Personal Automated Transportation:

Status and Potential of Personal Rapid Transit, Ridership Analysis

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NOTE: This report is published in a group of documents. Other documents in the group include an executive summary, a description of the technology, a comparison of PRT systems, and other supporting reports.

The full set is detailed on the web site: www.advancedtransit.org/pub/2002/prt

Summary

Traditional Mass-transit modes have declined in share of ridership in the last 25 years in Sweden. While this study was done in Sweden, these trends are echoed elsewhere. Research shows that delay and transfer times are perceived to more onerous by travelers than the actual travel time. Relative weights have been found, for example: delay times are weighted by travelers at four times more onerous than travel time. The total weighted trip time for mass transit, including walk, wait, and transfer is compared to that of auto trips, and the results show that weighted transit trips are twice the duration of auto trips. This helps explain the decline in transit ridership share despite mass transit investments.

Personal transit (or Personal Rapid Transit, or PRT), in contrast to *mass* transit, minimizes wait and delay time and eliminates transfer time. In one city where current average transit trip times are 36 minutes (weighted), a study showed that the application of PRT would result in average trip times of 8 minutes, or a 78% decrease! A case study of Stockholm shows a substantial market impact from a high level-of-service transit system such as PRT. Total transit ridership would increase by about 20-40% depending on the travel period.

Ridership of Mass Transit

Declining Trend

Why have the traditional modes of mass transit – the urban and city bus, the LRT, the metro and the commuter rail systems – had such severe difficulties in competing with the private automobile? Even in the European cities the transit market shares are declining, although from a higher level than in most US cities. As an analytical example we would like to illustrate the case from Stockholm; Sweden for the period 1973- 1997. The supply of transit seat-kilometers almost doubled, while the demand for trips increased by only 16 %. The average trip trends during a 25 year period was 2.6 % for auto trips and 0.7 % for transit modes, in spite of the rapid development of the transit supply.

This phenomenon with traditional transit modes loosing market shares as more or less "inferior goods" can't be understood, unless we examine the demand side, i.e. the perception of the travelers. How does the traveler evaluate the travel time components and the performance of mass transit.

Explanation of the Decline: Walk, Wait and Transfer Time

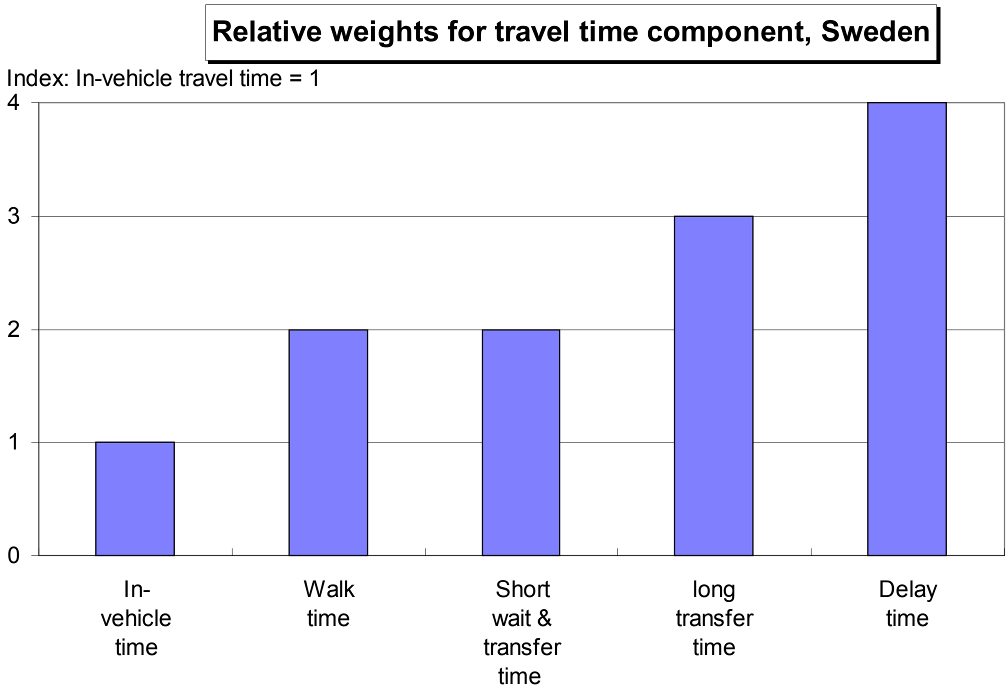
If you live on top of a railway station or nearby the bus stop – at both ends of o journey, mass transit might be highly efficient in carrying you from origin to destination. Very few do so.

