February 8, 2010

Strategic Research Directions, Priorities, and Performance Metrics for Implementing Personalized Transit in Urban Settings

Prepared for RITA Docket 2009-0005
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Introduction

The Advanced Transit Association (ATRA) encourages the Research and Innovative Technology Administration to consider emerging advanced transport systems as part of its package of strategies to improve the nation's transportation system. ATRA is a non-profit international organization that advocates for forms of advanced transit that are (1) completely automated, (2) demand-responsive, and (3) fully networked. Although ATRA is dedicated to the advancement of public transport technology, this type of urban and suburban transport has potentially significant benefits to improve productivity, decrease emissions and carbon footprint, and provide an alternative that can out-perform the automobile in many respects. These concepts are being realized in commercial systems overseas and have received various monikers including personalized transit, personal rapid transit (PRT), personal automated transport (PAT), or "podcars" in Europe, but are referred to as PRT in this response. Whatever the name, this form of transport has tremendous potential in several DOT key priority areas. The PRT concept is for small, driverless vehicles (one to four passengers) on a fully automated and networked system of guideways to provide direct origin to destination service, with no interim stops. The speed of travel can be fairly high for urban applications (40 km/h and greater) on exclusive guideways, elevated, underground or at grade.

Although commercial implementations are recent in coming, research studies funded by the U.S. government during the 1960s and 1970s produced conceptual designs of PRT vehicles circulating on dense, elevated networks with numerous stations in cities such as Los Angeles and Minneapolis. Although none of these networks was ever developed, a scaled-up version of PRT – with large (20-passenger) vehicles – was built in Morgantown, West Virginia. The Morgantown system opened in 1975, and continues to operate successfully today. A modern PRT system with 21 small vehicles and three stations is scheduled to begin operation at Heathrow Airport in London in 2010. The first truly dense PRT network is under construction in the Abu Dhabi eco-city of Masdar as of this writing. The first phase of the Masdar PRT is to be a double loop that connects a car-park with a university campus. As experience permits, the PRT network will be expanded to a 100-station, 2,000-vehicle network conceived to move people, goods, and garbage.

PRT systems have the potential to decrease traffic congestion, reduce the use of fossil fuels and foreign oil dependence, enhance personal mobility, including eliminating the need to park a motor vehicle, and lower personal transportation costs. Traditional public transit modes include bus, heavy rail, light rail, commuter rail, streetcars, and other forms. While there are many success stories in public transit in the U.S., and usage has been growing, fewer than 1% of all person-kilometers are by transit, and fewer than 3% of all trips. A new paradigm in public transport is needed to increase its impact on American travel, lifestyles, and the environment. If the mobility opportunities provided by the private motor vehicle are to be challenged, then new transport options must provide nonstop origin-to-destination travel in a private, secure environment. Personalized transit has these qualities and can, in fact, offer *advantages* over the private motor vehicle. These include:

- Lower overall travel time for most trips,
- No active driving required,

- No need to park the vehicle,
- No need to refuel the vehicle,
- No contribution to or involvement in traffic congestion,
- Safe, controlled regime of travel,
- Potentially improved interfaces with origins and destinations,
- Clean energy technologies integrated systemwide, and
- The ability to supplement and enhance the use of existing transit systems.

Although bicycles and Segways™ offer similar advantages in certain realms, by nature they are limited to mild climates and persons capable of operating the devices. ATRA envisions PRT as part of a multimodal framework that increases trip efficiency through the combination of the private motor vehicle, existing public transit options, pedestrian, cycling, and PRT. In one setting, for example, people would live in a compact, mostly car-free community in which walking, bicycling and other carbon-free modes dominate the transportation scene. A PRT system would be available as an alternative, and to serve trips that are too long for comfortable walking and bicycling. PRT vehicles might enter buildings – similarly to some automated people mover applications serving resorts in Las Vegas and Walt Disney World – to provide enhanced access. Most motor vehicles would be parked on the fringes of the community, while those involved in goods movement, the mobility-impaired, maintenance and emergencies would be allowed to penetrate the community. In another setting, a high-speed rail station would be connected to the surrounding community with a PRT system. The PRT would serve travel within the station's surrounding parking facility – which could be substantially large – and continue into the nearby community, possibly serving remote parking locations. The "nearby" community could consist of a collection of industrial developments, a medium to high-density residential development, commercial and retail centers, or a combination of these. Other settings appropriate for a PRT application are possible. In fact, near-term applications of PRT may be most suitable in activity centers, such as airports, university campuses, large retail developments and business parks. A PRT can efficiently link the attractions within these centers, and possibly supplant circulating motor vehicles that vie for close-in parking resources.

