Response to "Personal Rapid Transit – Cyberspace Dream Keeps Colliding with Reality," found on www.lightrailnow.org

by

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Introduction

There is a great deal of information available by a wide variety of groups showing that an optimized form of PRT, designed from scratch to minimize cost per passenger-mile as SkyWeb Express was, has an important place in the mix of alternative urban transportation systems. PRT can augment conventional rail systems and make them more effective. As a circulation system in a busy major activities center such as a downtown, a university, a hospital complex, or a shopping center, PRT can make bus systems more efficient by letting them drop passengers off at the periphery so that they need not enter highly congested areas, but can turn around at higher speed to carry more passengers. PRT will start out first with a test loop, then with small applications in area of high need, and only later in larger applications after it proves itself through daily service.

The 19-page paper to which I respond lists no author or authors. When a newspaper receives an anonymous letter, it is generally thrown in the nearest wastebasket. So why am I answering this? Some of my colleagues have counseled me not to bother for many of the statements are outrageous and the personal attacks unprofessional. Also, I am aware of four excellent responses already posted. But lack of response can be interpreted negatively and it is often useful to step back a little and reiterate the rationale for one's own activity. So I thank the anonymous authors of the subject paper for the opportunity to do so. I also invite them to come to our facility, ride in our automated vehicle, and engage with us in a discussion of their concerns. We presume that your motives are honest and that you simply need some education on the real characteristics of optimized PRT and the strategy for implementing it. I am sure that every one of your concerns will be cleared up. To save space in the following I will refer to our anonymous authors as AA.

AA found it necessary to attack not only the concept of PRT but the people working to advance it. Supposedly they believe we are "isolated theoreticians" and work on PRT as "an excuse to stall bona fide major transit investment programs." They also often say we are leagued with the highway lobby to prevent any transit system from being built. If we actually had the funds that could come from such a relationship, we would be much farther along than we are. My motivations are discussed in Reference 11.

AA appear troubled by all of the activity on PRT that keeps cropping up, notwithstanding their attempts to ridicule it. The internet has made the real difference. It is much easier now than formerly for ideas to disseminate and be discussed widely. In the case of PRT, past bungles have become widely known, but to the apparent frustration of AA, these bungles have not discouraged increasingly widespread discussion of and activity on PRT.

Much of what I would need to say in response to the subject paper I have already said in prior publications, so I refer the reader to a series of papers that can be found on our web page under "The System/Library," some of which are given in the list of references at the end of this paper.

Reference 3 gives the history of PRT as I saw it from personal experience and includes the bungles, of which there have been many, and the progress, of which there has been much. I will elaborate below on a few points that need clarification.

Reference 4 is short and is in my view the key set of rules that separate good design from bad. From my observations, the well-known bad PRT designs are a result of violations of these rules. If any reader would wish to comment on them or add to them, please let me know. They are now being used in several University senior engineering design courses.

Reference 5 is an invited paper that is the most comprehensive I have published in recent years and answers many of the criticisms of the subject paper.

Who Has Endorsed PRT?

- Northeastern Illinois Regional Transit Authority, in 1989, after riding on the Morgantown system, investigating the state of the art including Taxi 2000, and becoming convinced that a cost-effective PRT system could be built.
- The 20-person Sky Loop Committee (www.skyloop.org) of Cincinnati Area Forward Quest, in 1996-98, investigated over 50 elevated rail systems and selected Taxi 2000 as their preferred technology.
- Sweden. During the 1990s the Swedish Transportation and Communications Research Board commissioned a series of studies including system operation, planning, visual impact, ridership, and technical readiness. This was followed by the Evaluation and Demonstration of Innovative City Transport project financed by the EC. The last sentence of the conclusion of the later study was "Our recommendation would change in favor of Taxi 2000 if it becomes market-ready before a decision is taken."
- The Advanced Transit Association (http://www.advancedtransit.org) in January 2003 released a 250-page report "Personal Automated Transportation: The Status and Potential of Personal Rapid Transit," which was the result of a two-year study by a 14-person committee. They report on their studies of 14 potential PRT systems. Their conclusion: "Approximate costs of a PRT system of $5 million per one-way mile can be projected, based on a combination of actual prototype costs, bids, and several comprehensive costing studies. It is proposed that local governments update permitting requirements to legalize PRT, and follow rigorous planning and evaluation practices so that PRT systems

are compared fairly with other systems on the basis of their ability to meet well-defined public goals."

