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16. Abstract

This is a compilation of material that was presented at the Third UMTA R&D Priorities Conference Workshops on AGT and Advanced Systems. Part I deals with AGT socio-eonomic research and AGT applications and includes discussions of the AGT socio-economic research program, the Morgantown and Airtrans people movers, and the downtown people mover (DPM) program. Part II, AGT and advanced systems and technologies, contains discussions of the AGT R&D program, the advanced group rapid transit (AGRT) program, and the automated guideway transit technology (AGTT) program. This volume contains seven resource papers which can be found summarized in Volume I of this report along with summaries of other workshop sessions. Volume I also includes the proceedings of the general sessions and a listing of conference participants.

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PREFACE

This report contains proceedings of workshop sessions of the Third Urban Mass Transportation Administration R&D Priorities Conference which was held at the U. S. Department of Transportation's Transportation Systems Center in Cambridge, Massachusetts, November 16 and 17, 1978. This volume contains the following:

AGT and Advanced Systems Workshops

Part I : AGT Socio-Economic Research and AGT Applications
Part II: AGT and Advanced Systems and Technologies

These conferences are sponsored periodically by UMTA to enable them to communicate directly with those who represent the views of transit users, operators of public transportation systems, suppliers of equipment and services, the research community, and governments at the State, local, and Federal levels. The purpose of the Third Conference was to provide a current review of UMTA's research and development plans and to solicit recommendations for improving the direction and effectiveness of its program. The conference included general sessions on research and development policy and a total of fifteen half-day workshops on research, development, and demonstrations in urban transportation systems, technologies, planning, management, and services.

The volume containing proceedings of the general sessions and summarized reports of the workshops has been published by the Urban Mass Transportation Administration. However, because of the volume of papers, presentations, and discussions, detailed proceedings of the workshops have been compiled into separate reports by subject area. All of these documents are available from:

National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

When ordering copies of these reports from NTIS, please refer to the list of reports numbers and titles which follows.

1. Third UMTA R&D Priorities Conference, November 1978, Volume I: Proceedings of General Sessions and Summarized Reports of Workshops, DC-06-0157-79-1.

2. Third UMTA R&D Priorities Conference, November 1978, Volume II: Proceedings of Bus and Paratransit Technology Workshops, DC-06-0157-79-2.

   Part I : Paratransit Integration
   Part II: Bus Technology, Paratransit Vehicle Development, Flywheel Energy Storage System

3. Third UMTA R&D Priorities Conference, November 1978, Volume III: Proceedings of AGT and Advanced Systems Workshops, DC-06-0157-79-3.

   Part I : AGT Socio-Economic Research and AGT Applications
   Part II: AGT and Advanced Systems and Technologies

4. Third UMTA R&D Priorities Conference, November 1978, Volume IV: Proceedings of Service and Methods Demonstrations Workshops, DC-06-0157-79-4.

   Part I : Pricing Policy Innovations
   Part II: Conventional Transit and Paratransit Service Innovations

5. Third UMTA R&D Priorities Conference, November 1978, Volume V: Proceedings of UMTA Special Technology Programs Workshops, DC-06-0157-79-5.

   Part I : Safety, Qualification, and Life-Cycle Costing
   Part II: Consumer Inquiry Technology, National Cooperative Transit R&D Program, and Technology Sharing

6. Third UMTA R&D Priorities Conference, November 1978, Volume VI: Proceedings of Rail and Construction Technology Workshops, DC-06-0157-79-6.

   Part I : Railcars and Equipment
   Part II: Construction Technologies

7. Third UMTA R&D Priorities Conference, November 1978, Volume VII: Proceedings of Transit Management Workshops, DC-06-0157-79-7.

   Part I : Management Systems Developments
   Part II: Human Resources Development

8. Third UMTA R&D Priorities Conference, November 1978, **Volume VIII:** Proceedings of the Access for Elderly and Handicapped **Persons Workshops**, DC-06-0157-79-8.

   Part I : Planning and Regulation
   Part II: Demonstrations and Hardware

9. Third UMTA R&D Priorities Conference, November **1978, Volume IX:** Proceedings of the Urban Transportation Planning **Workshop, DC-06**-0157-79-9.

AGT AND ADVANCED SYSTEMS I

Chairperson: *Robert M. Coultas,* Executive Director - Technical Services, American Public Transit Association

AGT SOCIO-ECONOMIC RESEARCH: *Howard D. Eboy,* Office of Socio-Economic and Special Projects, UMTA

AGT APPLICATIONS: DOWNTOWN PEOPLE MOVER, MORGANTOWN PEOPLE MOVER, AND AIRTRANS: *Steven A. Barsony,* Director, Office of AGT Applications, UMTA; *John Marino* and *Vincent R. DeMarco,* Office of AGT Applications, UMTA

Panel: *Julie Hoover,* Assistant Vice President and Manager of Planning Division, Parsons, Brinckerhoff, Quade & Douglas

J. Douglas Kelm, Secretarial Representative - Region V (Chicago), U. S. DOT

Robert Maxwell, Transportation Group Manager, U. S. Congress Office of Technology Assessment

Frederick W. Walker Jr., General Manager, Transportation Systems Division, General Motors Corporation

Michael A. Powills Jr., Barton-Aschman Associates, Inc. and Chairman, Advanced Transit Association

Reporter: *Arthur Priver,* Automated Systems Branch, Transportation Systems Center

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AGT AND ADVANCED SYSTEMS I

AUTOMATED GUIDEWAY TRANSIT (AGT) SOCIO-ECONOMIC RESEARCH PROGRAM

HOWARD D. EVOY
OFFICE OF SOCIOECONOMIC AND SPECIAL PROJECTS, UMTA

ABSTRACT

The Automated Guideway Transit (AGT) Socio-Economic Research Program is a comprehensive, multidisciplinary public transportation research program sponsored by the Urban Mass Transportation Administration (UMTA). It is designed to assess the performance and cost experiences of existing AGT systems, to evaluate the merits and liabilities of AGT systems as compared to conventional forms of public transportation, to determine the potential market for AGT technology in urban areas, and to assess the social acceptability of this transit technology. Information obtained through this program is intended to aid local government desicionmakers; members of the professional planning, operating and engineering community; and others interested in considering AGT as a candidate transportation mode.

INTRODUCTION

Development of computer and automation technology, particularly in the last decade, has led to formulation of new public transportation concepts. These concepts offer some potential for overcoming major deficiencies of existing urban public transportation modes: degraded service and high operating costs. These new concepts, which are classified as automated guideway transit (AGT) systems, employ automated vehicles on exclusive roads or guideways.

Local government officials, planners, and transit operators have shown an interest in AGT systems as a potential solution for many mobility problems in urban areas. Their interest has been sparked by hardware research and development activities sponsored by the Urban Mass Transportation Administration (UMTA) and successful use of this technology in special activity centers--airports, university complexes, shopping centers and amusement parks.

Recognizing that knowledge of the possible urban impacts of AGT systems is necessary to achieve a full understanding of the potential value of AGT systems as an urban transportation mode, UMTA has supplemented its hardware research and development activities with a research program addressing socio-economic, environmental, institutional, and performance characteristics of AGT systems. This paper describes this ongoing UMTA program: the AGT Socio-Economic Research (SER) Program, which was designed to examine the appropriateness of AGT technology as a means of urban public transportation.

SUMMARY

The AGT SER Program is designed to address the social, economic, institutional, performance, and land use factors associated with AGT technology. This program will address the potential role and social acceptability of this transit technology in U.S. cities. The AGT SER Program has been organized into five major program activities. For a brief summary, Assessment and Costs activities will collect and evaluate information on existing AGT systems; the Generic Alternatives Analyses activity will perform comparative trade-off analyses of AGT and other urban transportation modes; the Markets activity will apply the findings of the generic analyses to specific U.S. urban sites; and the Communications activity will disseminate the findings of the various activities.

Results available from the program to date suggest AGT systems installed in urban locations have the potential for generating environmental improvements, encouraging desirable urban development and land use imapcts, minimizing petroleum consumption, and reducing transit O&M costs. However, local officials indicate the major impediments to urban AGT systems are based on the uncertainty of achieving these benefits. In attempting to resolve these uncertainties, UMTA will continue to focus its efforts on an array of hardware research and development programs, demonstration projects, and socio-economic research.

Ongoing and planned research of the AGT SER Program will provide additional evidence in support of the anticipated benefits of AGT systems installed in urban locations. Results of many researchprojects will be available in early 1979 and will be used to update the preliminary findings presented here. These research activities include:

- Feasibility Studies: The performance, economic, and impact characteristics of AGT systems in hypothetical and site-specific case studies will be determined.
- Market Research: Attitude surveys will be conducted to probe the perceptions of the general public regarding AGT service and impacts relative to conventional alternatives. An examination of the potential market for AGT technology will be undertaken.
- Costs: The influence of different stages of technology development and deployment on AGT system capital costs will be investigated.
- Energy: The energy consumption of existing AGT systems will be assessed; a preliminary analysis of the energy impacts of AGT-related land use changes will be made.
- Aesthetics: Aesthetic issues and design options relevant to urban AGT system installations will be analyzed.
- Policy: Federal policy options regarding future funding of AGT system research and development will be identified.

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STEVEN A. BARSONY
DIRECTOR, OFFICE OF AGT APPLICATIONS
URBAN MASS TRANSPORTATION ADMINISTRATION

As you well know, we are charged with the responsibility to insure that only existing, proven systems are deployed.

It appears that it is the much more complex problem than we originally thought, that even though we have the first opportunity to use R&D funds and Capital Grant funds mixed together, it's still a much more complex issue because we are confronted with institutional problems.

We announced the selection in the DPM Program of four cities in December 1976. We are near December 1978, two years later, and we are just slightly ahead. Los Angeles and St. Paul are completing their preliminary engineering, which is a long way from deploying operational DPM Systems.

There were people at that time that looked at the time line and said, "Hey, this is too optimistic, that's too short of a time, we can't function in that rapid progression."

We found that actually the federal government is more able to move and come up with decisions than the local government, and the local authorities. And the local authorities have their own bureaucracy to live with and they have to go through their own step-by-step functions and approval routes; and it appears that at this time we are not the villain. We are the ones who are pushing the local authorities to move faster.

Of course, this is wishful thinking. We all want to see these things deployed as early as possible but there are certain

restrictions and constraints that we have to live with, and therefore it is very hard for us who want to see these things to be actually deployed to wait and go through the normal process. We thought that we could shortcut the system somewhat by eliminating the alternative analysis requirement. We thought that we reduced the time required by postponing the EIS until the completion or concurrent completion with the preliminary engineering, but basically we really didn't gain too much.

We maybe gained in appearance, but we still have to go through the same slow process, and I think that maybe somebody will have to someday say we can't live this way, it costs us too much, and we don't get to the post office in time.

JOHN MARINO
OFFICE OF AGT APPLICATIONS
URBAN MASS TRANSPORTATION ADMINISTRATION

Today, I'm going to talk about two people movers, the Morgantown People Mover and the Airtrans People Mover, since the Office of AGT Applications has grants involving both of those systems.

I thought I'd start by giving you a quick summary of Phase I in Morgantown.

Phase I resulted in the building of three stations and 5.4 miles of single-lane guideway, with a fleet of 45 vehicles and a maintenance facility.

Formal acceptance of the system was in September of 1975. Revenue operation commenced the following month. Through July 3rd or 4th of this year, when the system was shut down to allow integration with the Phase II construction, the people mover carried 4½ million passengers and logged 1.7 million fleet miles without any operational-related injuries or accidents.

The system availability has been excellent to date. It's exceeded the specification requirements. I'd like you to note the year-to-year improvement and the maturity of the system over time as the operational personnel learned how to use the system and the system itself matured.

A brief summary of how the Phase II project is organized is as follows. UMTA has a capital grant with the West Virginia Board of Regents, the firm of Daniel, Mann, Johnson & Mendenhall is the staff support to the West Virginia Board of Regents. The

brick and mortar work is done by Trumbell of the A. B. Dick Corporation, and of course, the Boeing Company supplies all the vehicles, the command and control equipment, the power rail, etc. and the complete installation and check out and test of that equipment. F. R. Harris provides construction monitoring, inspection and design support.

The construction is basically completed except for some final punch list items.

A $63.6 million capital grant was awarded to WVBOR to expand the system in October 1976. The expansion includes 2½ stations; 15,400 feet of additional single-lane guideway; a new, expanded mini-maintenance facility; a new heated power rail (which will be throughout the new system), and also new fare collection equipment. In addition, the complete 45-vehicle fleet is being refurbished, and we've added 28 new vehicles to the system.

Now what I'd like to do is briefly identify some of the planned major Phase II improvements in the system. Probably the most significant improvement is in the power rail and collector area. A new rail was developed to allow heating the rail and to provide large phase-to-phase air gaps for electrical isolation.

The new collector was developed to be compatible with the rail and to allow longer brush life. The new collector system is now mounted on the unsprung mass of the Morgantown vehicle.

As you may have observed over the past couple of winters, the winter environment in Morgantown has been very stringent and some of these technical improvements will greatly enhance the people mover's operation.

The second major improvement in Phase II is in the steering system. The cold weather experience has shown that improved reliability is obtained by eliminating all the hydraulic components in most of the active elements in the steering system.

The new all-mechanical system is now powered by a single spring and it gives greater steering performance, meets lower maintenance requirements and has longer component life than the Phase I system.

The third major improvement is the hydraulic system. It uses a single, heavy-duty rated variable volume pump, and has fewer components for greater reliability. Quick disconnects gives easy servicability and most system components are now grouped in a very easily accessible compartment on the side of the vehicle. The fourth major area of improvement is the pneumatic system. This new system now also has improved components for greater reliability and has a larger storage tank available to insure overload protection. The pneumatic system has internal protection against freezing of the valves and controls.

A fifth improvement is in the braking system. Although there have been no major problems with the braking system, either in the service or the emergency modes in Morgantown, we have made improvements to the brake controls to limit the emergency deceleration to .45 G's.

And, finally, another system improvement is the fare collection system. New Duncan equipment is now used which accepts cash fares directly and eliminates the troublesome card transport system with the associated jamming problems that we had with

that gear in Phase I. A new card reader will now be in use. This Duncan equipment replaces the Phase I Cubic Corporation fare collection equipment.

That's all I'm going to say today about the Morgantown Phase II System.

Now I'll talk about the Airtrans Urban Technical Program. The Program was authorized by Congress in 1976. It's a $7 million program, divided into two phases -- the first phase was $2 million and lasted a year, and we're now halfway through the second phase of the program. Phase II is a $5 million phase.

The Airtrans Assessment Report, which was sponsored by UMTA and performed by TSC, identified back in 1975 that further technical development was necessary to make Airtrans suitable for urban deployment.

A number of specific areas were called out in that report for further development. The general objective of the Airtrans Urban Technical Program is to design and test specific improvements to the Airtrans vehicles and its associated support equipment in order to maximize the system's adaptability for urban deployment.

There's a picture of the utility vehicle which was retrofitted into the test vehicle which we're using in the program. The vehicle is being loaded on a truck prior to shipment to the Vought plant.

Next is a picture of the same vehicle being fabricated with an aluminum shell, and there's a photo of the test vehicle on the guideway during some of the tests. This picture shows the

fully-instrumented test vehicle which is capable of recording 50 channels of data onboard the vehicle. I might add that the grant we have on this project is with the Dallas/Fort Worth Regional Airport Board, and, of course, the prime contractor is the Vought Corporation.

Phase I Tasks basically address four major areas: the propulsion system, the collector system, the steering system and the command and control system.

There's a picture of the two motors, each 100 hp, which are replacing the single 60 hp motor to allow Airtrans to meet the most stringent anticipated DPM velocity and acceleration requirements.

Phase I has resulted in the propulsion-traction sub-system having vastly increased speed capability. Airtrans only does 17 miles an hour at the airport and anticipated DPM city requirements are for 30 mile an hour capability.

The improved collector design provides the necessary signal and power transmission efficiencies.

In the program we also looked at three different improved steering concepts for Airtrans; the improved mechanical, power assisted, and contactless steering. The improved mechanical system was selected. It uses less components and reduces the steering forces into the walls. The new steering system allows higher-speed operation with an associated increase in steering system reliability and maintainability, without compromising ride comfort. On the existing Airtrans vehicle there are two guide wheels on each of the four corners of the vehicle for

steering. Now, we have replaced those four assemblies with a single larger diameter wheel on each corner.

The Phase II Tasks include the construction of a new urban prototype vehicle, conducting further improvements to the onboard vehicle control and electronics unit, the developing and installing of improved communications, including new onboard video capability which the Motorola Corporation is participating in, and the development of a new passenger-audio announcement unit and some onboard graphics. There is also a sizeable severe weather test program included in the program.

There is a breadboard setup of the Vehicle Control Electronics (VCE) Unit in the Plant Laboratory. A new cassette recorder will be located on board the vehicle which announces passenger destinations and arrivals.

VINCENT R. DEMARCO
OFFICE OF AGT APPLICATIONS
URBAN MASS TRANSPORTATION ADMINISTRATION

There are a number of issues we've had to face in structuring and managing the DPM Program. It was clear to us that the only way we would be able to manage this program was to set our goals into specific objectives and establish a program plan which we could use to implement these objectives.

We also had to establish our measurement system which would be used to determine whether the program was a successful one in terms of the various objectives we had established.

