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PRT in Sweden: From Feasibility Studies to Public Awareness

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Abstract

Podcars or Personal Rapid Transit (PRT) has been discussed and analyzed in Sweden since the mid-1960's. Interests in PRT has gone up and down over time. Since the mid-1990's, however, the efforts of promoting PRT in Sweden have become more serious and frequent. Many pre-feasibility and a few feasibility studies were undertaken by researchers, consultants and cities against a wide range of vested interests in the automotive and public transport industries.

This paper summarizes a great number of studies, and tries to explain why PRT has not yet materialized. Up to now, the crucial point seems to have been the imbalance between risks and financial support: No local authority can buy a system, due to the development risks as long as it is an unproven technology; and no developer can invest fully in development, as long as there is no (mass) market for the end product.

Today, PRT in Sweden has entered a new era. A PRT test track is under construction in Uppsala, Sweden, by a vendor (Posco) who believes thart there is a mass market. Further, criticism and awareness of the unsustainability of the current traffic situation (due to concern for climate change and peak-oil) mean that we may now be likely on the threshold to acceptance of PRT.

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1 PRT Feasibility Studies in Swedish Cities

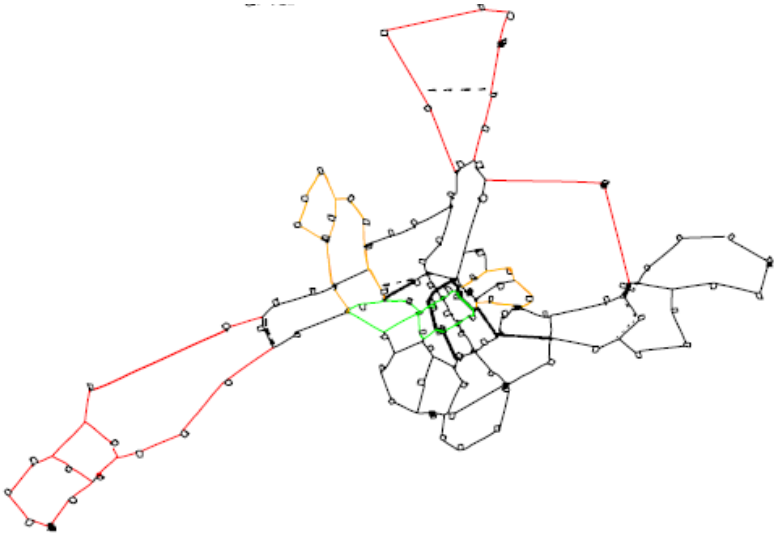
1.1 An early PRT interest in Gothenburg

Interest for Personal Rapid Transit in Sweden emerged in 1971 in Gothenburg, when two leading persons launched a study of raising the question: “PRT - how realistic is this mode of transport?” Ever since, several transport planners and researchers, not to mention decision-makers, have asked the same question.

1.2 Simulation analyses of PRT in 1991-94 in Gävle, Jönköping and Göteborg

The Swedish Transportation Research Board commissioned LogistikCentrum to develop what is now the generic PRT simulation software PRTsim in conjunction with the analysis of possible PRT networks for the **city of Gävle.** At the time there was no description of the control system, and initial simulations assumed synchronous control. A PRT network for the whole city area was developed with 77 km of guideway, 69 stations and 900 vehicles assuming 15 % of car trips would divert to PRT.

Figure 1. The Gävle PRT network in four development stages (with stage 1-4 in green, yellow, black and red)



In 1994 the control system was changed to point-synchronous (a variant of asynchronous control invented by LogistikCentrum). Thanks to the control changes it was possible to increase capacity by 50 % and avoid 18 bi-level intersections and 4 km guideway.

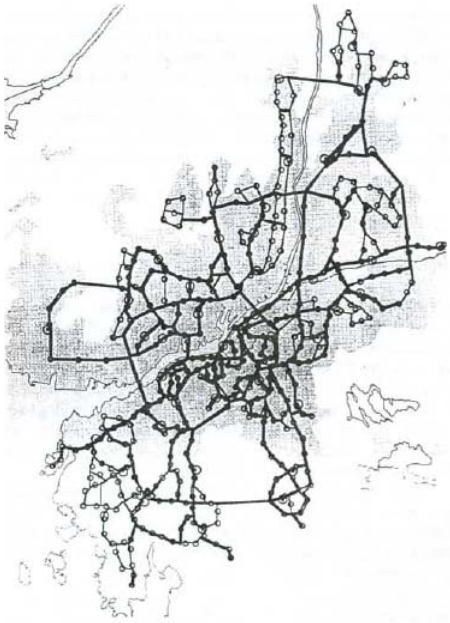
Logistikcentrum analyzed an implementation in 4 stages. The first stage was two loops and 9 km. The second stage was five loops and 23 km. The initial stages were designed to cover the largest trip generators so that they were more cost effective than the full network.

