visual encroachment in the urban environment compared with a PRT system under or on ground level. The study looked upon the design of guideway and station for three different types of urban environments – one which is a main arterial road corridor into the city centre, the other which is a local residential and city street in the Söder community, and the third one which is a tree-planted street in the core of the city. The entire track network is within the areas of the centre of the city of Gävle, which is pointed out as a national interest because of its cultural heritage (Gävle Kommun, 1994). This means there are limited possibilities to introduce new architecture in the area. The study also covers design and dimensioning of pillars, guideways, stations, and the design of the affected streets. Size and dimensions were taken from both Swedish and American models in order to be able to calculate on the system’s feasibility and its implementation in the urban environments. Besides from this several studies were carried out on the phasing of the whole development and economic calculations. The main conclusion of the study was that the visual encroachment in the urban environment can be decreased by a sensitive architectonic design of pillars, guideway, and stations. A uniform design programme which gives a timeless and light impression which is adjusted to the city’s own urban qualities should be worth striving for (Gävle Kommun, 1994, pg. 45). The study also discusses if the guideway and its pillars should be completely transparent in order to minimize its encroachment, this is suggested to be further explored in other studies. It also points out that the location of the network and stations are dependant on aspects such as the needs of the passengers, the urban environment, and functions within the society/city. The traditional city grid is highlighted in the study as a good condition for implementing a PRT system even in the urban environments of cultural heritage. The study also points out that a PRT system could actually pose a positive feature of the city image, “just as the wind power stations on the Danish countryside or the aqueducts in Rome” (Gävle Kommun, 1994, pg. 46).
11. Public space - physical planning for isolation and contact

11.1 Differentiated levels of the urban space

Because of the nature of the podcar system with its elevated features, it is interesting to look on urban planning and differentiated levels of public space. Maybe not entirely applicable to the PRT system, although interesting for public space in general, the work of architect and author on urban design, Jan Gehl, is interesting when discussing Personal Rapid Transit. The issue with elevated features in the urban space is ultimately about integration between different levels, or in some cases, about lack of integration. This is of course based on the normative idea that the planner’s goal is to design the urban space so that it is perceived as liveable and has the potential for people to interact within. Author and architect Jan Gehl points out a few aspects that the planner must bear in mind when planning for integration and to avoid isolation. The box below shows these aspects.

<table>
<thead>
<tr>
<th>isolation</th>
<th>contact</th>
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<tbody>
<tr>
<td>walls</td>
<td>no walls</td>
</tr>
<tr>
<td>long distances</td>
<td>short distances</td>
</tr>
<tr>
<td>high speeds</td>
<td>low speeds</td>
</tr>
<tr>
<td>multiple levels</td>
<td>one level</td>
</tr>
<tr>
<td>orientation away from others</td>
<td>orientation toward others</td>
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</tbody>
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Drawing upon this statement, a problem arises with introducing an elevated transit system. Despite the fact that an elevated PRT system clears the streets from buses and cars, and increases the possibilities for pedestrians to use the urban space to a greater extent, there is a new challenge of how to decrease the physical barrier between the different levels in the urban space. These barriers may bring isolation and explicitly unsafe urban environments when it comes to podcar stations and the environments that surround them. Thus, Gehl’s thoughts on the aspects of physical planning on isolation are applicable to the PRT system. As there is a possibility to attach stations to buildings and creating a new meeting place on a level above the street, the challenge for planners and architects is to design these new stations with integration in mind. Breaking the barrier and the differences between levels is a way of minimizing isolation and creating sight lines. Gehl quotes William H. Whyte who claims sightlines are important. If people do not see a space, they will not use it (ibid). So logically, unless people have a ticket to a podcar, there is a risk that they won’t use the urban space surrounding the station unless they’re going with the transit system. With this in mind, it is possible that these urban environments may become unsafe and not populated to a great extent. To this Gehl adds “if something happens on a level that is only a short distance up, possibilities for experiences are greatly reduced” (Gehl, 2001, pg. 99). Hence, the problem with lack of interaction is evident.
12. Analysis & Proposal discussion

12.1 Public space and public transit

There is a growing interest in new traffic solutions such as the personal rapid transit system and there are many incentives for implementing these types of systems in our cities. But as well as there are obvious reasons to implement the system, there are also a few issues to closely discuss and focus on; it has to do with the urban space and the architecture. This analysis and proposal discussion will focus on the urban space and the planning for integration, a discussion on implementation and phasing, and the Toronto context with its existing architecture and transit system.