These objectives included the following:

We need to demonstrate the operations and maintenance savings that could be obtained through automated, unmanned vehicle operations and unattended stations. We need to assess the economic impact caused by the deployment of a DPM, such as to what degree does the deployment of a DPM improve the economic functioning of existing activity centers.

We need to test the performance of DPM's as feeder-distributors for existing or new regional transit systems. Further, we need to demonstrate that DPM's are sufficiently reliable, maintainable and safe, to be considered as viable, urban transit alternatives.

Lastly, we needed to establish that the general public will accept completely automated and unmanned vehicle operations and that modern guideways can be effectively integrated into our downtown super structures.

In all, after this is done, we need to document the many lessons learned in these demonstration projects to permit other cities to emulate their successes and hopefully avoid failures.

We determined, early on in the program, that we'd have to manage these projects as "Control" Capital Grant Projects, specifically because of the many special management needs that result from the first deployments of such automated systems.

There is a need for UMTA to be formally involved in the technical review, monitoring and qualification process of these new, automated systems.

Because of the many disciplines involved in managing these demonstration projects, UMTA has established an internal Memorandum-Of-Understanding that assigns specific roles and responsibilities to the different offices within UMTA Headquarters and the Regional Field Offices.

It assigns the primary management responsibility for the programs to the Office of AGT Applications, under Steve Barsony, which is within UMTA's Office of Technical Development and Deployment under George Pastor.

To insure that there would be uniformity in the management and performance of these multiple DPM Projects, we issued a set of DPM Program Implementation Guidelines to the Grantees, to set forth what UMTA expects each DPM Grantee to accomplish in this Demonstration Program and to clearly state what the roles of UMTA, the Grantee and the Turnkey Systems Supplier will be in the implementation of these projects.

Of particular concern to us in the implementation of these

projects, is the need to establish and conduct an adequate technological qualification program for each of the selected system designs.

As Mr. Kiley described this morning, you can see how important it is to get this prototype testing done early and off-site. Doing it in the field is not the place to do it.

This is an area of immense concern to us and specific guidelines were developed to insure joint UMTA/grantee involvement in the determination of the requirements for product improvements and in-house compliance testing, which are to be included in the Grantee's contract with the turnkey systems supplier.

We will insist that only proven technologies be deployed and that sufficient in-house testing be accomplished at the supplier's facilities prior to any on-site installation and integration.

Our Office of Socio-Economic Research and Special Projects has been conducting a series of assessments, as you've heard just a moment ago.

These published Assessment Reports provide a useful data base to understand the economics and operability of existing people mover designs. They also provide us with the data that we can use in determining the degree of product improvement required for the various system designs.

At present, a total of 19 people mover systems are in operation and three are under construction.

In addition to these, a number of other systems are under development in Japan and in Europe.

We have determined that there is a need for a special

Procurement Policy for the DPM Program. Under this policy the first site may select any available technology; the second, all but that selected for the first; and the third, all of those selected for the first and second; the fourth and subsequent sites may select any available technology including those selected for the first three.

This policy was determined to be necessary to insure that as a result of these demonstration projects, at least three different system designs would be available to permit adequate and effective competition in future deployments of automated people mover systems.

Further, as a matter of policy, we will insist that the Grantee's procurement package for its systems supplier include evaluation criteria, which places heavy emphasis on experience in manufacturing and installing an operational people mover system.

During the past two years, and it's taken that long to get to this point, UMTA has conducted a number of formal program briefings as well as workshops and conferences to provide opportunities for the grantees, their consultants, and the system suppliers to become better acquainted with the status of the various DPM Projects and other ongoing UMTA AGT R&D Projects. These meetings, we feel, provide an effective means for an informal exchange of information amongst the various DPM participants.

Before I conclude, let me give you a brief status report on our DPM Projects. As you know, we have divided our projects

into two tiers, those which have been approved for preliminary engineering and environmental impact review under our Capital Grant Program, and those which have been approved for technical feasibility studies under our Technical Studies Grant Program.

For the first tier cities, Los Angeles and St. Paul have nearly completed their preliminary engineering efforts, and are expected to complete the environmental impact review process by the end of this fiscal year, that is by September 30, 1979.

We hope that we will be in a position to award Capital Grants for the construction phase for these projects during the last quarter of this fiscal year.

The remaining first tier cities - Houston, Detroit and Miami - are just beginning their preliminary engineering efforts and are about one year behind Los Angeles and St. Paul.

For the second tier cities, Jacksonville is about in the middle of their study and we expect that they will complete their study in about June of next year, while the others - Indiannapolis, Baltimore, Norfolk and St. Louis - are expected to complete their studies about a year later.

Briefly, here are some slides on Los Angeles and St. Paul. As you can see, the cost per single-lane mile for Los Angeles is $21 million, excluding the cost for the bus and auto-intercept facilities.

The new route in Los Angeles, for those who are not familiar with it, looks like this: it has thirteen stations and goes from Convention Center in the south to Union Station in the north.

Union Station is an intermodal facility that connects with the San Bernadino Freeway, and the rail starter line and is planned to have 2,500 auto and van pool spaces.

And, finally, in St. Paul, as you can see, the cost per single-lane mile is $15 million. The new route in St. Paul is basically the same as their original proposal. In both cases, we've progressed from the original proposals to now defined projects with defined capital and O&M costs. The next step is, hopefully, the successful completion of the environmental review process.

Let me conclude by indicating that it is my hope that my short talk, which I tried to keep under nine minutes, will stimulate some active discussion because that is what we're here for -- to learn just as much as we can about how we can improve this program.

JULIE HOOVER
PARSONS, BRINCKERHOFF, QUADE & DOUGLAS, INC.

My comments will relate to the AGT Socio-Economic Research and the Downtown People Mover Programs. Both areas are certainly worthy of investigation and both programs as presented today have many admirable features. From my own perspective as an urban planner who spends much of her time working in transportation, I found a number of research projects that I think will be useful. Also, I think the efforts to communicate the research results and to solicit the opinions of others have been outstanding, and whoever is responsible for this deserves a great deal of recognition and credit.

I do have a few problems regarding the overall program, however, mainly due to a lack of emphasis on issues I feel are important. Two of my major difficulties are in the areas of the relationship between the DPMs and American downtowns, and in public involvement. I will briefly review these problems in the hopes that future research efforts can address them, or that perhaps existing programs might be reoriented.

I will begin by raising a few conceptual issues about the Downtown People Mover Program. One of the most widespread assumptions about the program is that investments in a DPM system will serve as a catalyst for urban revitalization, reinforcing current public and private renewal efforts or inducing new development. Indeed, "revitalization of the CBD" has emerged as one of the main selling points of the DPM advocates.

Is this a valid notion? Hopefully yes, but at this point we have little beside wishful thinking to back it up. In fact, there is even some disturbing -- although not conclusive -- evidence to the contrary. Six years ago a study of new transit feasibility was made in a densely populated corridor connecting the downtowns of Newark and adjacent Irvington, New Jersey. AGT was one of the prime alternatives under consideration and in an effort to test its potential for stimulating redevelopment in the corridor, numerous private developers in the area were canvassed. Not one indicated that improved transit -- AGT or any other kind -- would affect their business decisions. Perhaps Newark does not represent the typical situation, but we must take seriously the recent

BART Impact studies and the very fine DeLeuw Cather report sponsored by USDOT called "Land Use Impacts of Rapid Transit: Implications of Recent Experience." Published in August of 1977, a major conclusion of this study was that "recent experience provided no evidence that any rapid transit improvements have led to new urban economic or population growth" and thus, "Federal policy might reasonably support the use of major transit improvements as one element of a coordinated package of efforts to revitalize a declining urban economy and social order, but should not rely upon transit investment as a sole or primary tool for such purposes."

Thus it would seem there is a real and immediate need for research concerning AGT/land use development relationships if the DPMs and other AGT systems are to realize their potential as a catalyst for development.

I think there is some room for optimism. During the last 2-4 years there seems to be emerging among developers in some places a new perception that there are opportunities for successful downtown projects. Underlying this redirection of interest away from the suburbs and toward the central cities are some key demographic trends, including the movement of certain population segments back to the cities. There also appears to be greater interest in downtowns on the part of representatives of business, government, and the entertainment industry. In order to take full advantage of these trends, however, the DPM people must do their planning within a comprehensive development framework. Additionally the prospects of success will be greatly enhanced by the initiation of other related downtown revitalization efforts. I spoke previously about a "coordinated package of revitalization efforts." What should be in these packages besides AGT? Examples of the types of actions that should be investigated include land use planning and zoning innovations, financial policies such as tax incentives for joint development and value capture programs, institutional improvements, new legislation, and measures to facilitate intergovernmental coordination. Another key area of inquiry should be the entire real estate development process. What are the attitudes and objectives of the private-sector real estate interests, particularly with respect to AGT? How are decisions made within the real estate market, and how might these decisions be influenced by the public sector?

My second area of concern is public involvement. I don't need to tell you how important public support will be in gaining the approvals necessary for implementation of AGT projects. Further, experience in a number of areas has shown that citizen participation in transportation can lead to better planning, better decisions in the long run. Why then, does a $3.3 million federally funded

AGT Socio-Economic Research Program have nothing of real substance in this area? Yes, I noticed the $65,000 "gaming" item, in the AGT Research Program, but even if one believes in the effectiveness of such gimmicks, and I remain very much unconvinced, it is obvious that games alone are not going to help your people out in the field deal with the really important community problems they are faced with. Key questions that remain unanswered include:

- Should public involvement for AGT be conducted any differently than for other transportation planning?
- When should public involvement be initiated?
- Should an effort be made to reach the general public, or should you just concentrate on directly affected groups?
- In what aspects of the planning process can the community make the most meaningful contributions? Is AGT too technical for effective citizen input?
- What activities should be part of the public involvement program?
- How much money should be allocated to it?
- Who should be responsible for carrying it out?
- What responsibility does UMTA have in making sure there is good public involvement?
- And, finally, should the public involvement process be highly structured and if so, how? Many of the DPM cities seem to be forming citizens committees. Is this a good approach to use? If so, how should the members be selected? I think the most outstanding example by far that we have a successful citizen participation structure in a related transportation planning situation is the one Dade County in Florida is using for their new rapid transit system. Would this model work for DPMs on other AGT installations? Someone should find out.

I could probably think of a dozen more critical questions that will remain unanswered after the current AGT Socio-Economic Research Program is completed.

AGT AND ADVANCED SYSTEMS II

Chairperson: *Robert M. Coultas,* Executive Director - Technical Services, American Public Transit Association

AGT AND ADVANCED SYSTEMS AND TECHNOLOGIES: *Charles Broxmeyer,* Director, Office of New Systems and Automation, UMTA; *Duncan MacKinnon,* Chief, Advanced Development Program, UMTA; and *Aldo DeSimone,* Chief, Systems Development Program, UMTA.

Panel: *Julie Hoover,* Assistant Vice President and Manager of Planning Division, Parsons, Brinckerhoff, Quade & Douglas

J. Douglas Kelm, Secretarial Representative - Region V (Chicago), U. S. DOT

Robert L. Maxwell, Transportation Group Manager, U. S. Congress Office of Technology Assessment

Frederick W. Walker Jr., General Manager, Transportation Systems Division, General Motors Corporation

Michael A. Powills, Jr., Barton-Aschman Associates, Inc., and Chairman, Advanced Transit Association

Reporter: *Arthur Priver,* Automated Systems Branch, Transportation Systems Center

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AGT AND ADVANCED SYSTEMS II

CHARLES BROXMEYER
DIRECTOR OF NEW SYSTEMS AND AUTOMATION
URBAN MASS TRANSPORTATION ADMINISTRATION

The government's effort in AGT research and development is now focused in two programs. Details from both of these programs will be presented to you in a few minutes, by persons in charge.

The first program, the Advanced Group Rapid Transit Program, had its origins in system concepts that were in existence prior to either Transpo or the Morgantown System projects, and that were embodied in both of these projects.

The origins of the Boeing concept can be seen in the Alden System, which was developed in the sixties. This development provided the starting point for the Boeing-developed Morgantown System.

And while the current AGRT design has little resemblance to either Alden or Morgantown, except for its rubber-tired suspension, it did indeed develop by stages from the Morgantown design.

The Otis system concept dates from the same period in the sixties, and the propulsion and suspension concepts have changed little. Thus, the two AGRT contenders have a venerable history that spans development of AGT technology in the United States.

While no aspect of system design has been slighted by AGRT, the emphasis has been on control and the achievement of higher performance.

Where foreign systems such as Aramis and CVS have aimed at extremely close headway operations, the American systems have tended to be more conservative, and in the AGRT Program, I think

it is well-known that we have stayed within the brick-wall stopping criterion. Our headways, in this case, will reach three seconds at a speed of about 18 miles an hour.

There are several reasons why we stayed with what some considered an overly conservative approach and which others felt was too radical a departure from the state-of-the-art.

Headway is, of course, intimately related to the kind of service that is likely to be afforded. I will be more precise about that in a moment. It is also related to the span of system likely to be built, measured in miles of guideway, and it can be shown that up to a point, shorter headways tend to reduce the amount of guideway needed to supply a given level of service.

Figure 1 is a possible downtown network with eight stations. It's fed from the four corners of the city. Since people ride into town in the morning and go home at night, double-guideway feeders are needed.

Double guideway downtown provides shortest time access to the eight stations. Note, however, the four three-way interchanges at the corners of the downtown route.

Figure 2 shows another possible downtown network. Again, with double-guideway feeders. This time we have a completely planar guideway, all guideway being single lane. The system is much less obtrusive than the first one I showed you.

The intersections at the corners are vastly simpler and would use far less space than the first guideway. Thus, this guideway would be much easier to get installed in the city.

If the headways are the same, however, this guideway can

accommodate about half as many vehicles per unit time as the first guideway I showed you. The first guideway, for example, has two paths going from east to west. This guideway has only one. Therefore its capacity is about half that of the first.

If, however, we cut the headways in half, say from six seconds to three seconds, then the capacity of the second guideway becomes about the same as the capacity of the first guideway, and while some of the paths are slightly more circuitous, system performance has been traded for guideway structure.

Figures 3 and 4 are schematics of the corner interchanges, and you can see that there is quite a difference. Now these are only schematics, but I think they will help you visualize the amount of structure that would be involved.

Leaving the question of the amount of structure, let's consider the question of performance and its relations to headway. The passenger will not care about headway, even if he knows what it is. What he cares about is the following:

How far is the nearest station? How long will I have to wait in the station for a vehicle? How many stops will I have to make on route? How many transfers? And, how long will it take me to reach my destination?

Yet, all these questions are intimately related to headway, as is the cost of the service and the amount of guideway necessary to provide the service. Let's consider how these questions are related to headway.

For the single-lane network shown, there is a definite relationship between the lane capacity of the downtown network

and the capacity of the feeders. The feeders will not be limited by control mechanization as the downtown guideway is, but by traffic saturation and inability to move vehicles into the congested downtown network.

For example, all vehicles from the southwest feeder have to pass the station at the southwest corner. All the vehicles from the northwest feeder likewise pass this station. However, about 25 per cent of the vehicles from northeast and 25 per cent of the vehicles -- and I'm assuming uniform distribution of passengers -- from the southeast, also pass the southwest station. Thus, in a given period of time, about 2½ times the number of vehicles pass the southwest station and the southwest corners as can be admitted from the southwest feeder. The minimum headway on the southwest feeder therefore is not three seconds, but 7½ seconds.

Now, suppose each vehicle follows a fixed, closed route from suburbs to downtown and back and suppose a given route has four stations on it, two in the suburbs and two downtown. If we can imagine such a route, the passenger will experience, at most, two stops. He'll experience two stops, one stop or zero intermediate stops. And the average number of intermediate stops is one.

In order to provide access from any suburban station to any downtown station, a sufficient number of routes have to be set up. However, the number of routes is limited by the capacity of the feeder and the passengers' waiting time in the station.

Figure 5 shows some computations affecting the capacity of

the system.

The maximum wait time is five minutes. If that's true, then we have to have vehicles circulating on that route at the rate of 12 per hour. We just get that by dividing 60 minutes by 5.

If we have one vehicle through the feeder every seven and a half seconds, then we have 480 vehicles per hour. However, 480 vehicles per hour, divided by the 12 vehicles per hour in each route, is 40 routes. So, the feeder can accommodate 40 routes.

Suppose the number of suburban stations in one quadrant of the city is 20, or 10 pairs of stations, and the number of downtown stations is eight, as in that second viewgraph, or four pairs of stations, and suppose that a route connects each suburban pair with each downtown pair. In order to set up such a route structure, we have to have the total number of routes equal to the ten suburban pair times the four downtown pair.

Each pair of suburban stations then is connected with a pair of downtown stations, and that gives 40 routes. However this exactly matches the capacity of the feeder as we just calculated it.

The service is summarized in Figure 6. You have a maximum wait time of five minutes, an average wait time of two and a half minutes and the average number of intermediate stops is one.