In most cities and regions, supported by a traditional transit network of radial bus lines or even by a (radial) rail mode such as metro or light rail transit (LRT), the door-to-door travel time usually is twice, three times, or in some cases up to eight times as long as the corresponding auto trip. This is mostly inherent in the fixed line/route strategy of traditional transit operation now in use almost everywhere. The general time concept is a useful framework for understanding the behavior of the trip-maker. All components that make up the trip is added into one single unit of measurement, either in monetary units or in time units.

Choosing a transit mode also includes walk to the bus/rail stop/station, waiting at the stop for the vehicle to arrive, riding the vehicle, and, on some occasions, also transferring to another line, and, finally a walk trip to the final destination. The corresponding auto trip also has its access and egress components, mostly limited to walking to and from parking lots at home and at the destination of the trip. Our research findings reveal much higher time values for all of these out-of-vehicle travel time components.

These research findings are summarized as in Figure 1.

Figure 1. Relative weights for travel time components



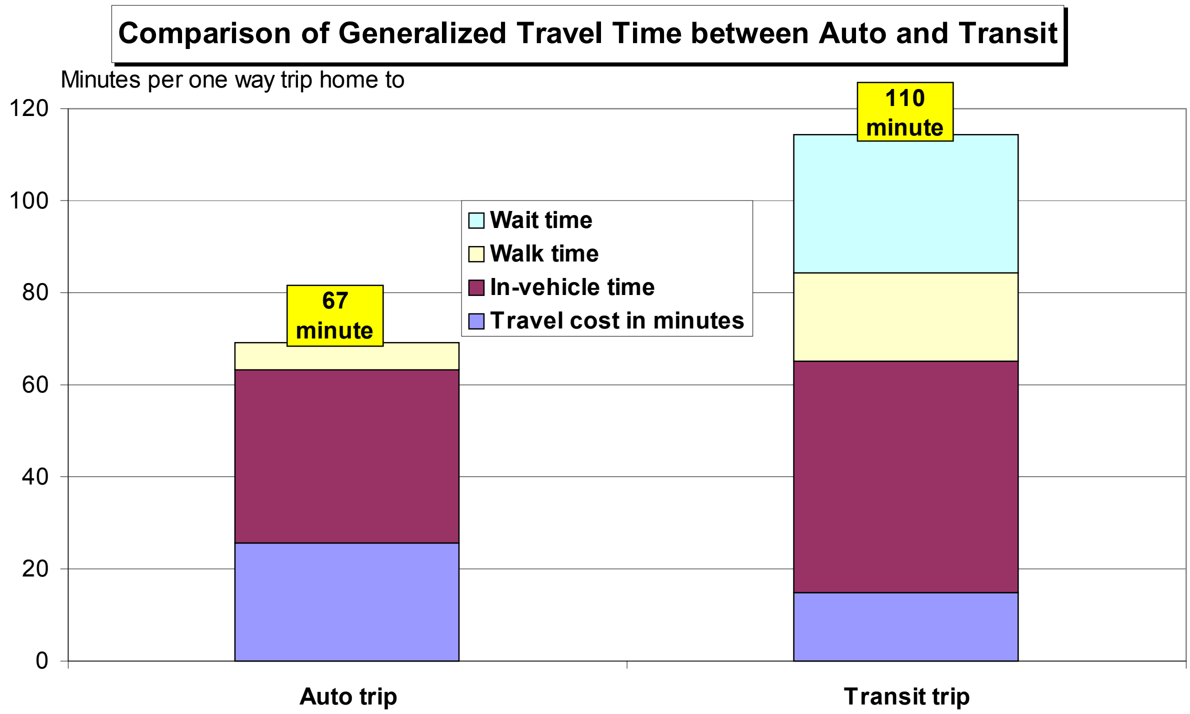
All travel time components spent outside the vehicle itself are valued *per minute* and much higher than time spend on board. This concept explains much of the competition problem for transit operators and planners. Thus, our conclusion from these findings are that traditional transit modes all have a serious competition disadvantage compared to all self service modes, such as the bicycle and auto modes, modes that brings the user direct to his/her destination without walk, wait and transfers. (Ref. A)

The out-of-pocket price of the trip is measured in time units (minutes) by transferring the costs, (with the travel time value associated), with the trip purpose, in this case the work trip. Travel costs are usually higher for the private auto trip than for transit trips.

