PRT consulting

Improving Transportation through Innovative Engineering

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PRT BENEFITS

INTRODUCTION

This document contains a discussion of each PRT benefit mentioned in the company brochure. This discussion is followed by a discussion of the comparative analysis of cars, transit and PRT summarized on the back of the brochure. Note that these discussions are based on analyses of the laws of physics and data from systems that have been operating for at least five years. Input from PRT vendors has not been considered.

PRT IS FLEXIBLE

Deployable in numerous configurations

PRT systems usually operate on guideways. These guideways can be on the ground, elevated or underground in tunnels. Some vehicles (Transportation Pods – or T-Pods) run on top of the guideways while others are suspended from the guideways (this can make switching from one guideway to another more complicated). Some systems follow magnets or wires buried in the guideway, some use on-board navigation systems backed up by sensors that confirm the T-Pod position relative to objects along the guideway. Yet others are physically constrained by wheels that follow guideway walls or other vertical elements.

PRT guideways will typically be laid out in a network or grid. In this way there will usually be more than one route connecting an origin and a destination. This allows PRT to maintain most service even when a guideway is out of service.

Just as the guideways can be at, above or below grade, so too can the stations. Given the necessary space, there is no reason why an above (or below) ground system could not have stations at or close to grade. Since stations are usually off-line, the main guideway could continue past the station at the same elevation as the remainder of the guideway. The station guideway would dip down (or up) to the station. This arrangement avoids the complication of steps and elevators at stations. It may not be appropriate for all systems or all applications however.

Negotiates tight turns and steep gradients

Most systems can follow curves of fairly tight radius. Rubber-tired T-Pods riding on top of guideways can typically turn as tightly as an automobile.

Numerous automatic vehicles operating on guideways have demonstrated gradients as steep as 10%.

Designed to match most needs

PRT systems are best suited to operating as transportation networks where numerous guideways are interlinked to provide numerous widespread stations and thus a wide assortment of origins and destinations. However PRT can be shown to provide better corridor service at lower cost (see next section) than light rail.

Elevated PRT systems have very little right of way requirement – a column every one hundred feet or so. For this reason even systems that serve a corridor are likely to have their inbound guideway located about half a mile from their outbound guideway. Since PRT station spacing is typically one half mile, a swath of land one mile wide will have PRT stations within maximum walking distances of one quarter of a mile. An LRT serving the same corridor with typical station spacing of one mile will serve the same swath of land one mile wide with maximum walking distances of one half mile.

PRT IS ECONOMICAL ON A PER-PASSENGER BASIS
Cost less to build than most other guideway systems

See "Analysis of Capital Costs" at News & Links/Informative for a detailed discussion of capital costs.

Cost less to operate and maintain than most transit systems

Following are actual operating and maintenance costs per passenger from existing systems:

• Morgantown PRT	$1.50
• Denver International Airport (DIA) Automated People Mover	$0.61
• DIA shuttle bus	$3.50
• Denver Regional Transportation District (Bus & Light Rail)	$3.75

The first two systems are automatically controlled and have significantly lower operating costs.

PRT IS SAFE
No traffic crossings (only merges and diverges)

PRT systems have one-way guideways. T-Pods needing to change direction take a guideway diverging away from the one they are on and merging with a guideway going in the desired direction. The only accidents that are possible are rear-end situations or side-on collisions with vehicles going in essentially the same direction. Note that many automated people mover and light rail systems have guideways or tracks that cross and head-on collisions are therefore theoretically possible with these systems.

Lower maximum speed for higher average speeds

Since T-Pods bypass all stations except for the destination station, the trip is non-stop and the maximum speed is close to the average speed. This is not the case for other systems that have to stop at each station. An LRT system with stations a mile apart must have a top speed around 55mph in order to average 25mph. A PRT system in the same situation needs to only have a top speed around 27mph.

The Morgantown PRT system has completed 110 million injury-free passenger miles. Conventional transit injures over a hundred people in that many miles.

PRT IS SECURE
No crowds for terrorists to target

Experience has shown that terrorists target buses and trains. They never target automobiles unless they are carrying prominent political figures. Clearly a T-Pod with a maximum of four passengers is an unlikely terrorist target.

The same argument applies to stations. Typical light rail stations require people to gather in a crowd for around five minutes waiting for a train. In a PRT system there would be at least twice the number of stations. In addition, people would have less than a minute wait time and crowds would thus never gather.

Even elevated PRT guideways will be relatively small and not present a very attractive terrorist target. In a network situation losing one section of guideway would not disrupt traffic too much and only a few stations would lose service.