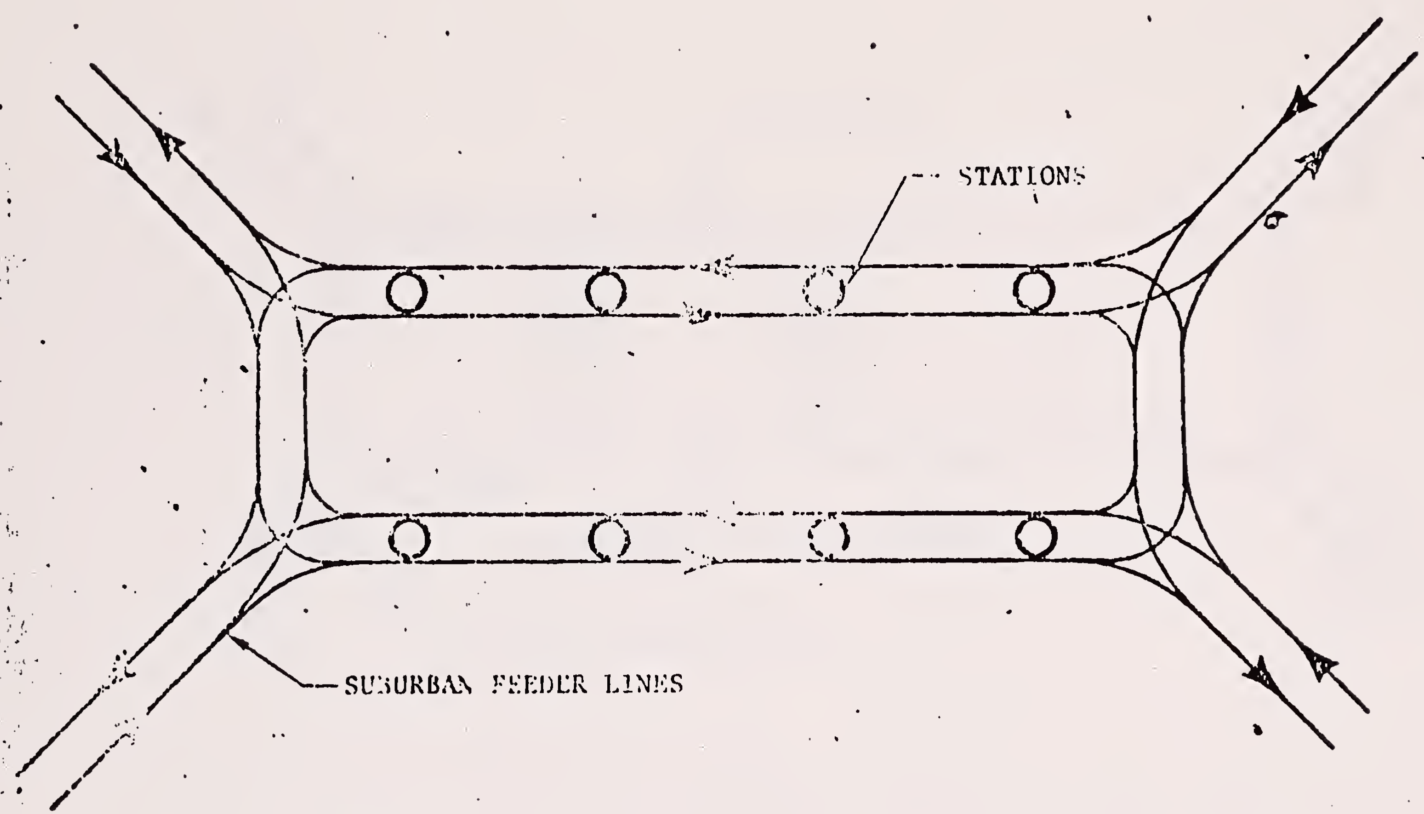
If we have a phased development where, say, one of the four quadrants is built first, then the headway on that feeder is still three seconds, and the service on that quadrant is improved.

Figure 7 is a listing of the number of stations. As you can

see, as the number of stations grows the number of intermediate stops grow, but they grow at a much slower rate. If we build all quadrants, the number of intermediate stops is still not excessive as can be seen in Figure 8.

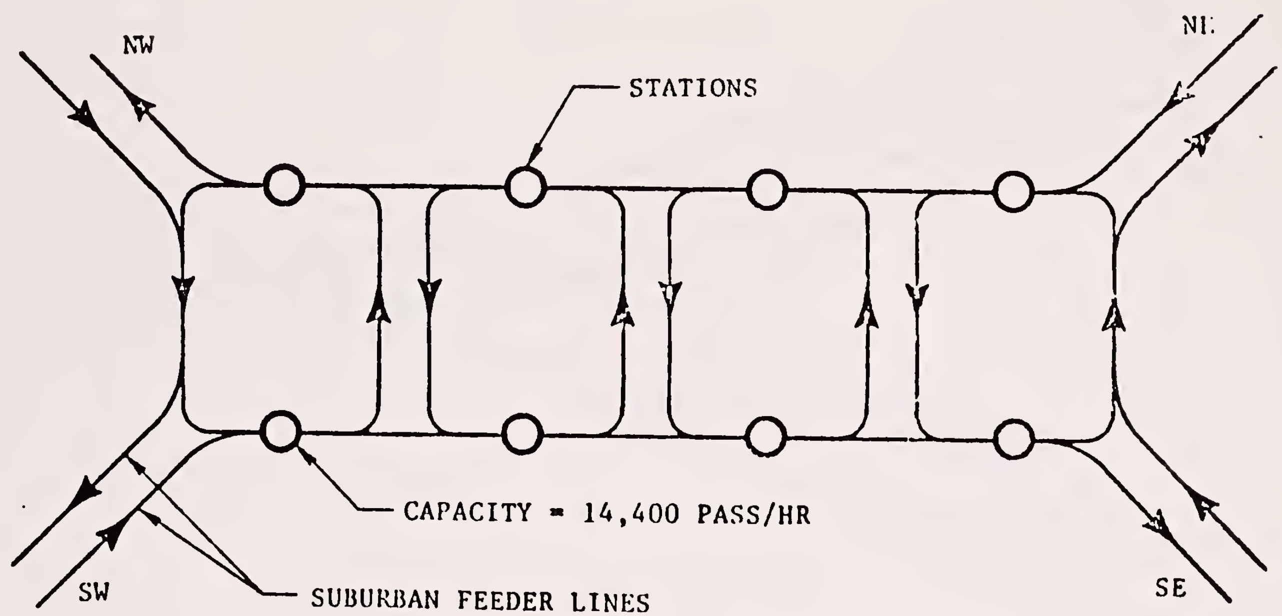
The meaning of these figures is that a three-second headway provides the potential for a vast improvement in the level of service provided by the conventional modes, or the automobile itself, for that matter.

FIGURE 1



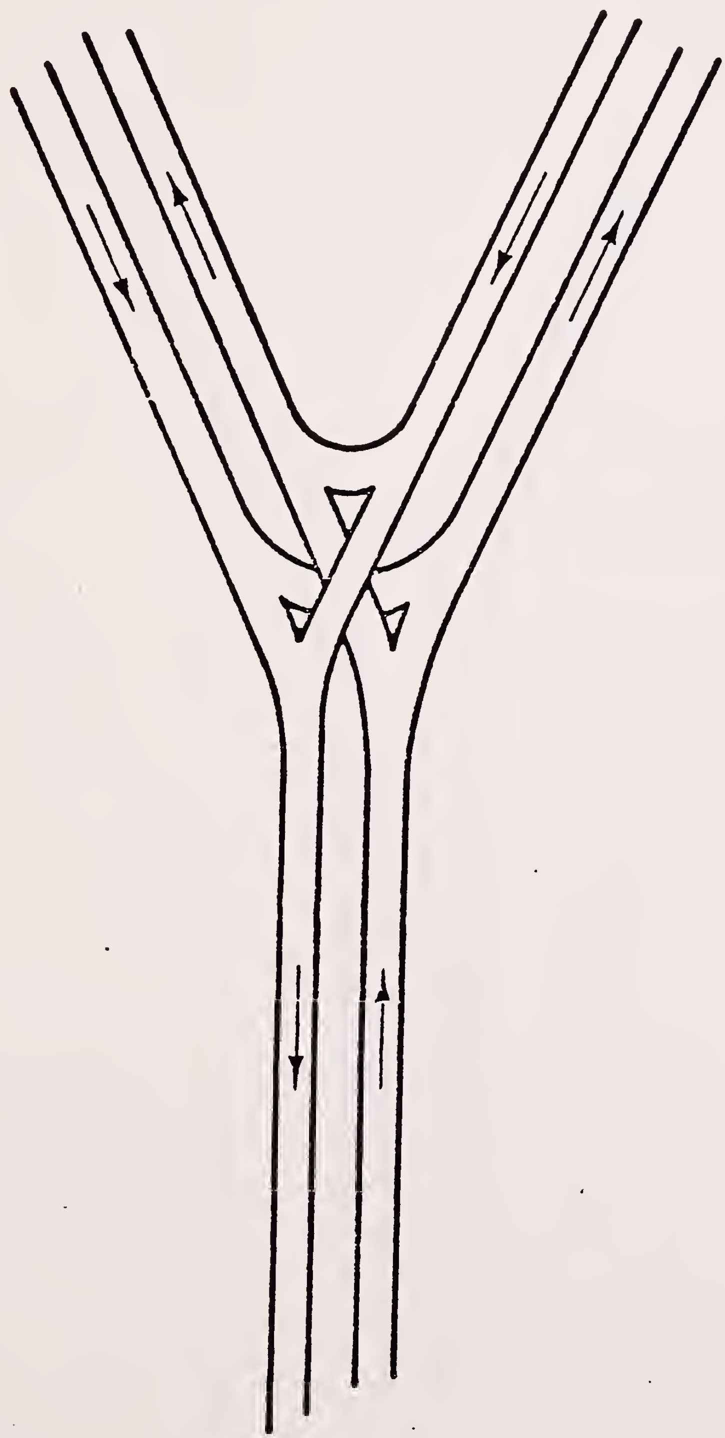
DOUBLE GUIDEWAY DOWNTOWN DISTRIBUTION NETWORK
WITH MULTILEVEL INTERSECTIONS

FIGURE 2



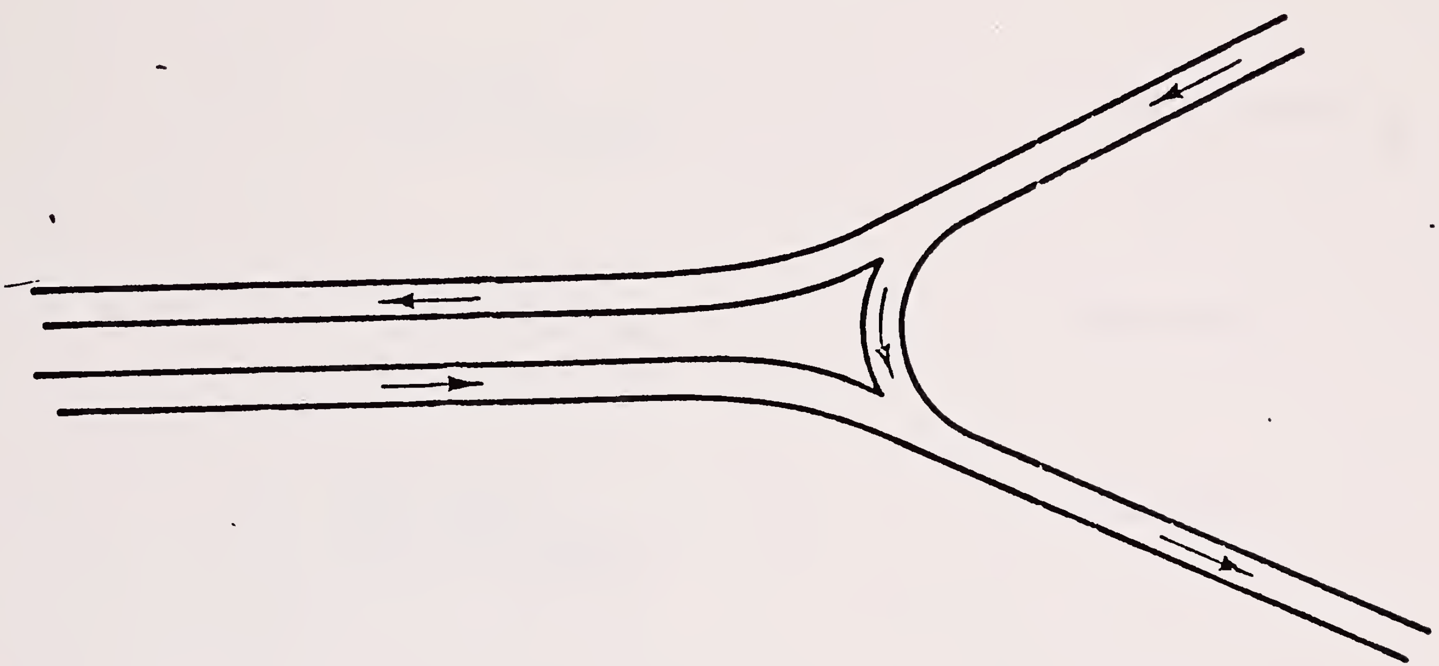
TYPICAL EIGHT-STATION AGRT DOWNTOWN CIRCULATOR

FIGURE 3



MULTILEVEL INTERSECTION DOUBLE GUIDEWAY INTERSECTING DOUBLE LOOP

FIGURE 4



PLANAR INTERSECTION DOUBLE GUIDEWAY INTERSECTING SINGLE LOOP

FIGURE 5

$$\frac{60 \text{ MIN/HR}}{5 \text{MIN WAIT/ROUTE}} = 12 \text{ VEH/HR/ROUTE}$$

$$\frac{3600 \text{ SEC/HR}}{7.5 \text{ SEC HEADWAY}} = 480 \text{ VEH/HR}$$

$$\frac{480 \text{ VEH/HR}}{12 \text{ VEH/HR/ROUTE}} = 40 \text{ ROUTES}$$

10 SUBURBAN PAIR X 4 DOWNTOWN PAIR = 40 ROUTES

FIGURE 6

MAX. WAIT TIME	5 MIN.
AV. WAIT TIME	2.5 MIN.
MAX. INTERMEDIATE STOPS	2
AV. INTERMEDIATE STOPS	1

FIGURE 7

SERVICE ANALYSIS

ONE QUADRANT SERVICE

AV. WAITING TIME = 2 MIN

SUBURBAN STATIONS/QUADRANT	DOWNTOWN STATIONS	AV. INTERMEDIATE STATION STOPS
10	8	0
20	8	1/2
30	8	1
40	8	1 1/2
10	16	1 1/2
20	16	2
30	16	2 1/2
40	16	3

FIGURE 8

SERVICE ANALYSIS

FOUR QUANDRANT SERVICE

AVERAGE WAITING TIME = 2.5MIN.

SUBURBAN STATION/QUADRANT	DOWNTOWN STATIONS	AVERAGE INTERMEDIATE STATION STOPS
10	8	1/2
20	3	1
30	8	1 1/2
40	8	2
10	16	1 1/2
20	16	2
30	16	2 1/2
40	16	3

ALDO DE SIMONE
CHIEF, SYSTEMS DEVELOPMENT PROGRAM, UMTA

My name is Aldo De Simone from UMTA, and I am going to brief you on the AGRT Program. Of course there is history to the program, but today I will focus on what is being done presently.

From the very beginning, (viewgraph #1) the philosophically approach was to take existing technology and extend it, develop systems from the technology and test their test track embodiments.

It was recognized that these systems had to be built from expandable building blocks. The approach taken in the development was to design a test track which would be a basic building block that could be replicated as many times as needed, central vehicle management would then tie the blocks together. The goals to be achieved from the beginning included performance, safety, cost and dependability. It was not sufficient to provide a high level of service, it had to be done at reasonable cost, the service had to be safe and dependable.

The designer must realize that these quantities are coupled and the design process must incorporate provisions to examine the effect of the coupling and allow meaningful design choices to be made.

Many of the system characteristics that deal with urban applications could not be verified of the test track. One simply could not take a system and install it in a city to determine its characteristics. Simulations were used to analyze this very important area.

The general characteristics (viewgraph #2) in summary include capacity of 14,000 seats per lane per hour, vehicles are capable of going at 40 miles per hour and climbing a 6% grade. The system is capable of normal scheduled and demand modes. Degraded modes allow service to be maintained in the event of system failures.

The program has evolved (viewgraph #3) in three phases. During Phase I, three contractors produced preliminary designs. The funding was modest, on the order of one half million dollars each (viewgraph #4). In addition, each contractor designed a test track system for installation at Pueblo, Colorado. Simulations also were specified for system verification and critical subsystems were identified by each contractor.

Work was continued by the three contractors during Phase II-A (viewgraph #5). The funding level was approximately $2 million each and the duration was 18 months.

During this time, each contractor — Boeing, Otis and Rohr — conducted design and test of critical technologies, and simulated the behavior of their system design on a simple network. Other studies conducted during Phase II-A included guideway-vehicle cross-section minimization and trained system operation. Phases I and II-A are now complete.

The implementation phase, Phase II-B, is now commencing (viewgraphs #6, #7, #8). During this phase, engineering prototype systems will be developed in test track configurations to functionally validate system performance. Two technologies -- air cushion by Otis, rubber tired by Boeing — will be developed into functional operating test tracks. The two competing contractors will design, build and test their systems. In addition, Boeing will be funded to develop the critical aspects of the Romag technology.