DOT Key Priority Areas

Personalized transit would address the DOT key priority areas as follows. **Safety**: Over 40,000 fatalities, and several million injuries occur in motor vehicle collisions in the U.S. annually. If PRT can successfully curtail or even reduce motor vehicle use, then there would also be a reduction in collisions. Also, the Morgantown system has had an exemplary safety record in its 30-plus years of operation. There have, in fact, been no fatalities or serious injuries in completing over 200 million passenger-km. Further, PRT promises to be less injurious, with far fewer fatalities, than conventional transit systems. **Livable communities**: Although there is no accepted definition of a "livable community," the general agreement is that "livable" means supporting existing infrastructure and alternative modes of transport, and excluding congestion, sprawl, and auto-dependency. In brand new developments, PRT can be integrated into the community framework. In Masdar, for example, the PRT network is being built in conjunction with the rest of the city. The city will be completely auto-independent. While Masdar would have a population between 45,000 and 50,000, covering an area of 6 sq km, it is possible to design smaller livable communities with PRT serving internal trips and connections to line-haul transit services. Although "optimal" community and PRT network sizes have not been determined, a single PRT line can serve an 800 m (1/2 mile) swath of medium-density development. A PRT network built as a series of loops, however, can cover an area, as opposed to only serving a corridor like conventional transit. In Sweden, studies have been performed on integrating PRT into existing, older cities. The general conclusion has been that integration is feasible, although there is concern over the effects of elevated infrastructure on the visual integrity of historical districts. An option for relatively small historic centers would be underground PRT, where the guideways run in small shafts right below the surface.

State of good repair: Personalized transit can indirectly help to extend the useful life of America's transportation infrastructure. If PRT can be interfaced with walking, bicycling, and other public transportation modes, as well as effective interfaces with the automotive networks, then there could be an increase in the proportion of trips made by modal alternatives, and a measurable decrease in private motor vehicle use. In the short run, the use of PRT systems could negate the need for costly upgrades to highway networks to accommodate growth and development. In the long run, the decrease would relieve highway infrastructure of a sizable share of the present car traffic. Also, a proliferation of transit-oriented developments, some with PRT systems, would reduce highway congestion. Annual operating and maintenance costs for the Morgantown system, running on dated 1970s technology, were about $3 per vehicle-km in 2005. This amount is competitive with commuter rail (~$8 per veh-km), heavy rail (~$5) and light rail (~$9), respectively. A modern PRT system would probably have per km costs in the dollar range. Motor vehicle per-km costs were about $0.35-0.40 as of this writing, but this is highly dependent on volatile fuel prices.

Economic competitiveness: The economic benefits of transportation investment, particularly in PRT, includes reducing the impacts of costly motor vehicle collisions and traffic congestion, increasing productivity by decreasing the time spent in congestion, increasing productivity by enabling commute time to be used for purposes other than driving a vehicle, and providing a high-quality alternative to those who may not be able to operate or afford a vehicle. The U.S. has become heavily dependent on motor vehicle transport, and consequently on fossil fuels. It can be argued that the U.S.' economic future hinges, in part, on becoming independent of foreign oil. One way that the U.S. can foster its independence is by investing in motor vehicle alternatives, including PRT. The use and proliferation of a new generation of transport can be part of a sound economic strategy in which the U.S. increases its competitive stature in public transportation technologies. **Environmental sustainability**: The development of PRT can have a direct impact on reducing carbon emissions, and on decreasing the use of fossil fuels. PRT systems not only use less energy per passenger-km (100 mpg equivalent and up), they can also provide such a high level of service that their integration could dramatically increase public transit use. Renewable energy sources, such as solar, wind, and geothermal power, can be harnessed to provide propulsion for a PRT system. Also, small PRT vehicles can extract electrical power directly from the grid, such that on-board energy storage is not required. This prospect reduces vehicle weight, energy consumption and toxic waste. Further, energy losses and idling emissions in stop-and- go traffic and intermediate stops can be eliminated.