- 70 individuals who have invested over $1,500,000 in Taxi 2000 Corporation since the year 2002, in full knowledge of past failures.
- The Duluth City Council. The Duluth-Superior Metropolitan Interstate Committee. The UMD Dean of the College of Science and Engineering.
- http://www.skywebexpress.com /Contact Us/Links lists a dozen web sites that promote PRT and originate in Austin, Cincinnati, Minneapolis/ St. Paul, Santa Cruz, Seattle, Silicon Valley, and Tucson.
- Over 4000 people who signed petitions at the 2003 Minnesota State Fair in support of PRT.

Network Size

AA comment on their page 2: "The concept requires a relatively vast network of guideways and stations . . ." Not true. AA assumes that what can be done must be done. We have found that PRT will costs less and perform better than conventional transit in some rather small applications. For example, in one hospital complex a system of only three stations performed a very useful function. Since the vehicles are very light and the guideway correspondingly small three things happen: We can fit the SkyWeb Express system in where the larger systems can't fit, the costs are lower, and the wait times are shorter.

Visual Impact

According to AA "the urban airspace would be filled with PRT guideways." Let's see how filled the airspace would be. Assume a PRT system with one-way guideways deployed in a grid a half-mile on a side. Then, calculate the fraction of that half-mile by half-mile area that would be covered by guideways. Our guideway is three feet wide, and we would deploy a station every half mile. So the area assigned to one of these half-mile areas covered by the guideway would be 3 x 5280 = 15,840 sq-ft. With such a grid, I showed in Reference 9 that the stations don't have to be very big even with quite a high population density. Four-berth stations would be more than enough. They would cover an area, counting room for an elevator, of 12 ft by 50 ft or 600 sq-ft, or 1200 sq-ft for two of them. Thus the area covered by system elements would be 17, 040 sq-ft. Dividing by the area of the square, 2640^2 sq-ft, we see that *the system covers a quarter of one percent of the area or one part in 400!*

But we don't use all of that area. For the guideway we need room for only the foundations of the posts. With 90-ft post spacing at about 5 sq-ft per foundation, in one mile we need area on the ground of only about 330 sq-ft. Adding to the land needed for stations, we need a total of 1530 sq-ft per half-mile square or *0.02% (1/5000th) of the land*, whereas the auto system requires about 30% of the land in residential areas and up to 70% in the central business district. Moreover, from reference 9, such a system could carry a large fraction of the trips generated in the city. *The fact is that optimized PRT is enormously land saving*, the implications of which for land development are great. For the environmentalist PRT is great too because much of the saved land could be restored to gardens and parks, and because, by attracting many auto trips in electrically powered cars, air pollution will be substantially reduced.

During the night when there is little traffic on the system, 25 to 30% of the vehicles can be stored in stations.[1] The rest must be stored in special storage sidings. How much space do they take up? A storage guideway will require a spacing of six feet. The width of four of such guideways would be 24 ft, which is less than the 28-ft width needed for a two-way light rail system. A very large storage area may have as many as 200 vehicles on each of these guideways, which will require a length of about three city blocks. This is much less than the space required in freight railroad yards.

Elevated Realities

On their page 3 AA show the well-known picture of a multi-level interchange of The Aerospace Corporation PRT system. On the whole, the system engineering on PRT of The Aerospace Corporation was the best anywhere and frankly it is unlikely that we would be talking about PRT today if it were not for their work, which is well documented. But their control concept required the use of multilevel interchanges. In the early 1970s, the Task Force on New Concepts in Urban Transportation at the University of Minnesota was funded by the Urban Mass Transportation Administration (UMTA) to do a visual impact study of PRT. From that work we determined that as much as possible only Y-interchanges should be used even though the control system would be more complex. The German joint venture DEMAG+MBB agreed and, even though difficult in the 1970s, they worked out such a control system. Building on that work, during the 1980s and 1990s we worked out completely the control techniques and software needed to operate a PRT system of any configuration and any complexity. This sounds implausible, but the engineers who have been briefed in detail agree that it is fully practical (Ref. 10).

