History of the Advanced Transit Association (ATRA) Year by Year

by J. Edward Anderson, first ATRA President.

1994 – The Nineteenth Year.

At the ATRA Board of Directors Meeting on January 11, 1994, attended by 18 ATRA members and seven others, as the first order of business William Merritt, ATRA member, eulogized ATRA cofounder and first ATRA Chairman Michael A. Powells, Jr. He had passed away on December 23, 1993 at his home in Evanston, Illinois. Several ATRA members provided recollections of Mr. Powells contributions to ATRA, to his company, Barton-Aschman Associates, of which he was a recently retired senior vice president, and to the field of transportation over a lifetime. All agreed that Mike would be sorely missed.

Steve Gluck, Director of Transportation Systems for Raytheon Company's Equipment Division, provided a briefing on the progress of his company in its development efforts concerning the PRT 2000 transit mode. Raytheon is operating under a development contract from the Northeastern Illinois Regional Transportation Authority (RTA), awarded on October 1, 1993. The objective is to move forward the realization of a true personal rapid transit (PRT) for use in the United States and elsewhere.

Raytheon has committed $20 million of its own funds to the PRT development effort, for use in the areas of system definition and engineering; system software design and verification; vehicle chassis design; analysis and verification testing; command and control; and development and construction of the necessary test facilities and test-facility equipment. In its partnership with Raytheon, the RTA committed up to $18 million to fund the building and testing of an engineering model and a prototype PRT system. The program schedule called for the demonstration of the engineering model in 1995, with a demonstration of the prototype model following in 1996. The engineering model will be a 420-foot section of the guideway, with a branch section and one operational vehicle. The prototype system will be a closed-loop configuration, with three vehicles and one off-line station.

The Raytheon presentation led to a general discussion of both the process of developing specifications and the critical nature of the underlying assumptions that impact the establishment of specifications. This was underscored in the question and answers that developed from the presentation made the night before and at the ATRA luncheon by Dr. Andréasson of Sweden concerning PRT studies in Gothenburg and Gavle in Sweden.

From both ATRA-member letters received by the Secretary and views expressed at the Annual Meeting, a strong consensus developed that (1) ATRA should stay active; (2) no other transportation organization appears to be actively encouraging the development and deployment of very low-cost transit that could be deployed more widely in transit-starved, traffic-clogged medium/lower density areas; and (3) much more needs to be done to draw the attention of investors, public and private policymakers, urban and transportation planners, and the media to both

the feasibility and now advanced development of new, very low-cost transit modes that could be used to spread transit more widely to help meet urban transportation needs and provide cost and service advantages for use as internal circulators in large activity centers.

The discussion turned to new or continued ATRA activities. Drs. Newmann and Harman and others noted that more analytical work has been and is being done about PRT, transit and other new transit concepts, and that critical choices are being weighted in such matters as speed, headway, capacity, safety, physical accessibility to disabled persons, individualized versus car-sharing travel, nonstop vs. multi-stop trip policies, construction and operating/maintenance costs, etc. relative to systems under development or being considered.

Based on the interest in this subject, Chairman Goldmuntz asked Drs. Harman and Neumann to develop a statement describing the objectives and nature of a critical data/issues development center for advanced transit.

My work on PRT during 1994.

At least I was being paid well for my work. I now began thinking of my future. But, first, I was invited by the Swedish government, at their expense, to give a lecture on January 12th at the 11th Annual Conference on Transport Research in Linkoping, my father's childhood home. I decided to take Cindy along. We left Boston on Sunday evening, January 9th, for an overnight flight to Amsterdam, and from there to Stockholm. We visited friends and exhibits in Stockholm that Monday and Tuesday and on Wednesday morning took the train to Linköping where I gave my lecture that afternoon.

We took the train back to Stockholm, stayed overnight with my friend, Dr. Eie Herlitz, who was a Member of the Stockholm City Council and strong promoter of PRT. We then flew to Gothenburg were we stayed with my friend Dr. Ingmar Andréasson, who was the lead person on a series of studies of PRT that continued for almost 20 years. He invited me to give a 90-minute lecture the following Monday. Dick Tauber managed to come along on this leg of the trip, and the four of us are shown in this picture. Ingmar is on the right and Tauber next to him.

