REPORT OF THE DEPARTMENT OF RAIL
AND PUBLIC TRANSPORTATION

The Viability of Personal Rapid Transport in Virginia Report

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

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The Honorable Timothy M. Kaine
Governor of Virginia
Patrick Henry Building, 3rd Floor
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The Virginia General Assembly
General Assembly Building
Richmond, Virginia 23219

Ladies and Gentlemen:

Attached for your review is the 2008 "The Viability of Personal Rapid Transit in Virginia Report" that was requested by the 2007 General Assembly session in HJ 603. This report is provided by the Virginia Department of Rail and Public Transportation on behalf of the Secretary of Transportation, and responds to the General Assembly's direction to:

i. Examine, to the extent possible, the current status of the use of APM systems in other jurisdictions and consider applications of APM systems that would benefit public transportation needs in the Commonwealth.
ii. Submit to the Governor and the General Assembly an executive summary and a report of the Secretary of Transportation's findings and recommendations for publication as a House or Senate document each year of the 2007-2008 biennium.

Sincerely,

Matthew O. Tucker
Director

cc: Pierce R. Homer, Secretary of Transportation

PREFACE

In February 2007, the legislature of the Commonwealth of Virginia passed Joint House Resolution No. 603, “requesting the Secretary of Transportation to study the benefits, costs, and overall viability of personal rapid transit as a public transportation option for Virginia.” The Virginia Department of Rail and Public Transportation (DRPT) provided assistance to the Secretary of Transportation in preparation of this report.

This report provides an overview of the concept of personal rapid transit (PRT), including technology requirements; considerations for implementation including ridership and capacity, cost effectiveness, and environmental concerns; case studies of systems previously developed or in development; and conclusions on the potential application of the technology in Virginia.

Currently, DRPT is not aware of any PRT system in commercial service worldwide, and analysis by industry experts indicates that additional research and development must be undertaken before such service could be implemented. If the Commonwealth considers pursuing a PRT application in Virginia, careful consideration should be given to the limitations of the technology available today and the likelihood that additional research, development and funding would be required in order to provide a sustainable personal transit system.

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I. Executive Summary

Currently, the Virginia Department of Rail and Public Transportation is not aware of any Personal Rapid Transit (PRT) system in commercial service worldwide, and analysis by industry experts indicates that additional research and development must be undertaken before such service could be implemented. If the Commonwealth considers pursuing a PRT application in Virginia, careful consideration should be given to the limitations of the technology available today and the likelihood that additional research, development and funding would be required in order to provide a sustainable personal transit system.

This report provides a definition of PRT, considerations for implementation in Virginia, three case studies on PRT and a discussion on the potential application of PRT in Virginia.

II. Background

In February 2007, the legislature of the Commonwealth of Virginia passed Joint House Resolution No. 603, “requesting the Secretary of Transportation to study the benefits, costs, and overall viability of personal rapid transit as a public transportation option for Virginia.” This report provides an overview of the concept of personal rapid transit (PRT), including technology requirements; considerations for implementation including ridership and capacity, cost effectiveness, and environmental concerns; case studies of systems previously developed or in development; and conclusions on the potential application of the technology in Virginia.

A. Definition

The concept of Personal Rapid Transit (PRT) is based on the concept that a combination of small vehicles, computer networking technology and exclusive guideway can create a transit system that would be competitive with the private automobile. With a PRT system, it is envisioned that passengers traveling alone or in small groups would approach a station and program in their destination. A small vehicle (no more than four seated passengers) would then take the passengers directly to their destination, with no intervening stops or need for transfer. Non-stop travel would be made possible through a network of exclusive guideways (generally assumed to be elevated) where all stations would be located off the main track so that vehicles would not need to stop behind other vehicles off-loading passengers. According to PRT theorists, this system would involve short wait times and high average travel speeds compared to all other modes, including the automobile. A fully realized PRT system would consist of a dense network of guideways and stations, enabling fast, efficient travel throughout a metropolitan area.