I digressed here into control because it is related to visual impact. Back to visual impact, on page 4 of the subject paper the authors show in the upper picture the 6.5-ft-wide Raytheon guideway, with its big posts and without its covers, superimposed on a Minneapolis scene, clearly hoping to convince the reader that that is the best that can be done. The SkyWeb Express guideway is a little less than three feet wide and about 38 inches deep. It has been thoroughly analyzed for structural integrity. Our posts are nominally 90 feet apart and need be only 20 inches in diameter at the base tapered to 10 inches at the top. Moreover, with its covers, which serve eight purposes, the appearance of our guideway can be varied to suit the community.

We have found many applications in which there has been no question about the acceptance of a guideway the dimensions of ours, but we recognize that there will be places in which it would be rejected. This is not a problem for us – we go where we are invited. The remaining market for a cost-effective PRT system such as SkyWeb Express is enormous.

Morgantown

AA bring Morgantown into their discussion, again seeming to hope to convince the reader that a system contracted 34 years ago is the best we can do now. The Morgantown contract was let in December 1970 with the stipulation that the system be operational 22 months

[1] People worry about vandalism, but with well-lit stations, television monitoring, and motion sensors, it will be easy to catch a vandal.

later – in October 1972 in time to reelect President Nixon. Here are a few of the problems that ensued:

1. Because of the rush, the fixed-facility builder F. R. Harris of Stamford, Connecticut, was told to assume in their calculations that the vehicles would weigh as much as a conventional rapid-rail car, which accounted for the heavy guideway and stations.
2. Eight months into the program, the designated system manager, Jet Propulsion Laboratory of Pasadena, California, resigned from the program because they found that UMTA was using them only for a money pass-through. They were given no budget for systems engineering. Boeing took over as system manager with only 14 months until the system had to be operational.
3. After Boeing had designed the vehicle, they found that F. R. Harris had designed curves – too late to change – so sharp that their vehicle couldn't negotiate them. In midstream they had to redesign to include back-wheel in addition to front-wheel steering.
4. UMTA told F. R. Harris that they had budgeted for borings at only about one post in five. F. R. Harris insisted that given the mountainous soil conditions in Morgantown they had to test the soil at every post. A big fight ensued, which was resolved only by UMTA giving F. R. Harris a memo taking responsibility for the consequences of the lack of borings. The foundations and columns were built, following which a number of them sagged. So at great expense the team had to dig them out, do the borings, design properly, and reconstruct.
5. In mid program, the team discovered that it snowed in Morgantown and that operating on a slippery guideway was not safe. So they laid pipes in the running surface to carry heated ethylene glycol. Much later, a student of mine who worked at Boeing on automated guideway systems showed me data indicating that on an annual basis it took *four times as much energy* to melt snow as it did to propel the vehicles.

Notwithstanding all of this and more, *they actually ran a vehicle in October 1972*. It stopped due to a sensor failure with Tricia Nixon in it, and of course that and the cost over-runs created great press. Over the next few years, the bugs were worked out and the system has been in daily operation ever since – with virtually no press. A few years ago Boeing rebuilt the control system. A visit to Morgantown and a ride on the system in 1989 convinced the Chicago RTA leadership that PRT would work and that a much lower cost design could be built provided that the vehicles were kept as small and as light in weight as possible, and that the guideway would not be over designed as happened in Morgantown.

As a basis for the Morgantown system, UMTA selected the Alden StaRRcar of Bedford, Massachusetts. They had designed a six-passenger vehicle and their cost estimates were based on that. The UMTA leadership increased the size to 20 passengers with eight seats. With the increase in size and all of the problems mentioned above, the cost skyrocketed. Now AA wishes that you, dear reader, will believe that this is the best that can be done 34 years later!

The effect of the Morgantown project on Congress was to cause them to lose interest in the PRT concept, and this held back PRT development for at least 15 years. Development of PRT has required understanding and cooperation among entities such as cities or high-use developments, investors, and suppliers. With interest in Congress dropped and the federal government telling cities not to look at any non-proven technology, it was much more of a challenge to get all of these people to together, and this is the major answer to the common question: "Why has it taken so long?"