We flew back to Boston on January 18th. In addition to my work at Raytheon, I now spent much of my time finishing my Maglev Performance Simulator, now a real drag.

North Park College, where I spent my freshman year in Pre-Engineering, invited me to give a lecture on March 1. They gave me an award as "Distinguished Alumnus Lecturer Citation" for "Outstanding Contributions to Society as a Distinguished Lecturer and Scholar." While I mean no disrespect, I suspected that the award had something to do with their knowledge of the RTA PRT project, which had received a great deal of publicity in Chicago. It was reasonable that they would believe that I could make a large donation to the school, which may someday come.

On the way back to Boston from the North Park lecture, I stopped in Washington, D. C. to give a lecture to a colloquium at George Mason University. John Bright, a structural engineer who had been a member of the Technical Support Group for the RTA project was a member of the Society of American Military Engineers. He invited me to give a presentation at their "Technology Partnerships Conference" in San Diego on March 29-30, 1994. This year, because of a reduction in military expenditures, the entire conference was related to conversion from military to civilian projects. Military engineers must feed their families just like anyone else. The major value of the conference for me was to be able to attend a lecture by Major General James van Loben Sels, who had been assigned the task of managing the reconstruction of Los Angeles freeways because of an earthquake that had occurred on January 17th. The remarkable finding was that horizontal accelerations up to 1.7 times gravity were measured. I recalled that an earthquake engineering textbook that I had skimmed a few years before said that the maximum horizontal acceleration that had ever been measured in an earthquake was only 0.25 times gravity. Now for the design of structures in an earthquake zone, the maximum horizontal acceleration load on a structure would have to be taken as 6.8 times the former value.

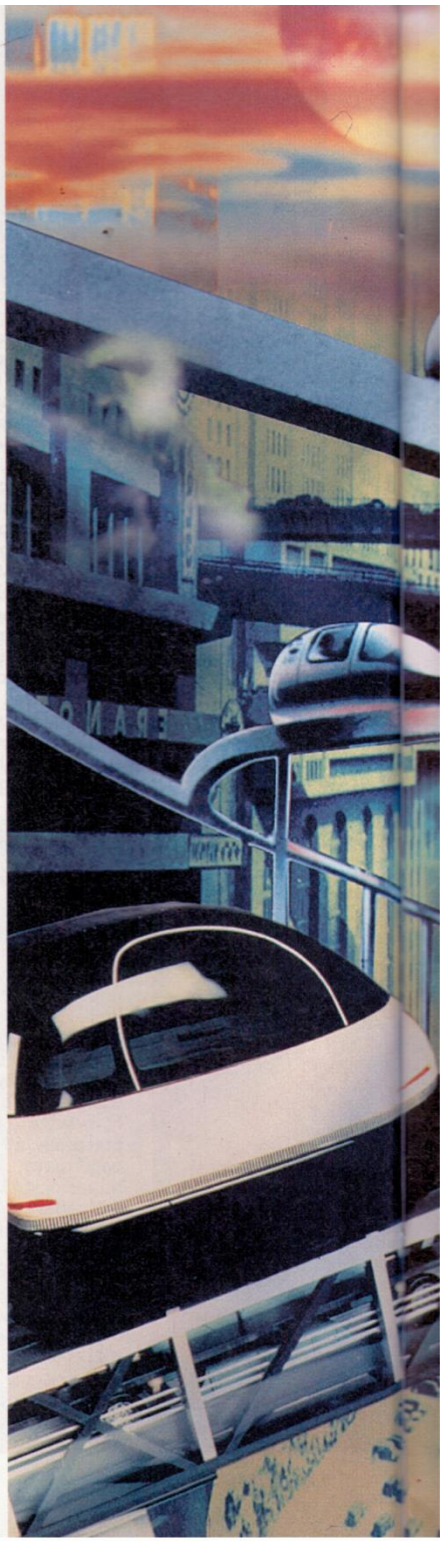
Back at Raytheon I was asked to modify my simulation program to include special vehicles for wheelchair occupants. This, unfortunately, took so much time that I had little left over to follow and comment on the other design work, much of which was leading to a guideway and a vehicle that were much too heavy. I argued repeatedly that they were designing themselves out of jobs, but my pleas fell on deaf ears. My simulation showed that it was possible to get the delay to wait for a wheelchair vehicle down to less than one minute, but the Raytheon engineer in charge of this problem thought it would be at least three minutes, so that is what he entered in his report. This made a big difference in how wheelchair riders would be handled.