The public space of our cities affects our life and behaviour and has the power to decrease and increase our possibilities of interaction with other people. It is important that the public space is secure, spontaneous, versatile, and have meeting places. Traffic solutions can often have a limiting effect on the public space and on the interaction between people, as they can also create unsafe environments. Concrete physical examples that may limit interaction and social congregation are the streets of our cities. When the car and the bus take up valuable space the result is a limited space for people. Trains and streetcars more explicitly create barriers for people because of the tracks. It is important to study how people get to these places. When the car and the bus are perceived from the outside despite if it’s a single station or an integrated station attached to a building or at a square a level up from ground level.

12.1.1 Public space matrix

The matrix of the public space (opposite page) shows the differences and the characteristics of the public space when the transit mode consists of a subway, a light rail transit, or a Personal Rapid Transit system.

The subway
This traffic system has more negative effects on the public space than it has positive ones. Measuring passenger capacity the subway is better compared to other public transit modes but when it comes to the public space its environment is dark and unsafe. Since the subway goes underground it is extremely dependant on artificial light. A lot of work is necessary in order to enhance the feeling of safety for its users. The public space is also divided and differentiated since it is extended under ground from ground level. Hence, we get two public spaces, one above ground and the other underground. The positive aspects are that it doesn’t create barrier effects for pedestrians, and that there is no visual encroachment.

The streetcar
Regarding the public space the streetcar is a better solution than the subway. Its assets are the access to natural light, safe environments and a concentrated and viewable public space. The rather big and spacious transit mode can create barrier effects, decrease the space for pedestrians and bicyclists, and to some extent increases the visual encroachment. Although when designed properly a streetcar line and its stop can result in integrated public spaces where people meet.

The Personal Rapid Transit system
As with the subway the public space of a PRT system is also differentiated from ground level, although upwards instead of underground. With this transit mode the positive aspects on the public space outweigh the negative ones. The access of natural light, no barrier effects, safe environments, and more space for pedestrians and bicyclists are all positive effects of a PRT system. The only negative aspect is that the elevated guideway brings visual encroachment to the public space and may cause alienation and isolation because lack of sightlines.

12.1.2 Station modes

In current studies on PRT systems one can find three types of stations (displayed below) - the single station, the 50/50 station, and the building-integrated station. With the urban space in mind, these types of stations all have pros and cons.

The single station
More early proposals of PRT stations just include a building where there is a staircase or lift from ground level to the second floor where the podcar departure from. These kinds of stations can be seen in the 1994 study in Gävle. Of the three mentioned types of stops, this is probably the cheapest and smallest one. Although from the perspective of urban space, visibility, and sightlines, this solution is probably not the best.

The 50/50 station
Another solution is when the podcar station is integrated with the urban space, for example a square or a similar place. With this type of station the problem with sightlines in the urban space is decreased as these places are more visible than the simple two-levelled station mentioned above. The main idea is to make the PRT system meet with the street level and to make the distance shorter to the surrounding urban space. This can be a quite expensive solution which most certainly requires a rather big geographical area and a lot of economic investment, and planning and design for the surrounding urban context. Although it may be suitable when creating new public places such as squares etc. Problems such as barrier effects may occur as it may divide the urban space if not well planned.

