A Personal Rapid Transit/Airport Automated People Mover Comparison

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Abstract

Airport automated people movers (AAPM) typically consist of driverless trains with up to about four cars each capable of carrying 20 to 100 passengers who are mostly standing. They have been successfully used for surface transportation in airports for over thirty years. A new category of automated people mover called personal rapid transit (PRT) is being implemented at London's Heathrow International Airport. Although the Heathrow system will replace shuttle buses, it may be more pertinent to examine the differences between PRT and traditional AAPM.

PRT uses small (3 to 4 passenger) vehicles (transportation pods or T-Pods) to automatically transport passengers and their luggage non-stop to their destinations along designated guideways. Trips are typically on-demand and T-Pods are often waiting at stations prior to the arrival of passengers. The resulting short wait and trip times combine with seated travel to provide an exceptionally high level of service.

This paper compares AAPM systems to PRT systems similar to the type being installed at Heathrow Airport. Items compared include infrastructure items such as stations, guideways and tunnels; level of service items such as waiting, standing and trip times; cost items such as capital and operating costs; as well as safety and security issues. The paper discusses PRT viability and concludes with a brief discussion of the ability of PRT to facilitate solutions to common airport issues such as in-concourse transportation and curbside congestion.

PRT is found to have many advantages over AAPM for transporting passengers and their luggage on airports. It is suggested that PRT alternatives should be included in airport planning projects.

Introduction

The first personal rapid transit (PRT) system came into service at West Virginia University in Morgantown over thirty years ago, a few years after the first airport automated people mover (AAPM) began operation at the Tampa International Airport. The key difference between these two systems was that the Morgantown system could operate only when needed (on-demand) and bypass vehicles stopped in stations thereby taking its passengers directly to their destinations non-stop. Another difference was that the Morgantown system suffered considerable teething problems resulting in other proposed PRT systems being cancelled and further PRT development languishing for about three decades. Modern PRT systems that almost all use much smaller vehicles than either the Morgantown PRT system or AAPMs are now rapidly emerging. The operating characteristics of these very small systems are quite different than those of conventional AAPMs and this paper is intended to provide an overview of how modern PRT systems compare to conventional AAPMs.

Figure 1. ULTra's at-grade open guideway.

PRT Characteristics

While the Morgantown system is called a PRT system, it does not meet the common definition of PRT and is more correctly classified as group rapid transit (GRT). This paper is focused on a definition of PRT that, in the author's opinion, is best suited for airport applications. This definition is outlined below and is similar to that provided by the Advanced Transit Association (2003):

- Small T-Pods (4 passengers plus their luggage)
    - Passengers all traveling together to same ultimate destination (little or no shared rides)
- On-demand, non-stop service
    - Little or no waiting
- Operates inside buildings
- T-Pods are typically constrained to guideways
- Guideways are usually separated from other traffic
- Guideways can be at-grade, elevated or

Figure 2. Postech's captive-bogey guideway.

Figure 3. JPod's suspended system

below grade
- Small turning radius (<20')

PRT vendors are presently providing (or planning to provide) three different types of PRT systems – open guideway; captive bogey, and; suspended, as illustrated in Figures 1, 2 and 3. It is likely that the open guideway systems will prove to be more common in airport applications primarily because of their small turning radius capability. This paper compares open-guideway PRT systems with conventional AAPMs.

Infrastructure

This section compares PRT and AAPM infrastructure in terms of the requirements for elevated and at-grade structures, tunnels and stations.

Guideways

The small size of PRT vehicles results in small-scale infrastructure being required. However, it can also result in limited capacity. Low-speed (less than 25 m.p.h. (40 km/h)) PRT systems can safely operate at headways as low as 2 seconds (PRT Consulting, Inc). While it is possible that lower headways will prove safe for PRT systems, this figure is used in this paper. Four-seat T-Pods at 2 second headways offer a maximum theoretical capacity of 7,200 passengers per hour per direction (pphpd). This compares to the maximum theoretical capacity of a typical AAPM with trains consisting of four 100-passenger cars and operating at 90 second headways of 16,000 pphpd. Thus one AAPM guideway could have more than twice the capacity of one PRT guideway. This suggests that, for guideway costs to be comparable, PRT guideways should cost about one half of AAPM guideways. However, this is not always the case as can be demonstrated by considering systems where the desired theoretical capacity is 7,000 pphpd or 20,000 pphpd. In the former case the PRT guideway could have the same costs as the AAPM guideway, in the latter case the PRT guideway should cost two thirds the cost of the AAPM guideway to be comparable.