Assume a typical home-to-work trip of 10 miles in length and with an average auto speed of 16 miles per hour and a transit (bus) speed of 12 miles per hour. Also assume the travel time value to be 6 US$/hour for work trips. This last value makes it possible for us to convert the travel cost in monetary value into minutes.

In Figure 2 below the generalized cost is shown for a typical work trip by auto and by transit modes.

Figure 2. Generalized cost for auto and transit for a typical work trip.



In this typical case the total perceived travel time amounts 110 (weighted) minutes for transit and to 67 minutes for the corresponding car work trip. The in-vehicle travel time is, on the contrary, longer for transit than for auto trips, due to the necessary stops en route (and slower acceleration at stops and traffic lights). However, what is an interesting observation, is the correspondence in the sum of this two components between transit and auto trips - almost the same magnitude. This means that if only travel costs and in-vehicle travel were the only two factors affecting the competition between the transit and auto modes, the mode choice would be 50 per cent each.

Another similar result is found in the overall travel speeds for urban trips. The average door-to-door speed is reported to amount 15.5 miles per hour for auto trips (all purposes) in the Stockholm region. The corresponding perceived speed for transit users (bus, metro, LRT and commuter rail modes, respectively) is only 9.3 miles per hour. The commuter rail service operates at an average speed of roughly 50 miles per hour from station-to-station. It is the walk, wait and transfer travel time components that contribute to the overall low door-to-door speed.

On average, even efficient transit systems competes mostly with the bicycle mode from the speed quality point of view. In reality transit travelers travel longer distances than cyclists.

Ridership of Personal Transit

Personal Rapid Transit – Individual Trips in Public Vehicles

By definition, *Personal* transit offers private trips to individuals or groups wishing to travel together, as opposed to *Mass* transit, which requires people to ride together and stop at each person's destination.

Personal Rapid Transit (PRT) offers individual trips in public vehicles – a competitive alternative to the most popular mode of urban transport – the private automobile. PRT is developed to offer some of the advantages of the private auto:

- It departs on demand without any timetable.
- It runs the quickest path without any stop and without any transfer.
- It offers a private trip alone or together with passengers of your own choice.

At the same time it avoids some of the major disadvantages of the private auto:

- Noise and exhausts.
- Congestion and accidents.
- Parking demand.

PRT is a system of small, automated vehicles on their own guideway that is demand-responsive and offers a direct trip to the destination without any stop en route.

Generalized Time at King's Curve, City of Huddinge

In a recent comparison of Transit Modes for King's Curve, City of Huddinge, Sweden, the importance of extremely short waiting times is very clear, as the PRT mode is compared to today's bus line, an improved bus system, a LRT network and an APM system.