The city of Gävle commissioned architects FFNS to visualize how a PRT system could be designed and integrated in the cityscape, as illustrated here.

Kjessler & Mannerstråle AB[7] lead studies in a suburb **of Göteborg** (1991) of a 27 km PRT system and of a 10 km system for **Jönköping** in 1993.

The **Gothenburg Traffic Authority** led another PRT study in 1993. The task was to establish whether a PRT system could replace all existing public transportation (buses and trams) and up to 60 % of car trips. It was found that this is theoretically possible, requiring 728 km of single guideway, 391 stations and up to 17 000 vehicles. Transit travel times would be reduced by about 50 %.

[7] Now: WSP Group Sweden



In a subsequent study PRT as shown below was compared to a light rail loop for central Gothenburg. With the same investment PRT would offer 50 stations, much better accessibility and attract 70 % more passengers compared to LRT with 11 stations. Yet the decision was to build the LRT loop.

This Göteborg study started with a question of where a GRT would be possible as a 10 km circle line. One of the bidders was Siemens together with SwedeTrack using the H-Bahn technology as used in Dortmund. However the political majority in Gothenburg shifted and it was decided to build the same line with conventional tram technique.

1.3 Market Demand and Social Benefits of a PRT System - A Model Evaluation for the City of Umeå

In the city of Umeå (80,000 inhabitants) a plan was developed to reduce traffic problems of similar cities - increasing congestion, road accidents and environmental

pollution caused by an increase in motorized traffic in the city center. In Umeå conventional bus service attracts 8 percent of all daily trips. Transek Consultants has carried out a comprehensive travel demand analysis and assessed four alternative proposed transport strategies for the city of Umeå:

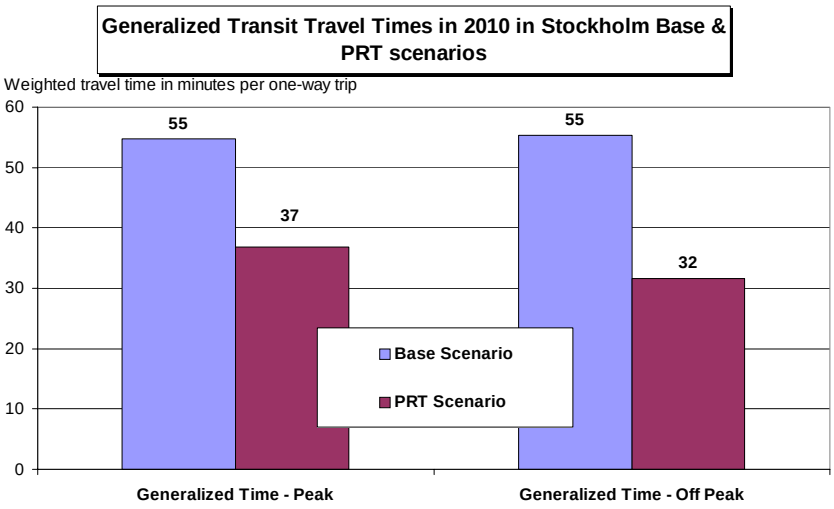
- by-passes to divert trough traffic outside the city center
- an improved bus service with a doubled service frequency
- an automatic guided rapid transit line (AGT) system
- a personal rapid transit system (PRT).

It was found that only a PRT system would be able to provide a substantial decrease in door-to-door travel times. The PRT system would more than double the transit modal split from 8 to 17 percent. This system would also reduce the number of auto trips by 14 percent. In the study, the PRT was the only transit system that yielded a positive net social surplus[8].

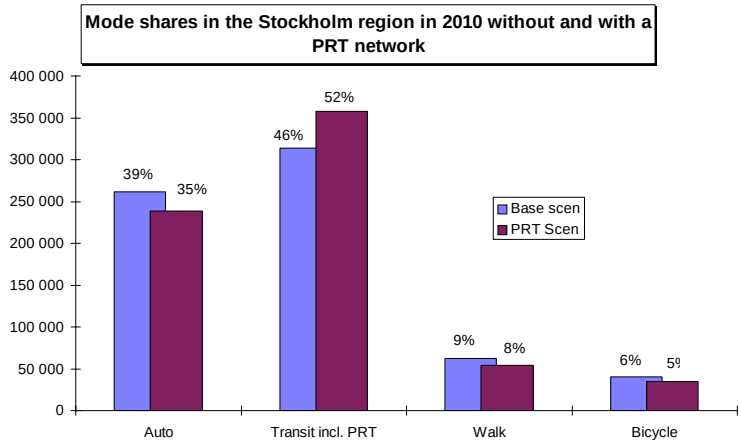
[8] This study was presented at the International Conference on PRT & Other Emerging Transportation Systems, University of Minnesota, Centre for Transportation Studies November 18-20, 1996

