November 1981

Transit Technology Evaluation

A Literature Capsule

U.S. Department
of Transportation

**Urban Mass
Transportation
Administration**

TECHNOLOGY SHARING A PROGRAM OF THE UNITED STATES DEPARTMENT OF TRANSPORTATION

Report No. DOT-TSC-UMTA-81-65

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Introduction

As part of its ongoing commitment to the principle of technology sharing, the U.S. Department of Transportation has initiated a series of publications based on research and development efforts sponsored by the Department. The series comprises technical reports, state-of-the-art documents, newsletters and bulletins, manuals and handbooks, bibliographies, and other special publications. All share a primary objective: to contribute to a better base of knowledge and understanding throughout the transportation community and, thereby, to an improvement in the basis for decision-making within the community.

The **Transit Technology Evaluation Literature Capsule** is designed to make the literature on transportation concerning promising new transit technology more accessible to users. Most of the publications surveyed in this capsule represent the results of projects funded by the Transit Technology Evaluation Program and its predecessor, the Automated Guideway Transit Socio-Economic Research Program, of the Office of Socio-Economic and Special Projects, Urban Mass Transportation Administration (UMTA). The Transit Technology Evaluation Program investigates the technical, social, and economic factors involved in the planning and operation of promising new transit technologies through studies in four basic areas:

- **Assessments** of operational systems to compile information on the performance, technical, and economic characteristics;
- **Cost analyses** including capital, operating and maintenance costs, as well as life cycle costing and cost trends;
- **Market research** to ascertain the nature and magnitude of the potential market for technology deployment;
- **Impacts investigation** to determine how the technology will affect users and the surrounding community with regard to aesthetic, environmental, and social issues.

Section I of the capsule contains overviews of selected documents representative of the above areas of study. Section II provides summaries of additional Transit Technology Evaluation Program documents. Section III presents summaries of publications which, for the most part, were prepared outside the Transit Technology Evaluation Program, but which are highly relevant to its work.

Readers seeking more detailed discussions of the subject matter are encouraged to refer to the original reports, which are available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia, 22161. NTIS numbers assigned to each report and by which they can be ordered have been provided whenever possible.

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SECTION I

Overviews of Selected Documents of the Transit Technology Evaluation Program

REVIEW OF LOCAL ALTERNATIVES ANALYSES INVOLVING AUTOMATED GUIDEWAY TRANSIT

R.B. Lee, W. Kudlick, J.C. Falcocchio, E.J. Cantilli, A. Stefaniuk; Urbitran Associates, Inc. and DeLeuw Cather & Co.
February 1978, UMTA-NY-06-0057-78-1, PB 291-334, 92 pp.

In numerous urban areas across the country, local government officials and metropolitan planning personnel have been considering various forms of new transportation systems as a partial solution to their urban mobility problems. Automated guideway transit (AGT) is one of the new transportation systems that has been considered in over 30 U.S. cities. The purpose of this study, as part of a broader effort to determine the future role of AGT systems in U.S. urban areas, was to ascertain how this alternative mode has been perceived locally and to identify problems or barriers relating to AGT implementation. The results of this study helped UMTA's Office of Technology Development and Deployment determine the structure of the Transit Technology Evaluation Program.

Study Approach

Of the hundreds of transportation planning studies made in the U.S. during the 10 years preceding this study, 23 were identified as having treated the consideration of automated guideway transit (AGT) alternatives in some depth. Of these 23 studies, 12 were considered to be alternatives analyses in which AGT was considered for corridor or regional application. Close examination and analysis

TYPE OF AGT APPLICATIONS CONSIDERED BY CITY*

Cities Considered AGT	Type of Applications Considered			
	City Center Circulation	Regional	Corridors	Activity Centers/ Airports, etc.
Denver	x	x	x	x
Los Angeles	x	x	x	x
San Diego	x	x	x	
Las Vegas			x	x
Santa Clara		x		
Honolulu	x		x	x
San Francisco			x	x
Sacramento	x			
Seattle	x		x	x
Portland, OR	x	x		
Aspen, CO			x	x
Detroit	x			x
Chicago	x			
Twin Cities	x	x	x	x
Cincinnati		x	x	
Cleveland	x			
Columbus, OH	x		x	
Milwaukee			x	
Kansas City	x	x		x
New York City	x			x
Wash., DC	x	x	x	x
Boston		x		
Pittsburgh	x		x	
Baltimore	x	x		x
Philadelphia			x	
Norfolk, VA	x			
Buffalo, NY		x	x	
Trenton, NJ	x	x		
Hartford, CT	x			x
Atlanta	x			
Dallas	x	x		x
El Paso	x			
Jacksonville	x	x		
Miami	x			x
San Antonio	x		x	
Orlando	x		x	x
Houston	x			x
Memphis	x			
St. Louis	x			
TOTAL	30	15	18	18