According to a report prepared for the New Jersey Department of Transportation and New Jersey Transit (NJ DOT and NJ Transit, 2007), there are five key characteristics of PRT. These characteristics are as follows:

- On-demand, origin-to-destination service;
- Small, fully automated vehicles;
- Small, exclusive-use guideways;
- Off-line stations; and
- A network or system of fully connected guideways.

The particular benefits of each characteristic are described below.

On-Demand, Origin-to-Destination Service
PRT theorists consider the line-haul nature of traditional transit systems, which often require transfers and involve wait times at stations, as a major deficiency particularly when compared with automobiles. On-demand, origin-to-destination service would enable PRT to compete with automobiles in a way that traditional transit could not.

Small, Fully Automated Vehicles
Small vehicles are designed to provide a level of privacy equivalent to that of an automobile. Typically, PRT vehicles are designed to accommodate three to four seated passengers and no standees. It is necessary that these vehicles be fully

automated since the efficiency of a PRT system depends on the ability of computers to maintain safe operation at relatively high speeds.

Small, Exclusive-Use Guideways

Exclusive guideways are essential components of a PRT system. They allow for automated operation without the unexpected movements of pedestrians or vehicles operated by people. Typically, PRT guideways would be elevated rather than underground due to the high cost of constructing tunnels. PRT developers claim that these guideways can be much smaller than traditional elevated tracks because the vehicles which will be traveling on them are much smaller and lighter than trains, minimizing the visual impact. The small size would also allow rapid, prefabricated modular construction, which would decrease the costs typically associated with guideway construction.

Off-Line Stations

Off-line stations would allow vehicles on their way to other destinations to bypass a station, even when other vehicles are stopped to load or offload passengers. They would also allow vehicles not in use to be stored at stations, so that they could be waiting when passengers arrive. Stations could be sized to demand, allowing smaller, less obtrusive stations in low-density areas.

Network of Connected Guideways

The final key characteristic of PRT is that vehicles travel on a network of guideways with the ability to move from one guideway to the next. This network is typically conceived of as a grid, similar to a street grid. The interconnected nature of the guideway eliminates the need for transfers, as in a traditional transit system, and enables origin-to-destination service.

B. Technology

In 2003, the Advanced Transit Association (ATRA), a group dedicated to the promotion of PRT, released a report entitled “Personal Automated Transportation: Status and Potential of Personal Rapid Transit.” The report presented an overview of PRT systems under development and described the necessary technology. According to the report, the ATRA believes that “PRT systems could be constructed using ‘off-the-shelf’ components” (ATRA, 2003). They divide the components into the physical system, the control system and the end-user environment. They note that although the physical system requirements are well understood and have been tested in various prototype systems, much work remains to be done on the design of control systems, particularly control methodologies and user interface issues.

The report prepared for the New Jersey Department of Transportation and NJ Transit also assessed the current state of PRT development based on a review of the ATRA report and a survey of leading PRT system developers and industry experts. The report reached the following conclusions (NJ DOT and NJ Transit, 2007):

- PRT systems are approaching but not yet ready for public deployment;
- Many of the technical components needed to support PRT systems are commercially available and are used in other industries;
- Global PRT interest and development programs are expanding;

- A fully operational PRT system is needed to demonstrate the theoretical benefits of PRT and establish commercial readiness;
- A comprehensive technology research and demonstration program is needed to develop a PRT system.

While a number of test tracks have been built around the world, it is important to note that no PRT system currently operates in commercial service. As noted above, analysis indicates that PRT implementation will require further research and demonstration projects before it can be considered a proven technology.

III. Considerations for Implementation in Virginia

A number of considerations should be taken into account when determining the application of a transit system for a given area. These include the expected ridership and capacity of the system, its cost effectiveness, ease of implementation and environmental concerns. The following sections present an overview of these considerations for PRT.