In January 1994 I received a letter from the new Dean of the Institute of Technology at the University of Minnesota, Frank Kulacki, saying that he had been a graduate student Mechanical Engineering in the late 1960's and had heard about my work on PRT. He invited me to visit him if I should visit Minneapolis. This got me thinking a bit more about my future. Now that the rights to build my PRT system were in the hands of Raytheon and the RTA, there was little reason for us to stay in Boston. Cindy had been flying to the Twin Cities frequently to assist her mother, and the need to be there was increasing. So I wrote to Dick Goldstein, Head the Mechanical Engineering Department, about what role I could have on a year-by-year contract. He responded positively and in both April and May I visited them both for preliminary discussions.

The March 5, 1994 issue of *New Scientist* carried an article about our work, the first page of which is shown on the next page.

High hopes for faster transit

City planners are desperate to unclog congested roads by luring us out of our cars and on to public transport. Enter the "personal train" that could be running in Chicago by the year 2000



Steve Nadis

A PROFESSOR of mechanical engineering sits typing at a computer keyboard, conjuring up a scene on his monitor that looks something like the classic computer game PacMan. White dots stream in from the right of the screen, switch to red, and merge with green boxes, which swiftly change colour to yellow and then red, while moving through a bewildering maze. But this is not a video game. J. Edward Anderson of Boston University is testing an urban transit system that he believes could revolutionise public transport worldwide.

For the past quarter of a century, Anderson has been promoting his version of a personal rapid transit (PRT). Other versions came and went in the 1970s, from Europe, Japan and elsewhere in the US, but he was so convinced of the idea's potential that he stuck with it and, in 1983, founded the Taxi 2000 Corporation to "commercialise" the initiative. Although the University of Minnesota, Anderson's employer until 1986, holds the patents to the technology, he is licensed to develop it and to sub-license other developers.

Since last year, Taxi 2000 has been working closely with Raytheon, one of the US's top ten defence contractors, to design and build a PRT2000 system, as they call their joint development, for the Chicago suburb of Rosemont. Raytheon paid Taxi 2000 an undisclosed sum for its sub-licence, and guaranteed a royalty on any PRT systems that were built as a result. Now the pair is advising city authorities across the US and in Europe.

Anderson believes that his system benefits from the mistakes of earlier PRT developers. "They went to hardware too soon," he notes, though none got beyond the prototype stage. Anderson says he has also been helped by improvements in the technology of linear induction motors and computer control systems, two key elements of his design.

PRT2000 is "personal" in the sense that it relies on small rail cars (approximately 1·6 metres wide by 1·5 metres high by 2·75 metres long) designed to carry up to four people who, as with a taxi, choose to ride together. The system is "rapid", not because of the speed of travel (a modest 50 kilometres per hour, according to current plans), but rather because passengers proceed nonstop to their destinations. Anderson says he expects fares to lie "somewhere between a bus fare and a taxi fare; hopefully closer to a bus fare".

Testing time

Soon Anderson will see his idea move out of the ethereal realm of digital simulation and into the real world. Last October, Raytheon began building a 1-kilometre oval test track in the grounds of one of its engineering divisions in Marlborough, Massachusetts, and by September 1996 expects to have tried out three prototype PRT cars on the circuit. If this project is successful, the company plans to start building a 4-kilometre pilot system the following year

One occasion for a visit was an invitation to give a presentation at a forum of the Minnesota Governor's Advisory Council on Technology for People with Disabilities. The forum took place on May 25th and I found that there was considerable support for Taxi 2000 since it was designed from the ground up to have no barriers to People with Disabilities.