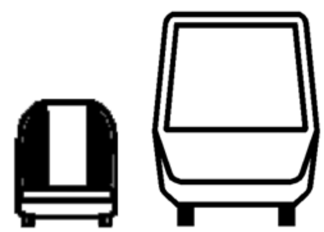

Figure 4. PRT/AAPM vehicle size comparison.

Another complicating issue when comparing guideway costs is that AAPM systems are usually laid out as two-directional guideways serving a corridor. PRT systems can be laid out in this manner too but can sometimes be more beneficial as one-way guideways which can serve a wider area but then may require additional inter-connecting loops resulting in more total guideway length. To overcome this type of difficulty in comparing dissimilar systems, it is sometimes desirable to compare total system costs on a per-station basis.

Elevated

PRT elevated guideways need to carry a live load of less than 10 tons per span while AAPM elevated guideway spans need to support about four times this weight. PRT column loads are approximately 10 to 12% of typical AAPM column loads (Kerr, 2005). Kerr states that an elevated PRT structure has a significantly lower loading than a footbridge which must accept crowding loads.

At Grade

The at-grade requirements for an open-guideway PRT system are not much more than that for a pedestrian sidewalk. Typically the guideway can consist of a seven foot (2.1m) wide pavement with eighteen inch (450mm) high sidewalls, all consisting of six inch (150mm) thick concrete and typically placed on about six inches (150mm) of gravel base. Where AAPMs run at grade they are typically supported by two, two foot by two foot (600mm x 600mm) concrete tracks on a supporting foundation varying in dimension according to the support capabilities of the subgrade soils. Comparing just the amount of concrete described above, the PRT guideway requires about 62% of the AAPM guideway.

Below Grade

Two PRT guideways will fit into a tunnel of half the cross-sectional area required for one AAPM guideway (Muller, 2005). Comparing PRT capacity to road capacity, a 200 square foot ($19m^2$) PRT tunnel could exceed the passenger-carrying capacity of a 950 square foot ($90m^2$) vehicular tunnel (Lowson 2005).

Stations

AAPM station lengths are typically governed by the maximum train length while the width is designed to accommodate the AAPM tracks plus all of the people boarding and deboarding. This results in a fairly wide platform since there could theoretically be a trainload of people boarding and another deboarding at one time at one station. Typically the design peak number is somewhat less than this theoretical maximum number but nonetheless can be quite large. The AAPM station at Denver International Airport (DIA) Concourse B is 177 feet long by 32 feet wide (excluding the tracks) and has an area of 5,667 square feet ($527m^2$). It has an estimated capacity of about 4,000 passengers per hour.

Using a 30 second dwell time, one PRT station bay can serve about 120 T-Pods per hour. If the average T-Pod occupancy is 2.0 (some ride sharing is likely during peak periods in an airport), this means each station bay can accommodate 240 passengers per hour per direction for a total of 480 passengers. Thus 9 bays would be needed to match the AAPM number for DIA concourse B. A 9-bay PRT station has an area of about 4,340 square feet ($403m^2$) (excluding the tracks except at each vehicle bay) which is 76% of the area of the AAPM station.

In practice, it may make more sense for a PRT system to have more stations with fewer bays, thus reducing walking distances. Such an arrangement will usually increase the relative PRT station area.

One of the major differences between AAPM and PRT stations results from the flexibility of the smaller PRT systems. Their ability to accommodate tight radii and steep gradients makes it possible for PRT stations to be accommodated within concourses and potentially at or close to grade. This offers the potential of easier use resulting in higher patronage. It also could result in the elimination, or reduction in number, of escalators and elevators. Figure 5. depicts a station designed to fit within Concourse B at DIA. It has a footprint smaller than that of the existing moving sidewalks.