A. Ridership Potential and Capacity

The ridership potential of individual PRT systems would depend to a large extent on the land use characteristics of station settings. As with any transit system, these include population and employment density, the mix of land use in the area, and the quality of the pedestrian environment. It would also depend on the extent to which the system links to desirable destinations and the availability and cost of parking at destinations. Ridership is also related to travel time, specifically the extent to which transit travel time is competitive with automobile travel time. The conceptual benefit of PRT includes improved travel time achieved by the elimination of transfers, shorter waits, and improved average travel speeds enabled by separated guideways and off-line stations.

Estimates of PRT capacity indicate that it would theoretically be equal to or higher than comparable bus and light rail lines at roughly 30,000 passengers per hour per direction (pphpd).[1] It should be noted that actual capacity is often much lower than theoretical capacity. The expected capacity of PRT systems would also be equivalent to the observed capacity of existing light rail and busway lines (roughly 10,000 pphpd). This is possible despite the much smaller vehicles due to the short headways enabled by automated operation and the higher average speeds achieved through separated guideways and off-line stations.

[1] Estimated and observed transit line capacities are drawn from NJDOT and NJ Transit, "The Viability of Personal Rapid Transit in New Jersey," 2007.

B. Cost Effectiveness

The capital cost and operating and maintenance cost estimates for PRT have not yet been proven in real-world settings. Additionally, capital cost estimates are for systems built once the technology matures. They do not take into account development costs and initial manufacturing start-up inefficiencies which can be expected for initial projects. Study estimates for capital, operating and maintenance costs indicate that PRT could be cost competitive with Light Rail systems while providing similar capacity.[2] Capital costs are assumed to be kept low ($30-$50 million per mile, according to the New Jersey report) due to the relatively simple guideway structure which allows for modular construction, and the limited need for property acquisition since the elevated guideways would run above existing streets. Operating and maintenance costs are estimated to be equivalent to heavy and commuter rail systems ($0.30 to $0.80 per passenger mile) due to the automated nature of the system, which reduces staffing costs, reduced energy use and vehicle wear as a result of on-demand service, and the use of advanced components such as linear motors that require less maintenance and repair.

C. Ease of Implementation

Currently, implementation of a PRT system in Virginia would require funding and a commitment to the development of a pilot project. Although there are a number of vendors that have been involved in the PRT industry over the past 30 years and have developed prototypes, a PRT system does not exist that is ready for implementation in revenue service. Therefore, development of a PRT service would require more time and more funding for initial development than would a traditional transit system such as bus or light rail. As noted in the report prepared by NJ DOT and NJ Transit, “Any State or agency choosing to implement an initial PRT system will assume higher risks of system implementation and operation and may incur greater expense and other difficulties in addressing problems that may arise from public operation” (NJ DOT and NJ Transit, 2007). Given the uncertainty of the feasibility and capital and operating costs associated with this technology, most transportation professionals would focus on modes with proven feasibility and more defined costs.

D. Environmental Concerns

Because most PRT systems are envisioned to run on elevated tracks above existing streets, environmental impacts can be assumed to be similar to that of other elevated transitways. If PRT were constructed underground in these areas, it would significantly increase capital costs. If PRT were to avoid these areas due to these impacts, its efficacy would be severely limited. Any analysis considering PRT implementation in a given area should seriously review the potential visual impact of the system. Noise impacts are expected to be less than with other rail transit modes due to the use of rubber tires on steel rails or concrete rather than steel wheels on steel rails. PRT systems are also expected to generate less air pollution than conventional buses at the point of operation due to the use of electric motors.

[2] Capital cost and operating and maintenance cost estimates are drawn from NJDOT and NJ Transit, 2007.

IV. Case Studies

Although no PRT systems are currently operating in revenue service, a number of prototypes have been developed over the past 30 years. The following three case studies present some of the lessons learned from prior and current attempts at developing a PRT system. The case studies include:

- **Morgantown, West Virginia:** A system similar to PRT has been in operation on the campus of West Virginia University since the 1970s. This system is not considered to be true PRT due to the size of its vehicles and certain service characteristics. However, it does provide origin-to-destination service and features off-line stations, both key elements of PRT.

