The Case for Personal Rapid Transit (PRT)

by Dr. Joerg Schweizer (Bologna, Italy) with editing by Lawrence J. Fabian (Boston, USA)

This white paper was reviewed by and technical and substantive comments were incorporated from the following members of the Advanced Transit Association (ATRA), www.advancedtransit.org:

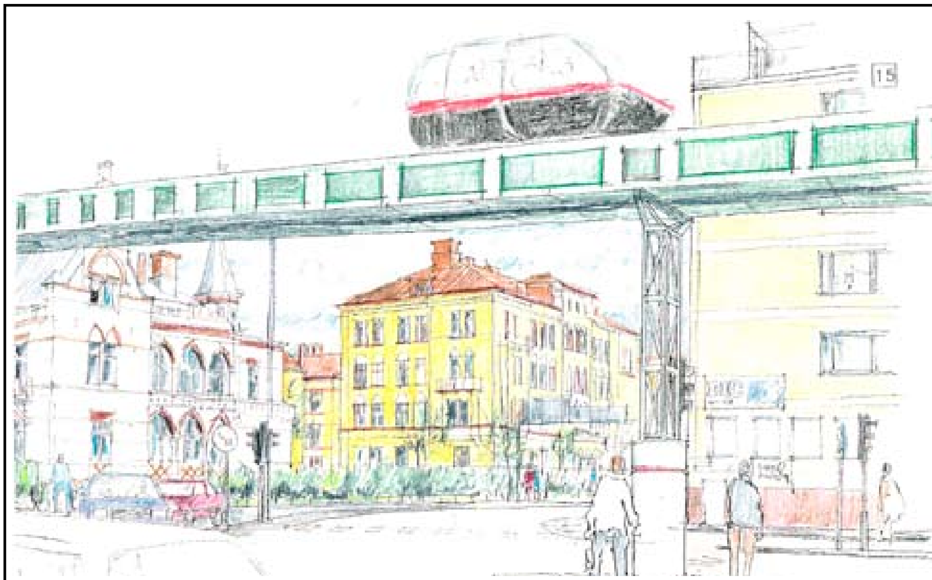
J.Edward Anderson (USA), Malcolm Buchanan (UK), Ian Ford (USA), David Gow (USA), Jarold Kieffer (USA), Shannon McDonald (USA), Goran Tegnér (Sweden), Richard Teychenne (UK), and William Wilde (USA)

PREFACE

Current strategies for reducing growing metropolitan area traffic congestion are not working.

Motor vehicle use continues to expand, and more roads are congested much of the day. Road expansions and their land requirements are becoming more costly and controversial. Air quality remains a concern. Use of conventional public transit modes (heavy and light rail and buses) over the past decade continues to be flat—3 to 5 percent of daily trips.

The reasons for continued growth of urban road congestion and lack of growth in public transit use are clear: (1) Widely diffused medium and lower density areas continue to grow at a fast pace and now contain the majority of residents and business activities; (2) These widely diffused areas are not well served by rail and bus transit because of the high costs of these modes; (3) Lacking effective transit service, most residents, workers, and visitors travel by autos.



Color, texture and style can help fit PRT in old cities.
- courtesy of the Swedish KFB (Communications Research Board)

Most policymakers believe that congestion in such areas is too great to be eased by transit improvements, yet they pay little attention to bringing forward more promising new technologies. Indeed, worldwide, there is little interest in low-cost, high-service technologies whose parameters are described on page 4 in the section ***Characteristics of PRT****.*

The Advanced Transit Association (ATRA), founded in 1976, is made up of transit professionals from many countries. In this paper, ATRA member Dr-Ing. Joerg Schweizer, a researcher at the University of Bologna in Italy, describes an off-road transit technology referred to as "Personal Rapid Transit" or "PRT" with special attention to claims of low cost and high service qualities that enable it to be feasible in medium and lower density areas. PRT has been intensively and objectively analyzed for over 30 years. However, nowhere in the world is a PRT in full public service. The closest example at West Virginia University (Morgantown) opened in the 1970s.