Research Direction

The research direction for PRT needs to be broad and multi-disciplinary in the long term. In the short term, the research direction needs to focus on technology and DOT key priority area impacts. Near-term (2010-2015) research needs should emphasize activities that will enable the implementation of PRT in locations in which minimal systems can demonstrate significant impacts by 2015. Long-term research needs (beyond 2015) should emphasize activities that will enable PRT networks in large urban settings, such as those that were envisioned in studies of the 1960s and 1970s. Automated or driverless transit is accepted as proven technology for traditional forms of mass transit (mostly overseas) as well as for shuttle systems frequently encountered at airports (in the U.S. and overseas). There were over 100 driverless systems in operation worldwide as of 2009. Some of these were carrying heavy passenger loads, such as the Hartsfield International Airport people mover in Atlanta, and driverless metro systems in cities in Europe and east Asia. The Las Vegas Monorail and the BART system in the San Francisco Bay Area are driverless, although the latter uses a "standby" operator on each train. The use of automation in these scenarios (as well as the long established used of automated controls in elevators) demonstrates the public acceptance of autonomous vehicles. PRT represents a small-vehicles version of driverless technology, with the addition of demand responsive, fully network operation. Priority research is critical in the U.S. to ensure its implementation.

To fulfill the near-term research needs, a four-pronged approach is recommended. The four research areas are as follows:

1. Technology – Although modern PRT systems are opening at Heathrow Airport and Masdar in 2010, additional research areas specific to U.S. settings are needed. Three such examples include control system scalability, passenger safety certification and standards, and structural guideway building codes and impact on PRT developments.
2. Scanning Tours – The Federal Highway Administration has long sponsored scanning tours to germinate ideas and help link professionals in various areas of the country. Although PRT began as a U.S. initiative in the 1960s, recent work is dominated by overseas advancement. As PRT does not fit easily into the existing division of public transit and highways, exposing elected officials and leaders to the modern implementations in Europe will spurn the imagination of our leaders in order to provide the top level leadership needed in the US..
3. Testing and Analysis of Existing Systems – Although simulation can be a useful tool in system design, the control and operations of PRT vehicles at close headways, as short as 1 sec, needs to be tested. Initial implementations would include pilot systems and full-scale test tracks to test vehicle movements, including merging, diverging and distribution Although the burden of innovation would be on system developers and vendors, publicly-funded research would have a role in establishing specifications, and ensuring that they have been met. The DOT has funded magnetic levitation demonstration projects that included the development of test tracks. Similarly-guided support toward the demonstration and development of PRT technology is needed.
4. Planning and Finance – Creating feasible business models that limit risk to public and private capital while not encumbering innovative solutions is long overdue, particularly to move the U.S. from a subsidy based model for public transit, to a capitalist “work-horse” model. Some researchers have estimated that a PRT system could “pay for itself.” Yet, innovative financing is still needed to fund construction. Planning issues, such as the ideal network length and density for a given service area, the potential patronage, public preferences, and public acceptance are all topics that warrant investigation.

Specific research topics and priority areas are discussed below.

Research Priority Areas

Technology Research

Safe Control Concepts for Close Headways. A number of processing and response issues must be addressed to ensure stable control at close (< 2 sec) headways.

Formalized Strategies for Non-Ideal Conditions in PRT Operation. Many PRT operating scenarios have been based on random passenger demands. Further study and strategies are needed for bunched passenger demand at transfer points with scheduled modes.

Empty PRT Vehicle Management. To minimize wait times, empty vehicles must be quickly rerouted to on-call locations. Some simulations have been done in this area, but additional study is needed.

Assessment of PRT Propulsion Options. Lightweight on-vehicle batteries are being used in the Heathrow PRT, but other options include guideway electrification, linear induction, and magnetic levitation. Renewable resources, such as solar and wind power, also warrant investigation and comparison.

Evaluation of PRT Guideway Infrastructure Alternatives. Suspended vehicles on elevated guideways, and supported on elevated and at-grade guideways have been designed. There is no consensus on the best design, however, in terms of materials, span lengths (if elevated), safety issues, costs, visual aesthetics, and other aspects.

Scanning Tour

Scanning Tour of Morgantown, Heathrow, Rivium, Masdar and Test Tracks. A panel of officials, administrators and-or researchers should undertake a tour of the Morgantown, Heathrow, Rivium, and Masdar systems and developments. The tour might also include visits to mature PRT prototypes and testing facilities. The dissemination of the panel's experiences and findings should enhance the general knowledge of PRT in the U.S., particularly among those having decision-making authority and influence.