1.4 PRT in Stockholm – Market Demand and Economic Viability

Transek Consultants was commissioned by the Stockholm County Council Traffic Office in 1998 to carry out a PRT Market Demand Study including a social Cost-Benefit Analysis (CBA). The study was financed by the Swedish Research Fund for Transport and Communications (KFB). Some major findings were that the highly competitive travel time performance of PRT – with waiting times between 1 and 3 minutes, a constant cruising speed of 36 km/h – yields substantial travel time gains for the users, especially in off-peak periods.

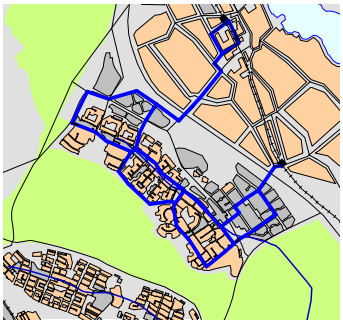


With an area-wide PRT-system, the demand for transit, would increase by 31 % (from 21 to 25 % in peak and to 41 % during off-peak periods)



Cost data were obtained from Raytheon, Swedetrack (suspended PRT) and from SkyCab (supported).

The PRT network for Akalla-Kista-Helenelund-Sollentuna C



A demonstration in the Akalla – Husby – Kista –Helenelund – Sollentuna area of Stockholm, shown above, was found to be economically viable and well justified in the low cost alternative. The cost-benefit ratio was calculated to be 1.3.From the analysis, one could estimate the maximum investment cost per system-kilometer for a PRT network of the relevant size to be about €12m per track-km (US$14m per track-km).

Our recommendation was therefore clear – a PRT system for Stockholm provides such a broad range of desired qualities that it should be given highest priority in research, development, testing and demonstration for implementation in the Stockholm metropolitan area[9]. However, due a shift in the political majority at the Stockholm County Council in 1998 the interest for PRT solutions faded away.

1.5 SkyCab's Feasibility Studies in Sigtuna-Arlanda, Linköping, Malmö and Stockholm

SkyCab[10] did a study for the Swedish City of Sigtuna with an 82 km SkyCab PRT system, equipped with 87 stations and 600 vehicles. This feasibility study of a PRT network at Märsta-Arlanda Airport[11] showed that a PRT could replace the existing bus network and attract 10 million passenger trips in the target areas (see figure below). In the peak hour 6,700 passenger trips would be made by 4,400 vehicle movements within the PRT system by 600 vehicles. Each vehicle would be needed for 7.5 trips in the peak hour.

SkyCab also made a study for the City of Linköping in 1999. A first stage consisted of 21 km guideway and 100 vehicles, linking the railroad station to the university. To

[9] This study was presented at the APM Conference in Copenhagen in 1999.

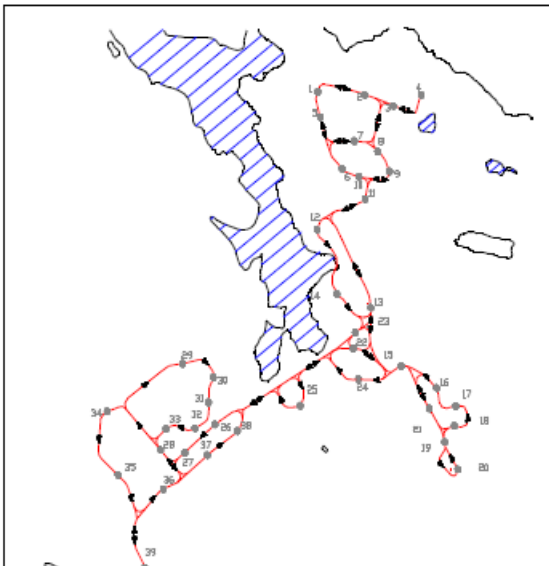
[10] Source: www.skycab.se

[11] "Vision SkyCab in Sigtuna Municpality – a Description and analysis with illustrations of a new, user-.friendly automated transit system -SkyCab® - at Arlanda Airport and its surrounding settlements Märsta/Arlandastad on behalf of the Municipality of Sigtuna, the Swedish Civil Aviation Authority and Arlandastad. Stockholm, January 2000.

divert 100 % of Linköping's bus trips, a network of 82 km of track, 79 stations and 590 vehicles, are needed.