*Out of 46 contacted, 39 considered one or more types of AGT applications.

of these 12 case studies included local perceptions of:

- Critical issues in mode selection;
- The role of AGT;
- System characteristics; and
- Impediments to AGT implementation/needed improvements.

In addition to examining and analyzing the identified alternatives analyses, personal inquiries and interviews were held with local officials, representatives of consulting firms involved in the studies, and others, for a total of 99 local officials and others in 46 cities.

Critical Issues in Mode Selection

It was found that most issues which concerned the decision-makers contacted are common to all fixed-guideway modes (whether automated or not). AGT technology differences were of little consequence to most of those contacted; the real choice seemed to be between bus systems and fixed-guideway systems, whether automated or not.

The critical issues, in order of importance, were found to be:

a. Capital and operating costs;
b. Acceptability of overhead structures (visual intrusion);
c. Availability of UMTA and local funding;
d. Technical risk;
e. Public and political support;
f. Crime and vandalism; and
g. Impact on urban form.

The Perceived Role of AGT

Over 70% of the people contacted saw the potential role for AGT systems in defined-area applications, such as activity-center circulation systems, and possibly as collection/distribution services for conventional line-haul systems.

In the context of regional or corridor applications, the emphasis was on trunk-line use rather than network coverage. Very few (less than 10%) of those contacted saw a role for AGT as a regional system, and most (over 50%) believed that, at best, AGT might provide corridor service if it evolved logically from an initial, more limited application.

Perceptions of System Characteristics

System characteristics seen as positive aspects of AGT by some of those contacted were deemed negative by others. These contradictions were much greater in comparisons between AGT and other fixed-guideway systems than between AGT and buses. Thus, the study found that, to non-technical persons, the real alternatives were bus versus fixed guideway.

About 40% of the alternatives studies reviewed found little saving in overall operating and maintenance costs with AGT. Some 30% assumed a need for personnel on the vehicles, even in fully automated systems, due to the uncertainty of public acceptance of driverless operation, or labor considerations. Automation was even perceived as necessitating an increase in manpower to maintain the control system. Other areas of concern involved AGT operational performance and reliability; the crime and vandalism potential of unmanned vehicles; safety, as related to short headways; maintainability of a complex control system or large number of vehicles; and how the system would function in urban applications (as distinct from specialized applications).

The most frequently cited positive aspects of AGT were:

- The potential for lower operating costs;
- A premium level of service and/or convenience (higher speeds than conventional transit, potential for higher capacities than conventional transit, routing flexibility);
- Suitability for special applications;
- Stimulus to the development of specific areas (central business district (CBD) revitalization or area development);
- The potential for a wide range of service inherent in demand-responsiveness and automation;
- The image of modernity and aesthetic value provided by AGT in comparison to conventional transit; and
- The exclusive right-of-way (ROW) aspects of an elevated guideway (the lighter guideway structure itself and the smaller amount of ROW required for AGT as compared to conventional fixed-guideway transit).

A number of these "positive" aspects were deemed negative by others, as can be seen in the following list of perceived negative aspects:

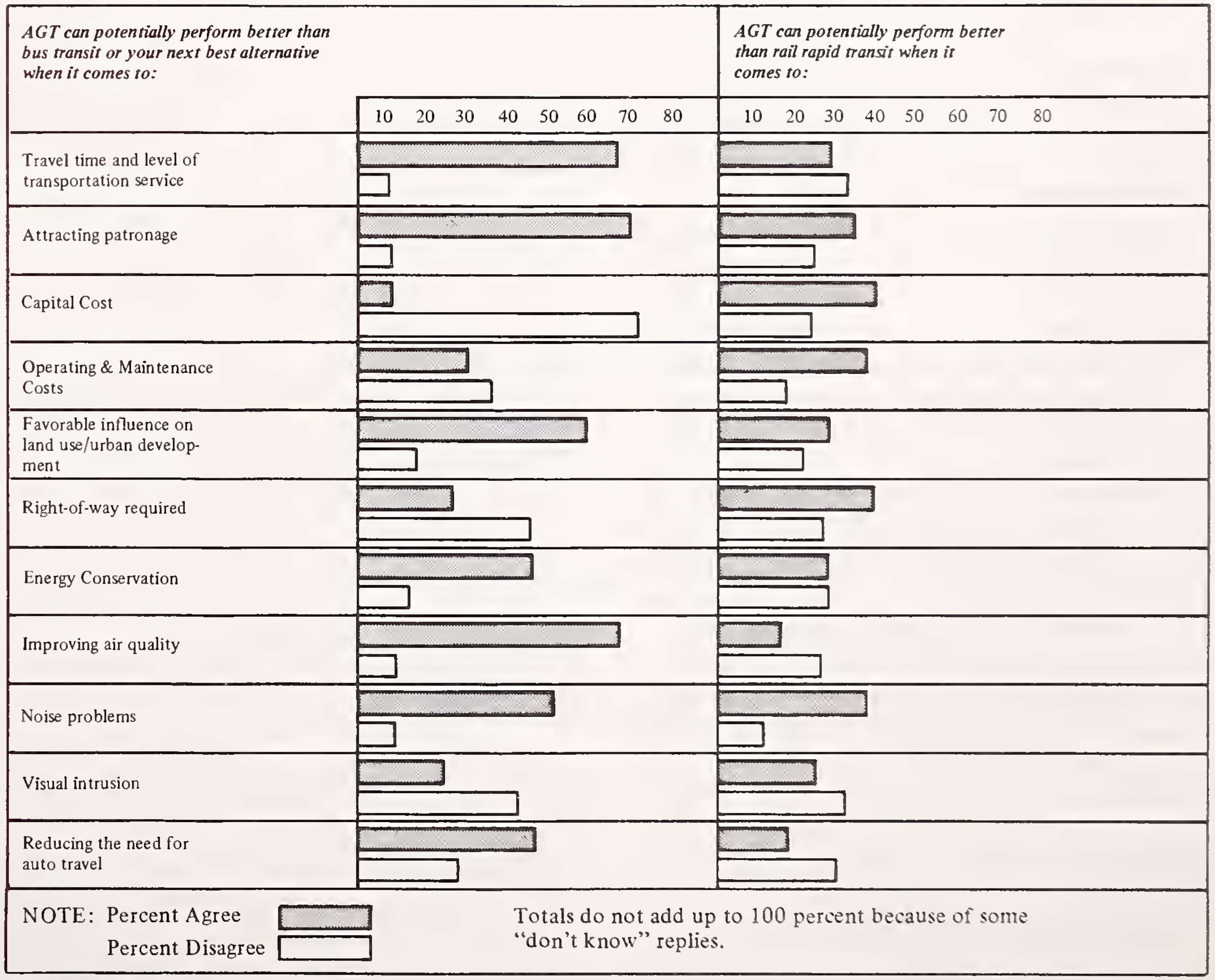
- The technical risks involved and the development time and money required for AGT;
- High capital costs (operating and maintenance (O&M) cost uncertainties, such as the extent of possible cost savings arising from automation);
- Overhead structures (as a cause of displacement and visual intrusion);

- The uncertainty of public acceptance of unmanned vehicles (concerns about safety, crime and vandalism);
- Low speeds and attendant problems of low-speed switching (the general uncertainty of performance levels and reliability);
- The limited capacity of AGT systems;
- The higher potential for accidents with unmanned vehicles;
- Political and institutional barriers; and
- The uncertainty of labor agreements which would permit the full benefits of automation to be realized.

Improvements Perceived as Needed

The study determined eight major impediments to the implementation of AGT, ranked in order of the number of times they were cited in the personal inquiries and interviews, as:

1) High capital costs;
2) Impacts and uncertainties of public acceptance of overhead structures;
3) Technical risk, uncertain reliability;
4) Uncertain or excessively high O&M costs;
5) Uncertainty of the availability of UMTA and local funding;
6) Political and institutional barriers;
7) Uncertainty of public acceptance of unmanned vehicles; and
8) Others, such as
   - lead time too long
   - negative land-use impacts
   - limited capacity



Strengths and Weaknesses of AGT as Perceived by Local Officials

- winter maintenance problems
- no product uniformity.