Two prototype systems are being developed to retain competition and, thus, maximum yield from the Government funding. Upon completion of the testing of the prototype systems, each contractor will upgrade the engineering prototypes and obtain meaningful reliability data.

The capabilities of the test tracks to be constructed at the contractor's facilities will include

(viewgraph #9) the ability to check out the important functional characteristics, such as vehicle merging and diverging, line speed operation and grade climbing. The schedule for Phase II-B (viewgraph #10) includes 48 months for engineering prototype development and an additional 20 months for upgrading for a total program duration of 68 months.

Two systems will be developed. Boeing will develop (viewgraph #11) a rubber-tired, bottom-supported vehicle riding in a U-shaped guideway. It is the logical extension of the Morgantown technology. Otis Elevator will develop (viewgraph #12) an air-cushion, bottom-supported vehicle riding in a U-shaped guideway. This technology is an extension of the Transpo-72 and Duke systems developed by Otis. The urban guideways (viewgraphs #13, #14) will be 8-foot wide, and both will have common cross-sections. The artist sketches of the two vehicles (viewgraphs #15, #16) are shown in typical urban settings. The engineering prototype test tracks (viewgraphs #17, #18) are similar. Circular sections allow sustained high speed to be maintained by the vehicles, and high speed merges and diverges can be verified on both test tracks.

A valuable output of the guideway cross-section studies conducted during Phase II-A resulted in the

establishment of a common cross-section for both guideways. The basic guideway (viewgraph #19) can be erected from the same basic structural members, and fitted for use by either Otis vehicle (viewgraph #20) or the Boeing vehicle (viewgraph #21). It is possible to strip a deployed guideway fitted for one technology and change it to the other.

ADVANCED GRT — MAJOR PROGRAM ELEMENTS

- Utilize Strong Existing Technology Base
- Extend the Technology
- Implement in Test Track Configurations
- Design Systems for Expandibility
- Test Systems to Verify:
  - Performance
  - Safety
  - Dependability
  - Cost
- Determine Service Characteristics by Simulations

GENERAL CHARACTERISTICS

- System Capacity
  - At least 14,000 Seats per Lane per Hour
- Vehicle Capacity
  - 12 Seated Passengers or Less (No Standees)
- Vehicle Climb Capability
  - 6% Incline at 40 mph with 30 mph Constant Headwind
- Operating Modes
  - Scheduled Mode
  - Demand-Activated Mode
  - Degraded Mode

PROGRAM STRUCTURE

- PHASE I — 3 CONTRACTS
  - — DESIGN, DEFINITION, SPECIFICATION
- PHASE IIA — 3 CONTRACTS
  - — ENGINEERING ANALYSIS, SUBSYSTEM DESIGN AND TEST, SIMULATION
- PHASE IIB — 2 CONTRACTS
  - 1) DEVELOPMENT OF ENGINEERING PROTOTYPE AT CONTRACTOR'S PLANT, SUBSEQUENT UPGRADING OF INSTALLATION TO TEST FOR RELIABILITY.
  - — LIMITED DEVELOPMENT OF ROMAG TECHNOLOGY
  - — TRAINED SYSTEM DESIGNS

PHASE I ACTIVITIES

- Urban System Preliminary Design
- Pueblo Test Track System Preliminary Design
- Network Simulation Specifications
- Preliminary Design of Vehicles, Guideway, Command and Control
- Identification of Critical Development Items

PHASE IIA WORK ACTIVITIES

- Central Management Simulation
- Detailed Local Control System Simulation at Sensor-Output Level
- Critical Technology Item Development and Test System Integration Studies (Performance, Cost, Safety)
- Availability and Reliability Studies
- Training Studies
- Guideway Cross-Section Minimization Studies
- Commonality Studies

PROGRAM STRUCTURE

- Two Competing Contractors
  - Boeing Aerospace Company
  - Otis Elevator
- Three Technologies
  - Rubber Tire (Boeing)
  - Romag (Boeing)
  - Air Levitated (Otis)
- Three-Phase (Originally Two-Phase) Program

PHASE IIB GOALS

- Engineering Prototype System
  - Validate Functional Operation of Control System
  - Determine and Correct Deficiences
- Upgraded Engineering Prototype System
  - Collect Test Data on System Reliability
  - Determine Architectural and Aesthetic Impact
  - Collect Performance Data
- Romag Development
  - Limited Component Development of Vehicle and Guideway Using Romag Technology

PHASE IIB ACTIVITIES

- Develop Two Technologies to Retain Competition
- Design and Install Engineering Prototype at Contractors' Plant
- Upgrade Engineering Prototype and Test for Reliability
- Design Trained Version of the Systems
- Develop Romag Technology

TEST TRACK CAPABILITY

- 6% Positive and Negative Grades
- Merging and Diverging
- Line Speed Operation
- At Grade and Elevated Guideway
- Typically Sized Curved Sections
- Two Stations

AGRT MILESTONES

ENGINEERING PROTOTYPE SYSTEM (EPS)	0 Mo
1) COMMENCE DESIGN	16 Mo
2) FREEZE SYSTEM SPECIFICATION	21 Mo
3) FREEZE EPS DESIGN	33 Mo
4) COMPLETE TRACK, EQUIPMENT FABRICATION	38 Mo
5) COMPLETE INTEGRATION	48 Mo
6) COMPLETE TEST	
POST-EPS	
1) COMMENCE POST-EPS DESIGN	36 Mo
2) FREEZE DESIGN	48 Mo
3) COMPLETE SYSTEM UPGRADING	55 Mo
4) COMPLETE TEST	68 Mo

BOEING TECHNICAL APPROACH

- Rubber-Tired, Bottom-Supported Vehicle
- Improved Morgantown Design
  - Command and Control Modification
  - New Steering System
  - Two Power Collectors on Each Side
  - Retention Arm in Diverge Areas
  - Improved Guideway Cross Section (8-Ft. Width)

OTIS TECHNICAL APPROACH

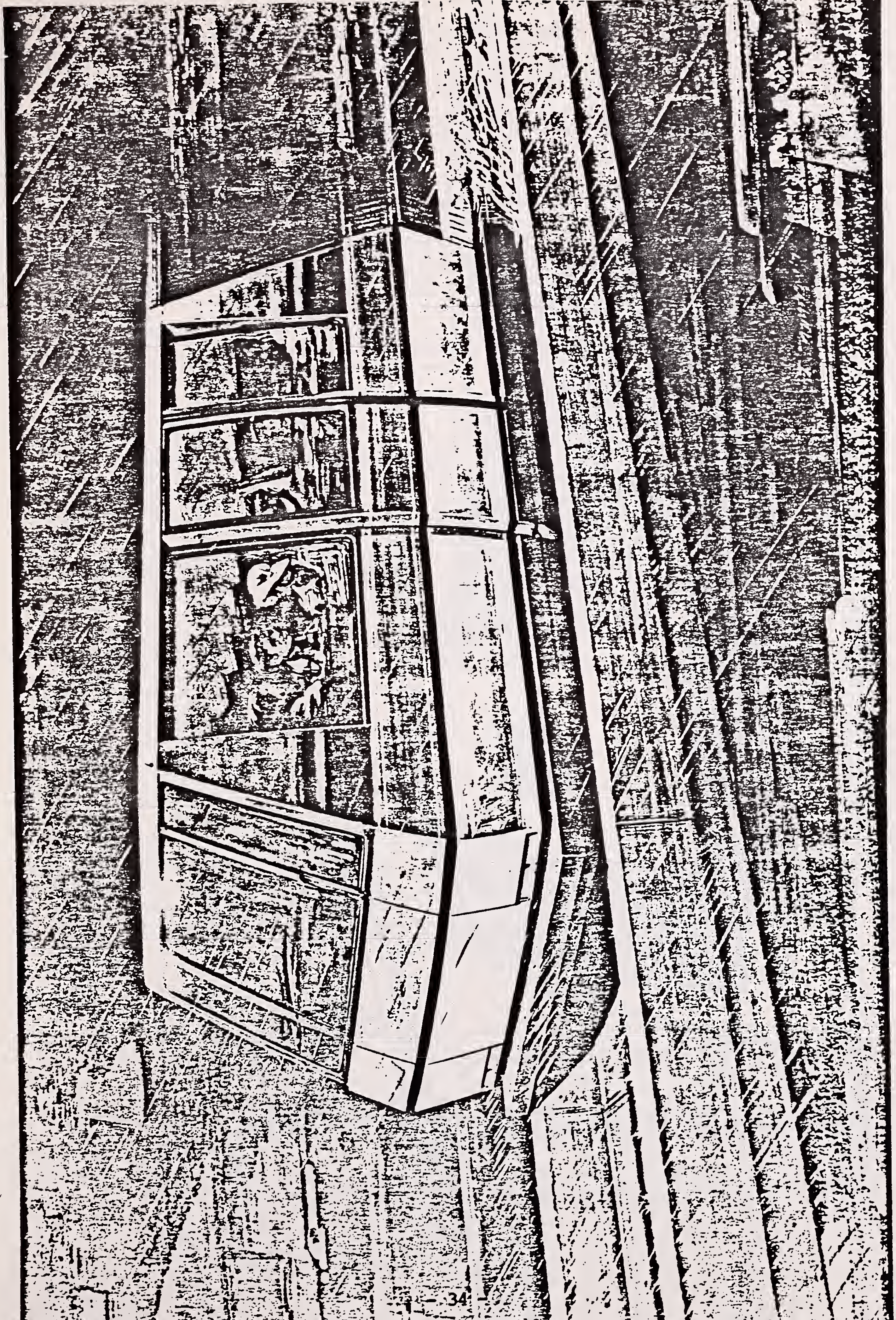
- Air-Cushion, Bottom-Supported Vehicle
- Lateral Docking
- Constrained Side-Guidewheel Steering
- Incremental Position Detection from Guideway
- Common Guideway Cross-Section (8 Feet)

BOEING URBAN GUIDEWAY

- 8-Ft. Width
- 90-Ft. Precast, Prestressed Elevated Spans
- Continuous Concrete Topping Cast in Place
- Heating Pipes Imbedded in Topping
- Common Guideway Cross-Section

OTIS URBAN GUIDEWAY

- 8-Ft. Width
- 100-Ft, Precast Sections
- Slipform Process at-Grade
- Continuous Reinforce Concrete Topping Cast in Place
- Elevated Section Prestressed Supported by Reinforced Concrete Columns
- Common Cross-Section



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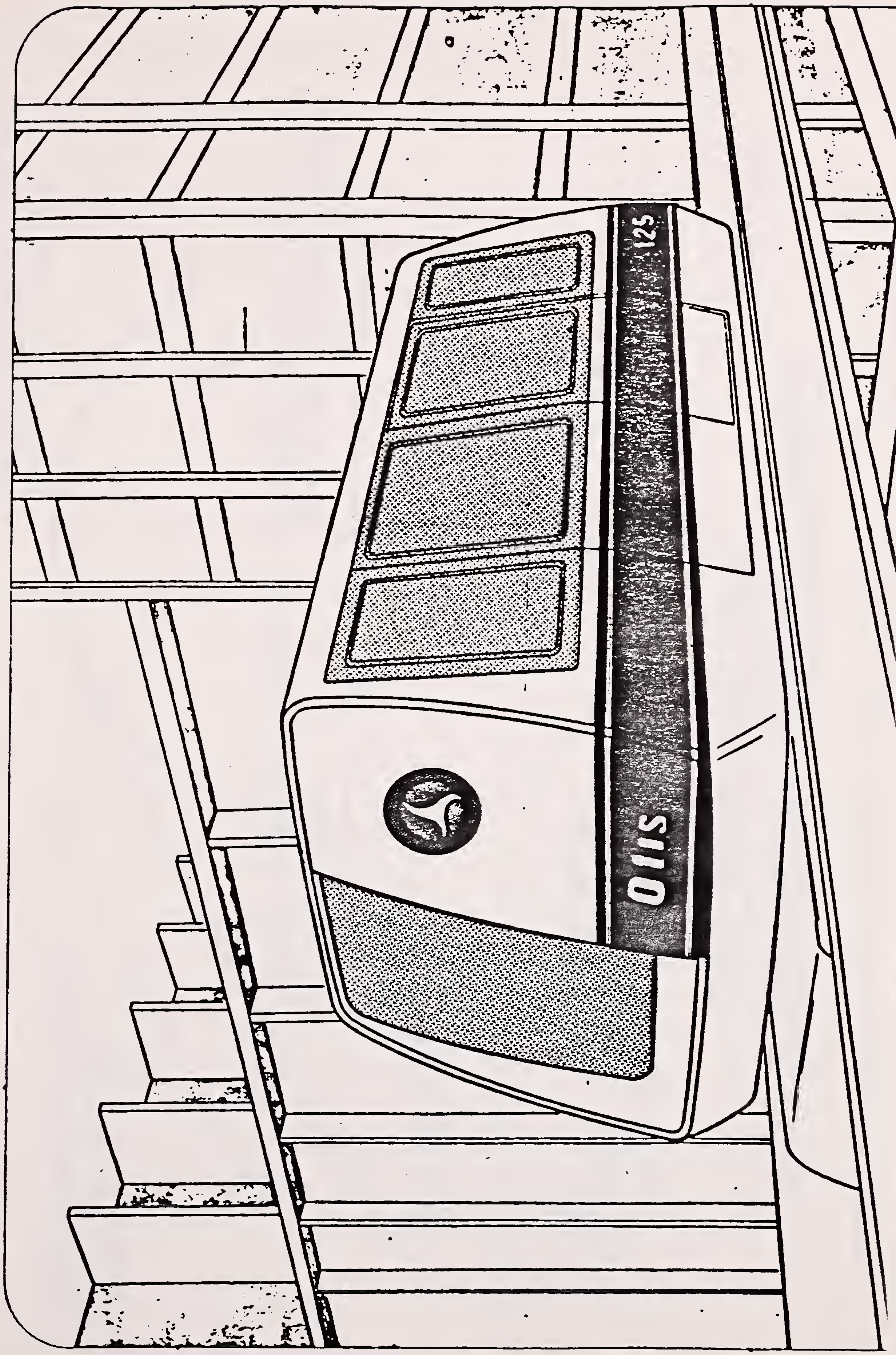
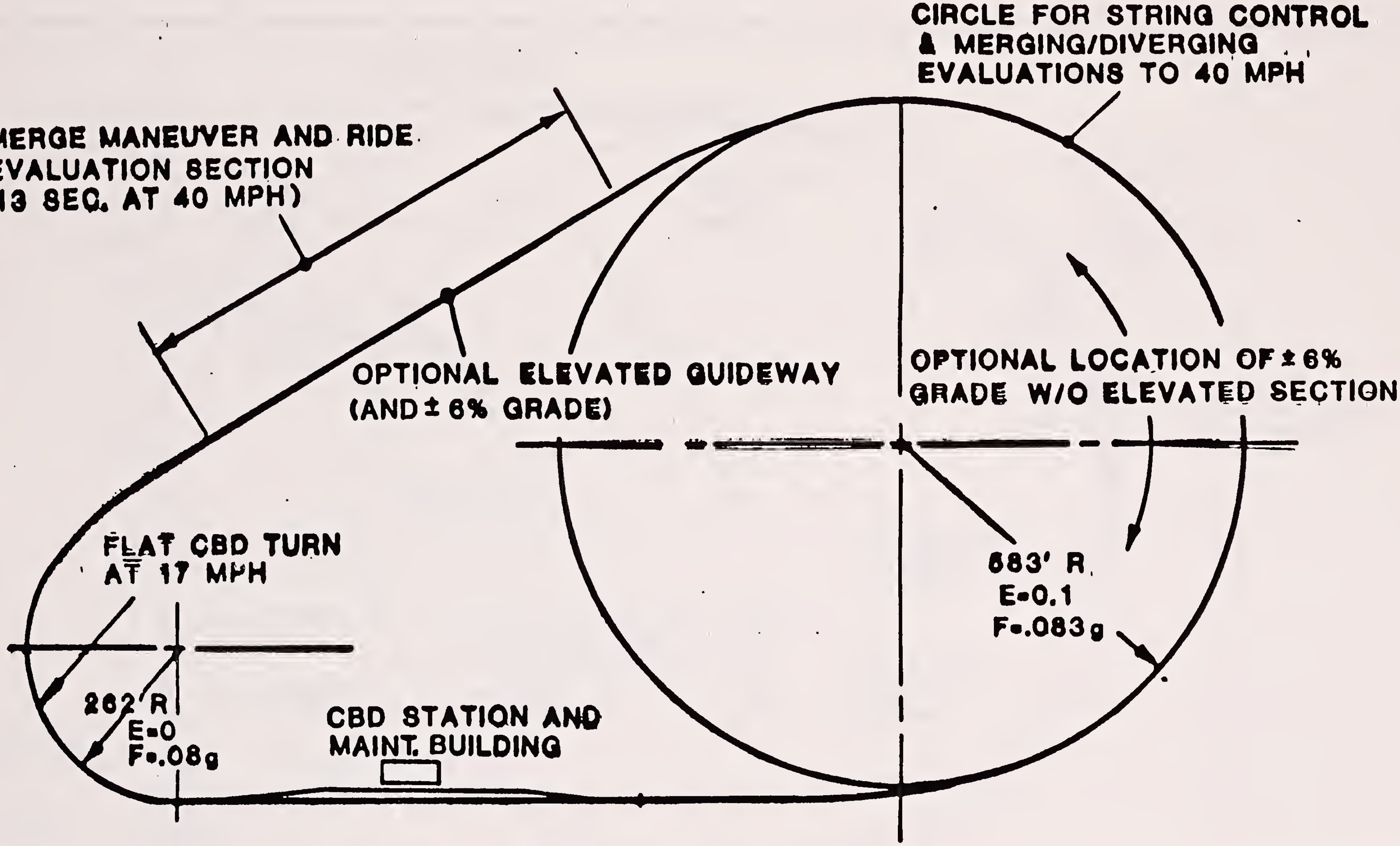