In 2003, the City of Malmö studied a SkyCab-system for the redevelopment area "Western Harbour"

A PRT network designed by SkyCab for the new development area **Vetenskapsstaden** "The Scientific City**, in Stockholm**. This network would connect the four university campuses. Within this area there will be some 85,000 workers in 2015 about 18 km track, 39 stations and 128 vehicles are foreseen.

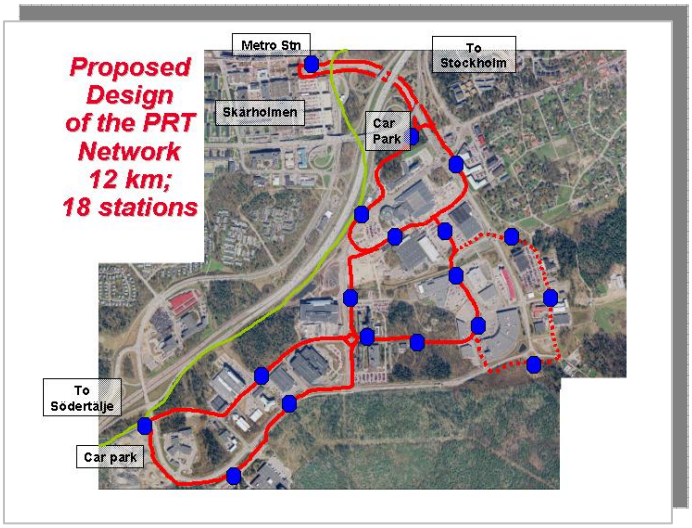


SkyCab vsion of a station

1.6 The EDICT Feasibility Study at Kungens Kurva

The European Demonstration of Innovative City Transport (EDICT) research program involved a consortium of sixteen organizations; local authorities, consultants, industry and academics from seven countries. Seven other cities were associated as "follower cities" and helped to assess transferability. The project started in 2002 and ended in 2004.

A dense PRT network was proposed to connect Stockholm's Skärholmen residential and shopping area (and metro station) with Kungens Kurva. It consisted of 12 km guide-way and 12 stations, of which two are inside parking garages.



Some of the major findings were the following:

The study found the following major advantages compared to traditional line-haul transits:

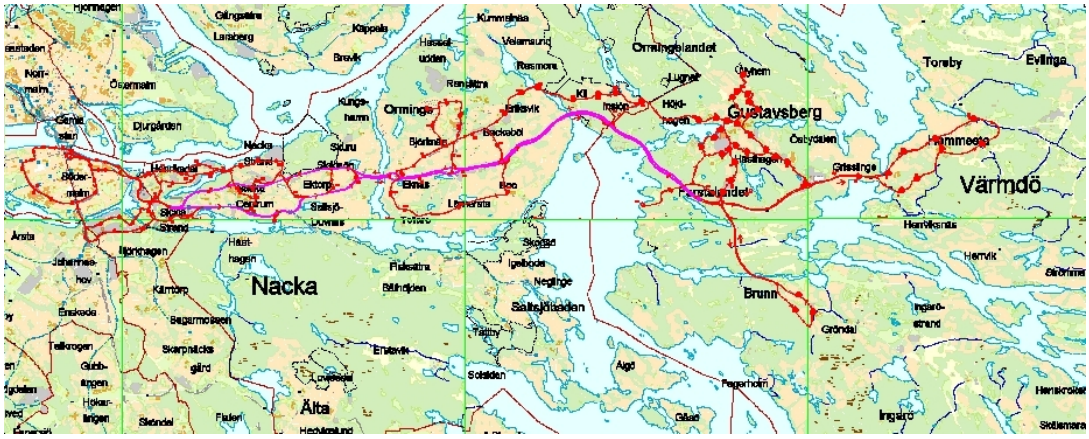
- Up to 50 % shorter travel times due to direct trips with very short waiting times with PRT
- Three times more transit trips with PRT compared to today's Bus
- Lower operating costs due to driverless operations
- Lower investment costs than LRT, due to a much lighter infrastructure
- Substantially higher willingness-to-pay for PRT compared to the bus mode, in the order 80 % higher
- Reduced car traffic by 8 % and better land-use for commercial activities
- Lower car ownership, due to a much higher transit performance (lower travel time costs)
- Reduced air pollution exhausts by 9 % due to diverted car traffic to transit
- Reduced number of traffic accidents by 9 %, for the same reason
- Accessibility for all groups of travelers
- A positive social net surplus
- Contributions to economic growth

In general, there were positive attitudes to PRT. However, due to a shift in the political majority in 2002, the interest faded away.