Figure 3. Comparison of generalized time for King's Curve, Huddinge, Sweden

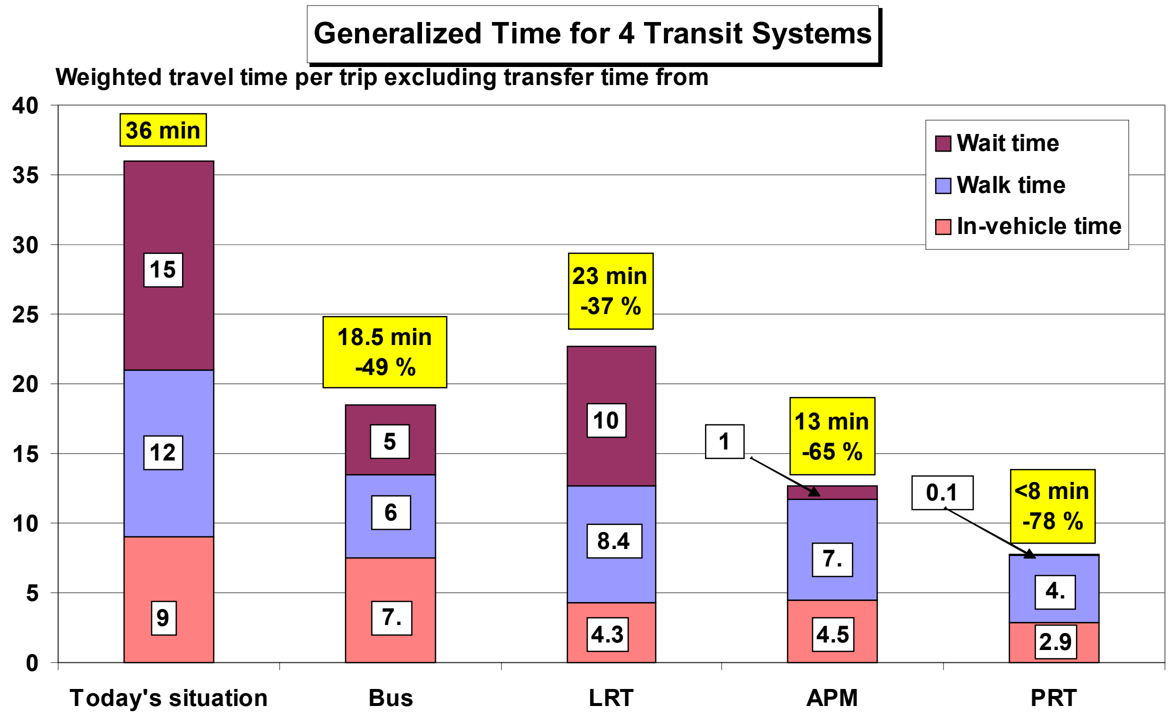


Figure 3 shows that a denser PRT network produces a shorter walking times than all the other analyzed transit systems.

As all passengers are assumed to be seating in a PRT vehicle, its higher acceleration allows a higher average speed, which reduces the in-vehicle time. The average PRT speed will be in the range of auto speed, or even higher, when congestion reduces the auto speed on the local street network. The almost non-existing waiting time (a few seconds) with a PRT network, contributes to an overall reduction in the perceived generalized travel time by up to 78 % according to this case study in the City of Huddinge, Sweden. (Ref. B)

