Dual-Mode, Captive-Vehicle PRT, and Pallet Systems

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This paper discusses the possible disadvantages of a pure dual-mode system compared with captive-vehicle personal rapid transit systems. A way is presented for combining the desirable features of both systems in a pallet system.

Dual-mode automated transit systems possess the important advantage that the passenger can remain in one vehicle from origin to destination just as in an automobile. It would appear, therefore, that a dual-mode transit system would be ideal and that it would require no variation in travel behavior from the automobile. Dual mode not only preserves the feeling of ownership thought by many to be extremely important, but also permits one to carry one's own things in one's automobile without suffering the inconvenience of transferring them from one vehicle to another. The advantages of dual mode do not come, however, without several important disadvantages that have led many developers to favor captive-vehicle personal rapid transit. At the present stage of development of dual mode and personal rapid transit (PRT), it is important that these differences be clearly understood and openly debated because such a process may save considerable funds that otherwise would be used to develop systems having minimum utility. Some of the questions raised in this paper cannot to my knowledge be positively answered at present. In some cases additional engineering testing is needed, and in other cases social experiments need to be performed to get a better understanding of the characteristics that should be built into any new transit system to optimize its performance and minimize adverse impacts.

In the past 5 years much of my work has been in cooperation with social scientists. I have found that there is indeed a process, though much less straightforward than in the case of engineering analysis or experiment, but a process nonetheless, by which solid evidence can be obtained about social variables of fundamental importance in engineering design. It is important for the engineer to recognize situations in which he or she should suppress his or her own prejudices about social phenomena and learn how to arrive at conclusions about social variables by an objective and prejudice-free process.

In this paper I will list and discuss seven areas in which I see possible disadvantages of the pure dual-mode system as compared to captive-vehicle PRT systems. Following the discussion of these areas I will discuss a way to combine the desirable features of both systems in a pallet system.

The term PRT is used in this paper in the sense defined by the committee of the 1973 International Conference on Personal Rapid Transit. PRT vehicles hold three to six seated passengers with no provision for standees and provide automated on-demand, nonstop service between a large number of stations in a network of slim guideways. Similar systems employing larger vehicles with provisions for standees and sometimes scheduled service are becoming know as group rapid transit (GRT) systems (1).

THE VEHICLE

Since a dual-mode vehicle is driven on both ordinary streets and guideways, it is inherently a more complex device than a single-mode vehicle and thus will probably be more expensive than either a PRT vehicle or an ordinary automobile. This means that, at a time when prices of new automobiles are increasing drastically, dual mode would be even more expensive and hence thought to be a luxury beyond the means of the ordinary citizen. This would inhibit the use of the system by the less affluent members of society and tend to make the dual-mode system more of an elitist solution to the transportation problem, a feature that in present societal conditions would appear to be untenable. A captive PRT vehicle can of course be run on a dual-mode guideway, and if there were no other disadvantages to dual mode this might be a desirable compromise.

SUSPENSION AND TRACTION

While operating on the street, the dual-mode vehicle would use wheels for both suspension and traction. Hence, to minimize cost, the temptation is strong to use the same suspension and traction systems on the guideway. In so doing two potential advantages of the captive system are lost: (a) the possibility of uncoupling traction from suspension and (b) the possibility of using a suspension system that can operate with a narrower guideway. The second point is discussed in the next paragraph.

Traction can be uncoupled from suspension by the use of linear motors, such as linear induction motors or linear pulsed-dc motors, and permits acceleration and braking independent of the coefficient of friction between the vehicle and the roadway. One advantage of this is that, since the coefficient of friction between the vehicle and the roadway can vary considerably under different weather conditions and from vehicle to vehicle, the problem of maintaining close headways would appear to be easier if traction is provided directly and electromagnetically between the vehicles and the guideway

rather than through wheels. A second advantage is that emergency deceleration rates higher than possible failure rates can be applied, thus permitting no-collision performance at very close headways (2). If the vehicles use wheels for suspension, a third advantage is that the requirement that they need not provide traction means that both the tires and the roadway can be made smooth, thereby minimizing noise. It thus appears that a captive-vehicle system may be designed to be quieter and to have fewer collisions for a given headway and speed than a dual-mode system.

THE GUIDEWAY

As mentioned above, since a dual-mode vehicle must run on ordinary streets, it would have wheels in the four corners just as an ordinary automobile. If these wheels are used on the guideway for suspension, the guideway would have to be wider than the vehicle. On the other hand, if the vehicle is designed to run only on the guideway, it is possible to use alternate types of suspension that permit a much narrower guideway. This means that the visual impact of the captive-vehicle system could be significantly smaller than the dual-mode system. Viewed from the side there will be little difference; however, viewed from underneath, the dual-mode guideway would be three to four times as wide as the PRT guideway.

Extensive public reaction I have obtained following hundreds of presentations on automated transit systems in many cities has led me to conclude that the visual acceptance of the overhead guideways is the most important single factor in obtaining widespread acceptance of either PRT or dual-mode systems. These systems could of course be placed underground, but in so doing the cost is usually considerably greater. Before a decision can be made between dual-mode and captive-vehicle PRT, comprehensive visual-impact studies of both types of guideways need to be conducted, remembering of course that the visual impact of either of these guideways is greater if the guideway is full of vehicles rather than empty.