Capacity

In reference 9, which was commissioned and later reviewed by the executive committee of the Advanced Transit Association (www.advancedtransit.org), I explain both line and station capacity of PRT using both practical observations of actual people flow and calculations. The lack of on-line stopping permits line flows of people in autos on a freeway lane to exceed those actually attained by light rail trains. What can we do with PRT, in which there is no stopping on the mainline? First, the sensing systems we use today are very reliable and very precise. (We stop our vehicle in our 60-ft section of guideway within 2 mm of our intended location.) Second, the reaction time of our computer-based control system is a few milliseconds rather than one or two seconds, which is observed in human beings that are not too old and not inebriated. Third, in a well-publicized test on a freeway near San Diego during the 1990s by the Automated Highway Consortium and supervised by the National Highway Safety Board (hundreds of papers on this work can be found on the web) four Buicks were operated at 60 mph at one quarter second headway. What we have determined by detailed analysis and observation of actual testing is discussed in some detail in both references 7 and 9. Since the early 1970s, I found, as a result of chairing three international PRT conferences and subsequent visits to all of the many projects on PRT going on then, that the rationale for half-second headway had been developed by many groups. Indeed, The Aerospace Corporation, one of the best systems engineering houses in the world, was confident that they could do 1/6th second headway at 60 mph.

In hearings before Congress on March 28, 1973, UMTA Administrator Frank Herringer told a Congressional Committee "This means that a high-capacity PRT could carry as many passengers as a rapid rail system for about one quarter the capital cost." Such a statement could be made only with substantial backing from the UMTA engineering staff, with input from industry. The problem of high-capacity PRT is not whether or not it can be done. It can be done, and because of that it is a threat to existing modes. We know that we must proceed with caution, starting with tests and then with low-capacity applications over a number of years before the full potential of PRT can be realized.

The control philosophy in railroad practice is that if one train stops instantly, the train behind must be able to stop without hitting it. Our philosophy is that if one of our cars were to stop instantly someone would have been killed. So, based on careful failure modes, effects and criticality analysis, we have designed our system so that the probability of any system event causing one car to stop suddenly is extremely remote. We have calculated the mean time for such events, and for collisions, and found the mean time to be millions of times longer than that experienced by the U. S. automotive system. Of course this must be tested thoroughly and we intend to do so. In the meantime in early systems we can live with the railroad philosophy, which in our system implies headways no less than two seconds. We will need to test many times to justify going to closer headways. AA disparages the use of theory, but the theory we use, better called the application of engineering science, is based on and confirmed by a great deal of practical experience.

On their page 7, AA make the common mistake of equating stopping time (speed divided by acceleration) with time headway. The latter is calculated from the formula for stopping distance, which contains the stopping time divided by two. See reference 7 for details.

Station Congestion

AA talk of 200 people approaching a station at once, and they pat themselves on their backs for being practical and realistic. An important point is that a PRT system will have many more stations than a light-rail system, so the peak flow into each station will not be as much. Moreover, simple observations, a number of which I describe in reference 9, shows that people don't arrive all at once – there is always a flow and that flow is generally such that it can be handled by a PRT system usually of moderate size. For the Cincinnati Sky Loop Committee I developed a simulation, the layout of which is shown on http://www.skyloop.org, with a flow aimed at seeing what can be done to bring people to the Cincinnati Reds Ballpark or take them away. I used four 14-berth stations, one on each side of the ballpark, and found that I could handle the designated flow with average wait times ranging from 0.6 to 0.9 minute with zero wave-offs. We use a distribution of loading and unloading times measured by observations of the movements of all kind of people.

When I was teaching engineering at Boston University I rode the Blue Line (a heavy rail system) followed by a transfer to the Green Line (a streetcar system), which passes through BU. At the transfer in Downtown Boston, the time to load was typically five minutes on occasions when the crowd was large. During that time about 150 PRT cars could have loaded. Charging a fare per vehicle rather than per person will encourage riding with friends so in this case one can assume about 1.5 people per car, giving 225 people in five minutes or 2700 people per hour.

Droppings

AA express concern about "the possibility of debris, lubricants, water, ice, or snow falling on pedestrians . . ." Come out to 8050 University Avenue in Fridley, Minnesota, and see our system. You will see a pair of linear induction motors in which the only thing that moves is electrons – no crank case, no oil. Our car is supported by wheels using sealed bearings – no dripping. We have very few moving parts and those we have are well engineered to not fall off. Much testing will have to be done on our Safety Certification and Training Facility to prove this, of course. Our guideway will have a slot in top only four inches wide so very little rain, snow or ice can enter, and most of the amount that does enter runs right through. To prevent accumulations we will run a few empty cars on the guideway during a snow or ice storm. A detailed study showed that only about 2% of the fleet is needed for this task. No "drip pans" will be needed. The need or lack of need for walkways was considered in detail in our $1.5 million PRT design study for Chicago. They will be used when the guideway crosses rivers.