1.7 Podcar Feasibility Study of Värmdö – Nacka - Stockholm

In 2006, Värmdö engaged the Institute for Sustainable Transportation (IST) to coordinate a feasibility study for the east region of the Stockholm, connecting to Nacka and Södermalm. The study developed at least two stages.

The network for the full area consists of about 100 km guideway and 94 stations. This large scale needs a high-speed link, i.e. PRT vehicles to cope with travel time, capacity and energy efficiency requirements. The high-speed link is marked in purple in the figure.



When travelling on the high-speed link the vehicles would be electronically attached to each other, and can be separated at. Estimated speed on the link is 70 – 90 km/h.

Pod-train, figure from SIKA (see chapter 4)

2 SkyCab and SwedeTrack – Two Swedish PRT Developers

2.1 SkyCab

SkyCab is a Swedish PRT development described in a separate paper at this conference.

2.2 SwedeTrack Systems

SwedeTrack has its roots back in the 1970's when the present chairman in the board, Sten Staxler took part in the Gothenburg studies mentioned earlier. The company was formally founded in 1991. The approach is less focused on PRT, but rather on GRT and Dual Mode. The hope is that either would make the first installation km profitable. SwedeTrack wants to develop H-Bahn into a new vision called FlyWay, which would accommodate busses, small passenger cabins and dual mode car movers under the same beam.

3 PRT Research Activities in Sweden

A multidisciplinary research program was sponsored by the Swedish TRB and directed by Dr. Ingmar Andréasson during 1994-97. Four departments at Chalmers University of Technology and Gothenburg University researched the following aspects of PRT:

- User attitudes towards PRT
- PRT in cityscape
- PRT guideway design
- Operations and implementation strategies
- PRT demand modelling
- Socioeconomic costs and revenues.

Some of the conclusions were:

- PRT technology is available
- PRT can feasible solution for small and medium-sized cities and for feeders
- PRT offers capacity to replace buses and trams
- PRT cannot replace commuter train and subway
- PRT is accepted by users
- PRT can reduce transit travel times to half
- PRT may attract up to 25 % of car trips
- PRT can be socio-economically profitable
- Visual intrusion is the most difficult restriction

4 The Concept of General Transport System (GTS)

The Swedish Institute for Transport and Communication Analysis, SIKA, is a governmental agency under the Ministry of Industry responsible for developing forecasts and planning methods, publishing, transport statistics and carrying out comprehensive surveys of long-term sustainable transport.

A recent case study is one of three whose aim is to answer the question: *How can the planning process be organised to enable us to assess the value of alternative*

transport systems? One identified weakness with the present planning model is its deficient capacity to identify radically different transport solutions and to assess whether they are superior to the established solutions.

A General Transport System – GTS – is a vision of what our combined transport systems would be like in the future. Other transport systems will not be replaced by GTS. Rather, these gradually may be complemented by or become a GTS. GTS has manifest advantages compared with existing transport systems as regards generality, safety, travel time, accessibility, the environment, energy and cost. However, we know little today about what a future GTS could entail, on the large and the small scale.

SIKA sees pressing need for new transport solutions in densely-populated urban environments – elsewhere at a later stage – which reduce traffic congestion and emissions, while at the same time making possible safe, comfortable and efficient travel. SIKA considers that PRT could be a transport alternative of this kind.

Considerable space is given to the effects of PRT in an underlying consultancy report[12]. The base material is studies made for a number of existing, planned and envisaged systems in Sweden and abroad. Among other things, they present estimated savings in journey times – which can be considerable and the increases in public transport share of the transport market. The consultants also present calculations showing the socio-economic benefit of introducing PRT. A cost model s, PRT can offer transport at a lower cost than most other means of public transport.

The consultants then move on to discuss the design. There are a number of technical issues that must be investigated: Should the vehicles run on girders or be suspended? Should the vehicles go on tracks only or also on roads? Should it be possible to connect the vehicles together on the track and how would that take? And so on. The consultancy group does not take a position in this type of "detailed reasoning" with the exception of certain recommendations, for instance, they draw attention to the advantage of the linear motor.

*Computer-generated picture of an envisaged PRT system in central Stockholm***.** Illustration: Hans Kylberg, Visulogik AB

The last chapter presents results from a couple of systems in the United States, which also show the socio-economic benefit. SIKA has not carried out its own assessment of the socio-economic estimates and

[12] In Swedish only, made by LogistikCentrum, Transek and SwedeTrack Systems

therefore refrains from taking a position on them at the present stage. However, the difficulties are underlined of making socio-economic estimates for a type of transport system which is not in operation anywhere in the world apart from in test facilities are emphasized.