Since most of these perceived impediments to AGT implementation are of a non-technological nature, the improvements to promote AGT technology perceived as necessary are generally non-technological as well. These included:

- More desirable design features of overhead structures to reduce or eliminate negative impacts;
- Improvement of system reliability and development of factual performance data;
- Favorable publicity for existing systems and demonstration/pilot projects in urban applications;
- Higher Federal share of capital costs and longer-term, more dependable Federal commitments toward both capital and operating costs;
- Streamline the decision-making process;
- Longer-term UMTA commitments; and
- Consistent application of Federal guidelines and closer cooperation between Federal Government and manufacturers.

ASSESSMENT OF THE PHASE I MORGANTOWN PEOPLE MOVER SYSTEM

C. Elms, H. Merritt, T. McGean, F. Cooke, W. Bamberg H. Theumer, F. Smith; N.D. Lea & Associates, Inc.

December 1979, UMTA-IT-06-0157-79-01, PB 80-177926, 400 pp.

Early in 1969, UMTA began a major demonstration of new transit technology by constructing an operational automated guideway transit (AGT) system in a small town environment. Opened in 1975, the Morgantown People Mover (MPM) is now the world's most sophisticated AGT system in regular public revenue service. As a result of intense public interest in the MPM experiences, a complete assessment of the entire project was carried out. All details of the system were thoroughly reviewed, including the project history, the technology, operational experience, cost, and public reaction.

Project History & Development

Transportation in the small city of Morgantown, West Virginia, became a serious problem after the West Virginia University (WVU) expanded its facilities to include three separate compuses in different parts of town. As many as 10,000 students and staff members used automobiles to travel between the campuses, making congestion on the only two street routes almost intolerable. The hilly terrain discouraged walking and bicycling, and the university-sponsored bus service was inadequate.

The transportation problem led the university to examine some alternatives and an automated guideway transit (AGT) system was viewed as a possible remedy. Morgantown's needs happened to coincide with UMTA's interest in constructing an AGT demonstration system.

Development of the Morgantown People Mover (MPM) project began with a feasibility study in June 1969. This study recommended an AGT solution to Morgantown's transportation problem and in 1970, WVU submitted a grant application to UMTA. In 1970, the Jet Propulsion Lab was selected as the first system manager, but was replaced by Boeing Aerospace Company in 1971. Construction began in 1971, and was complete enough for a public dedication in October 1972. Testing of vehicles in 1973 led to some substantial system changes which took another 2 years to complete. The system finally opened to the public in October 1975. Following 3 years of operation (Phase I), the system was shut down in July 1978 for construction of additional guideway and stations (Phase II). This expanded system began operations with the commencement of the fall academic term in 1979.

System Description

Phase I of the MPM consisted of three stations, somewhat over 2 miles (3.2 km) of two-way guideway, and auxiliary support facilities. Completed in late 1979, Phase II extended the guideway and added two new stations. The first three stations connected WVU's main, downtown campus with both the Morgantown central business district and the newer Evansdale campus on the northern edge of the city. In Phase II stations were added at the Towers dormitory complex and at the medical center, and a new vehicle-wash and minor maintenance facility was constructed.