Necessarily, a safety assurance program must be completed before policymakers and investors will consider building and operating a PRT system in public service. PRT's first applications will likely be for internal circulation in large activity centers, such as airports and hospitals, or educational and mixed use complexes. Indeed, a project is underway to demonstrate a British version of PRT at Heathrow Airport by 2008.

In the face of failing metropolitan transportation strategies, ***the need for fresh thinking is clearly evident and urgent.*** *ATRA offers this paper to public and private policymakers, investors, and urban transportation planners as an overview with recommendations.*

Current Urban Transportation Issues

Increasing travel demand, limited space in urban areas, and traffic congestion threaten the urban environment. The volume of road traffic is seen by Europeans to be the single most important environmental problem. Conventional public transport systems (buses, trams and rail) have failed to provide a satisfactory alternative to the automobile other than in certain special circumstances such as travel to major city centers. Continued reliance on conventional solutions alone is seen as unsustainable for our environment, health and the quality of life, at both local and global scales.

The amount of land required by transport infrastructure has reached extraordinarily high levels. Transport infrastructure typically occupies 30% of urban land and in some U.S. city centers like Atlanta or Los Angeles up to 70%. Urban residents show increasing resistance to plans to build new roads or rail lines. Future transportation is thus likely to remain unsatisfactory. In Europe, lost time caused by road congestion is estimated to cost between 0.5% and 2% of GDP. This is expected to double by 2010. Traffic congestion causes stress to drivers and produces air and noise pollution. Road traffic accidents take on average 100 lives per day in Europe and almost 120 in the US. Wide corridors are also barriers for wildlife and threatened species.

Moreover, current modes of transportation can be difficult to use for many citizens. Access to and use of rail, bus or

Cars, highways and parking dominate U.S. urban life.
- courtesy of Trans.21

cars is often restricted to the "young and fit" segment of society, and difficult or inequitable for people with physical challenges. If public transport fails to offer an adequate service, costly special help and services are required. In 1996 approximately 10% of European households could not afford a car, and 30% did not own one. In the US, 8% of all households do not own a car. In many areas car ownership is a necessity for basic needs. The problem of transport access becomes increasingly pressing as the population ages and oil prices rise.

Of increasing concern are the effects of transport on a global scale. Transport is the sector with the largest increase in energy consumption during the past decade, and now has the largest share of total energy consumption (31%). Furthermore, transport is the sector with the largest increase in greenhouse gas production (+24% from 1993 to 2003), thus jeopardizing the objectives set out in the Kyoto protocol. Road transport still depends entirely on fossil fuels.

In 2004, the World Business Council for Sustainable Development published *Mobility 2030* on the sustainability of current transport systems and potential technical improvements. The report, signed by the chairmen of the world's largest automobile companies, sets goals to be achieved for sustainable mobility: reduction of toxic emissions, greenhouse gases, deaths and injuries, noise, and congestion, as well as improvements in accessibility. The overall result is presented in the executive summary:

Mobility 2030 predicts that progress is possible on all seven goals. But it finds that few if any can be fully realized by 2030. Running through the report is recognition of a central dilemma. Mobility is an essential part of human development, but the way contemporary society moves people and goods is not sustainable indefinitely.

One alternative is to make conventional public transport more attractive by improving its service quality. Another is to introduce road use charges to encourage more people to leave their cars at home. But there is little evidence that high quality conventional public transport can be provided without massive government subsidies, in particular in

Parking causes sprawl and destroys the walking environment.
- source – www.apa-tpd.org

suburban and other semi-urban regions with lower population densities.