The building-integrated station
A final type of podcar station is the one integrated with buildings. This solution was also proposed in the 1994 Gävle study where a podcar station was attached to the façade of a shopping centre. Ideas are also on having a podcar station inside a mall as this increases the accessibility to the mall for physically impaired persons, as well as people who shops many or large products – hence, there is no need to walk longer distances from the transit stop to shops, restaurants etc. It is therefore more comfortable than the other types of stations. Problems arises with accessibility if the mall closes down during some hours of the day.
Public space matrix for 3 different transit modes

**SUBWAY**
- No visual encroachment
- Dark environment depending on lighting
- Unsafe environments
- Differentiated urban space, ground level and below ground

**LRT**
- Natural light
- Safe environments
- Concentrated urban space
- Big traffic solutions, barrier effects
- Small space for pedestrians and bicyclists
- Some visual encroachment

**PRT**
- Natural light
- No barrier effects
- Safe environments
- Space for pedestrians and bicyclists
- Extends the public space upwards, new market places
- Visual encroachment
12.2 Implementation and phasing strategy

The examples presented in this thesis shows that the most important issue regarding spatial planning when implementing an elevated PRT system is how it affects the public space, i.e. the visual encroachment, but also how it can cause isolation. The questions that follow are what design solutions can decrease the visual encroachment as how people perceive it, and also how a PRT system can be fitted into the urban space in a proper way to make the environments attractive and liveable for the public. To reach a more sustainable development, all of the suggested areas below should all be covered with a PRT system. Although, as it is my opinion that all of these areas should have PRT, it is also important how the advocates of the system and the politicians implement it as it affects the urban space a great deal. To gain acceptance from the public and to prove the benefits of the PRT system, from the urban space perspective the following implementation order is suitable:

Phase one:
- Airports
- External shopping centres
- Industrial and business areas
- New community development

Phase two:
- Existing sensitive urban areas

Although separated from each other in different phases, it is important that all of these areas can be connected to the same network in a future where all areas are covered with a PRT system.

12.2.1 Airports

PRT systems are being planned and built around the world today at airports, mainly because they are good people movers which airports need to be good at. As mentioned earlier a system is being developed at Heathrow airport connecting the new terminal 5 and the car parks. Discussions in Sigtuna Municipality about Sweden’s major airport Stockholm-Arlanda Airport have resulted in several studies on connecting the airport with adjacent town of Märsta. A PRT system would be very efficient at airports because of the number of people that travel, and the people that work at the airport who need to commute to the airport at all times of the day. It is economically difficult to introduce bus routes to and from the airport in the middle of the night. This is why a PRT system would be more efficient since it is accessible for passengers when there is a demand, day or night. The fact that there’s only one landowner, LFV, is also an advantage.

12.2.2 External shopping centres

A study is being carried out in the Municipality of Uppsala to connect an external shopping centre to the city with a PRT system. Many people drive their car to these areas to shop and besides the negative impacts on the environment with carbon dioxide emissions it is also segregating the city as these areas are not easy to reach with bikes or by walking. As people shop a lot and large products as well, a PRT system could be the solution, because PRT stations could be located close or at the entrances of the shopping mall. A stop could even be located inside a shopping mall.

12.2.3 Industrial and business areas

The study in the Municipality of Uppsala also concerns the industrial and business areas. These types of areas are suitable for PRT systems, a lot of people go here to work and there is hardly any public transit available. The built environment is not very sensitive to new architecture which is how an elevated PRT system is normally perceived.

12.2.4 New community development

Implementing a new transit system in existing built environments is difficult. Hence, having the system as an aspect in the early phase of a new community development makes it easier to fit it together with dwellings and workplaces. As with regular transit it can pose as the centre, the ‘spine’, of the area. It can also go through parks or even over parking lots. Because of the lack of noise it can also go through a residential area. Besides the ecological sustainability factor of implementing PRT, it is also economically beneficial to implement the PRT system from the beginning when planning new residential areas.