Steady stream of traffic facilitates processing of passengers

PRT has the potential to allow a secure perimeter containing security-screening points to be implemented around a facility like an airport terminal. Off loading bus or train passengers at such a screening point, screening them and the reloading them would be very difficult. On the other hand T-Pods would bring passengers in a steady stream. They could actually pass through the building between each screening station and then reload passengers who have been screened.

Since the PRT operation is self-monitoring, T-Pods could be automatically diverted to lightly loaded screening stations in the event one or more stations became backed up.

Once in a T-Pod screened passengers will remain “sterile”. They could be transported to another airport across town and yet have no opportunity to obtain unscreened items while doing so.

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Shared rides can be avoided

Most PRT vehicles are intended for use by small groups traveling together. There will usually be no need to share rides with strangers. It is probable that all stations and possibly all T-Pods will have CCTV monitoring to help prevent forced ride sharing. In addition T-Pods will usually be equipped with an alarm button that could cause the vehicle to be met by emergency response personnel at its next stop.

PRT SAVES TIME
Less waiting

The PRT concept is to divide public transit up into the smallest possible pieces. Instead of a few large vehicles carrying many people every 5 minutes or so, we have many small vehicles carrying a few people every 5 seconds or so. This translates into little or no waiting. With PRT the vehicles typically wait for the passengers.

Less Walking

Elevated PRT systems have very little right of way requirement – a column every one hundred feet or so. For this reason even systems that serve a corridor are likely to have their inbound guideway located about half a mile from their outbound guideway. Since PRT station spacing is typically one half mile, a swath of land one mile wide will have a PRT stations with maximum walking distances of one quarter of a mile. An LRT serving the same corridor with typical station spacing of one mile will serve the same swath of land one mile wide with maximum walking distances of one half mile. Average PRT walking distances will thus be about one half of average LRT walking distances.

Non-stop travel

This is a fundamental PRT concept. Each station has its own off- and on-ramp to the guideway (like a mini freeway interchange). This means that T-Pods stopped in the guideway are off-line from the main guideway and do not disrupt the passing traffic on the main guideway. Some PRT systems can accommodate station bays that are off-line to each other. That means that a person could delay a T-Pod in a station and other T-pods behind it could still get out without waiting.

Less waiting and walking combined with non-stop travel allow PRT systems to provide improved total trip times with relatively low maximum speeds. When high-speed PRT systems become available urban trip times will be dramatically reduced. Cities with widespread high-speed PRT systems should see a dramatic reduction in automobile use.

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PRT IS ENVIRONMENTALLY FRIENDLY
Less energy

PRT vendors claim it uses less energy than automobiles and public transit. Although this has not been verified it is likely to prove correct for three reasons. PRT travel is non-stop and so little energy is expended accelerating. PRT travel is relatively slow and so little energy is expended combating wind resistance. PRT systems should have less need to move empty vehicles around in off-peak periods.

Less emissions

PRT systems have fewer emissions because they use less energy. In addition they are typically electrically powered and so their emissions are associated with those of the power plant that is typically out of town and may even be augmented with clean energy such as wind.

Less noise

Rubber tires on concrete or steel, low weight and speed all combine to produce less noise and vibration.

PRT SYSTEMS ARE VARIED
Some are faster

The Morgantown PRT system has been operating at a maximum speed of 30mph for over thirty years. The 2getthere system at Schipol Airport has operated at 19mph for seven years. ULTra has been operating prototypes on a test track for three years at 25mph.

Some are more flexible

Systems that operate on a flat guideway tend to be able to accommodate tight curves. The minimum radii for Morgantown, 2getthere and ULTra are 30’, 20’ and 17’ respectively. Systems such as SkyWeb Express that have their undercarriage inside a slotted guideway tend to require larger radii.

All PRT systems are likely to be able to handle grades as steep as 10%. The limiting factor is more likely to be passenger fears than system capability except possible in icy conditions.

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Some have more capacity

System capacity is not the same thing as T-Pod capacity. System capacity is a function of both headway and T-Pod occupancy only. Speed has nothing to do with it. If T-Pods each carrying four passengers pass a point at the rate of one per second the capacity is 14,400pphpd. This is probably the highest theoretical capacity attainable by a single guideway PRT system. Safe operation at such low headways remains to be proven although we do so on highways (not very safely) and some vendors claim they will be able to achieve even lower headways. Filling all seats of a four-seat T-Pod system would require an operation that involved some waiting and would be somewhat counter to the basic PRT philosophy.

Morgantown achieves a relatively high maximum capacity of 5,000 passengers per hour per direction by offsetting its high 15 second headway with a high vehicle capacity of 20 passengers.

