How does Dual Mode Compare with Personal Rapid Transit?

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Advocates for improving urban transportation can be divided into the following six groups:

1. Advocates of conventional rail systems. For example, organizations of people dedicated to bringing the streetcar back.

2. Advocates for conventional bus or rail systems because nothing else is proven and there is no visible mechanism for proving better systems. This includes many public officials who have become convinced both that transit is needed and that they should work to obtain federal grants to build it.

3. Advocates of a network of small guideways on which small automated vehicles operate exclusively on the guideways, i.e. the vehicles are captive to the guideway. Optimally designed, such a system is expected to have much lower cost per mile and much higher attractiveness to riders than conventional rail. Such a system has been called personal rapid transit or PRT.

4. Advocates of an automated network of guideways that can accept street vehicles, i.e., a dual-mode system. http://faculty.washington.edu/jbs/itrans/ includes a series of papers on dual mode.

5. Advocates of automated highways such as tested near San Diego during the 1990's.

6. Advocates of an automobile-only society.

Among the means of urban transportation listed above, this paper compares the middle two options. The system of group #3 will be referred to hereinafter as "Single Mode" or SM. The system of group #4 is called "Dual Mode" or DM. DM has the advantage over SM for auto drivers that the same vehicle may be taken for any trip, just as occurs now with one's own automobile. DM has an advantage over conventional freeways in that automation is expected to substantially increase the throughput of a lane. In many respects, DM is much like the system envisioned by group #5 – an Intelligent Vehicle Highway System – except that special narrower guideways could be used for the automated guideway portion of the trip. Thus DM is expected to both decrease the cost of additional lanes and to increase their throughput. Since the automobile system in typical U. S. cities attracts about 95.4% of the urban trips[2] a percentage improvement of the throughput of the highway system will have far greater impact on congestion mitigation than the same percentage improvement of transit. SM advocates can't dispute that, but argue that SM is a transit system that will permit a major increase in transit ridership and with it major reductions in petroleum use, greenhouse gas emissions, and congestion.

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[2] C. Kenneth Orski, *Innovation* Briefs, Nov/Dec 2006.

There are important differences between DM and SM that need to be studied carefully before committing to one or the other. The differences should be clarified in the broadest sense taking into account economic, environmental, and social considerations. In examining the differences, the reader may be aware that I long ago committed to developing SM rather than DM, so my analysis must be viewed very critically, which I welcome warmly.

The following DM concepts have been considered:

1. The basic DM concept is one in which ordinary automobiles or buses are equipped with automatic control systems that permit them to operate automatically on a guideway. This would be similar, and perhaps identical, to those tested on a freeway near San Diego during the 1990s, except that a special, narrower guideway designed for autos only could be used. Since conventional highways are designed for trucks currently having gross weights up to 80,000 lb, whereas an automobile-only guideway could be designed for vehicles weighing a maximum of perhaps 5000 lb, the weight, cost, and size of this special guideway would be substantially less than a freeway lane; however, such a guideway would be substantially larger and more expensive than one that can be and has been[3] designed to accommodate captive vehicles.

2. In order to avoid both the cost of equipping a private automobile with the necessary automatic controls and the need for inspection upon entry to the DM guideway, some have suggested that the guideway be equipped with pallets on which private automobiles could be attached. The attachment device must be rapid and extremely reliable. If it is not rapid, i.e., secured in one or two seconds, the throughput at the entry points will be unreasonably compromised. If the mechanism were to detach while underway, the auto could fall off the guideway, kill the driver and possible pedestrians below – a catastrophic failure mode. Can a quick acting device be developed that would be so reliable that it could be accepted in this kind of service? Assuming that the necessarily almost perfect reliability can be attained day in and day out over many years is quite a risk – quite possibly an unacceptable risk.

3. In a third type of DM, to minimize the size and cost of the guideways, the street vehicle would be designed specially to attach to a narrow guideway. In this case, to make use of the guideway, the user would be required to purchase a special vehicle – a vehicle of a style and features that may not otherwise have been selected.

DM does not come without disadvantages, a discussion of which follows.

1. <u>Big, Expensive Stations</u>. Envision the process of getting an auto from the street onto the guideway. At a conference on Dual Mode Transportation held in Washington, D. C. in 1975[4] both Ford and General Motors brought for display models of DM stations showing the on and off ramps needed to permit autos to enter and exit the guideway as well as a loading platform for those who do not drive. With their ramps, these stations clearly could be seen to be much more expensive and land consuming than SM stations, which reduced enthusiasm for DM.

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[3] J. E. Anderson, "The Structural Properties of a PRT Guideway," available from the author upon request.

[4] Dual Mode Transportation, Special Report 170, Transportation Research Board, Washington, D.C. 1976.

2. Fault Monitoring. Maintenance of DM vehicles would be done privately, just as takes place with autos today, so the condition of vehicles entering the guideway would be much more difficult to determine than would be possible in a SM system in which the condition of the vehicles can be monitored and maintenance can be controlled.