Testing and Analysis

Pilot PRT Systems. The U.S. has fallen dramatically behind the rest of the world in PRT technology, despite having led its early development. There are two robust test tracks and two pilot systems scheduled to come on line, all overseas, in 2010. The U.S. can leapfrog the overseas progress by building pilot systems here. Pilot PRT systems are needed in order to demonstrate the feasibility of the technology, encourage its development and provide a platform for further testing. A number of U.S. public agencies, including the U.S. Army and some cities and large airports, perceive PRT to be the best solution to their surface transportation needs, but lack the funding to build initial systems without government support. A pilot system could be used to test and or verify aspects such as safety, reliability, system (station and guideway) capacity, scalability, and public acceptance.

Planning and Finance Research

PRT Network Design for Compact, Livable Communities. The integration of PRT into new, compact communities presents an opportunity to optimize the network layout, station locations, station sizes, capacity needs, and fleet size. Issues involved with placing stations inside buildings need to be investigated. The benefits and costs of elevated versus at-grade versus underground infrastructure also warrant study.

PRT Station Designs and Boarding Processes. Most PRT concepts feature linear, off-line stations. Multiple berths may be featured to accommodate heavy passenger demands, although sawtooth designs may require vehicles to back up. Research is needed on optimal station designs, and on how best to distribute and "assign" passengers in busy stations.

Non-Visual Control Interfaces. In a recent meeting with the National Federation of the Blind (NFB), the prevailing commentary was 'Being blind is an inconvenience, not being able to drive is a handicap'. Effective non-visual interfaces in the very first implementation (and appropriate standards for any implementation) is key to enable sectors of our populace to take full advantage of the new technology. The NFB has volunteered to participate in such an effort.

Financing Strategies and Business Models for PRT in Urban Areas Innovative business models and financing are needed to implement PRT in a sustainable fashion in urban applications. Innovation is especially critical during periods when governments at all levels are cash-strapped, and there are competing needs. While attention is rightfully being put on sustainability for the environment, there is also a dire need for methods of sustainable transportation financing.

Potential for Ridesharing in Small Driverless Vehicles. The traditional PRT vision is for single individuals, pairs, and small parties to ride in a vehicle. During periods of heavy demand, however, system capacity can be increased by maximizing vehicle use. Research is needed on ridesharing methodologies, passenger preferences in such situations, and on how ridesharing – or the lack thereof – might affect system capacity.

Environmental Impacts and Sustainability of PRT. As mentioned above, PRT has the potential to significantly reduce emissions and the use of fossil fuels, and to incorporate "green" materials and infrastructure. Research is needed to quantify these impacts.

Integration of Guideways into Development Infrastructure and Public Acceptance. A major drawback to PRT has been the perception that the public will balk at the visual intrusion of overhead guideways. Little work has been done on how the public will balance the negative effects of visual intrusion against the positive impacts of improved mobility. Further, research is needed on guideway design, expansion of guideways into "greenways," visualization, and other architectural treatments.

Performance Metrics for Research Outcomes

On a scale of performance measures that ranges from broad to very specific, the metrics that assess the outcomes of the proposed research would encompass aspects of both ends of the scale. The typical research outcomes of "discovery," "learning," and "stewardship" would be too nebulous for the proposed program, since the DOT suggests an urgency to implement findings, with the hope of achieving results in key priority areas. Thus, the following performance metrics are recommended:

- Dollars spent or needed versus budget forecast or available
- Estimated turnaround time of research results
- Results reporting and dissemination: number of publications; website "hits;" etc.
- Expected time to implementation of a PRT system in an urban setting
- International comparisons: progress toward implementation and technological developments
- Number of new technologies, including products and ideas
- Number of partnerships, including public-private and multiple-agency arrangements
- Number of commitments, such as cities and developers pledged to build PRT systems
- Number of pilot systems built or under development
- Number of proposed new designs, such as architectural treatments of guideways and stations
- Policy impacts (multiple measures possible)
- Number of multidisciplinary databases developed (results of testing and analysis)
- Commentary: positive and negative
- Level and extent of federal commitment to further research and development

Any of the preceding performance metrics could be classified according to a DOT priority objective, such as environmental sustainability, economic competitiveness, or livability.

Overall Guidance

DOT and RITA leadership is needed to recognize and communicate the need to jump-start investment in completely automated, demand-responsive and fully networked transport systems. Partnerships with other government agencies and private industry, including potential suppliers and community developers, should be investigated. Pilot PRT systems would provide unmatched research platforms, and the best possible way for RITA to leverage its own funds would be for it to help facilitate the early implementation of such systems. A research program investment in the short-term of $5 to 10 million per year would contribute significantly to the strategic mobility goals of the US government. Expedited action within the short term (one to five years) should result in measurable progress, with the potential for significant impacts by the year 2015.

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