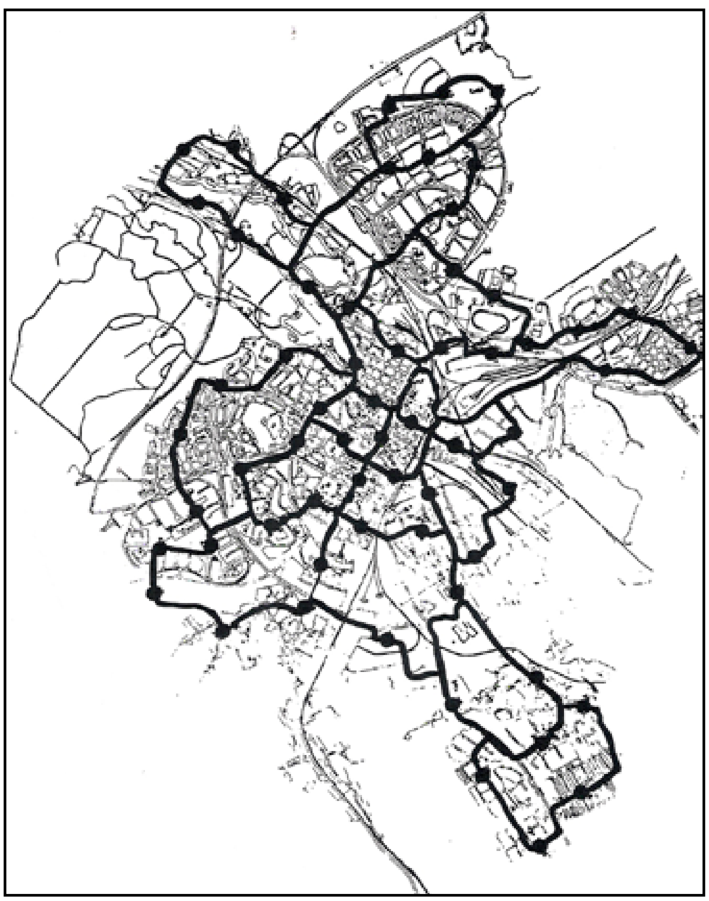
It will be expensive to make current transport systems sustainable. Moreover there is no evidence that such measures will actually reduce energy consumption, road accidents, and land consumption, while also improving equal accessibility to mobility. *Mobility 2030* mentions the technology that may point a way out of the present deadlock: Personal Rapid Transit.

The Characteristics of PRT

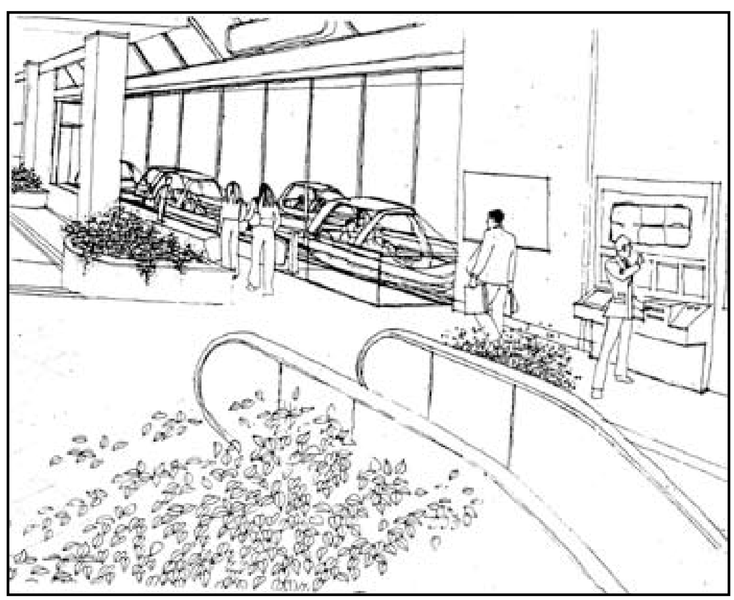
To provide a genuine alternative to the car, public transport systems must deliver better service at lower costs than conventional transit. This can be achieved by systems of small, lightweight, automatically controlled vehicles operating between off-line stations in a network of interconnected, small, low-cost, exclusive guideways. Use of off-line stations permits all trips to be nonstop, with little or no waiting, day or night, in seated comfort—features that will markedly increase ridership. Off-line stations permit high throughput of small, on-demand vehicles, which in turn can markedly reduce the cost, dimensions and visual intrusiveness of guideways. Flexible switching allows such systems to operate as networks, not a collection of independent lines. Moreover, they can also be easily adapted to hauling a wide variety of mail, goods, and other light cargo. A one-way guideway cross-section is about one sq.m. Spans between columns are typically 15-30 meters. Minimum radius of curvature is 3-5 meters.