On June 17th Fran and Jerry Kieffer, then living in Fairfax, Virginia, flew up to Boston to visit us. We had a great weekend with them. A highlight was that we drove them up to what was now called America's Stonehenge near Salem, New Hampshire. In the picture shown here, Jerry stands next to part of the American Stonehenge.

I was asked to visit the Southern California Council of Governments, which occupied the rest of that week. Because I was getting extremely disgusted with the process Raytheon engineers were using to design their PRT system, Cindy and I were firm on our plan to return to the Twin Cities and I spent most of the week of August 8th there looking at potential homes.

Ang Fergione had decided that a choice between the 30-inch-pipe guideway and a truss guideway would be made sometime in late August. As I have mentioned, I had not been able to get involved in this fundamentally important trade-off issue. From what I knew at the time he was being pressured to go with a 30-inch pipe, a design that some of the engineers called "Low Boy," and others "Fat Boy."

On the 17th of August, Roy Moore, in a long phone conversation, commented that Tom Parker, the man the RTA had assigned to oversee the Raytheon PRT project, was "trying to ruin it." Parker had been one of the managers on the VAL people mover that operates at the O'Hare Airport. It is a large-vehicle system with a massively expensive guideway. Now he was hired as the RTA lead on the PRT project as soon as it started on October 1, 1993. One of the Raytheon engineers who had attended the first meeting with Parker told me that Parker said that he did not think that PRT would work but that he was in charge. A great way to start, indeed! In addition, he commented or rather bragged that he was one of the people who worked to design the Morgantown system in a way that would make PRT too expensive to find a market. Some years before I had heard second hand that a UMTA engineer had said "We are going to design the Morgantown system to kill the idea of PRT once and for all." Now I had direct confirmation. That was the environment in which we were working. Elected officials and company top brass can express marvelous ideas, but they must work through their engineers, and if those engineers want to kill something they will find a way. The only real way for a new idea to take root is to have the engineer who invented it see it through to production.

In my conversation with Roy that August, I have it recorded that Roy had learned of the way the guideway decision was leaning. He said that "Raytheon had not told anyone in Washington State about a different design." SeaTac was still considered to be the first application after

Phase III. On September 2nd, Jerry Kieffer told me that someone in Citizens for PRT wrote to the head of the RTA saying that if they go with the new design, it would be a big mistake.

Cindy and I flew up to Minneapolis on September 1, 1994 to spend the Labor Day weekend there. On Friday the 2nd we looked at houses. I don't have any records if it was on that trip or on another one on September 13-14 where we felt not wholly satisfied with any of the homes we visited. During the early 1970s Cindy, as a real estate agent, had inspected homes in the south Fridley and north Columbia Heights area called Innsbruck. Cindy liked that area so she asked our Edina Real Estate agent if there were any homes available in Innsbruck. He checked on his computer and said no. The very next morning he called us and said that one home had appeared on his screen – a home at 5164 Rainier Pass. We drove out there immediately, rang the doorbell, and the man who answered, after introductions, asked me "Didn't you work at Honeywell?" I said yes, and we found that we both had worked in the Fuel Gage Section, me in design and he in the test department. His name was John Exon and he and his wife Mary had lived there since the home had been constructed in 1960. We hit it off right away. The home had everything we wanted, the location was great, and the asking price was reasonable. The Exon's were anxious to retire to a home they had built in Tucson, Arizona. We agreed on terms and signed preliminary papers.