Studies of PRT systems have been regularly discontinued when it became apparent how large the initial costs associated with introduction of these systems could be. SIKA's preliminary assessment is that it may be justified for the government to take increased responsibility for the PRT issue in Sweden.

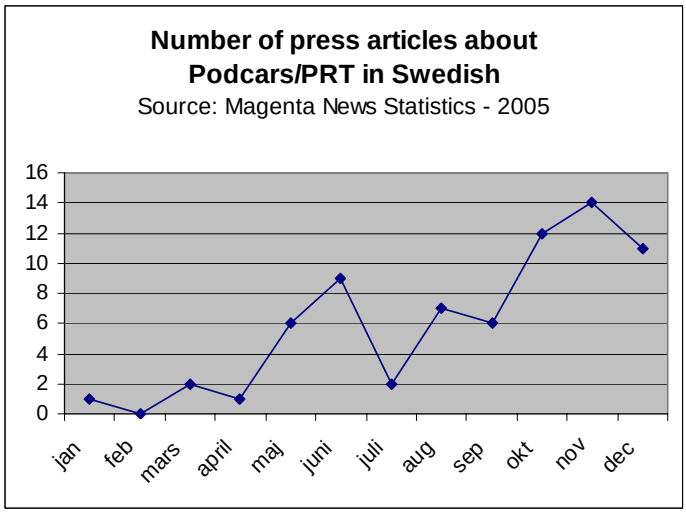
Why are these alternative transport systems not given scope in the process for infrastructure planning? Some working hypotheses on why there may be obstacles have emerged:

- The initial, and often substantial, costs can be a deterrent if they are to be fully borne by a particular municipality.
- All new systems are perceived as "ugly" before you get accustomed to them.
- There are no natural representatives for new transport modes – and hardly any co-ordinating actor which takes a holistic approach.
- The value of the ground space is not included in the social efficiency calculations.
- Many people may feel hesitant about new developments in general – which may be expressed in their roles as officials, investigators or decision-makers.
- New developments can be counteracted by established actors from the point of view of self-interest.
- A general inertia in the social machinery can strengthen the two above effects. People often tend to rely on established actors.

Obstacles that are closely related to system faults in the planning process could be added. All these, however, are questions that are to be dealt with in a future report.

5 Marketing and Promoting PRT

The year 2005 was a break-through in the Swedish media regarding podcars. IST has played a numerous activities, such as open seminars with experts and authorities, exhibitions, blogs, web-site, press articles, visualizations and a film (http://www.podcar.org/Vad/what.htm).



Lessons learned:

- an independent body can in some cases easier promote a PRT-concept than a vendor who speaks for a specific product
- give your vision away and let it be transformed into the subject of the listener
- produce a lot of pictures – media love pictures (and animations for the television)

During 2006 podcars was brought to the political arena by many activities. The governmental agency SIKA launched the report of GTS. Swedish Rail officially supported a test track initiative of SkyCab in Hofors, Sweden.

IST arranged two political debates about podcars: one with the leaders of all the political youth organisations and another with all the political parties in the parliament transport committee. The latter debate was broadcasted on Swedish television

The former Swedish Prime Minister Göran Persson started *the Commission towards Swedish Independency of Oil*, with the goal to be oil-independent by the year 2020. Dr Ingmar Andréasson made a presentation of podcar/PRT to the Commission.

6 PRT Tests Tracks in Sweden:

6.1 SkyCab

Hofors is a suitable location for establishing a PRT test site, according to SkyCab. Three alternative locations are at Hofors Industrial Estate, and two have existing buildings that can be utilized. The test site would employ at least 15 persons. Altogether more than 400 persons might be involved in the Hofors test site project. The costs for investment and the first five years of operations are estimated to be approximately €17-22 M.

6.2 Vectus

During the spring of 2006, ground was broken for the Vectus PRT test track. The 400-meter track is close to the Biomedical Centre in Uppsala, Sweden . In addition to the track and its three vehicles, a workshop, station and showroom are also being built at the site. Regular news and updates are posted on www.vectusprt.se .

Vectus chose Sweden partly on account of the Nordic climate. Any new transport system will have to handle ice and snow – which makes Sweden the ideal testing ground. Moreover, Sweden has an internationally recognized body for e approval of vehicles and the Swedish Rail Agency is to verify that Vectus' PRT solution fulfils all applicable norms and safety requirements.

Currently various tests for wheel types and durability, the communication and control system, and the drive system are performed in Sweden, the U.K. and S.Korea. The test track in Uppsala was completed in early 2007, Vectus plans to operate the whole PRT system: initially using one car without passengers, then one car with passengers, then two cars without passengers, and so on. Everything will be tested to ensure safety and that all the parts work together. Other tests will be performed to assure reliability, availability, maintenance, durability and passenger-perceived qualities.