- **Rosemont, Illinois:** During the 1990s, the Chicago Regional Transit Authority (RTA) and Raytheon Corporation teamed to develop a PRT pilot project connecting O'Hare International Airport, land uses in Rosemont, and the Chicago Transit Authority's (CTA) Blue Line. The project was abandoned in 2000 due to financial considerations and the loss of political support.

- **ULTra, London Heathrow Airport:** A PRT system is currently under development at London's Heathrow Airport. The system is intended to connect parking facilities and airport terminals and is due to open in 2008.

A. Morgantown, West Virginia

Initiative Description
In 1972, West Virginia University completed initial construction of the elevated track StaRRcar transit system, designed to shuttle students among its three campus locations in the City of Morgantown. The University selected this mode due to the city's already congested road network, University interest in this emerging technology, and funding available through the federal Urban Mass Transit Administration (UMTA), now known as the Federal Transit Administration (FTA), and the US Department of Transportation. Technically, StaRRcar is Group Rapid Transit (GRT), as it carries up to twenty-one passengers (eight seated passengers) per vehicle, however, it is the closest example of Personal Rapid Transit (PRT) in use today. The Morgantown system has 8.7 miles of track, offers approximately 15 minute headways, and can transport up to 30,000 people per day.

Cost
Construction costs for the Morgantown system were four times the initial estimates. However, PRT proponents argue that StaRRcar construction costs could have been cut by 80% had designers and engineers had enough time to research vehicle and track structure options.

Figure 1: Photograph Showing the Morgantown StaRRcar Vehicle and Guideway

Figure 2: Photograph Showing the StaRRcar Guideway from Street Level

The operating expense per unlinked passenger trip for the Morgantown system during the 2005/2006 school year (the system does not operate when WVU is not in session) was $1.45 per trip. This compares with averages in Virginia in fiscal year 2005 of $1.79 per trip for heavy rail (Metrorail in Northern Virginia) and $1.40 per passenger trip for buses. The high effectiveness of the Morgantown system is largely due to its automated operation, which eliminates the labor costs associated with drivers and the very limited distance it operates and a captive population of students.

Viability
The StaRRcar system has successfully demonstrated the potential of on-demand service and off-line stations..

B. Rosemont, Illinois

Initiative Description
In 1990 the Chicago Regional Transportation Authority (RTA) undertook an extensive PRT study with the expectation of leading a nationwide transition to PRT-based public transit. At the time, RTA Chairman Gayle Franzen believed PRT to be the best hope for meeting increasing transportation demands. RTA conducted a multi phase evaluation of PRT, including competitions for most appropriate technology and best pilot project location in the Chicago region. In a partnership with RTA, Raytheon Corporation built a testing facility, including 2,200 feet of track, an off-line station, and three prototype vehicles in Marlboro, Massachusetts. The partners selected the City of Rosemont, a Chicago suburb, as the demonstration site for the new technology. The system design would have connected O'Hare International Airport with Rosemont hotels, office buildings, retail and a convention center. In 2000, prior to ground breaking, the project lost its political support due to financial and technological concerns. The project was never built.

Cost
The RTA and Raytheon joint development initiative ultimately cost RTA $21 million and Raytheon $45 million (1993 dollars). This contract included all technology development and extensive testing at a new prototype facility. The team expected to design a system at the cost of $30 million/ mile, including guideways, vehicles, and stations. Cost estimates indicated that this facility would cost half the price of a typical light rail system, while it was designed to provide an equal or better level of service. By the time the prototypes were completed, however, cost estimates had risen to over $40 million/ mile (1993 dollars). When engineers modified the originally selected vehicle technology to incorporate transit design elements already in use, these elements created a much heavier vehicle that required a larger, heavier, more visually intrusive track. Costs increase as a result of the design enhancement and it was determined that farebox revenues could not cover the higher bond financing costs and Rosemont faced the possibility of subsidizing operations. Rosemont's elected officials were unwilling to take such a risk and Raytheon was not prepared to offer a warranty on operations and maintenance cost estimates. As a result, the project halted.