12.2.5 Existing sensitive urban areas

In several old cultural building areas, introduction of an elevated PRT system brings an explicit conflict. Environments such as the Old City in Stockholm, and one of Unesco’s World Heritage sites in the City of Karlskrona are examples of sensitive urban areas that a PRT system might affect to some extent in a negative way. As a politician in Karlskrona said, an easier way of implementing a PRT system is by doing it gradually starting with the less sensitive urban environments. Thus, these kind of built environments are last on my list of possible types of urban areas to implement an elevated PRT system in. Although as the study of Gävle shows, implementation of PRT in these environments can be done with consideration to their heritage.

12.3 Toronto public transit

When contemplating on a new transit system, there is always the need to analyse the current situation and focus on what we want for the future. It is important to study the travel patterns of the city and to actually ask what people want out of public transit. In Canada public transit is not as well developed as it is in many European countries, hence dependant on cars as the main mode of transportation. But when comparing Canadian cities, Toronto has probably one of the best transit systems in the country. Its fleet consists of buses,
streetcars, and subway trains which connects the different parts of the city. The aim in Toronto is to make the public space around the transit systems more appealing and more suitable for the citizens. Extensions of the transit lines are also underway which means more areas are connected to each other, thus more people have the ability to use the public transit. The path that the City of Toronto has chosen is about making the existing public transit more efficient and user-friendly. Toronto is not considering PRT systems as their future public transit, development of existing streetcar and bus lines is their main focus; hence it is ground level traffic that they are focusing on. The planning documents support these types of transit modes, and in fact even the PRT system. As the Toronto By-law talks about reducing the need for car use, the most efficient way of doing this is by implementing a PRT system.

12.4 North American and Torontonian architecture

Questions on suitable urban environments to implement PRT systems in are extremely interesting to ask and to discuss in the light of today’s debate on the climate and global warming. It is extremely important to discuss what consequences for the public space that comes with an elevated feature such as the PRT system.

The City of Toronto should investigate further an eventual implementation of a PRT system. This statement rests upon two issues: 1) that the Toronto waterfront will be distinguished by its leadership on sustainability (Toronto Sustainability framework, pg.1-1) and, 2) the current architecture in the Toronto context poses as a unique opportunity to respectfully implement an elevated mode of transportation which complies with the existing architecture.

North American cities are traditionally relatively young and mainly built upon the needs of the car compared to European cities. Hence, the amount of historical and cultural building environments are less and a more contemporary architecture is dominant, even in Toronto. With this thesis we have chosen to study a few places at the waterfront in Toronto where planning and building have been carried out through the years and will continue in the future. The majority of the development which has been built can be categorised as high exploitation on a very narrow geographical area; quite many high-rise residential and office buildings as well as big sports arenas. This has been done with a contemporary expression in the architecture with façade materials consisting mostly of glass, concrete, and steel. Thus, the existing built environment is not too sensitive and dependant on an extreme consideration of the proposed new development (i.e. stations and guideway). Another aspect regarding the North American style of architecture, which also corresponds with the PRT system, is the amount of elevated architecture. During our stay in Canada we also did some trips to other North American cities where we found some interesting architecture. In Chicago people can use the “El-train” which is an elevated city train which connects the city centre with a loop, and the rest of the city with different radial train lines. Its visual encroachment is extremely evident and since it was introduced during last decade of the 19th century it has an old feeling and design. In Calgary the city has built several connecting elevated walkways between the indoor malls that can be found in the city centre. These glassed-in walkways are very much evident in the city and make the car traffic run smoothly in four to six car lanes around the malls. In the Toronto context we have also found these architectural elements. At Bremner Boulevard behind Union Station there are similar architectural elements. A glassed-in walkway has been built between Union Station and the CN Tower, which crosses the train tracks that cuts through the city and normally makes people use the unfriendly and car-adjusted passages under the Gardiner Expressway. Instead people can get to Bremner Boulevard or Union Station just by using the elevated walkway. These three examples of elevated architecture shows and at the same time legitimize a traffic mode such as the PRT system, and it would fit well in this Toronto context. At the same time it should be noted that these elevated elements should have been implemented with much more caution. The old El-train in Chicago brings a lot of visual encroachment, and the elevated walkways in Calgary creates a rather car oriented public space. Since technology today have brought light pellars and guideways there is an interesting challenge to introduce them in the urban space. One important aspect of PRT is that it works well in the typical city grid, and since Toronto is mainly built up with a city grid, implementing a PRT system seems to be rather easy. When implementing such a new system as the PRT, with its architecture, it is important to use some basic design principles. The public space should be secure, liveable, and desirable to use, which leads to a few basic design guidelines. It is important that the new transit system doesn’t negatively affect the public space and can contribute to make it better for pedestrians and bicyclists as well.
13. Design guidelines