3. Lower Station Throughput. At each point of entry to the guideway, DM vehicles will need to pass an inspection station one at a time and then enter the guideway. This reduces the throughput of the entry point. In a SM system vehicles can be batch loaded, which permits the station throughput to increase with the number of loading berths.[5]

4. Inspection Time. DM vehicles will have to be inspected carefully before entering the guideway. If the inspection time is only a second or two, throughput is barely compromised; however, if the inspection time is say 10 seconds, the throughput at each entry point will often be unacceptable.

5. Heavier Vehicles. Because DM vehicles must be designed for both the street and the guideway, they will be heavier, longer, and more expensive than SM vehicles. Street vehicles must be designed to meet all federal safety standards, including design for side collisions and rollovers, whereas SM vehicles captive to a guideway do not.

6. More Expensive Vehicles to be Purchased. Since DM vehicles of the first and third types given above would be more expensive than regular automobiles, they would be purchased near the beginning of DM operation only by the subset of wealthy people interested in experimenting with new ideas.

7. More Expensive Guideways. The requirement for operation on the street limits flexibility in design of a minimum size, minimum cost guideway. Moreover, since guideway cost will be proportional to vehicle weight per unit of length, a DM guideway will cost substantially more than an optimally designed SM guideway[6]and will possess correspondingly greater visual impact.

8. Inadequate Guideways. I have discovered some 32 criteria for guideway design[7]. Developing a DM guideway that will meet all of these criteria has not been demonstrated. Every DM guideway design I have thus far seen has had serious problems.

9. Longer Station Platforms. Because road vehicles are the intended primary users, DM will be of no use to those who cannot or choose not to drive. If a political decision directs that transit users must also benefit from a DM system, guideway would have to be designed to accommodate both SM and DM vehicles. But, since DM vehicles would be longer than SM vehicles, the stations would be longer and hence more expensive than in a SM system.

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[5] Irving, J. H., Bernstein, H., Olson, C. L., and Buyan, J. *Fundamentals of Personal Rapid Transit,* Lexington Books, D. C. Heath and Company, Lexington, MA, 1978, Section 3.2. See also Section 1.6 for a discussion of DM.

[6] For example see either the paper cited in footnote #3 or reference #5.

[7] See the paper of footnote #3.

10. A Question of Equity. A question then arises: How much guideway would have to be built before even a wealthy person would purchase a DM vehicle? At least in early stages the return on investment would be unattractive to private investors; therefore taxes would have to pay for installation of the guideway, a guideway that only the wealthy could in early stages afford to use. There has been much debate on this question related to requirement for payment for use of high-occupancy toll lanes on freeways. This debate will be much more contentious when it comes to paying for a whole system of guideways that early on could be used only by the rich.

11. Downtown Congestion. In downtown areas, DM vehicles cannot always be permitted to enter the street system because congestion could then back up onto the guideway, so some DM advocates suggest that there simply be no off-ramps in the downtown area. Instead, some sort of automated vehicle storage (parking) and retrieval (valet) would occur at downtown stations. Otherwise the downtown network would operate identically with SM, but with bulkier guideways and longer stations.

12. Wasted Resources. DM vehicles would be stored like conventional autos, sitting unused all day, whereas a SM vehicle is ready for the next trip as soon as one is completed, thus not taking up parking space. Studies have shown that one SM vehicle could serve up to six to ten trips during the day, giving a great economy in the cost of the vehicle fleet. Moreover, DM requires more land and resources devoted to park vehicles.

13. The DM driver must wait. The time required to retrieve a DM vehicle at the end of the work day will be much longer than the time to wait for the next SM vehicle. Moreover, if the DM vehicle is called in advance and the driver is delayed, the vehicle would have to be recirculated, thus adding to congestion on the guideway.

14. Minimal Assistance to the Non-Driver. Because the driver of a DM vehicle might not mind driving say two to three miles to an entry point, DM designers usually speak in terms of only a minimal guideway network being needed. While saving on guideways, this feature would render use of the system marginal for those who do not drive.

15. Little Improvement in Transit Usage. A more important concern about those who cannot or chose not to drive is that as baby boomers approach retirement age there will be a great many more people who would rather not or should not drive. A DM system will leave their lot pretty much as it is today – often dependent on others or marooned. As a matter of public policy, equity in provision of public transportation should be foremost in the minds of transportation planners. SM can provide that equity. DM cannot.

16. Less Potential Usage. With a minimal guideway network, if DM were to have as much capacity as SM, DM would have to have many more entry points per mile than SM, yet because of their complexity, size, and cost DM proponents recommend fewer entry points. Moreover, as mentioned in item #3 the throughput of a DM entry point will be less than possible with SM.