OTIS

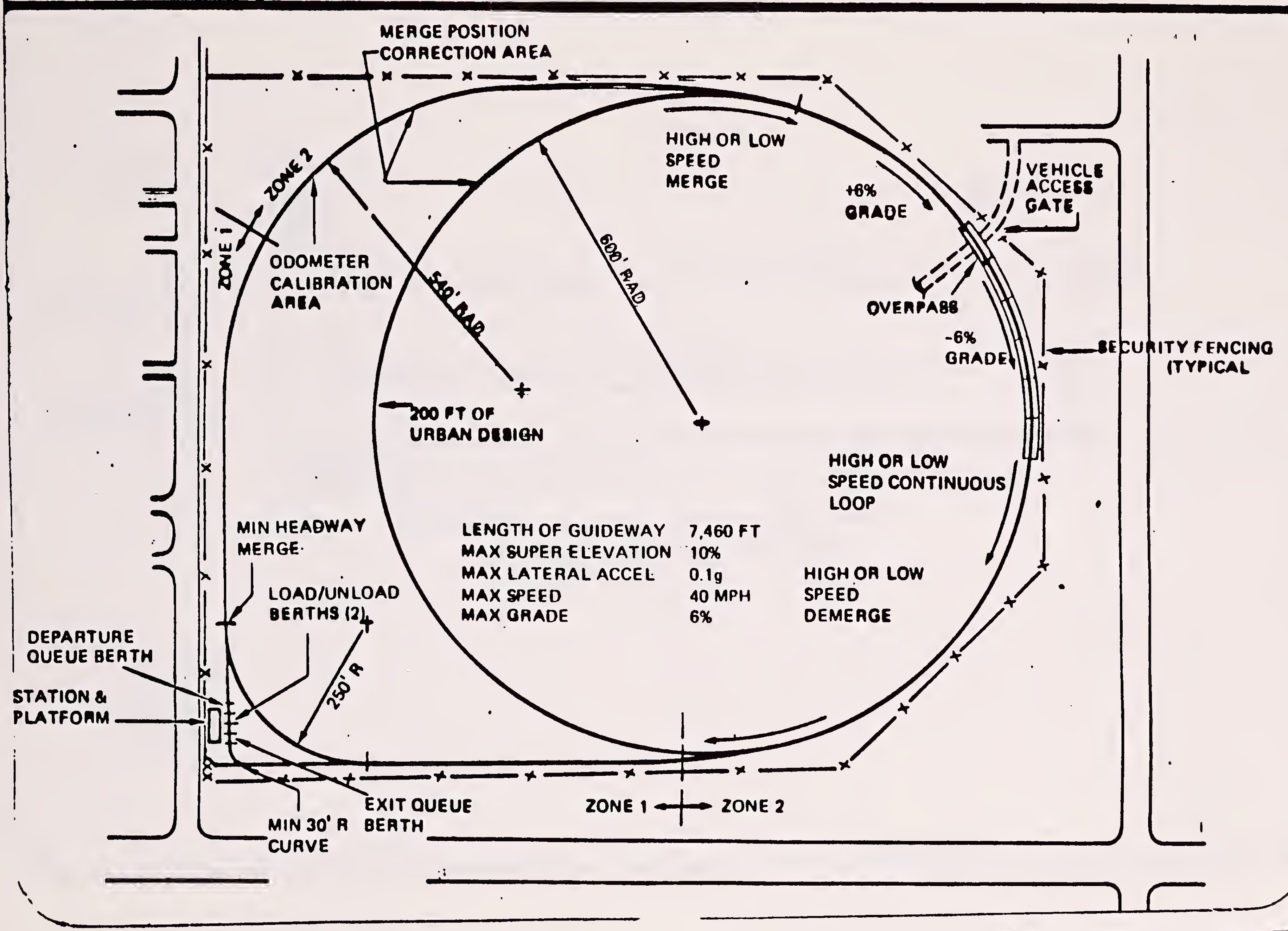


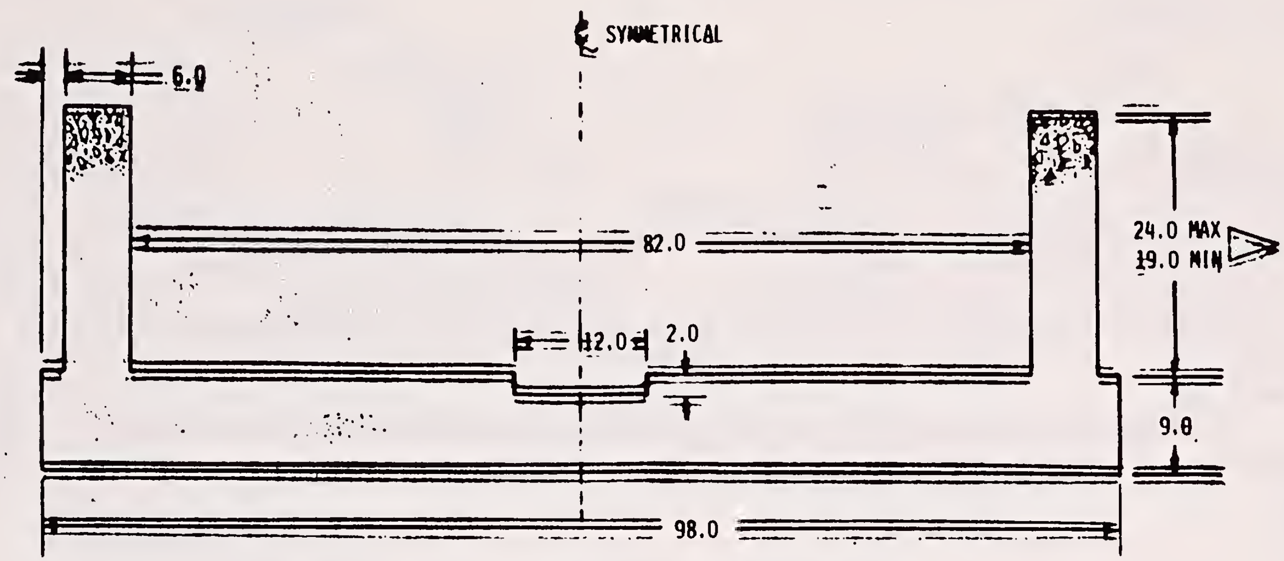
TEST TRACK FUNCTIONS

AGRT IIB ENGINEERING PROTOTYPE SYSTEM

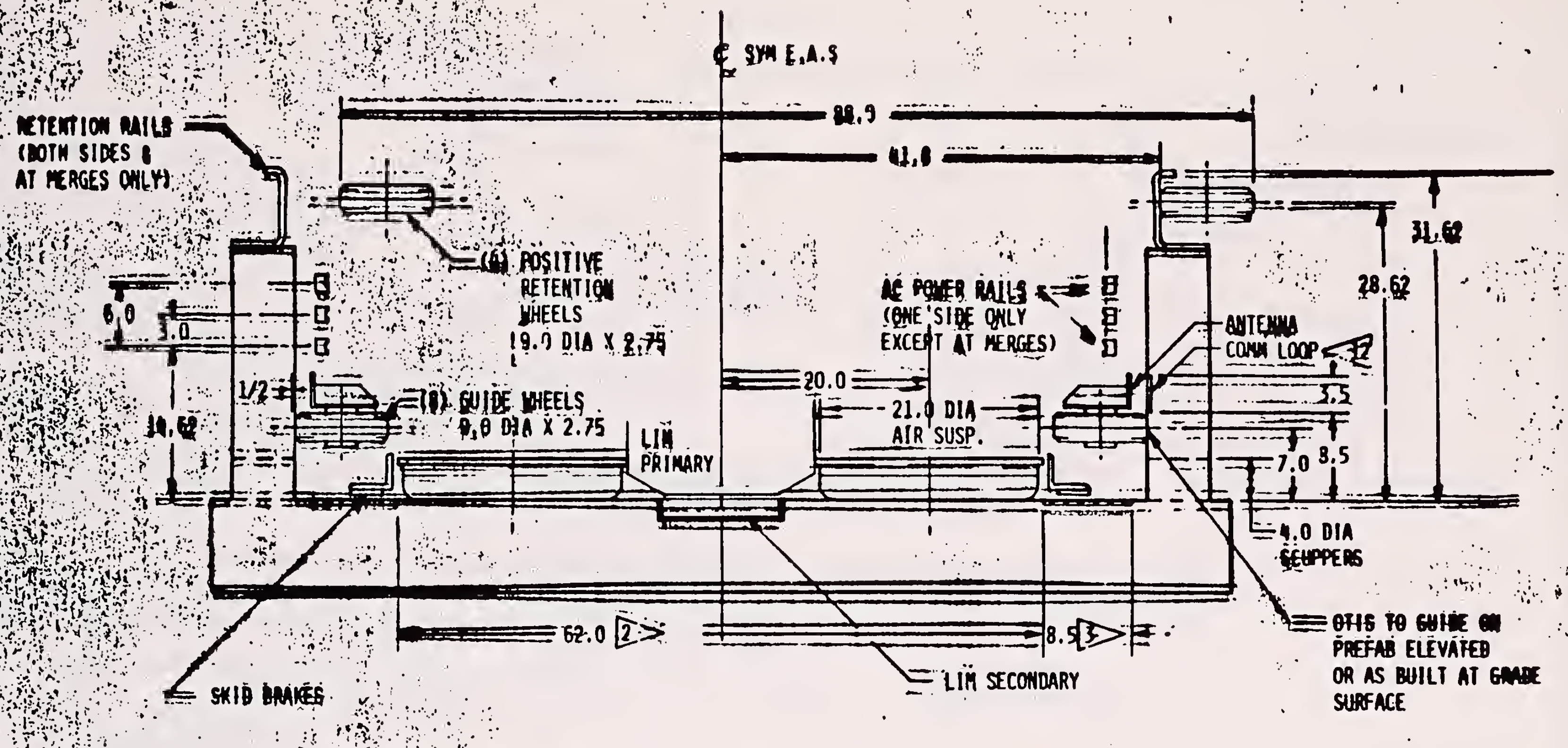
037-12-1180

ENGINEERING PROTOTYPE TEST TRACK



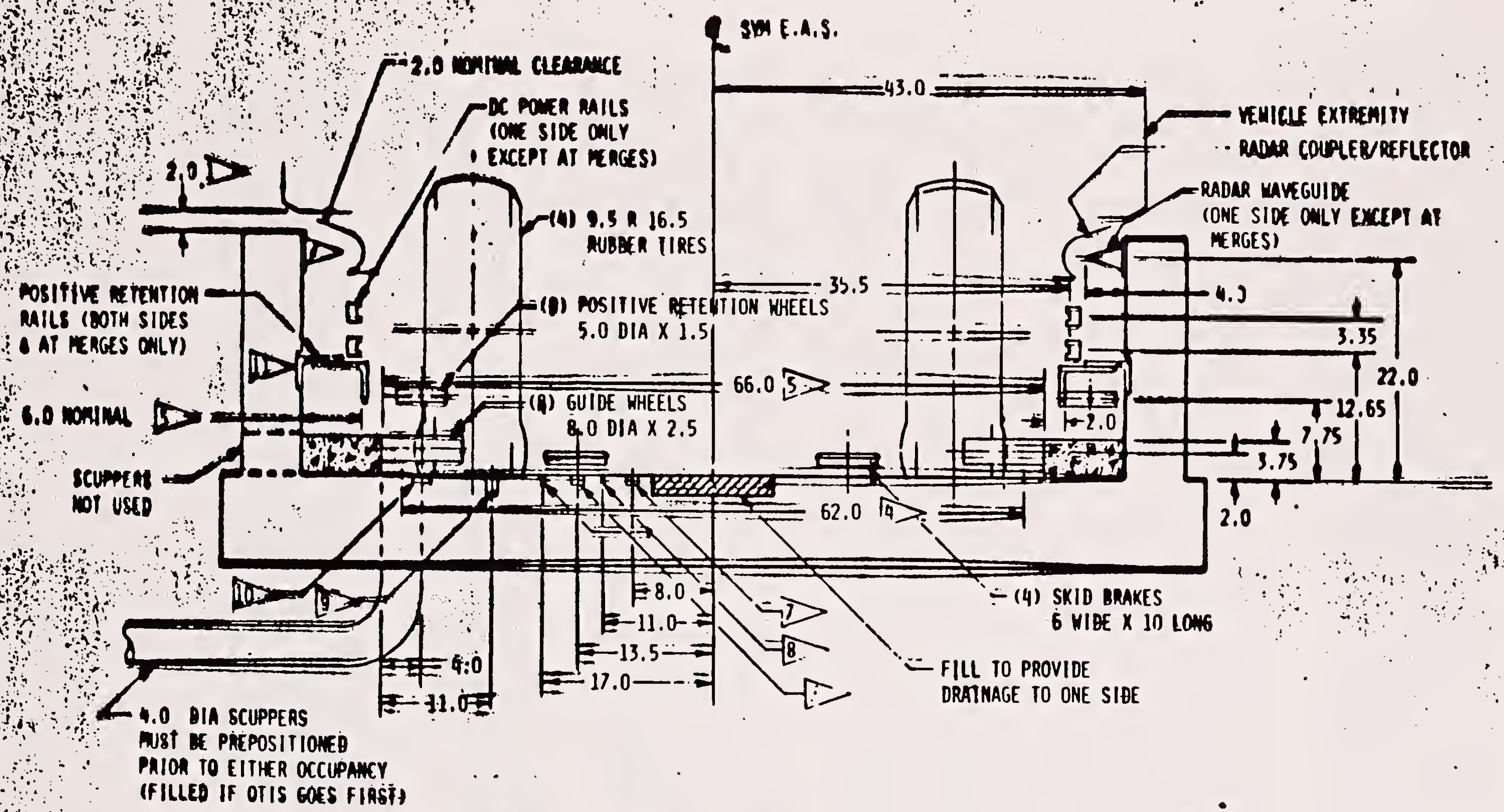


COMMON AT GRADE GUIDEWAY
BASIC STRUCTURE
OPTION A2



OTIS VEHICLE/GUIDEWAY INTERFACE.

CONFIGURED FOR R.H. TURN



BOEING VEHICLE/GUIDEWAY INTERFACE

CONFIGURED FOR R.H. TURN

DUNCAN MACKINNON
CHIEF, ADVANCED DEVELOPMENT DIVISION, UMTA

This presentation concerns a program which has been in existence since 1975 that is called the Automated Guideway Transit Technology (AGTT) program. It's a very broad, complex program and all I can really accomplish in this presentation is to provide a very shallow overview. A more comprehensive description of the program is provided in the Proceedings of the Conference on AGT Technology Development which was held at TSC in February, 1978.

The concept of Automated Transit emerged in the early 60's, spurred by the successful application of the concepts of automatic control in the areas of defense and industrial process control. One of the first major developments of an automated urban transit system was the Westinghouse "Transit Expressway" which was developed under Urban Mass Transportation Administration sponsorship in the 1960's. Capable of automatic operation at 60-second headways, the service characteristics of the "Transit Expressway" were similar in many respects to conventional rail rapid transit systems. Towards the end of the 60's, it was recognized that improvements in service and ability to adapt to the diverse trip patterns in modern urban areas could be achieved by operating smaller vehicles at shorter headways with off-line stations. This led to serious studies of short headway operation, the development of system concepts, and the deployment of the "Airtrans" and "Morgantown" Automated Guideway Transit (AGT) systems which began revenue service in 1973 and 1975, respectively.

While technological development continued, the severe operational problems encountered by the deployed systems in the early stages of revenue service eroded confidence in the ability of automated transit to solve urban transportation problems. It was recognized that Government sponsorhsip of research on solutions to the critical problems of automated transit systems and a complete assessment of existing AGT designs were required to achieve a sound basis for urban deployment.

In response to these demands, the Urban Mass Transportation Administration established the Automated Guideway Transit Technology (AGTT) and AGT Socio-Economic Research (described elsewhere) programs in 1975. This presentation summarizes the activities currently in progress in the AGTT program.

The AGTT program is not directed towards developing solutions for specific systems but rather towards results applicable to the entire range of AGT systems from Shuttle Loop Transit (SLT) to Group Rapid Transit (GRT) to Personal Rapid Transit (PRT). Baseline specifications used throughout the program are indicated in Table 1.