Empty Vehicles

AA has likely misunderstood the operation of empty vehicles. First, how many of them would there be? If the demand was completely uniform, i.e., the same number of trips from every station to every other station, no empties would be needed. On the other hand, if all the flow were say from home to work at a central location, 50% of the vehicles would have to be empty. Thus it is not surprising that many simulations have shown that typically about one third of the vehicles will be empty and moving to points of need. We determined how to do this very efficiently, and we account for the empties in our economic calculations. Every transit system has a certain amount of deadheading, and there is much more of it in scheduled systems, which require continued movement of vehicles off-peak even with few riders. PRT vehicles need move only when there is demand, and that cuts substantially the number of miles per day that each vehicle need travel, which saves energy.

AA assumes that movement of empties will markedly increase energy use. AA's use of words such as "undoubtedly," "seems apparent," "perhaps," etc. indicates that they are only speculating. *They have never developed any simulations of PRT systems and are apparently unaware of the substantial body of literature on them.* In reference 8 I calculated the energy efficiency of eight modes of urban transportation including energy for construction, HVAC, air drag, road resistance, and the kinetic energy that must be added to a vehicle to accelerate it to line speed. I start with a barrel of oil and assume on one hand it is refined into gasoline and used to drive cars, buses, or vans; and on the other hand it is burned in a power plant with an efficiency of one third and used to drive electric vehicles. I found in this way that our PRT system is equivalent in energy consumption to an auto system averaging 70 to 90 miles per gallon. As I discuss in reference 8, many factors enter into the energy calculation: vehicle weight, average load factor, number of stops per trip, amount of material used per passenger-mile over the life time of the vehicle, etc.

Another factor is whether the system runs on demand or must be scheduled. In a meeting at UMTA in 1980 held to show me why PRT wouldn't work, one of the presenters commented that when in their simulations they switched from scheduled to on-demand service in the off-peak period the number of vehicle-miles traveled *dropped by a factor of five*! By the end of the two-day meeting they had caved in on every point. Shortly thereafter the associate administrator over R&D resigned and his replacement wrote me a letter saying that they wanted my help in developing a high-capacity PRT system to be operational in the 1990s. These engineers had ten years of practical experience in the design and operation of a wide variety of automated guideway transit systems.

<u>Costs</u>

Reference 6 is my basic paper in which I show why and under what circumstance the break-even fare per passenger-mile of a PRT system can be less than a reasonable fare that can be charged. If the reader understands this paper he or she will understand why the PRT concept is so compelling.

Our costs were first generated while I was at the University of Minnesota. They were later reviewed from scratch by Davy McKee Corporation in Chicago, then again by United Engineers and Constructors in Boston with the assistance of a professional engineer from the Volpe National Transportation Systems Center, then by the Raytheon Equipment Division in 1990, then by Stone & Webster, and most recently with the assistance of our current team of suppliers. Early costs have been updated using cost-escalation factors found in the *Engineering News Record*. All of our cost numbers include an elevator in each station and HVAC in each vehicle.

Raytheon

On their page 17, AA discuss the Raytheon program, a program sponsored by the Northeastern Illinois Regional Transportation Authority (RTA). This program started in 1989 after the RTA leadership concluded that they could not solve the problems of transportation in the Chicago Area with just more roads and more conventional rail systems – there had to be a new idea somewhere. In the Act that established the RTA, the Illinois Legislature said that the RTA should "encourage experimentation in developing new public transportation technology." Thus the RTA had a mandate to consider PRT. After being exposed to the concept of PRT, the RTA investigated over a number of months, including a ride in the Morgantown system, and in April 1990 released a request for proposals for two parallel $1.5 million PRT design studies. Taxi 2000 won one of these with Stone & Webster Engineering Corporation as prime contractor.

Once the study was complete in 1992 (it considered every objection AA express) the next Phase would require detailed design, construction, and test of a PRT system. S&W was in serious financial trouble and could not come up with the $20 million needed. In late September 1992 Raytheon stepped in and agreed to develop a proposal to prime the test-track phase. In June 1993, the RTA Board selected Raytheon as prime contractor assuming Taxi 2000 technology.