13.1 Guideway

13.1.1 Lights
Lighting of the guideway and bike and pedestrian lanes underneath can be done simply by attaching the lights on the pillar of the guideway. This is very important because it increases the security around the PRT system as well as it emphasizes the system’s existence in the neighbourhood. This should be stated in a Light plan as well as lights at podcar stations.

13.1.2 Shelter
A roof directly underneath the guideway acts as a shelter from rain, hail or snow for the people using the bike and pedestrian lanes. These roofs should be standard in the most direct bike lanes between popular destinations. The roofs should have solar panels.

13.1.3 Benches
Apart from its primary objective of transporting people, the track network should also have resting places for pedestrians and bicyclists. Benches can be attached on the pillars of the guideway which will then create a more liveable public space.

13.1.4 Air for bikes
On strategic intervals the pillars of the PRT system should have stations of free air for bicycles. This should be implemented where there are podcar stations as well as along the direct sheltered bike and pedestrian lanes, hence creating another transport corridor underneath the PRT system.

13.1.5 Aesthetic design
Design of the exterior on a system such as the elevated PRT system is difficult and every place/city has to decide what it wants from the design. Introducing plants (like the sketch shows), lighting from the inside when there is a transparent construction and design, or making the pillars and guideway to a forum for public art can all be interesting suggestions on the design. A community can design its own parts of the guideway as part of public interaction in order to prevent graffiti or damage etc. which has been done before in the different communities of Toronto.

13.1.6 Vegetation
Rows of trees can be planted along the PRT network when the guideway is desired to be hidden away or when the area surrounding it is desired to be more green.

13.1.7 Bike parking
Bike parking can be attached to a pillar but also at strategic places close to services or in residential areas or in a park where the podcar pass by.
13.2 Station

13.2.1 Façade
The façade of the podcar station should be dominated by glass. This is important in order to make them safe for people to use any time of the day and because they’ll be more easily perceived from the outside. The security aspect is vital.

13.2.2 Roofs
The podcar station should have green roofs or roofs fitted with solar panels to be more sustainable. The roof angle should be adjusted to the needs of which solution is chosen; the green roof or the solar panel roof.

13.2.3 Outdoor steps
Because of its elevated feature steps in the public space is needed to make podcar stations accessible for its passengers, besides lifts. These steps can also be used for sitting places for pedestrians and should also be designed for this purpose. This will also help create sightlines and hopefully populated and well-used places. Lights can also be integrated with the steps.

13.2.4 Elevated Square
An elevated square could be designed at different levels which will create sightlines and a viewable space. Different functions such as stores and offices could then be located under the elevated square.

13.2.5 Multi-option entries
Bright and viewable entries to the PRT station are vital in order to make them safer. When stations are connected to buildings or elevated squares it is also important to have several entries to the station, because of security matters as well as accessibility for physically impaired people. This can also be about several lit-up paths to the station, for example in a park.

13.2.6 Vegetation
Around stations such as the elevated square or a podcar stop, trees or other vegetation can be planted.

13.2.7 Bike parking
Monitored bike parking should be available close to a podcar station for people who commute with the PRT system.

13.2.8 Lighting
A Light programme should be developed for all types of stations where emphasis is to make the public space safer and aesthetically appealing. Lights can be attached on buildings, in trees, between steps or integrated in the ground, and should create a friendly atmosphere. The design of light fitting should be individual and consistent with the City’s architectural design and stated in the Light programme.