17. No Improvement in Ridership. DM has been shown[8] to be unable to attract more riders than SM.

18. Little Congestion Reduction. Higher cost guideways for DM vehicles would likely restrain the number of routes could be built. That limitation directly misses one of the most critical anti-congestion challenges in metro area transportation planning. ***People continue to rely upon their autos because they lack effective non-auto options***. Worldwide, metro areas are spreading out, with increasing numbers of employment, business, and recreation activity centers. Non-auto transit options that cannot get people to these spread out centers in time-effective and cost-effective ways will not reduce road congestion.

19. Legal Responsibility More Difficult. Because of the combination of public and private assets, assigning legal responsibility for accidents would be more complex for DM than SM.

20. More Difficult Startup. For DM to begin as intended – a system of special DM guideways serving a fleet of privately owned especially equipped automobiles – it would seem have to start from Day 1 as a regional system covering a metropolitan area. DM could of course start experimentally with one DM guideway and with a fleet of DM cars leased from the builder of the DM guideway to perhaps randomly selected individuals who would use the DM guideway and report on the experiences. On the other hand, SM can start as a small system serving a special application such as an office park, a theme park, etc. It would seem then that the resources, education, and approvals needed to initiate SM are vastly less than needed for DM. Starting small likely means working at first with a single client and being able to prove the system in daily practice quickly – proof that will be needed before the system can be extended to a metropolitan area. SM can and should be designed so that it can be expanded in both extent and speed.[9]

21. DM suffers from the attempt to combine two different functions, and as a result fails to excel at either.

Urban Planning Implications of SM vs. DM

In SM one either walks or rides a street vehicle from home to a station, and at the destination (job, store, school, restaurant, theater, stadium, etc) one would walk a short distance, probably no farther than from a parking ramp into a building. Once a trip on SM is completed the vehicle is instantly available for the next trip. In the central city, SM guideways could be placed a quarter to a half mile apart. For its posts and stations, SM will occupy a tiny fraction of the urban land – about 0.02%. Moreover, with an optimally designed guideway, visual impact will be small and more land could be devoted to gardens and parks.

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[8] Irving, J. H., Bernstein, H., Olson, C. L., and Buyan, J. *Fundamentals of Personal Rapid Transit,* Lexington Books, D. C. Heath and Company, Lexington, MA, 1978, page 25.

[9] J. E. Anderson, “An Intelligent Transportation Network System,” www.prtnz.com.

Because

- the system cost of optimally designed SM will be less than 25% of the cost of conventional surface rail and the stations of SM can be placed typically at half the spacing of conventional rail stations without sacrificing trip speed, about eight times as much land can be placed within walking distance of stations for the same investment with SM as with an urban rail system;
- there is little or no waiting for an SM vehicle;
- SM vehicles will be available any time of day or night; and
- the trip is nonstop and therefore in many cases faster than an auto trip;

a much larger fraction of trips will be attracted to SM than to conventional transit. With livable higher density, many more of the longer trips will be taken by SM and many more of the shorter trips by walking and bicycling. For these reasons SM would make possible higher density, more energy-efficient, less polluting communities that in some cases could become auto-free zones.

DM does not answer the legitimate criticism of the auto system that everyone in an urban area should have equal access to transportation. In a DM system one boards a private DM vehicle at home and proceeds perhaps one to three miles away to a DM guideway, then perhaps ten to fifteen miles[10] on the guideway to the destination, where the driver must search for a parking spot just as occurs today. The private DM vehicle then sits all day in that parking spot taking up valuable space, is of no use to anyone, and expensive land must be provided to park it. Improvement in land use is therefore not apparent. DM does not answer the legitimate criticism that the auto system promotes urban sprawl, with the encroachment of the auto on rural land possibly already past the point of sustainability. Due to DM being an extension of the current highway system through automation, its effect would be the same as adding more highway lanes. It will exacerbate already unsustainable land use patterns.

Many of us envision a future in which energy will be much more expensive and the continual encroachment of the auto on farm land will result one day in too little land for agriculture and recreation. A conflict manifests between those who envision the future pretty much as it is today and those of us who envision the changes that can be expected to occur on a finite earth as more and more people grasp for fewer resources.

Concluding Remarks

There is nothing in the remarks I have made that would indicate that DM is not feasible. I conclude though that on a per-mile basis DM will be much more expensive than SM; that the capac-

[10] Unless the trip is at least this long, it will be difficult for an individual to justify the cost of a DM vehicle and the guideway toll.

ity of DM will likely be disappointing; that, by proposing that DM guideways be much farther apart than SM guideways to minimize cost, DM will not change the balance between people who drive and those who cannot or should not drive; that DM will do nothing to improve current land-use patterns; and that initiation of an automated highway mode is much easier with SM than with DM.

We observe with great enthusiasm the current efforts in England, Sweden, and the United Arab Emirates to commercialize these new modes of travel and trust that by their example deployments will begin in the United States in time to contribute to alleviation of the problems of excessive CO_2 release, dependence on oil, increasing congestion, urban sprawl, and equity in transportation modes.

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