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ANALYSIS OF CAPITAL COSTS

The following discussion compares PRT to light rail transit (LRT) over a distance of 12 miles with ten stations. It is assumed that the PRT is artificially constrained to operate in the same corridor with the same number of stations. This would not be the best way to configure a PRT system but it will serve to allow a fair comparison with LRT.

In order to compare per-passenger costs system capacity must first be established. The LRT maximum capacity is 7,850 passengers per hour per direction (pphpd). This is based on an analysis of twelve systems reported by the Transportation Research Board's Highway Capacity Manual. 66% of these systems had capacities less than 7,850pphpd. Using a four person T-Pod with the same assumption (that all vehicles are full) the capacity is 4 x 60seconds x 60 minutes /number of seconds between vehicles. The number of seconds between vehicles is called the headway and is obviously a critical factor in calculating the system capacity. Various PRT vendors claim various headways – some less than one per second. The Morgantown PRT system has been operating at 15-second headways for over thirty years. The ULTra PRT system has permission from the British Rail Authority to carry members of the public at headways of 3 seconds. These are fairly widely varying numbers and some discussion of a reasonable headway is appropriate.

Since PRT vehicles are similar to automobiles in size, it is reasonable to look at automobile headways. A freeway lane operating at capacity carries 2,400 vehicles per hour at 75mph (Highway Capacity Manual, Transportation Research Board). This yields an <u>average</u> headway of 1.5 seconds. Lets consider a 2 second headway for PRT.

A reasonable worst case scenario is a to have a T-Pod malfunction and come to a stop at a rate equivalent to perfect brakes and tires with perfect friction on the pavement. This rate is 32.2 ft/sec/sec. Assume the vehicle behind can only slow down at a rate equivalent to that used by 90% of automobile drivers enabling them to keep control on wet surfaces. This rate is 11.2ft/sec/sec (AASHTO-recommended design rate for automobiles).

At 25mph and a 2 second headway, the second T-Pod stops 21 feet short of the first. At 40mph and a 2 second headway, the second T-Pod stops one foot short of the first (assuming a 12' T-Pod length). This is not much of a margin of error but perfect friction is actually not possible.

Using the above scenario and rates of deceleration for two cars traveling 2 seconds apart at 75mph, the second car would hit the first car (which would be stopped) at 65mph! This assumes instantaneous reaction by the second driver, which is not humanly possible.

This shows that a 2 second headway is reasonable for speeds up to 40mph and provides a much greater safety factor than currently exists on our freeways. A 2 second headway results in a capacity of 7,200pphpd. This is 92% of the capacity of the LRT system. So, in a line-haul configuration, one PRT guideway has similar capacity to one LRT rail line.

Note that the above assumes that a PRT control system can be built that will automatically fit T-Pods in on a guideway at 2 second intervals and 30mph while allowing them to bypass undesired stations. Optimum route selection is not required in this scenario. The Morgantown control system operates in exactly this fashion at 15-second headways when in demand mode. It was built in the early seventies when computers were in their infancy. It is hard to imagine that 2-second headways are not achievable today as claimed by many PRT vendors.

Let's assume the PRT maximum speed is 30mph (the same as Morgantown). If all four passengers were destined to different stations, each passenger would experience an average of 1.5 intermediate stops (remember this is a comparison with LRT – most PRT systems would go non-stop from origin to destination). Using American Association of State Highway and Transit Officials (AASHTO) recommended comfortable acceleration/deceleration rates and the same station dwell time measured on LRT (36 seconds), the PRT average speed is 28mph. The actual measured LRT average speed over a similar route was 25mph (the maximum speed was 55mph). This is because LRT stops at every station.

Now we have proved that PRT can provide similar capacity at similar average speeds as LRT. How much will it cost?

The cost of any guideway system is driven largely by the size of the vehicles. Since T-Pods designed to carry 4 passengers can be expected to be of similar size to a small automobile we can assume they will also weigh about 2,500lbs. This is a little more than 600lbs per passenger and seems conservative since the Morgantown vehicles only weigh 417lbs per passenger.

The PRT system described above requires about 370 T-Pods. These would have a total weight of 462Tons. Using similar arithmetic the LRT system requires about 36 cars with a total weight of 1,440Tons. Mass production opportunities combined with the lower total weight lead one to believe the T-Pods should cost less to manufacture than the LRT cars.

The measured right of way for a similar LRT system is 30'. T-Pods have been demonstrated to operate safely with four-passenger vehicles operating on guideways with an overall width of seven feet (ULTra). Thus two guideways only require a right of way of about 20'.

Since the individual vehicle weight and wheel loads for PRT is substantially less than LRT, the pavement/rail bed requirement should also be significantly less.

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If PRT vehicles weigh about 3,500lbs full (this allows about 250lbs per passenger) and are 12 feet long, they will impose a loading of 42lb per square foot. This is less than ½ the 85lbs per square foot loading required by AASHTO for a footbridge. Simple observation of light rail bridges compared to footbridges leads to the conclusion that most structural dimensions will be less than half and the overall cost of elevated guideway structures should therefore be less than half.

PRT vehicles will typically have heights similar to automobiles (less than six foot above the guideway). This is done deliberately to ensure that passengers are seated thus allowing slightly higher rates of acceleration and deceleration. This means that PRT tunnels and underpasses need only be about seven feet high. LRT on the other hand requires about 16’. Again the cost of these items should be less than half that for LRT.

LRT station platforms are typically about 300’ long and 20’ wide. If we assume that the 7,200 PRT passengers must board at eight stations in one hour, we find that 72 station bays are needed (9 per station). The platform size required is about 325’ x 20’ – similar to LRT.

Both PRT and LRT require power distribution systems and control systems. Some PRT systems are battery powered and only require power at the stations, which should cost significantly less than the overhead power distribution systems for LRT. PRT control systems have to automatically control many vehicles and can be expected to be more expensive than LRT control systems. Its reasonable to assume that the overall costs of these two systems will be more or less similar.

The above discussion has shown that, based on actual systems that have been operating for more than 5 years, PRT should provide similar capacity as LRT. It also indicates that the capital cost of a PRT system should be less than that of LRT on a per passenger basis.