How to Reduce Congestion: An Idea that will not Die!

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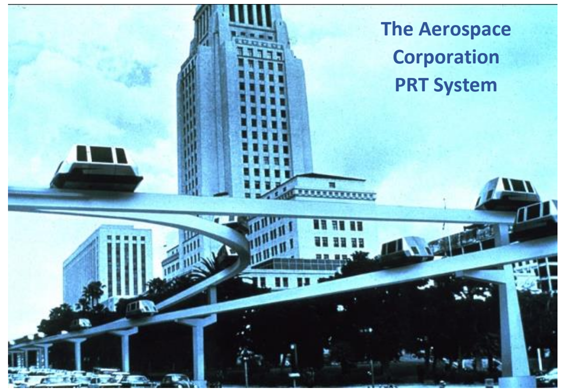
As a Professor of Mechanical Engineering at the University of Minnesota, I became interested in urban transportation in 1968 because the newly formed Urban Mass Transportation Administration (UMTA) invited proposals from Universities to set up interdisciplinary research and training programs in the application of new technology to urban transportation. I read the UMTA report *"Tomorrow's Transportation: New Systems for the Urban Future*," which was the summary of 17 studies performed by major corporations and research institutes. This report made clear that the most promising new system was **Personal Rapid Transit (PRT)**. The main conclusion of the studies, as I interpret from the summary article "Systems Analysis of Urban Transportation" in the July 1969 *Scientific American*, was that if only conventional transit systems were deployed in cities to meet future transportation needs, congestion would continue to increase; but if that most promising new system were deployed **<u>congestion would reduce</u>**. We proposed and received one of the grants, which among other things gave me travel money to visit work on the new systems.

In the 1890s, planners in Boston, New York, Philadelphia, Cleveland, and Chicago concluded that the only way to avoid **congestion** was to go to a new level – either elevated or underground. They did both and at great expense deployed the technology then available – large, manually driven vehicles that stopped at all stations and resulted in large, unsightly, very expensive guideways. In 1953, two transportation engineers, Donn Fichter and Ed Haltom, working independently, both envisioned that if the large, heavy vehicles were replaced by many very small, light-weight vehicles, the weight and cost of the guideway could be markedly reduced – we found by a factor of at least 20:1. They knew that these small vehicles would have to be automatically controlled; and that to **obtain sufficient throughput**, the stations would have to be placed on bypass guideways, just like stops off a freeway. **This is PRT.**

With these **off-line stations**, each trip will be nonstop – bypassing all intermediate stations, and the vehicles need move only if there are demands for service. The service will thus be available 24/7, wait times will be very short in rush periods and zero in off-peak periods, stations can be more closely spaced because intermediate stations do not reduce the average speed, stations can be sized to demand, and a traveler will ride only with known companions or alone. Much study shows that this combination of features markedly reduces system costs and increases ridership. Several other inventors developed similar ideas, and the totality of these ideas attracted the attention of Congressmen who placed a paragraph in the 1964 UMTA Act that directed the new agency to study the new systems, hence the above-mentioned studies were authorized.

We soon interested the **Minnesota State Legislature**, and at the end of their 1971 session an Act was passed (H. F. No. 1937, CHAPTER NO. 915) that gave the Center for Urban and Regional Affairs at the University of Minnesota $50,000 to develop a proposal to demonstrate "an advanced form of public transportation." I was placed in charge of that work; and, in 1973, after extensive investigations, we proposed a demonstration of The Aerospace Corporation PRT system at the Minnesota State Fair Grounds. The Aerospace Corporation, by their charter, cannot go into production, but could lead the construction and operation of a demonstration, which could then be put out on bids.



In 1973, the Minnesota Senate Transit Subcommittee, headed by Senator Robert North, held hearings on transit alternatives and conducted field trips. That work resulted in 1974 in an Act (S. F. No. 2703, CHAPTER No. 573) that directed the Metropolitan Transit Commission (MTC) to plan "an automated small-vehicle, fixed-guideway system." Two proposals were submitted to the MTC, one from The Aerospace Corporation, and one from a consultant who had no experience with PRT. The MTC, having lobbied for a conventional solution, selected the latter. The MTC was the fox the Legislature by law had to put in charge of the proverbial hen house.

The only so-called PRT system then in operation was at Morgantown, West Virginia. It uses 20-passenger vehicles, an unusually large guideway, and is not in reality a PRT system, but a group rapid transit system (GRT) and a poorly designed one at that. It is an enormous contrast to the optimally designed Aerospace Corporation PRT system. The MTC consultant laid out the Morgantown system on paper and calculated its cost, which was very high. We could have told them that without spending any money at all. The result was that in Minnesota agencies, "PRT" was declared to be too expensive.

With the able assistance of the University's Department of Conferences, I chaired international conferences on PRT in 1971, 1973 and 1975. The proceedings of these conferences occupy 1653 pages and included 150 papers by authors from Canada, England, France, Germany, Japan, Sweden, Switzerland, and the United States. While many hundreds of engineers and planners participated enthusiastically, by the mid-1970s lobbying by conventional transit managers killed all federal work on real PRT. We learned that while in the military sector, where I had spent my early career, <u>fear drives innovation</u>, in the civilian sector <u>fear inhibits innovation</u>.