Back in Marlborough on September 8th Fergione announced the expected decision. Over the next weekend I wrote a 12-page memo to Fergione, Gluck and Gene Stockton, a vice president and senior manager in the Equipment Division who had managed a review of Taxi 2000 a couple of years before and had come away as a strong supporter. I include the first four pages of the memo on the next four pages. I left off the last six pages because they are too detailed. They discussed the weight and size of the vehicle, payload, safety, ADA requirements, pitch stability, vehicle length, door automation, the propulsion system, various failure modes and effects, emergency stopping, the guideway design, the chassis, and the switch. The main factors were 1) that the Raytheon engineers had let the vehicle weight increase to 3000 lb by then and later to close to 5000 lb (this for a four-passenger vehicle), 2) that the guideway had more than doubled in width and height and more than tripled in weight, and 3) that they had abandoned the linear induction motor for a standard rotary induction motor, which resulted in a problem I have mentioned, for which they had no solution. I commented on an outline of rules of engineering design that I had discussed in the two-week course I had given the previous fall to a group of about 25 Raytheon engineers including Fergione and Gluck, and I showed how basic design procedures that any good designer should have practiced were violated again and again. Later, taking onto account the sloppy Raytheon engineering, I wrote up these rules in a document I call "16 Rules of Engineering Design."

11 September 1994

MEMORANDUM

To: Ang Fergioni, Steve Gluck and Gene Stockton
From: J. Ed Anderson
Subject: Reexamination of the Taxi 2000 Design

Executive Summary

The "low boy" configuration will seriously foreshorten the market for PRT. The enthusiasm of many people including planners and decision makers who have been following the Raytheon program after listening to presentations and reading literature prepared by us and others will be lost.

Departure from the smaller, lower-cost Taxi 2000 configuration as described in our August 1990 proposal to the RTA and later in more detail in my document "The Design of the Taxi 2000 System" was a serious mistake and was not necessary on technical grounds. Exhaustive analysis of the Taxi 2000 design under our direction may result in some different recommendations for thicknesses and spacings, but need not result in changes in the configuration; however, recommendation of a new configuration is perhaps an inevitable result of turning a design in midstream over from one group of engineers to another.

If it could be possible to implement a separate program to commercialize the Taxi 2000 System, we could proceed immediately as follows:

1. Perform first a static, then a dynamic finite-element analysis of the guideway configuration under my direct supervision, in which I could direct the parameter variations that may be needed to optimize the design. The dynamic analysis would include vehicle dynamics. I would want to use mechanical engineers experienced in dynamic finite-element analysis and accustomed to R&D.

2. Contract with Prof. Richard Thorton to do the detailed design and fabrication of his new version of a LIM, which is yet to be disclosed to Raytheon.

3. Perform the bench tests recommended in our Phase I report to the RTA.

4. Using results of step 1, build a section of guideway through a curve and a switch complete with power rails and communication cables, and test up to a speed of 25 mph one engineering-model chassis with the proper weight simulating the cabin, the Thorton LIM, and the complete control system.

5. Using results of the previous steps, build a prototype test track designed for a 25-mph cruising speed and perform the tests we described in the Phase I report.

6. Our estimates show that this program can be accomplished in 18 months.

Reactions to the Design Decisions

Based on a series of subsystem decisions and lacking a comprehensive understanding of system implications, a PRT system design called "Low Boy" was recommended that has a 70-inch by 70-inch guideway with running surfaces at the top completely open to the environment and supporting 3000-lb four-passenger rotary-drive vehicles, each with the capability of holding a wheelchair facing forward. People who have followed the AGT field will be reminded of the evolution of the Alden Starr Car PRT system into the large-guideway system constructed at Morgantown, West Virginia, which has not sold anywhere else and set back the field of PRT two decades. **Low Boy will be seen a repeat of Morgantown.**

People who have been deeply involved in planning PRT systems know intimately the lack of enthusiasm for and lack of practicality of such large guideways. Environmentalists who have been attracted to PRT because of possible low energy consumption will be repelled once they realize that, because the new configuration uses traction through wheels with running surfaces directly open to the atmosphere, it requires that the running surfaces be maintained above freezing on the coldest days, thus requiring dumping of copious quantities of heat directly into the atmosphere through convection and radiation. We can no longer claim increased energy efficiency. When oil becomes scarce again, this will be a serious problem. The recommended design is not an advance but a regression.