The lack of adequate data on the operating characteristics of various AGT systems in different applications has often thwarted adequate planning for AGT system deployment. The object of a System Operation Studies program in progress at General Motors is to develop computer tools which can be used to accurately model the behavior of AGT systems in urban deployments. The models and their application are indicated in the Deployment Analysis Flow diagram shown in Figure 1. The basic analysis inputs are zone to zone trip demand (Z/Z Demand), the transit network geometry (Network) and the system characteristics (System). A subprogram in the Discrete Event Simulation Model (DESM) and the Feeder System Model (FSM) map the zone to zone trips onto the transit network using the designated technology to produce station to station (S/S) trip demand and travel time (Impedance) data. The station to station demand data together with the network and system characteristics provide the necessary data for coarse passenger and vehicle flow-based analysis using the System Planning Model (SPM) or detailed analysis using the Discrete Event Simulation Model (DESM). The DESM provides data on individual passenger and vehicle behavior permitting accurate evaluation of system performance. The DESM together with system failure data also permits an evaluation of service reliability as perceived by the passenger or operator using the Service Availability Model (SAM). An analysis of capital, operating and life-cycle costs may also be performed using the System Cost Model (SCM). All of the models interface with the AGT/SOS Data Base as shown in Figure 2 permitting information exchange between various models and systematic accumulation of results.

Currently the models are being tested and evaluated prior to general distribution to planners, system developers, government agencies and other interested users. A simplified version of the DESM model has already been developed specifically for studying the performance of the Downtown People Mover (DPM) systems and is being implemented at a number of DPM sites including Detroit and Los Angeles.

The objectives of the AGTT development effort are (1) to establish the service and cost characteristics of all classes of automated guideway transit systems and (2) to develop the critical technologies that are required for the successful deployment of such systems, with particular emphasis on control, safety, reliability, and maintainability.

The five major projects in the AGTT program are addressing:

(a) System Operations Studies,
(b) System Safety and Passenger Security,
(c) Vehicle Longitudinal Control and Reliability,
(d) Vehicle Lateral Control and Switching, and
(e) Guideway and Station Technology.

The major projects account for 68% of the total $12,525,000 approved for the AGTT program.

The Longitudinal Control and Reliability project is identifying and evaluating techniques to improve the reliability of the classes of AGT vehicles indicated in Table 1. The reliability studies have been coupled with longitudinal control because the major contributors to reliability problems such as power collectors, power conditioners, motors, drive trains, brakes, suspension components, etc., are associated with the longitudinal control system. Specific techniques studied include fail-operational-redundant implementation and improved component design and application. Vehicle control concepts considered include fixed- and moving-block vehicle protection, vehicle- and point-follower control as indicated in Table 2, and electronic (platooned) and mechanical (trained) vehicle coupling.

The longitudinal control designs will be evaluated using two vehicles originally developed for Transpo 72. The experimental control system features a Motorola microprocessor-based onboard controller shown in Figure 4, a triple-redundant Motorola microprocessor-based wayside safety system in Figure 5, and a dual redundant shared memory Tandem minicomputer system for processing wayside control information shown in Figure 6. The programmability of the vehicle and wayside elements permits a wide range of longitudinal control techniques to be experimentally evaluated.

The test vehicles will be operated on the Otis 764 meter test track near their plant in Denver, Colorado. In addition to the control and reliability studies Otis is exploring the problems associated with implementing automatic coupling on AGT vehicles. To date several automatic coupler designs have been developed and coupling maneuver requirements identified. Results to date indicate that ride quality jerk limitations must be relaxed and coupling accomplished at low relative speeds in order to achieve reasonable coupler complexity, weight and cost. As a result of gathering range limitations of conventional couplers, an actively positioned coupler such as that shown in Figure 7 appears necessary if coupling maneuvers are to be performed on sharp curves.

To complement the longitudinal control research, the Vehicle Lateral Control and Switching project is developing improved steering and switching techniques. Comparative studies and experiments will be made on purely mechanical and power-assisted mechanical systems utilizing side wall-following guidance sensors as well as power-assisted mechanical systems utilizing a buried radiating wire as a lateral position reference as illustrated in Figure 8. The variable geometry experimental test vehicle shown in Figure 9. The Ackerman steering mechanization of the experimental vehicle in Figure 10 permits wide variations in steering geometry and suspension parameters. The wall-guided steering systems are being evaluated on the 764 meter Otis test track. The wire-follower system is being tested on a vehicle test area at Lowry Air Base in Colorado. The results of the project will provide a clear picture of the advantages and disadvantages of the three control approaches applied to each of the vehicle classes in Table 1.

The major capital investment in an AGT system is the guideway and station infrastructure. The Guideway and Station Technology project being performed by De Leuw, Cather is aimed at reducing the cost and installation time of guideways and stations. The project includes a comprehensive analysis of existing guideway and station technology including the guideways shown in Figure 11. In addition the project is evaluating a wide range of column, footing and beam technology as indicated in Figures 12 and 13. The benefits of prefabricated, offsite fabrication to reduce installation time and costs are receiving particular attention. The results of the studies will be presented in detailed tabular and graphical form to permit incorporation of site specific characteristics. Case studies using techniques such as models and photomontage are being used to reduce the visual impact of AGT structures and to explore the problems associated with installation in urban areas. A major project task is directed towards the development and evaluation of techniques to improve the all-weather operation capability of rubber-tired AGT systems. Methods such as improved power rail orientation, reduction of the heated guideway surface to the tread track widths and insulation techniques appear to hold the potential for saving up to 80% in guideway and power rail deicing energy.

In addition to the major projects described above, a number of smaller research projects are being funded under the AGTT program addressing:

(f) Hardware Reliability and Service Availability,
(g) Station Security Features,
(h) Personal Rapid Transit,
(i) Vehicle-Guideway Dynamics,
(j) Vehicle Control,
(k) Automated Transit Technology Requirements,
(l) Automated Mixed Traffic Vehicle Technology,
(m) Hydrostatic Drive Development, and
(n) Vehicle Data Acquisition.

The specification of service reliability as perceived by the passenger, operator, and developer is an important issue in the development of procurement documents and in-service evaluation. The Hardware Reliability and Service Availability project was established at Battelle in Columbus, Ohio, to survey and define measures of service availability which have been used by operators, manufacturers, and researchers to characterize the operating reliability of AGT systems. This project included a workshop which was held in October 1977. Measures of interest to developers, operators, and passengers have been identified and documented.

The Station Security Features project examines the security features required to adapt stations to the security characteristics of different urban sites. This project was performed by W. V. Rouse and Company.

A significant contribution to AGT research was made in the early 70's by the Aerospace Corporation in Los Angeles through an extensive in-house funded study of the feasibility of AGT systems using very small vehicles at fractional-second headways. The Personal Rapid Transit project provided funds to the Aerospace Corporation to update this research and to place the results in the public domain.

Dynamic interaction between the vehicle and the dynamics of elevated guideways can signficantly affect ride comfort. The Massachusetts Institute of Technology has been performing research in this area under UMTA Office of University Research sponsorship since 1974. Sponsorship of this research is continuing under the AGTT program in the area of Vehicle-Guideway Dynamics and operational analysis of training and platooning.

Independent non-profit organizations such as the Applied Physics Laboratory of Johns Hopkins University and the MITRE Corporation have played a valuable role in the UMTA AGT program through independent analyses and assistance in monitoring system design, integration and test activities. The Applied Physics Laboratory has been conducting theoretical studies on AGT system control since 1969. The current Vehicle Control research is extending previous results with particular emphasis on the problems of longitudinal control at medium to short headways, improved vehicle operation strategies for AGT stations including online acceleration and deceleration and analyses of communication and sensor requirements.

The MITRE Corporation is performing a variety of research tasks as part of the AGTT Independent Studies activities. The Automated Transit Technology Requirements project is directed towards establishing performance characteristics (speed, cost, capacity) which will result in viable deployments for new transit technologies, assessment of hybrid propulsion technology and AGT energy requirements.

The Hydrostatic Drive Development at Mobility Systems and Equipment is directed towards the test of a hydrostatic drive for AGT vehicles. The major objective of this project is to reduce hydrostatic drive noise to an acceptable level. Hydrostatic drives permit the elimination of the complex electronics power modulator and the use of a common squirrel cage motor, resulting in significant cost savings and electromagnetic interference reduction.

The innovative concept of an automated transit vehicle which is capable of safely mixing with pedestrian traffic on existing rights-of-way offers the promise of providing inexpensive transit in applications such as shuttles and loops in auto-free zones where passenger volumes do not justify the capital investment implied by conventional AGT or moving walkway systems. The Jet Propulsion Laboratory (JPL) in Pasadena, California, has been developing an Automated Mixed Traffic Vehicle transit technology which utilizes a small vehicle equipped with sophisticated sensors permitting the vehicle to operate at low (2-5 kph) speeds in pedestrian areas or at higher speeds on semi-protected rights-of-way. The project is funded jointly by the National Aeronautics and Space Administration and the Urban Mass Transportation Administration. A breadboard test vehicle has already successfully operated on a 600-meter loop at JPL. Current studies are focusing on the development of a transitworthy vehicle design and improved control techniques.

A Vehicle Data Acquisition system is being developed by the Port of Seattle which will collect and record data from 30 test points in a specially instrumented Sea-Tac Satellite Transit System vehicle. The recorded data will help maintenance personnel to rapidly diagnose vehicle failures thus reducing vehicle downtime and maintenance costs. This system uses an onboard microprocessor (Intel 8080) and semiconductor memory to record data which may then be transferred to a wayside microprocessor terminal via a mini-magnetic-disk recorder unit for anlaysis by maintenance personnel.

In addition to the project work a substantial effort has been made to communicate the results of the research to the transit community. Six workshops have been held covering areas such as passenger security, system performance measures, service availability, and system operation

simulation and analysis in order to solicit comments from the transit industry, system manufacturers, consultants and Government experts. A major conference on AGT Technology Development was also held in Cambridge, Massachusetts which attracted 241 attendees. The major projects are providing data and guidelines for the design and specification of critical system elements which are being distributed to the DPM cities and other interested users.

Table 1

Automated Guideway Transit Vehicle Categories

Category	Minimum Headway (SECS)	Maximum Line Speed (KM/HR)	Energy Utilization $\frac{\text{KW-HR}}{\text{VEH. KM}}$	No. of Passengers	Empty Vehicle Weight (Newtons) Per Passenger[5]	Sizes (Meters) Length	Width	Height
SLT[1]	>60	25-100	2.0	20-120	45,000-135,000	7.5-12.0	2.5-3.0	3.0-3.8
(Nominal)	(90)	(50)		(80/30)*	$\frac{(110,000)}{1,300}$	(11.0)	(2.75)	(3.5)
GRT_L[2]	15-60	25-100	1.4	20-50	35,000-90,000	4.5-7.5	1.8-2.2	2.5-3.5
(Nominal)	(20)	(65)		(30/20)**	$\frac{(55,000)}{1,750}$	(6.0)	(2.0)	(3.0)
GRT_S[3]	3-15	25-80	0.60	20-50	13,000-65,000	3.5-5.0	1.8-2.2	2.4-2.8
(Nominal)	(5)	(65)		(15/10)*	$\frac{(45,000)}{2,225}$	(4.1)	(2.0)	(2.5)
PRT[4]	<3	30-75	0.15	(2-6)	4,450-13,000	2.2-3.0	1.2-1.8	1.5-1.8
(Nominal)	(0.5)	(50)		(4)**	$\frac{(6,500)}{1,550}$	(2.5)	(1.5)	(1.8)

* Total Vehicle Capacity, (Seated and Standing/Number of Seats)

** All Seated

1. Shuttle-Loop Transit
2. Group Rapid Transit-Large Vehicle
3. Group Rapid Transit-Small Vehicle
4. Personal Rapid Transit
5. Nominal vehicle weight divided by number of passengers

Table 2

Longitudinal Control Systems

Classification	Minimum Headway (Secs)	Vehicle Protection	Vehicle Class	Operating Policies
Fixed Block Control	20-90	Fixed Block	ART[1] GRT SLT_L	Not applicable
Point-Follower	2-15	Moving Block	GRT_S	Constant Headway Constant K-Factor Constant Separation (Platooned)
Vehicle-Follower	2-15	Moving Block	GRT_S	
Point-Follower	0.2-0.5	Moving Block	PRT	Constant headway Constant K-Factor Constant Maximum Collision Velocity Constant Separation (Platooned)
Vehicle-Follower	0.2-0.5	Moving Block	PRT	

[1]Automated rail transit

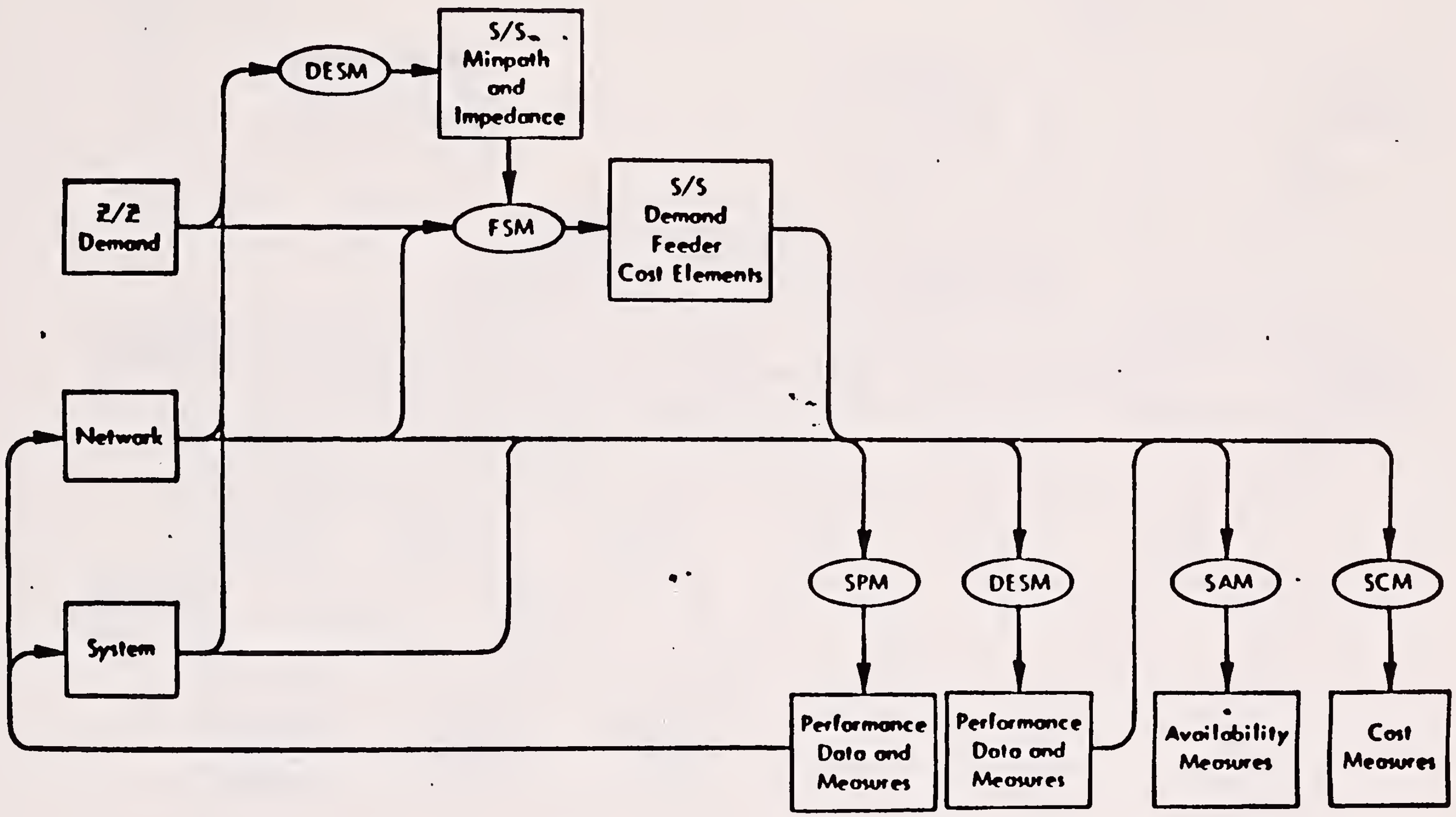


Figure 1: AGT system operations analysis flow diagram showing the phasing of model application for typical AGT deployment analysis problems