This concept emerged over 50 years ago. In the 1970s it became known as Personal Rapid Transit. PRT and its possible technological approaches have been extensively studied. The Advanced Transit Association has defined this class of transportation systems in terms of these specific characteristics:

- Small, fully automated electric vehicles (i.e. without drivers).
- Small guideways that can be elevated above ground, at or near ground, or underground.
- Vehicles captive to guideways and reserved exclusively for them.
- Vehicles available for use by individuals singly, or in small groups traveling together by choice. These vehicles can be made available for service 24 hours a day, if required.
- Vehicles able to use all guideways and stations on a fully connected ("integrated") PRT network.
- A direct origin-to-destination service, without need to transfer or stop at intervening stations (i.e. "non-stop" service) within a whole network, not just down a corridor.
- A service available on demand rather than on fixed schedules.



Unlike linear rail, PRT is amenable to networks.
- Source: German research in the 1980s.

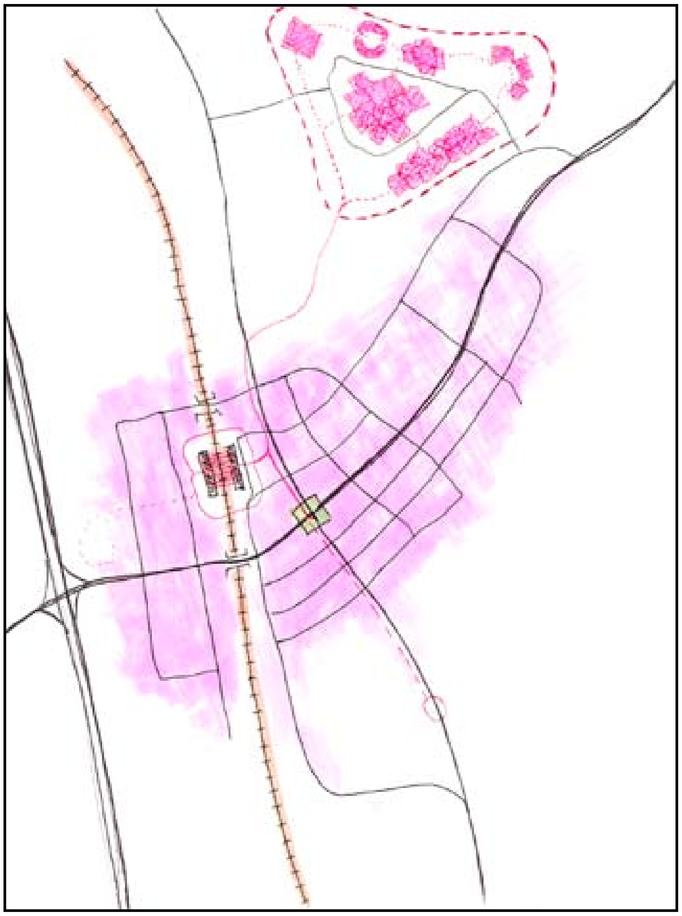


PRT is small in scale, compatible with a building lobby.
- courtesy of Taxi 2000

- courtesy of Studio Z Imagery and www.bettercampus.org

PRT is thus a sustainable transport mode:

- PRT makes efficient use of electrical energy due to the absence of intermediary stops and starts, high efficiency of electric motors, and partial recovery of energy during braking. PRT is independent of fossil fuels.
- PRT has zero tailpipe emissions.
- PRT is safe. Full automation removes the most frequent cause of accidents: the human driver. Safety standards are similar to those applied to modern trains, Automated People Movers, and civil aviation.
- PRT provides a taxi-like service. This is attractive to current public transport users, and also to a large portion of car drivers, as there is no stress from driving or problems with parking.
- PRT is easy to access and use: all that is required is to select the name or number of the destination, and to use a fare card or purchase a ticket from a vending machine. This ticket allows entry to any available vehicle at the station. Vehicle floors are level with the station platform, pushchairs and wheelchairs easily roll onto the vehicles. The system will automatically route the vehicle to the desired destination within the shortest possible time and without need for further user interaction with the system. Unlike today's conventional transit, PRT passengers will need no specific knowledge about the PRT layout.
- PRT is affordable: The capital costs of PRT are governed by the economies of mass production. The use of minimum-size, minimum-weight vehicles requires only a light track and thus reduces the capital cost to a fraction of that required for conventional rail, tram or bus systems, even on a per-seat basis. The absence of drivers and on-demand service are major factors in reducing the operating costs per passenger-km.
- PRT's low costs make it affordable in districts poorly served by conventional mass transit, which can enjoy enhanced patronage as PRT users transfer to regional rail.



PRT's smaller scale can help planners connect remote sites to regional transit.
– courtesy of Trans.21

There have been many lessons learned from early PRT experiments. The ever-increasing speed and decreasing costs of microprocessors and communication equipment are leading the development of PRT designs that will become commercially available within the next 5 years. As evidence, the next section describes a demonstrated technology, followed by descriptions of two others in design and prototype stages.

Demonstrated PRT Technology

With three decades of operating experience, the Morgantown PRT in West Virginia uses 20-passenger vehicles along a modest 5-kilometer corridor with five off-line stations. Several PRT development programs have demonstrated PRT capabilities, including one by Raytheon in the 1990s. More currently, the Advanced Transport Systems Ltd (ATS), has been testing the ULTra PRT since 2003 on a full-scale 1km test track near Cardiff, Wales. This technology is expected to be commercially available within the 3 years. Its characteristics illustrate planning parameters which public and private officials can use in the development of PRT scenarios to be compared with other modes of transit:

The Morgantown PRT has operated very safely in West Virginia for three decades.
– courtesy of Trans.21

- *Vehicle speed*: Prototype systems have been tested at line speeds of 40km/hr (considerably faster than typical average urban arterial speeds). Note that average speed is close to maximum speed, since there are few decelerations and no stopping during the trip.
- *Capacity*: Vehicles can presently run at approximately 2-second headways, even though early commercial operations may use longer intervals. This means 1800 vehicles or 7200 passengers per hour if fully loaded. Assuming an average occupancy of 1.2 passengers per vehicle, this implies a practical capacity of 2160 passengers per hour per direction. It should be emphasized that the strength of PRT is its functioning as a network as opposed to line haul system. The limitation of any single link capacity can be overcome by distributing PRT traffic across a denser grid network. Currently used technologies and achieved headways satisfy the "brick-wall" stop criteria corresponding to rail safety regulations.
- *Energy usage*: Comparisons with the average car indicate an energy reduction of more than 60%.

This rendering shows how the PRT demo at London's Heathrow Airport may look.
– courtesy of ATS

- *Costs*: Capital costs (excluding right-of-way, planning, and contingencies) have been estimated at $6-8 million/ km (5.0-6.5 million €/km). This is about one third of LRT costs. For a given investment in LRT, one therefore will get 3-4 times more coverage and even more stations with PRT. PRT operation and maintenance costs have recently been estimated to be less than for bus lines, which are currently considered the cheapest form of conventional public transport.
- User acceptance: Customer interviews and reactions of test riders show that the vast majority believe PRT will deliver an attractive service. Preference for PRT as a transportation mode is significantly higher than for conventional public transport. The higher usage of PRT will improve revenues for the operator. Case studies show that revenues can be sufficient to operate a PRT network at a profit.