The many people who have been watching enthusiastically the progress of the Raytheon PRT program will be sorely disappointed because the evolution away from the well-reasoned Taxi 2000 design is not well founded and need not have occurred. The fact that it did occur, however, was probably inevitable, not for technical reasons, but for psychological reasons. At the course I taught eleven months ago, I included in the course notes a sheet I entitled "Design Philosophy." I changed the title to "Some Rules of Engineering Design" and attach them. I developed these rules through many years of design and development practice and teaching of engineering design. I believe that if they had been followed rigorously, the Taxi 2000 design would not have been abandoned.

Please read the first paragraph of the enclosed letter on RTA stationary. The August 1990 Taxi 2000 proposal had been accepted by the RTA staff as the single outstanding proposal of 12 submitted. They and consultants only debated which proposal would be the second they would recommend be funded. Several months later the RTA staff wanted, via the above letter, to throw out all of the prior work, start over, and design a PRT system from scratch in one year with a project manager who had never in his career been involved in development and design and with a team that had zero experience in design of transit systems. A year later I had an opportunity to ask Marc Hillier, who is copied on the letter, what was behind that first paragraph. He said that he had worked for an engineering company in which a engineer had invented a new device. The inventor turned out to be more hurtful than helpful and had to be removed from the project. So Marc assumed that

all inventors were the same and that I had to be removed right away. There was no interview, no examination of facts or attitudes. He was prosecutor, judge and jury all rolled into one. This is an example of a psychological problem in engineering. If I had had an opportunity to explain to him my "Rules of Engineering Design," perhaps he would have seen the difference and perhaps some dumb, but recoverable, decisions could have been avoided in Phase I. Two years later he commented before the RTA Board than an advantage of the Raytheon proposal was that Raytheon had on its team an engineer with two decades of experience in PRT.

In my presentation to you over two months ago, I began with the above story and with another side of the psychological problem of engineering: I related the experience of Honeywell Aeronautical Division management that every design initiated in Aero Research in Minneapolis and turned over to their design and production group in Clearwater, Florida, was unrecognizable by the time it came through production if it ever did. The management established a policy that any device transferred from Aero Research to Clearwater had to be accompanied by the engineer who had started the project. Not only did they not want the inventor removed, they insisted that he stay and lead the project through production. This also is recognition of a bit of *psychology of engineering*. The problem was not technical. The fundamental urge of any good engineer, proud of his experience and trained in school to do his own work, to make his mark in a new design assignment in the only way he thinks he can–by changing the design–is overpowering. At the first sign of a problem, there is a strong temptation to change everything.

Your problem was more severe. Your division has been accustomed to dealing with a sophisticated customer, the DOD. In the present situation the customer has only superficial experience in PRT and assigned for Phase II technical support a man who announced at the beginning that PRT won't work. Can you imagine the DOD doing that? To do PRT, one must in the gut want to make it work. What was needed to meet the stated goals in the short time allotted was an inclusive atmosphere in which Raytheon, Taxi 2000 and the RTA would work together, listen to each other, take advantage of the work already done, and endeavor to develop together the best possible PRT system. Instead the process was exclusive and adversarial, an environment in which the chance of a profitable result in development of a new system in a field new to the engineers involved in a short time was remote indeed.

On June 5, 1993, the RTA staff urged the RTA Board to select Raytheon over Intamin, stressing that Raytheon had working with them an engineer with two decades of experience in PRT. Yet, Raytheon negotiated a contract with Taxi 2000 Corporation in which the experienced engineer could work only two or at most three days a week. The experienced engineer was not asked if he preferred this arrangement. Indeed he had thought that he would have to be totally immersed in the project and even thought of moving to Marlborough. Not being able to be around all the time, the experienced engineer was not able to become completely engaged, which handicapped him when on rare occasion he was invited to meetings. Moreover, Raytheon engineers felt that they had to conduct all negotiations with the RTA by themselves to show the RTA that they were on top of the prob-

lems. Lacking the necessary experience, i.e., the ability to explain the consequences of certain decisions, compromises in the design specifications were made that caused the design to unravel.