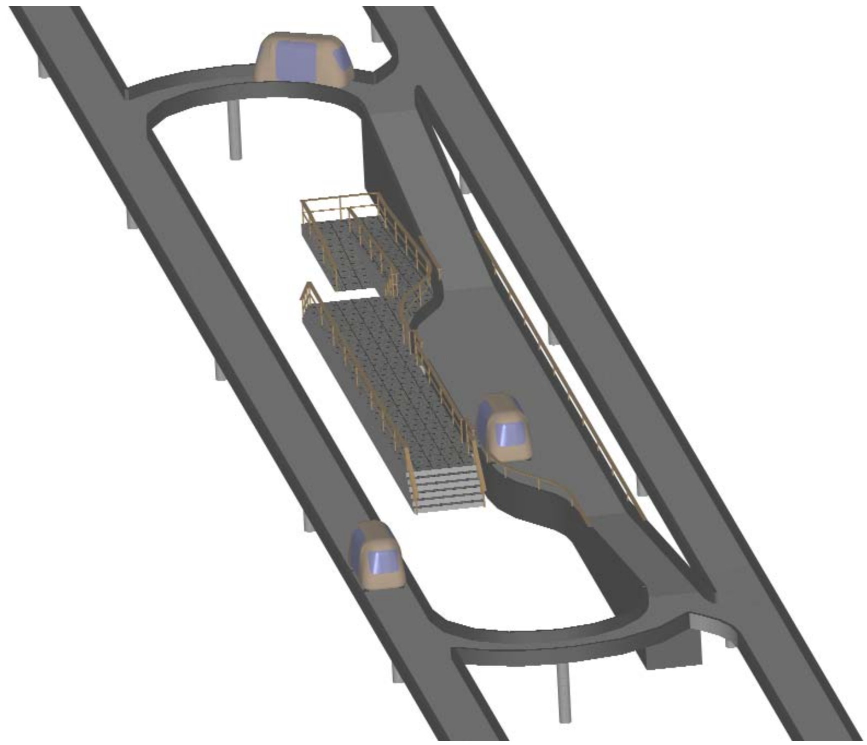

Figure 5. In-concourse PRT station.

Costs

Unfortunately there is not much good data available with which to compare either capital or operating costs of PRT with AAPMs. PRT is too new for much data to have accumulated and AAPM costs are often presented in a way that makes it difficult to determine just what elements (such as stations) are included in the costs.

Capital Costs

The only known source of modern PRT capital costs based on a construction contract is the ULTra project at Heathrow International Airport. The capital cost including guideways, stations, vehicles and operating system but excluding column footings is reported to be less than US$10 million per one-way mile. This cost is for a system that is not expected to have a high demand and is thus probably on the low end. This type of open-guideway PRT system can be expected to cost between US$10 and US$15 million per one-way mile (Advanced Transport Systems Ltd.).

Kerr (2005) provides AAPM capital costs of US$24 to 75 million per one-way mile. This is approximately 2.4 to 5 times the PRT costs quoted above and indicates that PRT systems will usually cost less than AAPM systems for the same capacity. This seems to confirm the results reported by Muller (2005) in a study comparing actual AAPM capital costs at Denver International Airport with estimates provided by three different PRT vendors. This study found the PRT capital cost to be 35% of the AAPM capital costs.

Operating Costs

AAPMs are typically installed in high capacity situations and therefore have relatively low (less than $1.00) operating costs per passenger. Modern PRT systems are expected to have even lower operating costs but this has not yet been proven. The Morgantown PRT system has operating costs of about $1.50 per passenger.

Level of Service

PRT level of service is designed to better match that of an automobile in uncongested conditions than that of any conventional form of transit including AAPMs. Service is on-demand with little or no waiting. Passengers are taken directly to their destinations with no stopping and in seated comfort. Way finding is simplified because the only knowledge needed is the ultimate destination – the system will find the best route. Passengers are transported in privacy with little or no need to share rides with strangers. There is little or no need for the trip to be punctuated by a public address system.

While PRT travel speeds are likely to be relatively slow initially (25 m.p.h. or 40 k.p.h.), the total trip times are likely to be less than AAPM trip times because of the reduced waiting times and the elimination of intermediate stops. Muller (2005) found PRT trip times to be 45% of AAPM trip times. In addition, PRT systems are likely to have more stations resulting in reduced walking distances and times.