PRT Technology in Development

There are several ongoing PRT projects around the world aiming to commercialize PRT products with improved performance and lower costs. The Korean Vectus PRT will soon have a test track in Europe. In Germany the full scale test vehicle of the Neue Bahnteknik Paderborn (NBP) system is under construction and designed to run on existing rail tracks. Within 5 to 10 years, PRT systems are expected to offer higher speeds, closer headways and a range of vehicle sizes. This means capacities above 3600 vehicles per hour. The required control systems have been designed with an extremely high level of safety and reliability by using modern fail-safe, fault-tolerant technology.

PRT Applications

With its narrow guideways and short curve radii, a PRT network can be readily integrated into existing city districts, with stations close to the user. Stations inside buildings are a promising option, especially in hot or cold weather areas. PRT can provide substantial transportation service while requiring a tiny fraction of urban land, leading to the potential for highly livable, higher density, more sustainable urban areas.

Short-term Applications
The situations where PRT can provide high-quality transportation service in the near term include:

- Networks linking parking garage and rail stations to airport terminals
- Downtown networks circulating from intercept parking, transit nodes, event facilities, etc.
- Suburban networks designed to enlarge the catchment areas of rail stations
- Networks for major shopping and office centers providing links to parking garages, hotels and transit stations
- Networks designed to replace bus service in small towns.

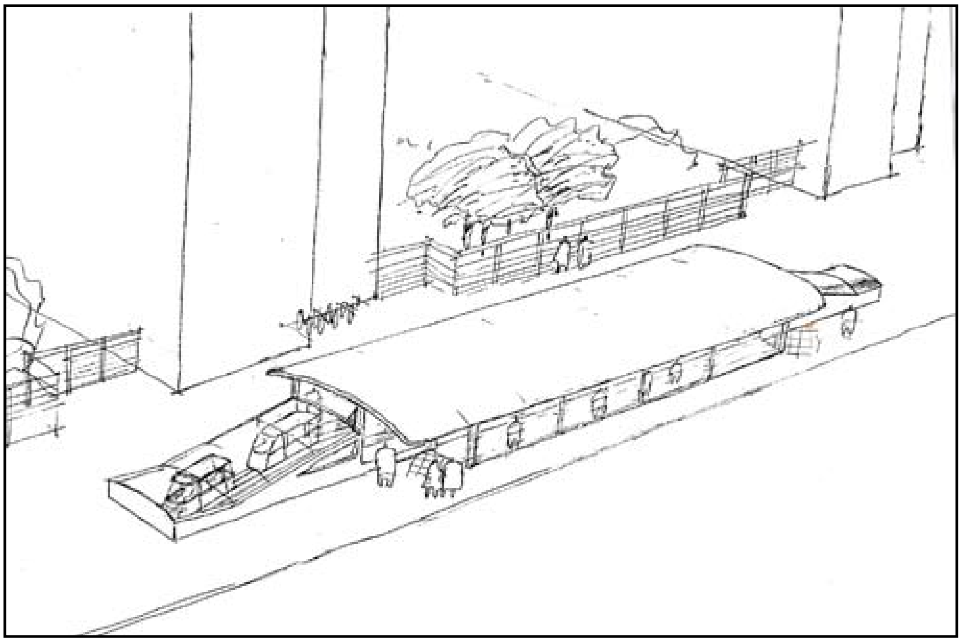
Long-term Applications
In the longer term, high capacity PRT can provide substantial area-wide services, causing a significant modal shift from street traffic to PRT. In some cases, PRT can become the primary means of mobility. The overall attractiveness of public transport will be improved so dramatically that significant shifts in car ownership patterns can be expected. Many people are likely to use PRT to such an extent that they will choose to live in areas well served by PRT with significantly fewer cars.