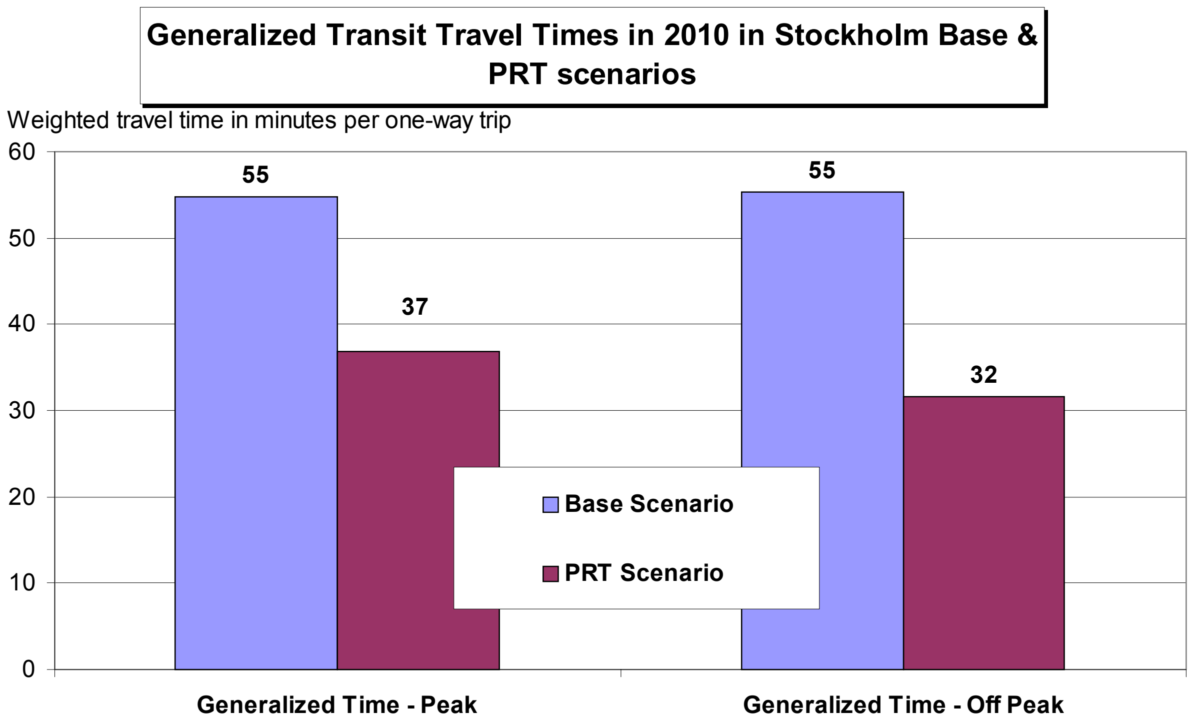
A PRT study for Stockholm, Sweden, 1999

A PRT trip demand analysis was carried out in 1998 for the entire Stockholm County Area (population; 1,775,000 inhabitants in 1998), with the simplified assumption that a PRT-station would be (theoretically) available in every traffic zone (1,043 zones) and running on the present major road links in the network.

The major changes in the generalized travel times that could be achieved by the PRT system, are mostly a dramatically reduction in the waiting and transfer times, compared to the present day modes of mass transit.

As the PRT system operates as an automated and a demand responsive system, the time spent waiting for the vehicles, does not differ at all between peak and off-peak time periods; this being the opposite for today's manually driven fixed line service. Thus, the major travel time gains with PRT will occur during the off-peak period. The weighted generalized time[1] is calculated to be reduced from almost one hour (55 minutes) in the base scenario to a little more than a half-hour in the PRT scenario.

Figure 4: Generalized transit times without and with PRT in Stockholm in 2010

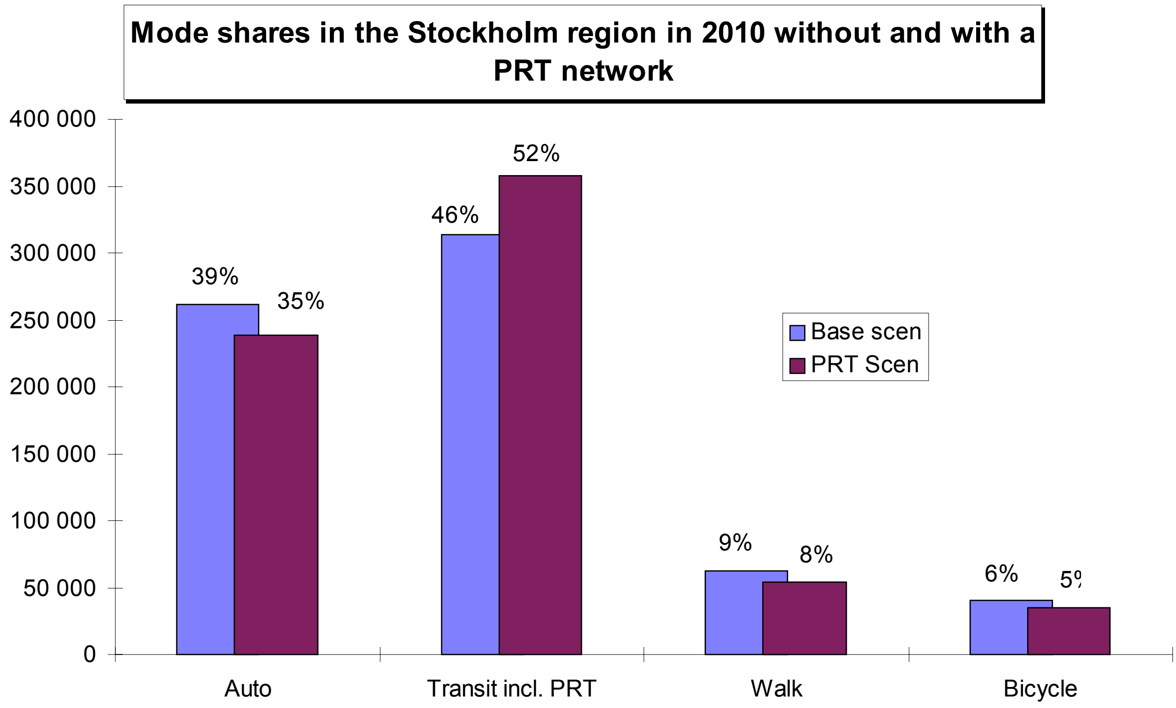


If an *area-wide PRT system* would be introduced in all Stockholm region, a substantial modal shift from the auto mode (-4 % units) would occur; also a slight shift from the walk and bike modes towards the transit modes, including the new area-wide PRT-system.