The first tests on the test track are scheduled for spring 2007, and the ambition is to receive approval from the Swedish Rail Agency by the middle of 2007. Vectus is planning to operate the test track until 2010.

7 Governmental Support for PRT or not?

Who decides about a new transportation mode and why do we need one? Traditionally, transport investments have been closely related to political decisions and local and regional planning. Economical and technical aspects dominated.

- Today, we can see a shift of perspective on transports, from a purely local issue to a more combined view with what is happening in the society, in the EU and elsewhere in the world. Some examples are: ies, e.g. as a socio-technical system
- under-privileged groups (children, women, elderly, ethnics, handicapped etc) in the current car oriented society are more in focus, e.g. meet demographic changes, tame urban sprawl, ease ethnic integration etc)
- the fear of an accelerating global warming and the risk that the era of cheap oil will suddenly end.

Today, the picture is more complex. Even if local problems such as accidents, congestion and emissions are not unmanageable, the broader scope creates really challenging problems. The understanding of the necessity to form a more social, economical and environmental sustainable mobility situation for people and goods is growing. The Oil Commission is an example of that. However, the social de-construction of the problem picture of transportation and the possible solutions is not only a governmental task.

A broad society debate about problems and possibilities shuld be driven by experts, politicians, media, NGO and citizens.Transport issues are now far too embedded in society, to only be handled by transport experts/consultants/authorities. The task of making them visible and subject to broad interest, learning and involvement is as important as showing the new technology. It will demand social networking, mobilisation and creativity.

In Sweden, a number of municipalities, politicians, media and NGOs are now debating transportation in a broad sense and also bringing up PRT as a possibility. Support has also come from the government. The authors of this paper believe that podcars can contribute to a more sustainable society. The next step is to build pilot tracks, 3-15 kms of guideway, for public use in the build-up environment.

8 Lessons Learned

- New systems are difficult to introduce no matter how good they are.
- It is easier to get consensus to improve existing systems than to introduce a new system.
- It is unrealistic to expect a local community to take the cost and risk of introducing an unproven system.
- The benefits of PRT grow with the number of destinations served.
- The initial stage of implementation is the most difficult one to prove profitable.
- According to Darwin each step of development must give an improvement over existing solutions.
- Test tracks and early implementations are crucial for credibility.
- There is a window of opportunity for PRT in Europe now.
- Political interest for PRT in Sweden is growing.

- Several applications of PRT in Sweden have been proven feasible
- International cooperation would reassure pioneering cities

9 Summary and Conclusions

Up to now, the crucial point seems to have been the imbalance between risks and financial support: no local authority can buy a system of its own, due to the development risks associated with PRT as long as it is an unproven technology; and no developer can invest full in development, as long as there is no (mass) market for the end-product.

Besides, there is also a "political risk", as long as financial support is a prerequisite for the implementation. As most of the Swedish feasibility studies show, it is not enough to convince the present political majority of the merits of a PRT system. Next election period, there is a more or less completely new set of politicians to convince.

Today the situation of podcar awareness in Sweden has moved into a new era. A PRT test track is under construction.

In the final report from the EDICT-project[13], the following conclusions were drawn, and they still hold, we believe:

> "On paper, PRT looks much more attractive than conventional public transport. But as yet no system exists in public use, and although many public authorities are interested in the concept, not one has committed to installing such a system.
>
> The answer lies in risk. The ULTra system is one which is nearer to full practical development than any other. It has a working test system and two vehicles. So far, the development has kept within its intended time and budget, and most people who see and try the system are enthusiastic. But there is still a big gap between a test system and full public operation. For the investor, there are technical risks that the system will not ultimately perform as proposed, and that it may cost more and take longer to bring to satisfactory operation than the designers claim. Whether the decision is made by a local authority using public funding, or by a company using private capital (as for example in an airport) there are serious political risks attached to failure. However competent the developers, and however strong the reassurance they can give that all the uncertainties have been considered and addressed so far as possible, the commitment to install requires a high level of faith in the product, and strong leadership from purchasing body. This has been true with all major innovations, of course, but in the case of a public PRT system any failure will be highly visible. Against this, the lead city or company can expect to earn considerable attention and praise for the first successful system.

[13] EDICT Deliverable 8: Demonstration report, June 2004

> It seems clear, nevertheless, that once a successful PRT system is in public operation, there will be a very large number of towns and cities which will want one."