Visual Impacts of PRT

Questions have been raised concerning the visual impact of a dense, area-covering network of PRT guideways, whether

Longer spans are possible if higher columns support cable stays.
- courtesy of SwedeTrack AB

elevated or on the ground. It is important to carefully integrate new guideway structures into the townscape. The small cross-section and tight turning radii of PRT guideways as well as the silent, clean and emission-free vehicles allow flexible and aesthetic integration into existing streetscapes, even into buildings. Visitors who have used the PRT test track in Cardiff were asked “How do you feel about an elevated track?” 74% responded that it is “probably OK” or “no problem”. It is also important to consider the “dense” spacing of PRT network: ideally guideways would be about 0.8 km (a half-mile) apart.



When necessary, guideways can be underground with stations designed open to the sidewalk.
- *source: Swedish PRT studies in the 1980s*

Public acceptability of PRT networks depends on many city-specific factors only resolvable in a full public arena. The following observations are relevant:

- It needs to be evident to the local population that the installation of guideways brings benefits, such as reducing traffic, providing high quality mobility, and leaving more road space for delivery of goods and emergency services. Street lanes can be transformed into pedestrian walkways or bicycle paths.
- Further benefits are possible when PRT implementations diminish the need for controversial and expensive highway expansions.
- Guideways can be designed to match that of the surrounding architecture or according to a desired theme or style.
- In sensitive districts, underground guideways in small tunnels are an option, but raise costs.
- It may be possible to integrate useful utility conduits into guideways so as to create infrastructure benefits and revenue flows.

PRT and Urban Form

New forms of transport stimulate new forms of urban development that are often difficult to predict. First railways and then cars radically altered the structure and density of cities. PRT is expected to compete with car travel in many auto-generated environments. With its tight low requirements and ability to replace car traffic, PRT can help bring about a return to more humanly scaled, pedestrian-friendly districts not threatened by speeding traffic or choked by congestion and parked cars.

Living in compact neighborhoods can be considerably more attractive with PRT. In such districts, it will be easier for neighbors to know each other and enjoy small public places. Parents will be free of constant fears that their children might be injured—or worse—by traffic. Community life will be more unified. The air will be cleaner and quieter. PRT can help make it a reality. It is a vision worth pursuing.

Recommendations

Infrastructure investments have far-reaching consequences that last many decades, even centuries. It will be advantageous to make decisions on PRT based on similarly long perspectives. To assure sound decision-making, the following are recommended:

1. Consider PRT as an alternative to BRT, LRT, AGT, or other rail solutions and include it in planning studies as a conventional mode.
2. Provide funds to research the potential environmental and economic benefits of PRT.
3. Provide funds to implement demonstrations of PRT in urban settings.
4. Prepare and circulate literature describing the characteristics of PRT to architects, city and regional planners, urban transportation officials, and elected leaders.
5. Organize conferences, workshops and seminars to convey this body of knowledge to interested officials and professionals.

For Further Information

Schneider, Nordmann & Hinterberger: *Road Traffic Congestion: The extent of the problem*, World Transport Policy & Practice, Volume 8, Number 1, (2002) 3441.

European Environment Agency: *The European environment - State and outlook 2005*. Online at http://themes.eea.eu.int/Sectors_and_activities/transport/

World Business Council for Sustainable Development (WBCSD): *Mobility 2030: Meeting the Challenges to Sustainability, 2004*. Online at http://www.wbcsd.org

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.

J.E. Anderson, *Transit system theory*, Lexington Books, Lexington, MA, 1978.

M. Lowson: *A New Approach to Sustainable Transport Systems*, 13th World Clean Air and Environmental Protection Congress London August, 2004.

C. Cook: *Passenger Response to a PRT System*, U.S. Transportation Research Board Paper 04-3058, Committee on Major Activity Circulation Systems (A1E11), 2004. Online at http://www.atsltd.co.uk/media/papers/

P.H. Bly: *Three financial and socio-economic assessments of a Personal Rapid Transit system*, European Transport Forum, 2004.

M Buchanan: Why we need a Transport Revolution. *Public Money and Management* Vol 25 No. 3 June 2005.