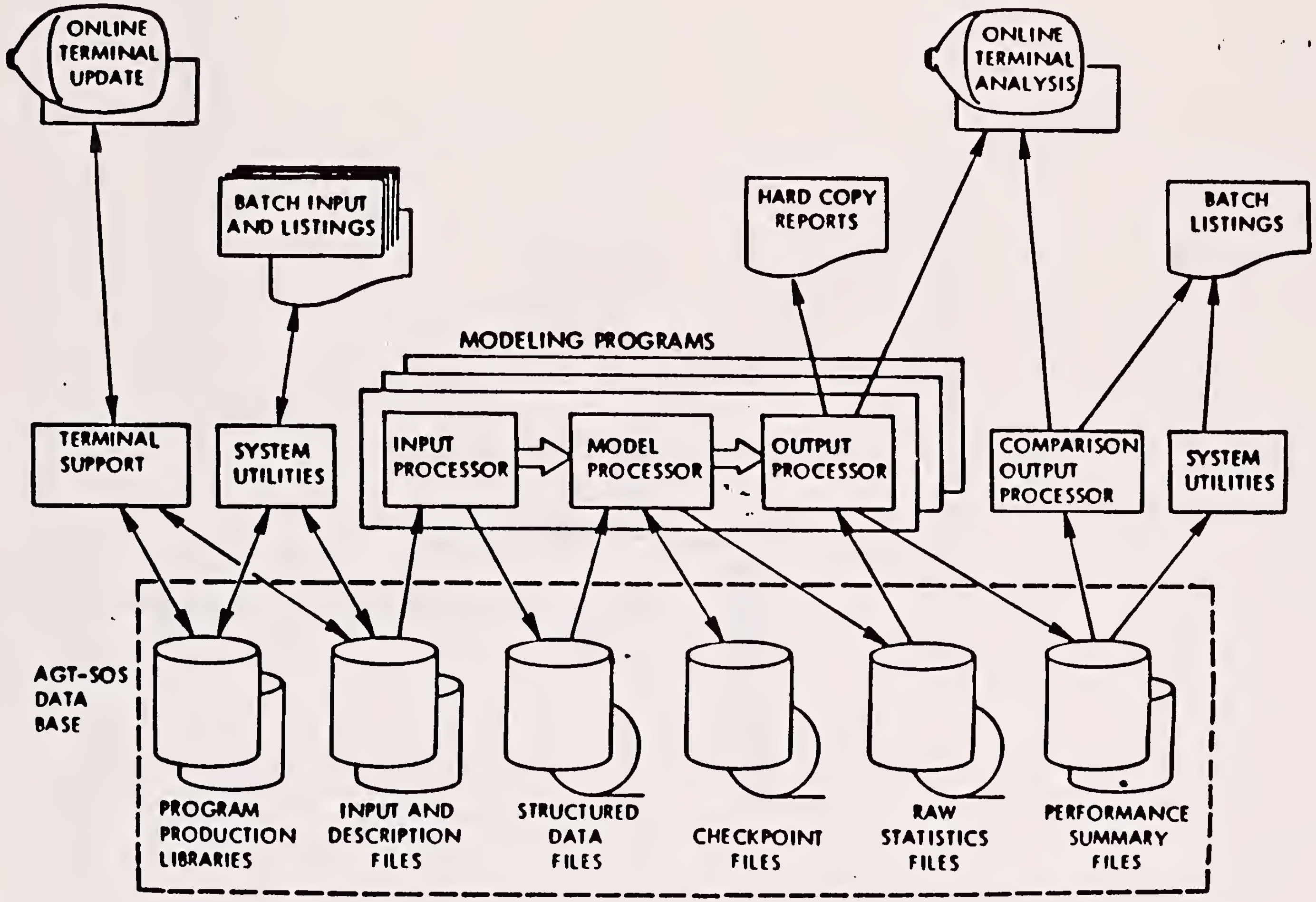


Figure 2: System operation studies analysis models and data base organization illustrating the coupling between the models and a common structured data base

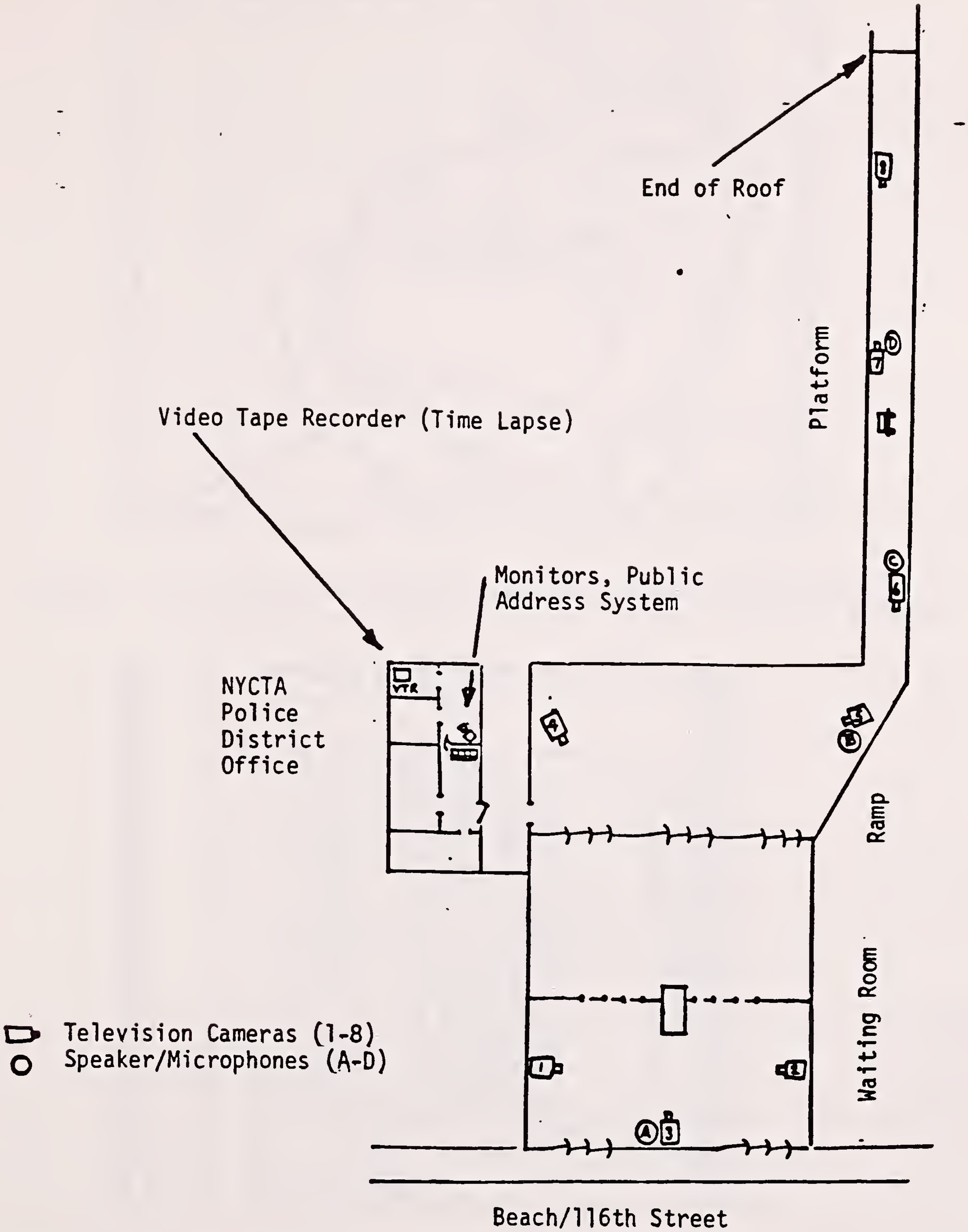


Figure 3: Rockaway Park rail rapid transit station closed-circuit television and sound monitor security enhancement system

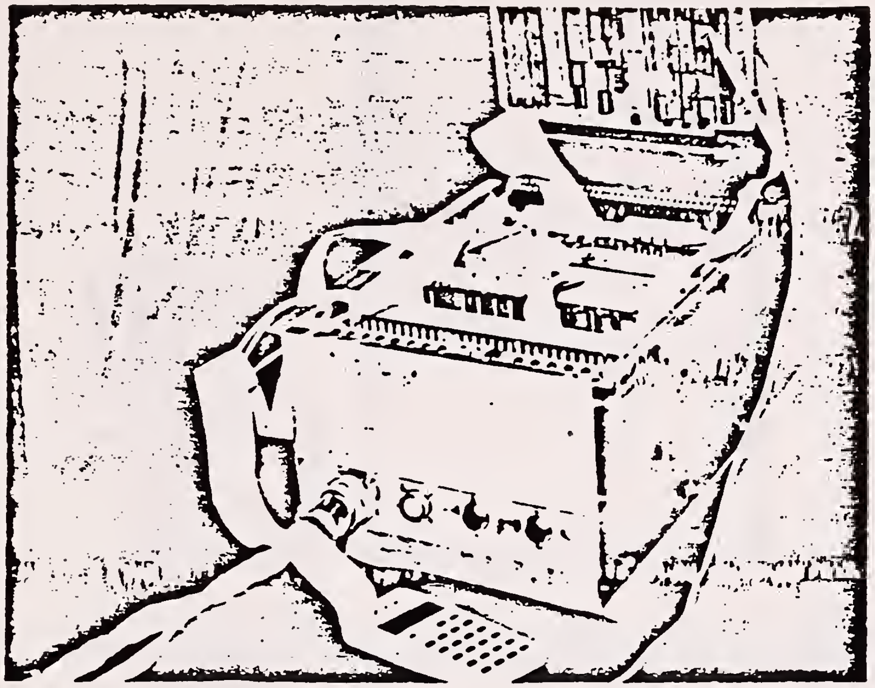


Figure 4: Onboard Motorqla M6800 microprocessor-based programmable AGT vehicle onboard control system

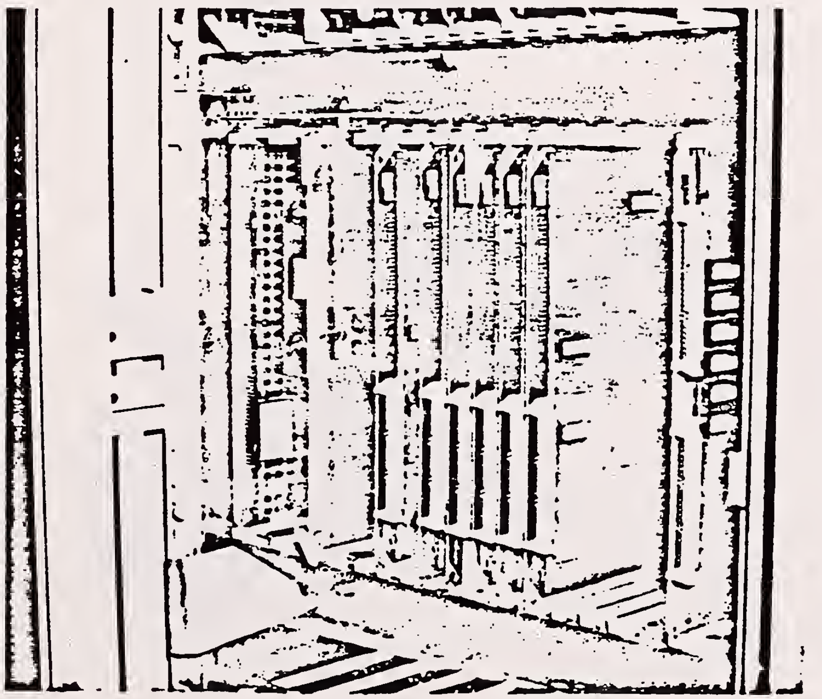


Figure 5: Triple checked-redundant failsafe Motorola M6800-microprocessor-based wayside vehicle safety monitor

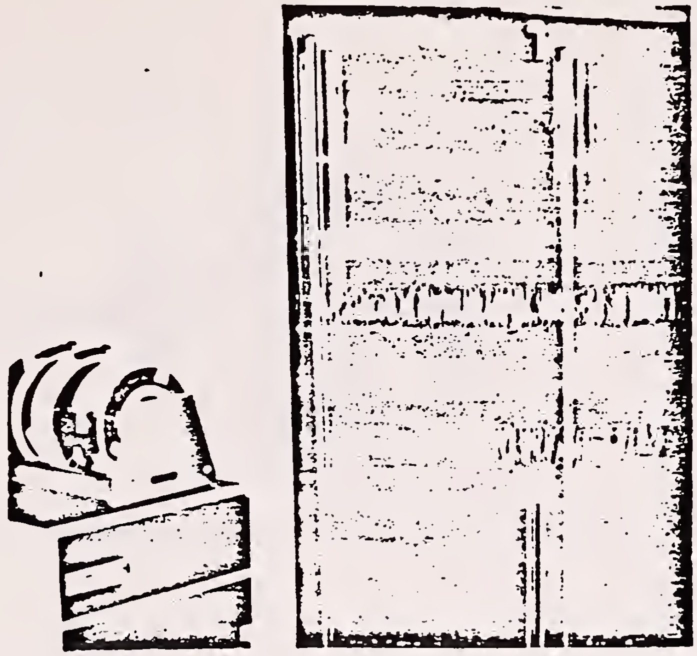


Figure 6: Dual-redundant Tandem minicomputer with shared 96 Kilobyte memory programmable wayside control processor

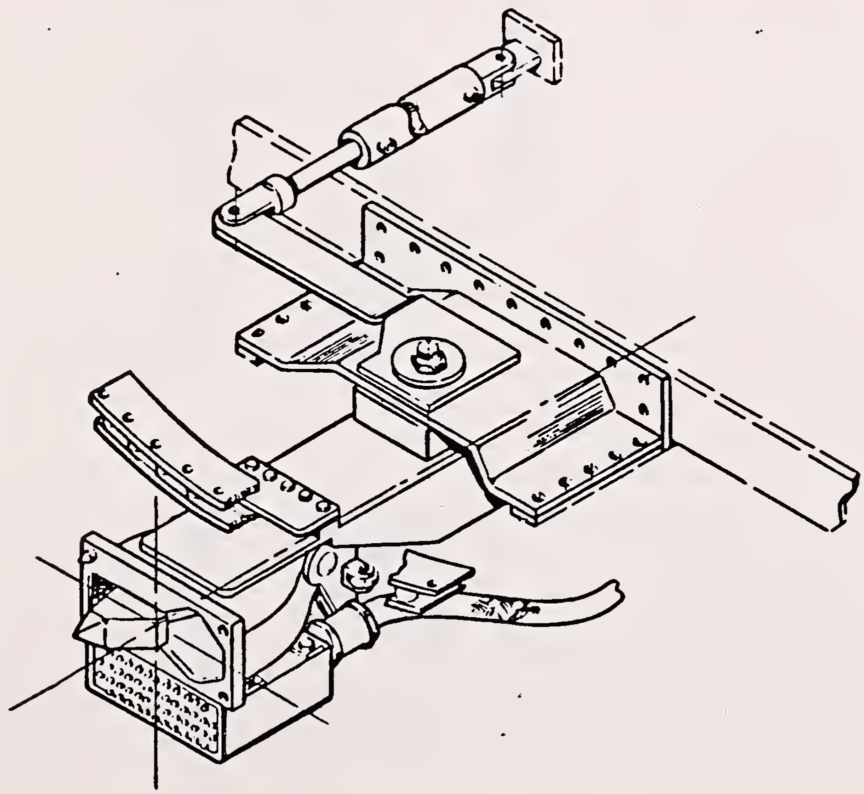


Figure 7: Steerable tight-lock automatic coupler with electrical connector

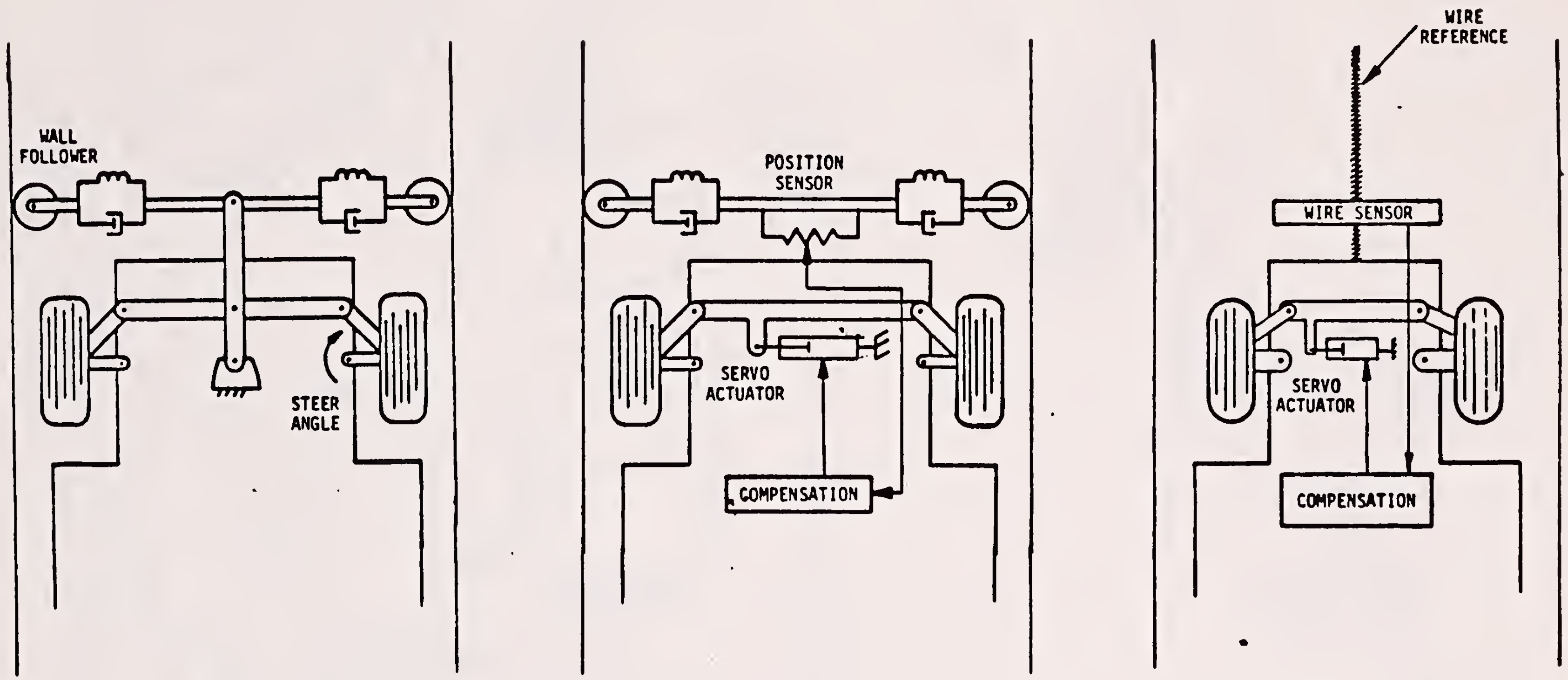


Figure 8: Wall-follower passive, power assisted wall-follower, and wire-follower lateral steering control system schematics