One of the Swedish vendors, Mr. Jan-Erik Nowacki of SwedeTrack, put his conclusions in this way:

> "I thought that, when we first presented the FlyWay vision, the whole society would applaud and say – This is what we want!! That proved very over-optimistic! I have now worked mostly without funding for 20 years. I have learned that the timing of efforts is much more essential than enthusiasm. The only way today's western societies will accept any changes in transport, will be when the oil supply is cut off completely and permanently. I guess that the Chinese or the Koreans will be far ahead of western societies then. " /Jan-Erik Nowacki/

Kjell Dahlström, head of the governmental agency SIKA, stresses the need for a standard development of such a new technique. Strong purchasing bodies probably need to unite in a complex international technical competition. Such competition needs advanced cooperation between governmental and market bodies; neither of these main actors can have progress without a strong cooperation. When the now established transport modes, like roads, railways, air and sea transport were in their innovation phases they certainly had a tough way to go to convince the general societal establishments. Today we also have to face the fact that society is filled by different physical networks and their supporters who naturally try to keep their business alive and consider new modes as a major threat.

References

1 Camp, Sixten & Rolf Oom (1970) Spårtaxi i Göteborg, Kjessler & Mannerstråle, Göteborg

2 Spårtaxi –Hur realistisk är den? (PRT- How realistic is it?). Reprint from Väg- och Vattenbyggaren nr 12, 1971

3 Andréasson, I., 1991, Simulering av spårtaxi i Gävle, Etapp 1, TFB-Rapport 1991:25

4 Blide B., m.fl., Spårtaxi i Göteborg, Utredningsetapp 2 (kommuntäckande system), Trafikkontoret Rapport 8:1993

5 Andréasson, I., 1994, Studie av spårtaxi i Gävle - Analys av utbyggnadsetapper, KFB-Rapport 1995:2

6 Andréasson, I., m.fl., 1996, Research and development in advanced transit systems - Survey of academic and industry efforts, Rapport Chalmers Industriteknik.

7 Tegnér, G., "Market Demand and Social Benefits of a PRT System: A Model Evaluation for the City of Umeå, Sweden". Infrastructure, Vol. 2, No. 3, pp. 27-32, 1997, John Wiley & Sons, Inc.

8 Johansson, O., 1997, Are PRT systems socially profitable? Göteborgs Universitet Nationalekonomi

9 Åredal, Å., m.fl., 1999, Att resa p å ett nytt sätt i Linköping. SkyCab AB

10 Tegnér, G.: Benefits and Costs of a PRT system for Stockholm. 7th APM Conference. Copenhagen, May 1999.

11 Åredal et al., 2000, "Vision SkyCab in Sigtuna Municpality – a Description and analysis with illustrations of a new, user-.friendly automated transit system - SkyCab® - at Arlanda Airport and its surrounding settlements Märsta/Arlandastad on behalf of the Municipality of Sigtuna, the Swedish Civil Aviation Authority and Arlandastad. Stockholm, January 2000

12 Tegnér, G and Fabian, L.: Comparison of Transit Modes for Kungens Kurva, Huddinge, Sweden; 8th APM Conference in San Francisco, July 2001.

13 Tegnér, G. and Andréasson, I: Personal Automated Transit for Kungens Kurva, Sweden - a PRT system evaluation within the EDICT project. 9th APM 2003 Conference, Singapore, Sept. 2003

14 Tegnér, G.: EDICT – Comparison of costs between bus, PRT, LRT and metro/rail. Transek, February 2003

15 Tegnér, G.: Ridership Analysis; in: Personal Automated Transportation- Status and Potential of Personal Rapid Transit. The Advanced Transit Association, January 2003. (ATRA). http://www.ianford.com/prt/ridership.pdf

16 European Commission, 2004, DG Research, 5th Framework Programme, Key Action: "City of Tomorrow and Cultural Heritage", EDICT Final Report, Deliverable 10, December 2004

17 European Commission, 2004, DG Research, 5th Framework Programme, Key Action: "City of Tomorrow and Cultural Heritage", EDICT Huddinge Site Assessment Report, June 2004 (Ed: G Tegnér, I. Andréasson, N.E. Selin)

18 Tegnér, G., 2005, PRT Costs compared to Bus, LRT and Heavy Rail, Some Recent Findings. Paper to be presented at: AATS European Conference in Bologna 7-8 Nov, 2005"Advanced automated transit systems designed to out-perform the car"

19 Dahlström, K, et al, 2005, A General Transport System – A Case Study within the project: The Value of Alternative Transport systems. SIKA Report 2006:1 (including two reports in Swedish)

20 Hunhammar, M, Tegnér, G. & Andréasson, I., 2006, Spårbilar Värmdö, Nacka, Stockholm – Förstudie Gustavsberg. Värmdö kommun.