The transit modal split is estimated to augment from 46 to 52 % by the new PRT system, i.e. a 13 % growth in market share for all trip purposes.

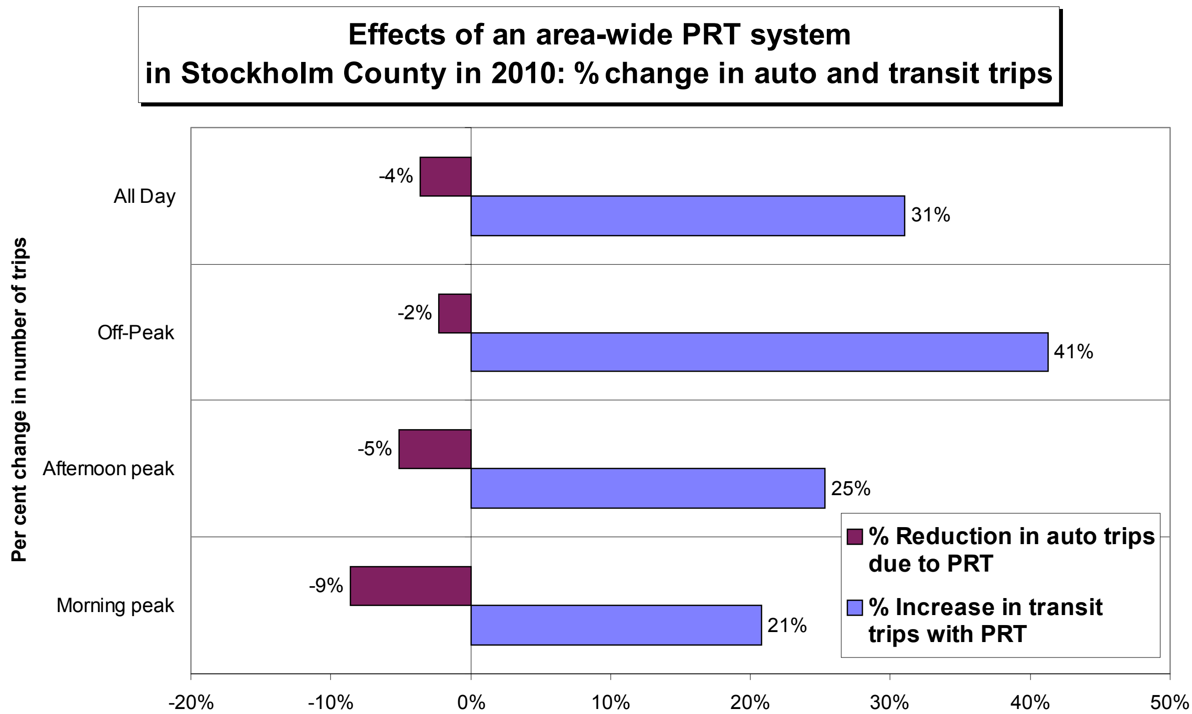
[1] The weights are 2 for the walk, wait and transfer travel time and 1 for the in-vehicle travel time (see Reference 6).

Figure 5. Mode shares without and with PRT in Stockholm in 2010.



The number of auto trips – for work trips – is calculated to be reduced by 9 % in the peak period, with its dramatic and positive impacts in terms of reduced congestion, air pollution and road traffic accidents. Transit trips – including the new PRT mode – is forecast to expand by almost one third (31%) during all day, and by 41 % in the off-peak period for work trips.

Figure 6. Impact of PRT on work trips in Stockholm in 2010



This Stockholm PRT case study clearly shows the substantial market impact from a high level-of-service transit system such as PRT, when it is compared to the more traditional mass transit modes, such as bus, LRT, metro and commuter rail. The more traditional transit modes have, so far, not succeeded to compete with the private automobile, due to the travel components spent outside the vehicle. (Ref. C)

References

A) Tegnér, G., (1997) "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.

B) Tegnér, G. (July 2001): "Comparison of Transit Modes for Kungens Kurva, Huddinge, Sweden". Paper presented at the 8th International Conference on Automated People Movers, San Francisco, 8-11 July, 2001.

C) Tegnér, G. (April 1999) "Personal Rapid Transit in Stockholm: Market Demand and Economic Viability", Article at the Innovative Transportation Technologies web site: http://faculty.washington.edu/~jbs/itrans/goran.htm