Some are unproven

Morgantown and Schipol Airport (2getthere) are the only known PRT systems to have been in operation for more than 5 years. Both are considered a success – Morgantown is considering an expansion and Schipol was a one-year pilot that ran for seven years.

Neither operation is considered true PRT but both prove that automatic control of small vehicles on guideways is viable. In addition, Morgantown has proven that the basic PRT concept of automated vehicles bypassing stations is viable – even with ancient computing technology.

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BENEFIT COMPARISON

	Bad	OK	Good
Legend			

	Transit	Car	PRT
New technology			

Transit and car are both mature industries subject only to incremental improvements. PRT has been with us since the early seventies in the form of the Morgantown system. Although this system overran its initial capital budget, it has since performed well and has proven the basic PRT concept. It has completed over 23 million injury-free passenger miles at a current operating cost of about $1.50 per passenger.

With the exception of 2getthere, no PRT vendor can provide a system that has a proven history of successful operation in public service. Even 2getthere is scrapping the vehicles that have been in operation for about seven years in favor of a completely new model.

PRT has now reached the point where a number of vendors are ready to respond to requests for systems. BAA's recent request for proposals for a system to be installed at London's Heathrow Airport by the end of 2006 elicited three responses (2getthere, ULTra and York).

PRT does have two trump cards in its ability to overcome the fact that it is relatively new technology:

1. It has very significant and obvious advantages over other systems
2. It can be designed and constructed in much shorter timeframes than other guideway systems.

The latter advantage means that an agency considering a PRT system in place of, say, an automated people mover (APM) system could commence the design of both systems at the same time. While doing this they could install a small portion of the PRT system as a test. If the test system pans out they could continue to install the entire PRT system.

Since PRT design and construction should take less than half the time for the APM system, they will be able to run the full PRT system in test mode for probably a year or more and still complete the project in less time than required for the APM system. Even including the cost of the scrapped APM design they will probably still be within the original budget. If the PRT system failed the initial test and they had to revert to the APM system they would be out the PRT costs to that point. The likelihood of the PRT system passing the initial test but failing the ultimate test would probably be small.

	Transit	**Car**	**PRT**
Trip Time			

Automobile trips in urban areas do not typically result in low travel times because of the numerous stop signs and traffic lights that have to be negotiated. This is true even for trips that are undertaken at high speeds on freeways. Low speed segments at each end of the trip invariably offset these high-speed trip segments. Analysis of trips at all times of the day in the Denver Metropolitan area reveals that trips shorter than xxmiles are undertaken at average speeds of less than 30mph. Simple observation indicates that bus speeds are even slower.

Light rail (LRT) seems fast with its 55mph maximum speed but this is impacted by the numerous stops that must be made. The 12.5 mile light rail trip from Mineral Station to Downtown Denver is scheduled for an average speed of 26mph.

A PRT system with a maximum speed of 35mph will average about 32mph over a twelve mile trip. This takes account of acceleration and deceleration at the origin and destination as well as the fact that there will be no intermediate stops. It also takes account of the extra travel distance of approximately one half mile due to a one-way guideway system with guideways and stations at half mile intervals.

Thus a PRT system with an maximum speed of 35mph can be expected to have faster travel times than LRT, bus or car over a distance of less than xxmiles in an urban setting.

However, travel time is only part of the total trip time. Buses and LRT almost never pick up their passengers at their homes and deposit them at their workplaces. Even cars have to sometimes be remotely parked. Almost all public transit trips involve walking segments at the beginning and end and many also require transfers. PRT networks should be built so that stations are located throughout the service area on a spacing of approximately one half mile. If this is accomplished, the maximum walking distance should be about one quarter of a mile and this portion of the trip should take less time than on other forms of rapid transit.

Another aspect of total trip time is the time spent waiting for transit. Few transit systems have times between vehicles of less than 5 minutes during peak periods. Off peak this can increase to half an hour or more. PRT systems should be designed such that T-Pods are usually already waiting at stations and so the average wait times should be less than one minute at any time of the day or night.

When all of the above factors are considered total trip times for PRT (35mph max. speed) over distances less than about 25 miles are much closer to total trip times for cars than transit. These PRT trip times are still not considered good. Good trip times will become available when a one half-mile PRT guideway grid covers a metropolitan area and PRT maximum speeds exceed 40mph.

	Transit	Car	PRT
Cost per passenger	(yellow)	(yellow)	(green)

Costs have two basic components – capital cost for the initial vehicles and infrastructure, and operating and maintenance costs for running the system. Operating costs are somewhat less complex and will be dealt with first.