Viability
Experts agree that the RTA/ Raytheon PRT initiative failed largely due to its inability to provide public transit at a cost lower than that of existing public transit services. The

heavy vehicles led to high construction costs and operating cost estimates that were unlikely to be recovered though fare-box income alone.

Figure 3: Photograph of the PRT 2000 Vehicle and Test Track in Massachusetts

Figure 4: Simulation of the PRT 2000 Vehicle and Guideway on a City Street

C. ULTra Pilot Project – Heathrow Airport, London

Initiative Description
ULTra (Urban Light Transport) is a PRT technology developed by Advanced Transport Systems Ltd. (ATS). The British Airport Authority (BAA) is working with ATS to construct a pilot ULTra project at Heathrow Airport. In early 2008 this system is planned to replace the current bus service between airport parking lots and terminals. BAA hopes that the new system will not only reduce transit time for passengers, but also help meet its goal of reducing Heathrow Airport carbon dioxide emissions to 15% below 1990 levels by 2010. The track will be 4.7 miles long, run 47 vehicles, and carry approximately 8,000 passengers per day. Officials expect travel times to decrease by eight minutes, on average. Each ULTra vehicle carries four passengers.

Cost
ULTra technology development has been financed by ATS Ltd., commercial investors, and government entities including the United Kingdom Departments of Transport and Trade and Industry; the UK National Endowment for Science, Technology, and the Arts; and the European Commission. ATS estimates capital construction costs, including vehicles, to be £3 million ($5.95 million). Operating costs will be approximately £0.80 ($1.59) per passenger trip. This operating cost would be 40% lower than that of the existing bus service.

Viability
ULTra technology has been used on two British test tracks and demonstrated its ability to offer six second headways and potentially serve 2000 passengers per kilometer.[3] This service capacity is significant in that no other UK light rail system currently operates at this capacity. Vehicle weight and energy efficiency were high priorities for LTS in this product's development. Additionally, tracks are one-way in order to limit the visual impact on cities. Many ULTra investors see PRT as a way to implement the widely successful "just in time" delivery model to the public transit industry.

[3] It should be noted that "headways" in PRT terminology refer to the minimum spacing possible between vehicles when operating, not to the time between vehicles arriving at a station, which is the usual definition of headway. This is because of the on-demand nature of the service. System design assumes that waits at stations will be less than one minute.

Figure 5: Photograph of the ULTra Vehicle and Test Track in Cardiff, Wales

Figure 6: Image Showing the Interior of the ULTra Vehicle

Potential Application of PRT in Virginia

Based on the elements described above, PRT could theoretically have application for short trips of four to ten track miles in urban dense areas throughout the state with land use characteristics appropriate for medium-capacity transit modes, such as urban centers, dense neighborhoods, and residential areas close to high-capacity transit lines, for which PRT could serve as a feeder. PRT could also have application connecting activity centers, such as college campuses and nearby town centers, or as circulators in retail, employment, or entertainment centers or college campuses.[4] It also has potential application as an airport circulator.

PRT is not yet ready for commercial application. Any decision to implement PRT at a location in Virginia should recognize the significant time and funding that would be required to fully develop and test a pilot system. Given this uncertainty, it may be appropriate at this time to follow the development and testing of the technology in other applications before developing it in Virginia. However, the Commonwealth may also choose to take a more active role in PRT development by supporting research.

[4] The system closest to PRT application in the United States operates on the campus of West Virginia University in Morgantown, West Virginia, where it connects the main campus to satellite campuses and the downtown. However, the Morgantown system is not considered true PRT because it operates relatively large vehicles with capacity for 8 seated passengers and 12 standing.

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