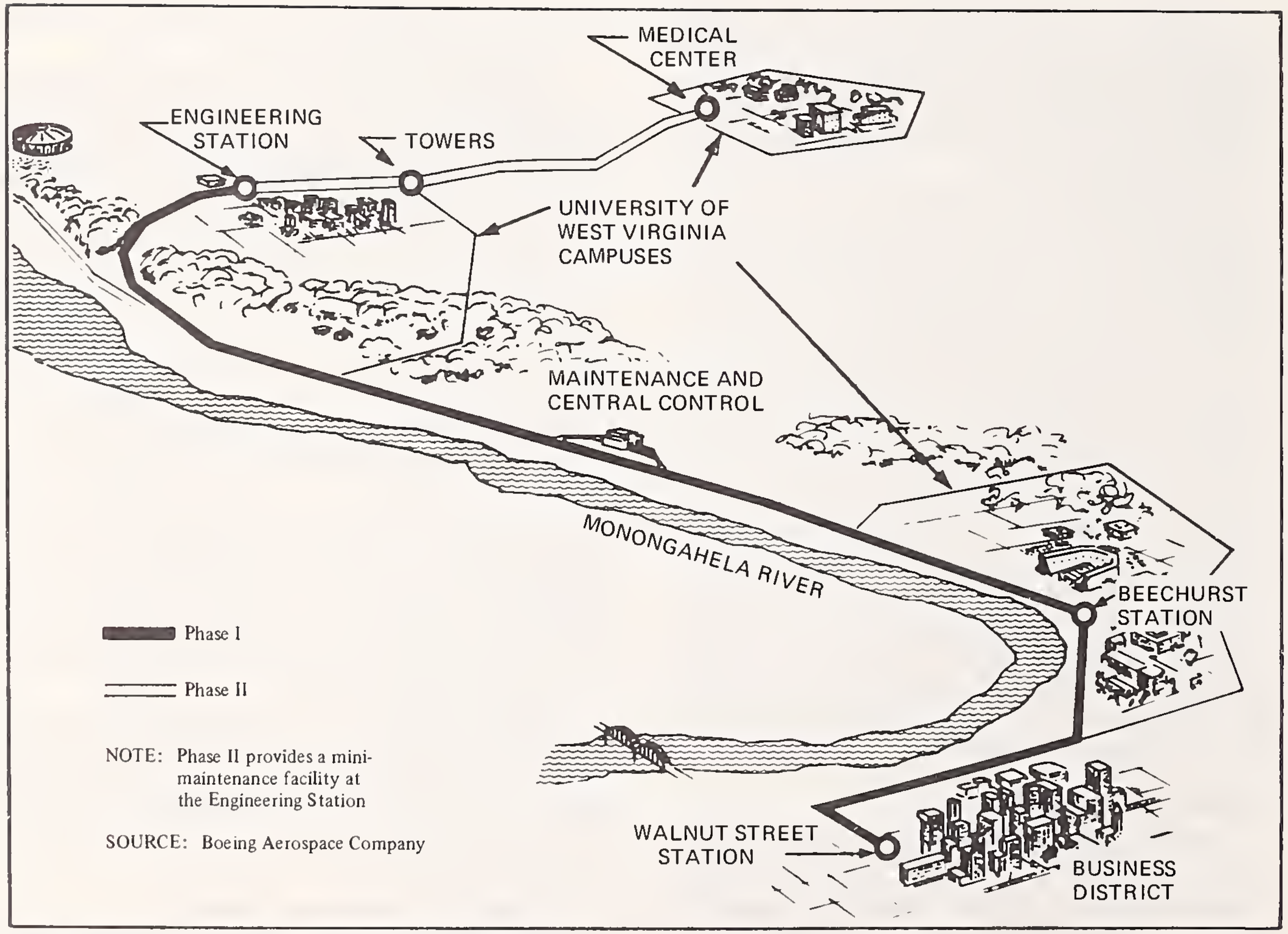
The guideway structure is primarily elevated, although parts of it are at grade. The running surface is constructed of reinforced concrete. In elevated sections, the guideway is supported by a steel superstructure mounted on concrete piers.

The completely automated, driverless vehicles of the MPM system operate under computer control and monitoring at 15-second intervals. The vehicles are relatively small, 15.5 feet (4.65 m) long and 6.7 feet (2 m) wide. Each has seats for 8 passengers and space for 13 standees, and travels along the guideway system at speeds up to 30 mph (48 km/hr).

Forty-five operational vehicles were delivered in Phase I. An active fleet of only 29 vehicles, however, was maintained in good working order because passenger demand during Phase I could be satisfied with 22 vehicles in service and 7 vehicles in reserve. In Phase II, 28 new vehicles were supplied. The 45 original vehicles have been retrofitted, bringing the total fleet to 73.

Unlike most other AGT systems in service in the United States, MPM provides nonstop service from origin to destination in both scheduled and demand modes. During Phase I, scheduled service was generally used during periods of heavy travel, with on-demand service available at other times.

Operations during severe winter weather require that the guideway be kept free of ice and snow. This is accomplished by circulating a hot water solution through pipes imbedded in the concrete running surface. Natural-gas-fired boilers provide the required energy. The MPM system was severely tested by the second two winters of Phase I operations. The 1976-1977 season was recorded as a "100-year" winter



Morgantown People Mover System Route

where the temperature fell to -15°F. Though there were some operational problems, on only two days was the system not in operation due to severe weather.