The current cost of operating and maintaining the Morgantown people mover system is $1.50 per passenger. This includes both the vehicles and the infrastructure. It compares with $3.75 per passenger for the Denver Regional Transportation District (note that tickets are subsidized and therefore are sold below cost). While this includes buses and the light rail trains and infrastructure, it does not include maintaining the streets the buses run on.

The IRS recognizes the cost of operating and maintaining an automobile as $0.41 per mile. This exceeds the Morgantown costs after the trip length exceeds 3.6 miles. It also excludes the cost of maintaining the road system used by automobiles.

The operating costs of some transit systems are provided below:

- Morgantown PRT $1.50
- Denver International Airport (DIA) Automated People Mover $0.61
- DIA shuttle bus $3.50
- Denver Regional Transportation District (Bus & Light Rail) $3.75

Since modern PRT systems are expected to function at least as efficiently as Morgantown, it seems clear that operating costs should be very competitive with other forms of transit and with automobiles.

Capital costs are somewhat more complicated to compare. First one has to prove that one PRT guideway can carry approximately the same number of passengers as one light rail line under the same conditions. See "Analysis of Capital Costs" under News & Links/Informative for a detailed discussion of this issue. If one guideway has similar capacity to one rail line then it is easy to see that the tiny T-Pods (compared to the heavy "light" rail cars) will require much less infrastructure and therefore less capital cost. In addition, although there are many more T-Pods than rail cars required, their total weight is less than the total weight of rail cars. This, combined with the economies of mass-producing many small vehicles should result in lesser capital cost too.

When compared with the infrastructure required for automobiles, T-Pods require much less width because they are automatically (and therefore much more accurately) controlled. A T-Pod guideway should only need to be about seven feet wide compared to the eleven to twelve feet width of a typical highway lane. The cost savings of the narrower guideway will be somewhat offset by the extra cost of sidewalls usually required. If the guideway needs to be elevated then the costs may well exceed those of a highway lane. A PRT tunnel will probably be even more expensive than an elevated guideway

On the other hand a PRT tunnel or elevated guideway should be much less expensive than an automobile tunnel or elevated roadway because of the narrower width, the reduced need for ventilation and the restricted height and weight of the vehicles.

	Transit	**Car**	**PRT**
On-demand 24/7			

Transit systems usually only provide frequent (5 minutes or less) service during peak periods. The service typically gets less and less frequent away from peak periods and is totally non-existent in the early hours of the morning. On the other hand automobiles are available all of the time.

PRT systems should be designed and operated in such a way that empty T-Pods are automatically routed to empty stations where they will wait for passengers. Except during heavy peak periods, passengers arriving at a station should be able to immediately board a waiting T-Pod. During off-peak periods empty T-Pods will be stored at stations waiting for passengers, in a maintenance facility and/or in a storage area. There will be no need for the system to ever shut down

In a network layout guideway segments can be shut down with little impact on the remaining system (especially off peak). Only the stations associated with that particular guideway segment would be put out of service.

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	Transit	Car	PRT

Transfers

Unlike transit, cars and fully developed PRT systems should seldom require transfers. Transfers from other systems to PRT should be relatively convenient because the close station spacing will provide numerous options and the minimal waiting time will reduce disruption to travel.

	Transit	Car	PRT

Seated travel

Both cars and PRT systems are designed for seated travel. This allows vehicles to accelerate and decelerate more rapidly. Transit provides seated travel much of the time except during peak periods when most travel actually occurs.

	Transit	Car	PRT

Private

Except for systems specifically designed to operate differently (in airports for example) PRT systems will be operated on the basis of people only traveling together if they know each other and have the same destination. While this does mean that T-Pod occupancies will be low, it also ensures privacy and a non-stop trip.

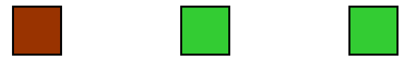
All T-Pods will have alarm buttons and possibly, video surveillance. T-Pods subject to alarms could be directed to stations where emergency personnel are waiting.

	Transit	Car	PRT

Non-stop

Transit has been rated more negatively than cars here because much transit travel is done in buses which stop more frequently than cars. However it should be pointed out that light rail may stop less frequently than cars. T-Pods are designed never to stop from origin to destination.

	Transit	Car	PRT

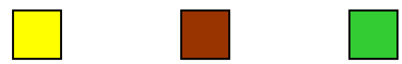


Vehicle waits for passenger

Except for end-of-line situations, transit vehicles almost never wait for the passenger, quite the reverse is true. On the other hand automobiles almost always wait for their passengers. This is what causes the high demand for downtown parking spaces.