In this memorandum, I review a series of design decisions that lead to the unraveling of the Taxi 2000 design. I have seen nothing in the processes of the past eleven months that has caused me to believe that the original Taxi 2000 configuration, the one described in our proposal to the RTA of August 1990 and later in the document "The Design of the Taxi 2000 System," would, with detailed analysis and some parameter variation such as changing the thickness or spacing of some members, not have been substantially superior to Low Boy. If I had the opportunity now, just as in 1989, I would be ready to move straightforwardly into the detailed design and production of the test system in less time and for lower cost than possible under present circumstances. The reason is simply that my colleagues, who included Raytheon engineers, and I had over a period of many years learned to understand the complex design criteria needed to make PRT work, we had time to do the analysis needed to make all of the important tradeoffs, and we worked out a detailed development plan. For a long time, we have been ready and eager to go!

I met with Fergione and Gluck on Monday morning, September 12th and I must quote here verbatim my notes from that meeting: Fergione said "We decided that Ira Smith and George Matisse could provide all input needed from Taxi 2000 and that you (JEA) wanted to do other things anyway." This is the pivotal statement. I was covertly lied to. This explains why I was not invited to meetings. I was treated as excess baggage, to just be asked to work enough to support the office with no real involvement. I was strung along. Last spring, I could have opted to go back to Boston University full time. By not squaring with me, my university career is destroyed. The past year has been a sham. Fergione came into the project after all negotiations were finished. Steve must have directed all prior negotiations. Where would he have gotten the idea that I only wanted to work part time?"

The above paragraph is so embarrassing that I debated including it. But leaving it out would leave out an essential fact. Ira Smith had always told me that he was not good at basic engineering, but concentrated on tasks like developing task lists and program plans. George had worked with me as a student for about three years, mostly on planning projects with Chuck Harris. There was no way these two had the experience to stand up to a new engineering team. The irony was that I had been paid an adequate full-time wage anyway. On September 14th Steve told me that he did not remember Ange's comment – said he was focused on technical issues. (This is

alway a convenient excuse.) How was I to respond? I am quite sure that most engineers would have flown into a rage, maybe started a fist fight. Likely I was saved from this reaction because I had been meditating every day. Apparently Gene Stockton, who was senior to both Gluck and Fergione in the Equipment Division hierarchy, must have leaned hard on them, because they suddenly wanted my full-time involvement – they wanted me to do in a few weeks what their engineers had not accomplished in six months.

I went at it full bore. On Monday, September 19th I handed them a four-page memo I had written over the weekend entitled "System Analysis Tasks," which outlined work on the vehicle design, station design, weight budget, and guideway analysis. In my last sentence I said "This work will surely consume my time for several years, but right now I think it is the only way to achieve a PRT system that will find the large market that you have anticipated." On September 26th I handed them a 26-page memo entitiled "The Guideway." The issues were the natural frequency of the guideway and vehicle suspension. My design used clamped beams, an idea that I took from public documents on The Aerospace Corporation PRT work. Simply-supported beams were more conventional so, with no consultation, the structural engineer assumed them, which lowered the natural frequency by more than a factor of two. Moreover, a pipe guideway weighs almost four times as much per foot as a truss guideway and the natural frequency is inversely proportional to the square root of the guideway weight per foot, so going to the pipe guideway reduced the natural frequency by an additonal factor of two. On suspension, I showed them that with small and easily obtainable changes, secondary suspension was not needed. These two simple actions would reduce the size of the guideway to a commonly acceptable range and make the vehicle lighter and cheaper. On September 29 I sent them a revised memo with the same title "The Guideway," in which I added further evidence to my conclusions. On October 6th I handed them a 10-page memo entitled "Ride Comfort Over Constrained Running Surface." The last paragraph of this memo says: "The compelling conclusion of this memorandum, supported by the Reference Memo, is that, on the grounds of dynamic motion, the U-shaped guideway configuration need not have been replaced by the pipe guideway, which has a cross section larger by more than a factor of two and will have more severe winter-weather problems. The bottom line of course is the difference in the market attracted. My experience with this problem of visual impact and ease of engineering a PRT system into a community is the main factor that caused me to design the Taxi 2000 sysem. With no hope of guideway size and cost reduction, I would have remained with Cabintaxi."