Since off-line guideways are needed for stations and interchanges, there must be a double guideway in many parts of the system. A monorail guideway, possible with captive-vehicle PRT, would have a width of approximately 8 m (2½ ft) and would detract considerably less from the acceptance of the system than the guideway 1.8 to 2.1 m (6 or 7 ft) wide needed for the duorail systems. Since cost is related to the volume of material in the guideway, it appears likely that a monorail captive-vehicle PRT guideway would be less expensive per mile than a corresponding dual-mode guideway. Also, the monorail guideway would be less bulky and, hence, easier to ship and easier to erect, thus reducing the cost and time of installation. These considerations lead us to feel that it may be possible to develop a more extensive network of monorail captive-vehicle guideways than dual-mode guideways. The use of a more extensive network with captive-vehicle PRT would at least partly compensate for the need to transfer at the PRT stations from a street vehicle to the PRT vehicle and would make the automated system accessible to a wider range of people.

NUMBER OF VEHICLES

A privately owned dual-mode vehicle would be reserved for one individual as with an ordinary automobile. As a consequence, the total number of vehicles in the system would not be reduced below that of the automobile system. Studies performed at the University of Minnesota (3) indicate that, with a captive-vehicle PRT system, each PRT vehicle would handle as many trips per day as approximately 10 automobiles because of the multiple use of the vehicles.

With dual mode, this problem can be reduced if one thinks in terms of publicly owned, rental dual-mode vehicles. In this case a person leaving work in the evening would go to a station area, pick up the first vehicle in line, cruise automatically to his exit ramp, drive home, park the vehicle in his or her garage overnight, drive it onto the system and back to work in the morning, and then turn it over to the system for use by other people. This of course eliminates any advantage that may have been felt for privately owned vehicles.

VEHICLE INSPECTION

When a dual-mode vehicle enters the automated guideway, there must be an inspection procedure to ensure that the propulsion and control systems are functioning normally and that the vehicle is in reliable operating condition. This procedure would not detract from the dual-mode concept if it takes little time. At present, however, there is inadequate information as to how much time this inspection would take. If it is not much shorter than the time required for a person to disembark from his or her automobile at a PRT station, walk to the entrance of the station, and board a PRT vehicle, one of the advantages of dual mode is lost.

OPERATION IN DOWNTOWN AREAS

In operation in downtown areas, there is concern that congestion on the streets beyond control of the automated system could cause vehicles leaving the system to be blocked and hence backed up on the guideway. This could of course be sensed by the guideway system so that the vehicles approaching such a demerge point would be routed to other demerge points. Thus, it is not clear that this would be a significant problem.

A more significant problem is that, if private dual-mode vehicles are used, the dual-mode vehicles would have to be stored in the downtown areas. This poses the same kind of vehicle-storage problem we have with the automobile system. For this reason many advocates of dual mode feel that the system would have no off-ramps in the downtown area but only off-line stations. One would disembark at a station identical to a PRT station, and the empty vehicle would be shunted automatically into a storage barn. This procedure has the disadvantage that the wait time for retrieving a specific vehicle would be considerably longer than the wait time required to take the next vehicle coming along. Also, the requirement to retrieve a particular vehicle means that the volume of the storage facility would have to be several times larger with a dual-mode system than with a captive-vehicle PRT system.

COMPLEXITY OF STATIONS

One would generally think of dual-mode stations as being able to combine the functions of handling vehicles captive to the guideway and dual-mode vehicles. The captive-vehicle portion of the station would be identical in geometric form to the stations of a purely captive-vehicle PRT system. To this would have to be added ramps for getting vehicles from the street to the stations. Thus each dual-mode station would be more expensive than a corresponding captive-vehicle PRT station and would take more land.

PALLET SYSTEMS

Even with the indicated disadvantages, the idea of dual mode is appealing and should not easily be dismissed. More comparative analysis is needed to determine the extra cost and complexity of systems with dual-mode features, and the extra ridership that possibly could be attracted to the system as a result of the dual-mode feature. The ridership question is more difficult than the cost question and requires more comprehensive behavioral analysis than has been done up to the present time. Behavioral analyses could lend weight to the evidence of the importance or lack of importance of the dual-mode feature when compared with features of a captive-vehicle PRT system.

If after this analysis the dual-mode feature is still felt to be worthy of consideration, it could be developed without sacrificing the advantages of captive-vehicle PRT systems by making the unit attached to the guideway a pallet capable of carrying a variety of types of passenger and freight compartments and street vehicles. The pallet system looks interesting only if the evident increase in the total weight of the vehicle-pallet combination as a result of duplication of functions does not become excessive and as long as the greater complexity of system operation that would result with a pallet system remains manageable. Much more light can be shed on the important questions of these differences by combining engineering analysis with behavioral analysis. Studies of this type are needed to guide development of captive-vehicle PRT and dual-mode systems more effectively.

REFERENCES

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