We noted that there are a great many ways to design a PRT system. Except for The Aerospace PRT system, all (over 40) of the 1970's-era PRT systems had been hurriedly designed, did not meet all requirements, and, finding no market, were eventually abandoned. In 1981, having given hundreds of presentations on PRT in many countries, having obtained from those presentations a great deal of feedback from both professional and lay people, having absorbed the work of the authors who presented papers at the PRT conferences, under no serious time pressure, and using my knowledge of Systems Engineering, I began to develop a new PRT system. In June 1982, the University's Patent Office gave me a grant of $100,000 to work full time with two graduate students on that project. From then on, the story is long and tortuous, but we persisted.

Through the years, I have again and again refined the design of the new system and have recently compiled my papers on all aspects of it in a 1500-page, three-volume book I call *Contributions to the Development of Personal Rapid Transit*. The first volume can be downloaded from www.advancedtransit.org/Library/Books. The situation now is that we offer an electrically operated system we call an Intelligent Transportation Network System (ITNS). An artist's rendering is shown to the right. It operates in all kinds of weather (except extreme winds) on an attractive guideway that is only 36 inches wide by 38 inches deep. A HUD Director for Sustainable Cities called it "an essential technology for a sustainable world," and a Chicago sculptor called it "moving sculpture both for what it is and what it does."

In contrast to light rail, ITNS can be built and operated for less than 10% of the cost per passenger-mile, uses less than 25% of the energy per passenger-mile, can carry four times as many passengers per hour, uses 3.5% of the surface land, and can attract roughly 10 times as many riders. Is ITNS too complex? It is simpler than the design and construction of a modern passenger airliner and uses only components well within the state of the art. It will work! The only questions are with exactly what cost and what reliability.

Our **next step** is to build a demonstration. We have an investor ready to provide $30M to build and operate ITNS <u>if</u> there is local support, and after the demonstration is successful he is ready to fund operating systems costing hundreds of millions of dollars in return for the revenue, i.e., as **<u>a fully private venture</u>** not requiring any public subsidy. We see ahead of us a market where there are dozens of applications in many countries. **WE WILL CONTRIBUTE TO THE REDUCTION OF CONGESTION WHILE BRINGING TO LIFE A NEW INDUSTRY.**

Autonomous Automobiles

We are very much aware of autonomous automobiles. The promoters of course never mention the downside. We see them as a compliment, not as substitute. <u>Will autonomous autos reduce congestion?</u> The stopping distance of a road vehicle depends on the slipperiness or roughness of the running surface and the smoothness or roughness of the tires. On dry days, the vehicle will have a certain stopping distance, which of course depends on the speed of the vehicle, the condition of the tires, and the properties of the roadway. On wet or snowy days, that stopping distance will be much longer, and will be longer still if the car is either travelling downhill or in a tail wind or both. How will the computer in an autonomous auto "know" the conditions of the running surface, the tires, the grade, and the local weather?

The autonomous car company must build into the computer carried in each car the safe stopping distance, and can do that only if the computer "knows" the condition of the tires, the properties of the running surface, the tailwind, the grade, and the weather conditions, all of which vary. The stopping distance and speed determine the safe time spacing or safe headway between vehicles, and we keep in mind that autonomous cars will mix with manually driven vehicles. Highway safety officials recommend a minimum headway of 3 seconds between vehicles at freeway speed, which of course is affected by the response time of a human being. If two autonomous cars were to maintain a three-second headway, invariably a manually driven car will slip in between them, forcing the rear autonomous car to slow down.

A way to provide the minimum safe headway to each vehicle could be to email from an office in a city to each car the safe headway as a function of speed and weather. Yet, there is no known way to keep a deliberate hacker out of a computer. Local effects would have to be considered negligible, and the system must be 100% hack proof. A better way might be to provide sensors on each vehicle able to detect all factors that determine stopping distance.

The car company will know that it is responsible for specifying the safe headway. Knowing that it will be sued if an accident occurs, what minimum headway will it chose? Company lawyers will of course argue for the longest minimum headway. Will "the system" allow each car company to select a minimum headway? It can't! This is something that must be done collectively, just like agreeing that for everyone **red** means stop and **green** means go. What will happen to that mandated minimum headway? It will of course increase!

Conclusion: Autonomous cars will not increase the throughput of freeways. It is more likely that they will decrease throughput. Congestion is likely to increase!

Because of these problems, in the design of ITNS I chose to not accelerate and brake through wheels. ITNS vehicles are suspended on wheels, but they are rollers only, not used for traction. Instead I chose **linear induction motors (LIMs)**, with which the above-mentioned problems do not occur − the available braking force is determined by electromagnetic interaction between the vehicle and the running surface. That braking force is totally controllable in all weather conditions, and by design of the LIMs sufficient. Thus, by using LIMs for propulsion and braking, the safe headway is much less than if braking depends on friction at the running surface, and thus the safe throughput is much greater. LIMs can be used only on a special running surface – a guideway, usually elevated to avoid congestion. The picture here shows the vertical chassis I designed and its builder, Robin Russell. A pair of LIMs built by Force Engineering, Ltd, lie in the lower left corner of the picture, not yet installed. ITNS is designed in such a way that no connection with the Internet is needed. We are hack proof!

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