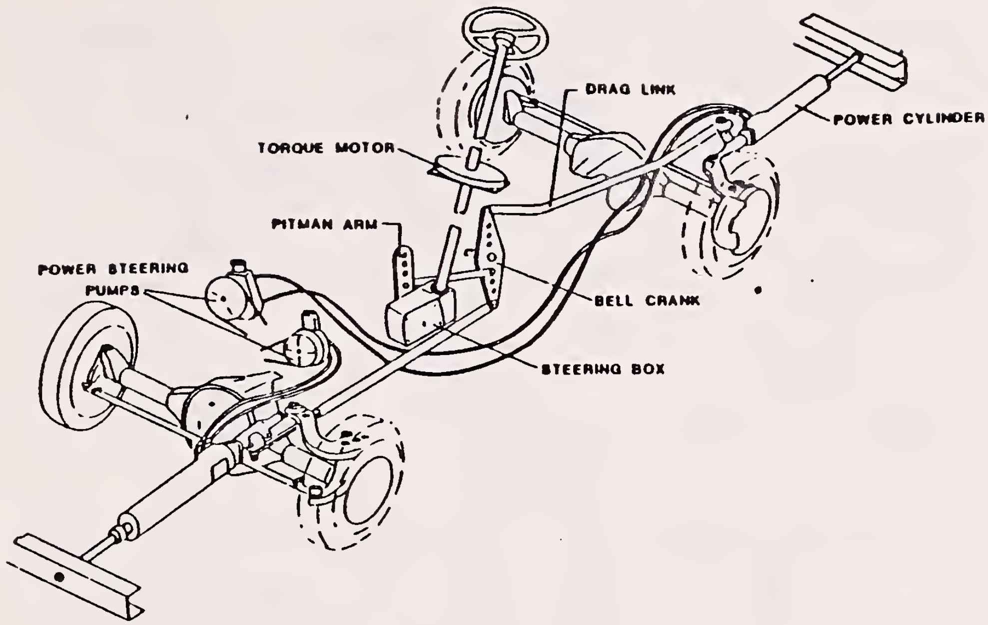


Figure 9: Experimental test vehicle power-assisted four-wheel variable geometry steering system components

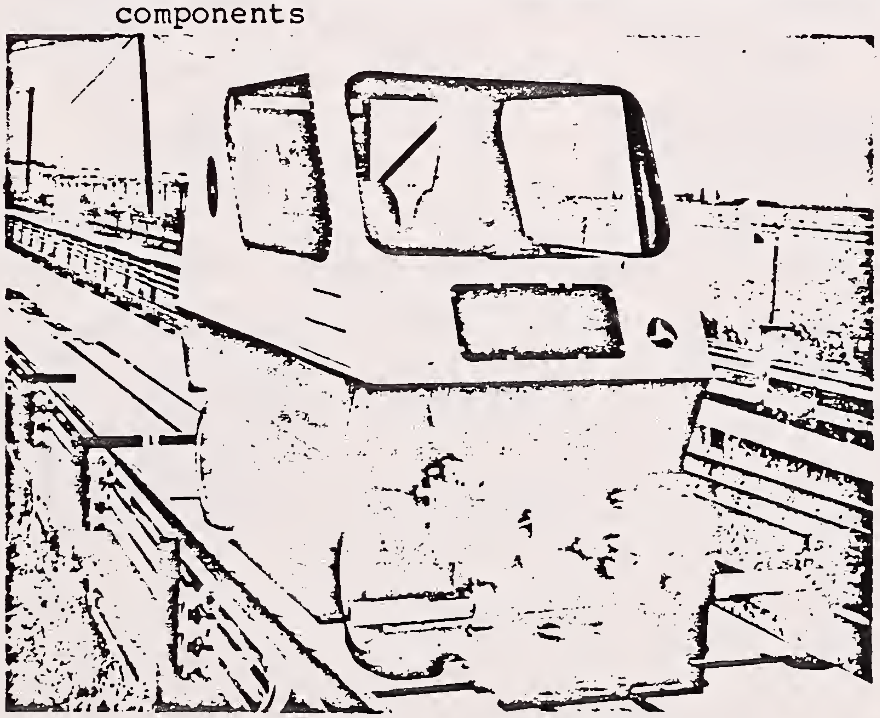


Figure 10: Variable geometry lateral control system test vehicle with 2-or 4-wheel drive and single or dual axel steering

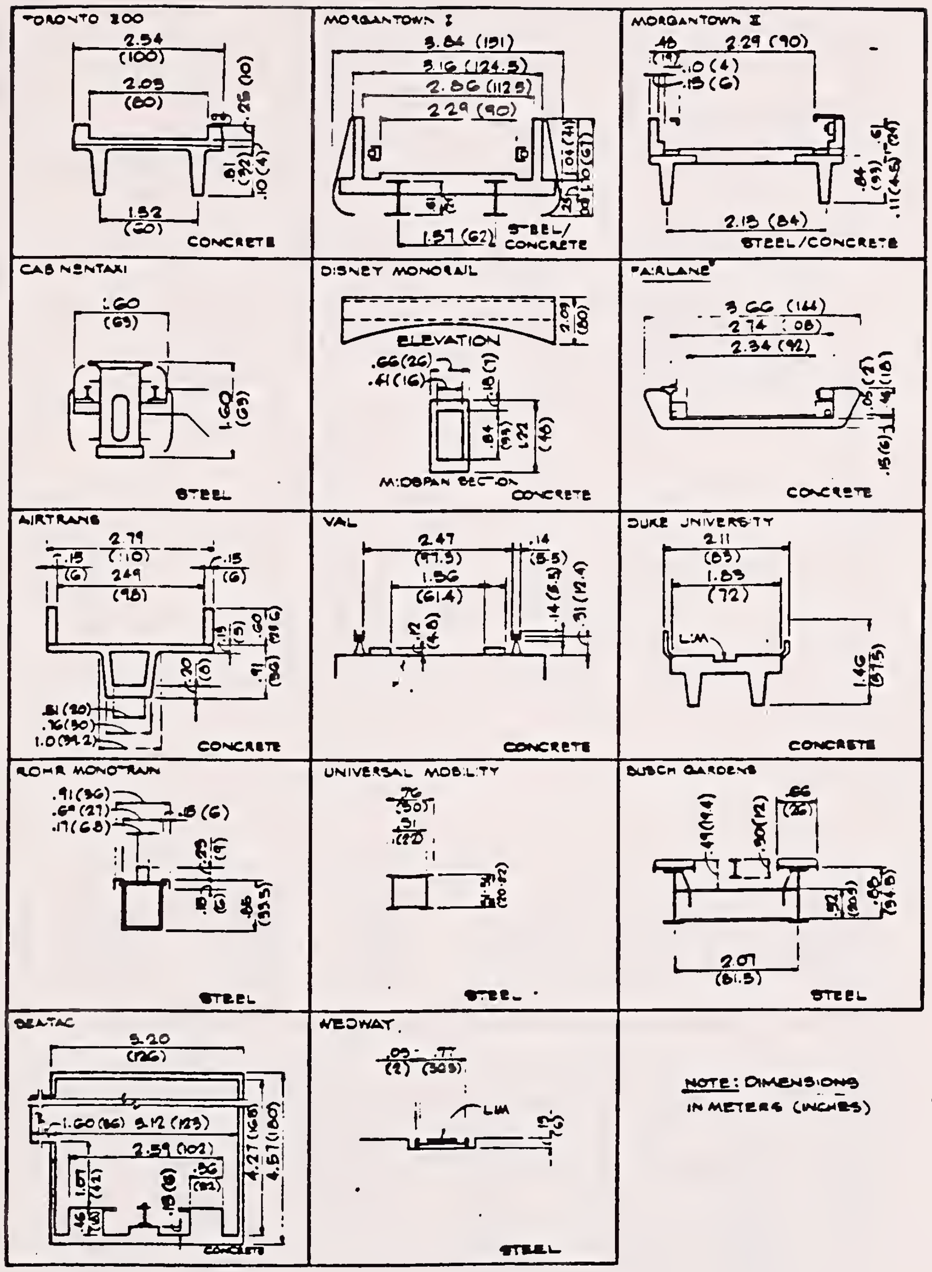


Figure 11: Existing AGT system guideway technologies included in the guideway design review and design improvement studies

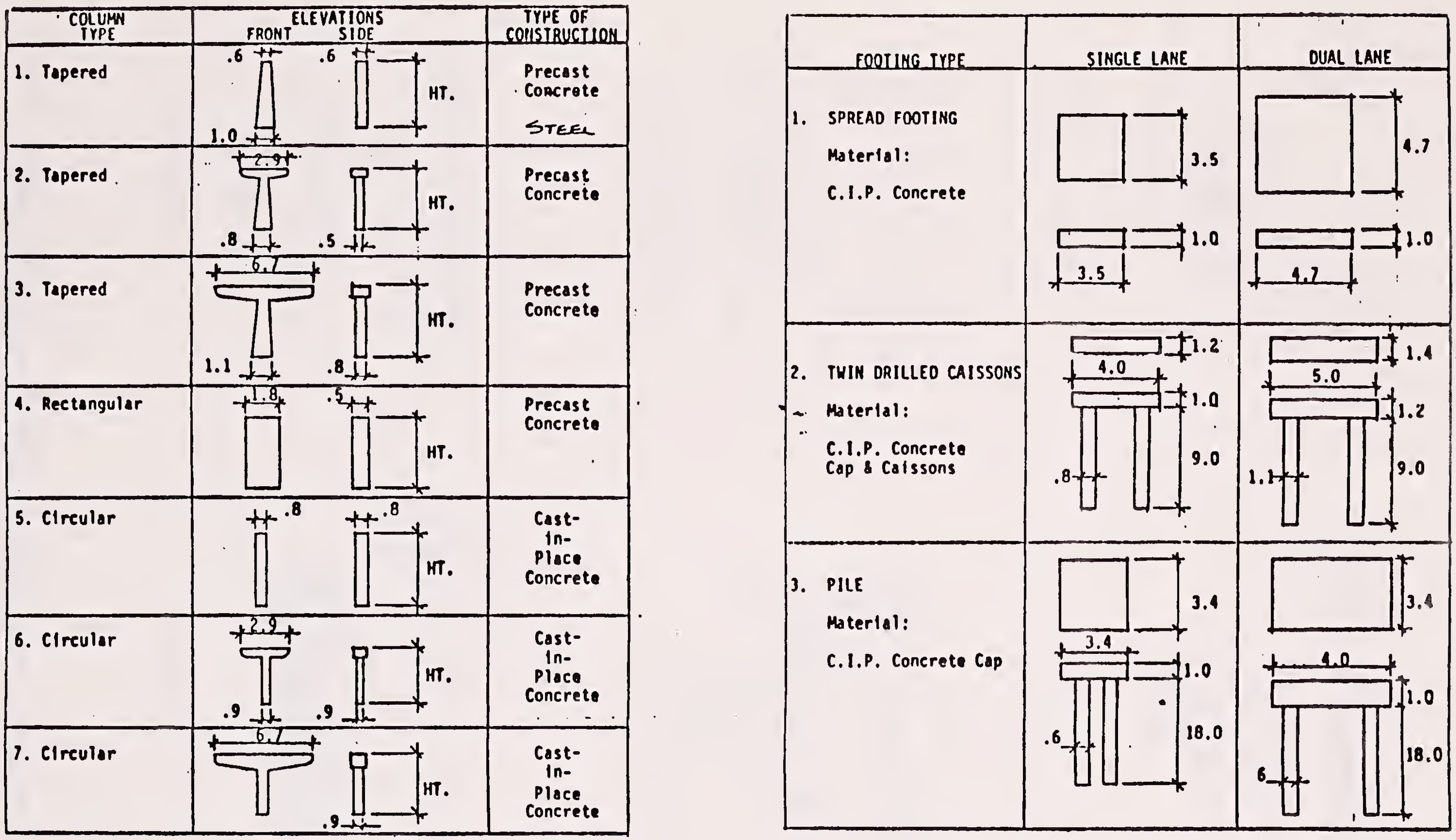
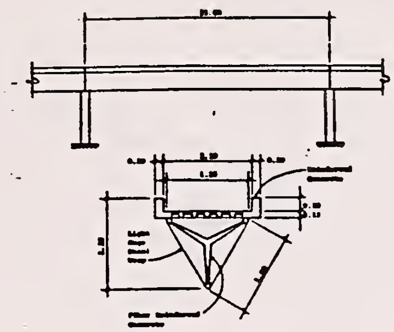
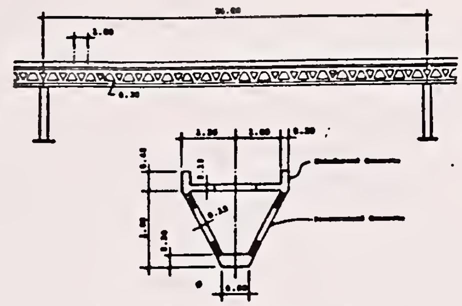


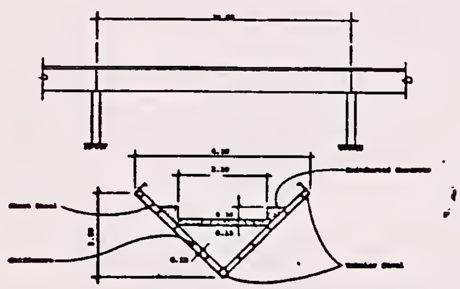
Figure 12: Guideway column and footing configurations included in the guideway technology studies



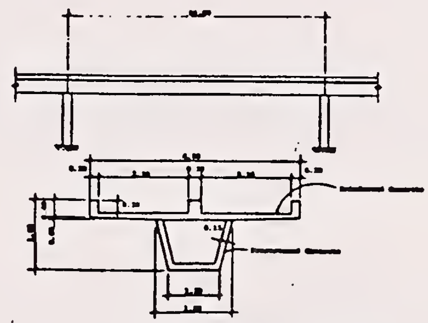
Captive Column



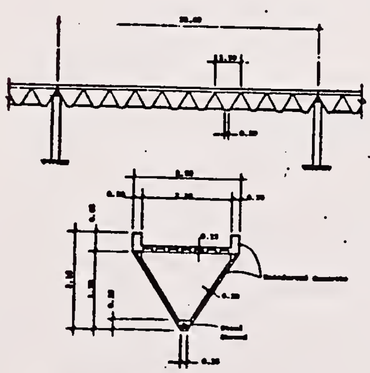
Precast Truss



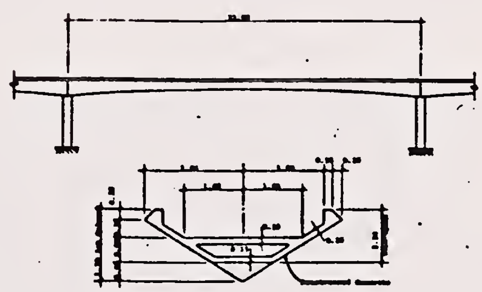
Light Gauge Steel



Tandem Dual Lane



Tetrahedron



V Girder

Figure 13: Guideway beam design variations included in the innovative guideway technology studies

JULIE HOOVER
PARSONS, BRINCKERHOFF, QUADE, & DOUGLAS

The importance of operating costs in gaining public acceptance of AGT or other advanced transit systems cannot be stressed enough. As an example, in Jacksonville, Florida, I recently conducted over two dozen in depth personal interviews with a wide range of the city's community leaders -- including a number of the members of the City Council, many of the area's prominent businessmen and the owners of small businesses, and representatives of diverse civic and neighborhood organizations -- and over 70% of these people named "operating costs" as their number one concern with respect to the proposed DPM there. Most members of the Establishment had a prudent attitude toward public spending and were fearful that operating deficits would cause their taxes to rise. Representatives of the city's minorities and low income groups were concerned that the DPM would drain off revenues from their bus system, leading to neglect and poor service. Almost everyone indicated that they did not want a system that would not be self-supporting. There are important implications for federal research in this strong concern for financial feasibility.

The first obvious one is that emphasis should be placed on planning and designing systems that have the lowest possible operating costs, even at the expense of higher construction costs initially. While UMTA may have the greatest personal interest in capital cost savings because their financial participation is currently much more substantial in system construction, it is the operating costs that will a) have the greatest significance over the long run, and b) be most critical to local acceptance, and therefore, they should receive the higher priority and the greatest attention.

Second, and this is what I do not see very much of at all in the research efforts currently underway, we must deal openly and directly with the matter of operating subsidies. If they are required, can public education be used to overcome community resistance? Should it be even attempted? What innovative tools or institutional arrangements might be used to lessen the burden? If systems are stripped of all their amenities and extra features in an effort to cut costs, will they still attract a decent ridership? Finally, what will/should be the federal and state roles in supporting local AGT transit operations in perpetuity?