Now here was a real problem for PRT: The RTA knew of no consulting firm competent in PRT that could work as their Technical Support Contractor (TSC), so they picked a firm that had experience in large-vehicle automated people movers, not realizing that there is a profound difference between these systems and real PRT. The lead engineer of the TSC insisted that only transit-proven components be used, and the RTA staff mistakenly did not seriously challenge him. As one example, a result of the S&W PRT design phase was that the tires to support the vehicle, then weighing 1500 lb, needed to be only 13 inches in diameter. The only transit-proven tires were 30 inches in diameter. Everything scaled up in proportion and that four-passenger vehicle ended up weighing almost 6000 lb. The Raytheon team tried to resist but they were under their own constraints, one of which was that they were directed to use for the base of their guideway 3-ft-diameter pipe that one of their companies made for the oil and gas industry. That pipe is visible at the bottom of the guideway shown on AA's page 4. The rest is the structure welded on to support the vehicles.

Perhaps the most important point here is that the Cincinnati Forward Quest Committee, first called the Advanced Elevated Rail Committee and later Sky Loop Committee, being fully aware of the Raytheon/RTA debacle, selected Taxi 2000 as their preferred technology over 50 other elevated rail systems, which were in various stages of operation, testing or design. The 20-member Sky Loop Committee was fully independent of Taxi 2000 or of any biases toward any form of elevated transit – their mandate was to find the best solution they could.

The next step for the Sky Loop Committee was to find funds for a comparative study of PRT and other modes. The problem was that the study had to be managed by the organization, called OKI, that was promoting surface-level light rail. Because the SkyWeb Express system was not fully proven, it was easy for OKI to reject it, but it is important for the reader to know that notwithstanding that rejection eight members of the Sky Loop Committee were part of a group of 68 investors who in 2002 invested over $800,000 in Taxi 2000 Corporation and made the construction of our pre-prototype possible. The Sky Loop Committee prepared a detailed rebuttal of the OKI study, which can be found on http://www.skyloop.org.

It Won't Work Because it Can't Work

I am reminded of a statement by Lord Kelvin in 1900: "Heavier than air machines will never fly because they can't fly." On their page 17 AA repeats Vukan Vuchic's tired old argument that the basic concept of PRT is "inherently unsound – it won't work because it can't work." On Professor Jerry Schneider's web page "Innovative Transportation," referenced in the AA paper, there is a PRT Debate Page, where Vukan has a posting, followed by one by me, and back and forth several times. The reader may read that to get into some depth in the arguments. As well as I can tell, Vukan must be assuming that PRT will have the massive structures used in Morgantown, which no engineer in his right mind has or would use again. We have done many detailed layouts and accurate simulations of real applications, we have worked with many city planners, and we have followed the work of every group of consequence around the world, the most detailed of which in recent times was done in the 1990s in Sweden (Ref. 2). Over the years I have given a great many presentations to a wide variety of groups including many transportation and planning professionals, and I have listened to and recorded their comments and questions. I have seen no evidence that Vukan or any other PRT detractor has done anything but speculate on the characteristics of PRT. None of their arguments hold water when examined in detail.

Conclusions

Using words like "hypothesized," "Lilliputian," "amazing," "far gloomier," "minuscule," "speculation," "near-total disconnect," "pessimistic fantasy," "diabolical," "bizarre scenario," "the killer," "going splat" and finally the plea on page 18 to drop all work on new systems and embrace LRT as the only real, practical, proven solution, AA admit their biases and their terrible anxiety that PRT is gaining ground. One can only wonder why they don't say who they are.

Every new idea has started as a vision in someone's head. Over the past half century, starting with a vision, and then adding to it engineering science and experimentation, the concept of PRT has gradually emerged. I urge AA to criticize the best of PRT rather than trying to disparage it by trying to convince readers that failures of the past are failures of the present. In this way AA could make a real contribution to the improvement of urban transportation. Engineering is an error-correcting process. We have over the past decades observed in the real world many errors and we have seen how to correct them. Based on the 2003 ATRA Report on PRT there are now at least 14 groups and likely more that are developing various versions of PRT. Because of congestion, pollution, land use, accidents, need for a driver's license, road rage, and dependence on oil, PRT will emerge. Again, dear AA, please visit us and let us reason together to solve a fundamental problem of society.

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