Safety and Security

PRT systems are expected to be significantly safer than conventional transit systems and to match the safety record of AAPMs. The Morgantown PRT system has completed over 110 million injury-free passenger miles (Muller, 2007) providing evidence of the safety of PRT operating concepts.

Small vehicles providing on-demand service at small stations result in a lack of crowding, which in turn means that PRT systems do not present likely terrorist targets. In addition, PRT systems deliver a steady stream of traffic which could facilitate security screening. Future PRT systems could be equipped with on-board check-in kiosks which could facilitate airline transactions as well as the gathering of security pre-screening data. Ultimately it may be possible to prescreen passengers and their bags for undesirable substances while they are traveling in the PRT vehicles.

PRT Viability

The Morgantown PRT system has proven the viability of the PRT concept. The system can and does operate in an on-demand, PRT mode (as well as in other modes). Since the manufacturer (Boeing) no longer provides PRT systems, there are currently no PRT suppliers with proven viability. Until recently, the only PRT suppliers (except for 2getthere, a Dutch company with associations with larger companies) were small, relatively under-capitalized companies. This is rapidly changing.

When BAA selected the ULTra system for Heathrow Airport, they liked it so much they decided to purchase stock in Advanced Transport Systems, Ltd., the supplier. The Korean steel company, Posco (one of the world's largest) has formed a subsidiary called Vectus that has constructed a significant test track in Sweden and is aggressively developing a PRT system. Thus PRT suppliers now include a number that are backed by billion dollar companies.

Nonetheless, there are presently no modern PRT systems in public operation. 2getthere has a GRT system operating in Holland and has had experience with other PRT-like systems operating in the public domain. The first modern PRT system is under construction at Heathrow Airport and is scheduled to come into public service in 2008. Other PRT deployments are anticipated to follow rapidly.

Potential Airport Design and Operational Impacts

This paper indicates that PRT could provide better service than AAPM at lower costs in many airport applications. However, PRT has the potential to be more than just an improved, lower cost version of AAPM. Its flexibility, low cost and high level of service combine to potentially allow it to change the way airports are designed and operated.

A PRT system replacing the airport shuttle bus system serving parking lots and rental car facilities could reduce curbside congestion and the need for consolidated rental car facilities. Such a system could completely avoid the curbside by bringing passengers right into a mezzanine level of the terminal as depicted in Figure 6.

Figure 6. Rendering of a PRT system inside the DIA main terminal. While the system looks large in the foreground, observing the return guideway in the background provides an appreciation of its small scale.

AAPMs allowed airports to have remote concourses connected to the main terminal by the underground people mover. However, these concourses have become very long (up to one mile (1.6km)) and can involve considerable walking distances. PRT systems have the flexibility to rise up into the concourses and deliver passengers to within a short distance of their gate rather than to a central underground station. This could allow seated travel from the terminal to the gate. It could also allow long concourses to be divided into multiple shorter concourses. These shorter concourses could be quite a significant distance from each other and/or from the main terminal potentially allowing additional flexibility in airport layout planning.

In the future, on-board airline functions and security screening (facilitated by each T-Pod only carrying small groups all traveling to the same destination) may change the required functionality of the terminal building and allow just-in-time passenger delivery to the gate. This concept has the potential to consolidate waiting in a consolidated concession area thus helping to improve the airport's bottom line.

Conclusions and Recommendations

Table 1 summarizes the findings of this paper. For each category PRT and AAPMs are rated on a scale of 1 to 5 with 1 being poor and 5 being excellent. Note that the ratings are intended only to highlight the differences between these two systems and thus a system rating poorly relative to the other in any one item may still be quite acceptable in that item.

Table 1. Summary of Results. 1 = poor, 5 = excellent.

Item	**AAPM**	**PRT**
Elevated guideways	2	4
At grade guideways	2	3
Below grade guideways	2	4
Stations	2	3
Capital costs	1	3
Operating costs	3	4
Level of Service	2	5
Safety	4	4
Security	2	4
Viability	4	3
Flexibility	2	4
Potential side benefits	2	5

There is little doubt that modern PRT systems are coming and will soon be operational at airports. The opportunities they bring for improving airport functionality and revenue as well as passenger level of service are such that airport planners should be taking PRT into account now as they develop their plans for improving airports around the world.

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