PRT manages to have T-Pods waiting for passengers most of the time while also avoiding the very low passenger to vehicle ratio exhibited by automobiles. During any one day a T-Pod will carry many tens of passengers – possibly more than a hundred for short systems.

	Transit	Car	PRT



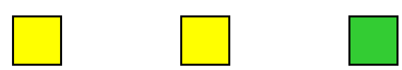
ADA compliant

Transit systems comply with the Americans with Disabilities Act but at large expense. Light rail stations require special ramps, buses require special lifts and service must be augmented with special buses.

Automobiles do not accommodate handicapped people very well – the blind cannot drive and wheelchairs usually require special vehicles. In addition cars often require special modifications to be able to be driven by the handicapped.

On the other hand most PRT stations will allow wheelchairs (pushchairs and luggage on wheels) to easily roll on board. ULTra has demonstrated the ability for T-Pods to park at stations with less than ½” tolerance thus ensuring the narrowest of gaps between platform and vehicle. The ½ mile spacing of most PRT stations will also facilitate handicapped access.

	Transit	Car	PRT



Safe and secure

PRT systems are inherently safe because there is no crossing traffic – only merges and diverges. This is borne out by the Morgantown PRT system, which has completed 23 million injury-free passenger miles. By contrast the injury rate in 23 million miles for highways is 19 and for transit is 31.

PRT offers the ultimate in transit security since it simply removes the potential terrorist target by eliminating crowds at stations and in vehicles.

	Transit	Car	PRT
User friendly			

Transit is fairly user friendly but the user is required to understand routes and timetables. In addition they need to know which origin and destination stations to use.

Cars require ownership and a driver's license in addition to an understanding of routes.

PRT only requires knowledge of the origin and destination stations.

	Transit	Car	PRT
Snow and ice			

Transit systems vary in their resistance to snow and ice – steel wheel on steel rail systems typically have little trouble while buses will be stuck in slow traffic along with automobiles.

PRT systems are likely to be less tolerant than steel wheel on steel rail systems but more than cars and buses. The Morgantown system has operated successfully with a heated guideway system. Some PRT systems have their undercarriage almost fully enclose by the guideway and expect to be very resistant to snow and ice.

	Transit	Car	PRT
Minimal walking			

Transit typically involves quite a lot of walking. Most people are located beyond reasonable walking distance (1/4 mile) from a stop. Many are forced to park and ride.

While automobiles typically involve little walking, remote parking is sometimes required.

A good PRT system will have guideways and stations spaced at about one half-mile intervals. This should keep almost all walking down to les than a ¼ mile.

	Transit	Car	PRT
Environmentally friendly			

Transit is generally considered more environmentally friendly than automobiles. This is probably true for light rail and possibly natural gas powered buses. It is hard to believe for diesel powered buses that spend large portions of the day driving around mostly empty.

Automobiles are notorious for air pollution. Hybrid cars may help this situation but are catching on slowly. Roads and freeways devour an awful amount of real estate.

In corridor or line-haul mode PRT should be as environmentally friendly as light rail or more so because of the low energy use due to non-stop trips. In network mode PRT has the potential to return some of the real estate used by roads. This is particularly true in downtown situations where one lane can only carry about 500 automobiles per hour. One elevated guideway has the capacity to replace a four-lane downtown road freeing up the land for development or greenway.

Small electrically powered T-Pods will make little noise and vibration.

	Transit	Car	PRT
Energy efficient			

Transit is generally considered more energy efficient than automobiles. This would be true if transit vehicles did not have to operate mostly empty most of the day. Even during peak periods transit vehicles generally start fairly empty in the neighborhoods and arrive downtown fairly full. They then have to return to the neighborhoods fairly empty again. Thus even in peak periods they are only operating half full at best.

PRT on the other hand is energy efficient for three reasons. PRT travel is non-stop and so little energy is expended accelerating. PRT travel is relatively slow and so little energy is expended combating wind resistance. PRT systems should have less need to move empty vehicles around in off-peak periods.

	Transit	Car	PRT
Visually appealing			

This is such a subjective factor that the same rating has been given to each system.

	Transit	Car	PRT

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Operates inside buildings

Transit systems are typically too big to operate inside buildings although it would be possible to incorporate a light rail station inside an airport terminal building for example.

Buses and cars cannot readily operate inside buildings because of exhaust gas issues.

PRT systems are small and electrically powered and can relatively easily be accommodated inside buildings. Studies have shown that PRT systems could operate inside airport concourses replacing moving sidewalks.

PRT vehicles parked end to end only provide a floor load of about 41pounds per square foot which is less than the design loading for most building floors.