An important factor is that Stone & Webster, a long established enginering firm, had no trouble in the Phase I study with my truss guidway. Some time during this exchange Gluck told me, as I have mentioned, that the Chief Engineer of Raytheon Engineers and Constructors had insisted on the pipe guideway, and that if he and Fergione overruled him, he would go directly to the Senior Vice President that he reported to and get the decision reversed. Sometime later, one of my engineering friends told me that one of the Raytheon engineers had told him that the reason for the pipe guideway was that it could be manufactured by a division Raytheon owned in Idaho that made this kind of pipe for the oil and gas industry.

During the Phase I Stone & Webster project it was determined that the first system would cost $13.4 million per mile. The Raytheon estimate was now about $43 million per mile. That did not trouble a group of military engineers – they were accustomed to outrageous costs when the

motive was fear that the enemy would surpass us. The idea that for PRT to be practical, the guideway had to be as inexpensive as possible, and that meant that the vehicle weight had to be as small as practical had not sunk in. They apparently thought the RTA would buy anything.

Sometime during this period, Taxi 2000 board member Shep Arkin told me that in an airport waiting room he had run into a retired Raytheon Senior Vice President who had been Chief Engineer for the whole company. Shef told the story I describe above and the Senior VP responded that in his opinion the Equipment Division was not capable of a project of this type. They certainly proved it! On October 24 my colleague Ray MacDonald called me and said: "Got latest brochure from Raytheon. Thinks it is awful. Vehicle looks clumsy, amateurist."

On Saturday, October 22nd, I gave a paper at the National Electric Transit Symposium, held at Saint John's University in St. Cloud, Minnesota. This was a Minnesota event, sponsored by 28 Minnesota businesses and governmental organizations. It was devoted to objective understanding of transit alternatives and urged public officials "to develop an evaluation framework that accurately compares transit technologies, no matter how difficult that comparison and process may be . . ." The kickoff presentation was given by Denis Hayes, Co-founder of Earth Day, and he set the tone that true sustainability required fundamental thinking about the problems of people movement. But the agenda was clearly biased towards reintroducing the streetcar, a technology that had been effective a century ago when the competition was a horse cart on a mud road. Introducing a new idea like PRT was extremely difficult because it was weighed against intrenched bureaucracies, and lets face it: the burning desire of some outspoken people to bring the streetcar back, as if it represented some kind of idyllic society.

On Friday, October 28th Cindy and I were back in the Twin Cities to attend the closing of the deal for our new home. Now the papers were signed, we shook hands with John and Mary Exon and we could establish and announce a moving date. After consulting with North American Van Lines, we selected Wednesday, November 16, 1994.

I had been invited to give a lecture on PRT control to the Boston Section of the IEEE (Institute of Electrical and Electronic Enginneers) Control Systems Society, which met this time at the offices of the Volpe National Transportation Systems Center in Cambridge. My appointment calander shows that I spent at least 20 hours preparing this lecture. After this lecture, my main activity was to meet for lunch on successive days with my closest friends. On the evening of November 10th, Taxi 2000 Corporation, Raytheon and Stone & Webster held a going away party for Cindy and me.

After watching the van pack up our goods and leave 474 Revere Beach Boulevard, we drove off in our two cars at about 4 pm on November 16th. Cindy drove behind me on our way west, now heading into a new phase of our lives! We arrived at 5164 Rainier Pass at 10 a.m. Sunday morning, November 20th, just ahead of the first snow fall of the year and having beaten the van by exactly one day.

Most of my time during the next few weeks was of course taken up with getting settled, but I also found time to renew old acquaintances at a series of lunch meetings. I was asked to fly

back to Boston for a two-day consultation with Raytheon on December 14-15 and returned to Boston for a design review on December 19-21.

At the design review at Raytheon, I made a short speech stating that the heavy vehicle and large guideway would markedly reduce the market for the Raytheon PRT system they called PRT 2000. In the notes of the meeting taken by various engineers, two of them commented that "Ed Anderson may be right;" however, nothing was done to change anything. None of those engineers had any experience laying out PRT systems in cities or in talking to politicians, planners and interested citizens, which is the only real way to understand all the requirements for a viable PRT system.