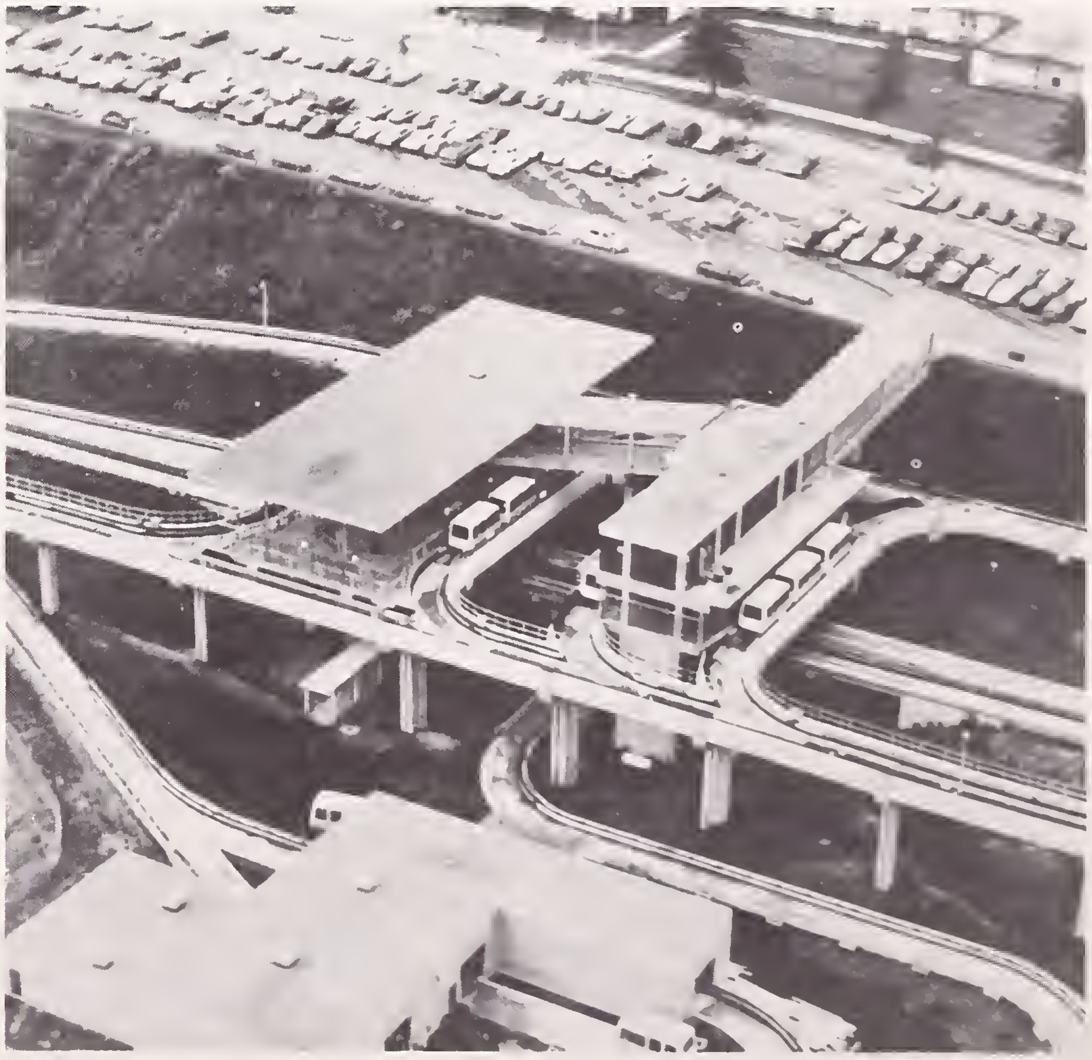
MPM stations were designed differently from conventional rapid transit stations. Each station is located off the main guideway with separate alighting and boarding berths and space for storage of vehicles awaiting a trip request. The design thus includes island platforms, with multiple straight-through or turn-around channels. The Beechurst station is the most complex, consisting of two island platforms, six channels, and multiple berths in each channel.

Technical Subsystems

The MPM has a number of highly technical subsystems, which the automated nature of the vehicles requires. The most important is the control and communication subsystem which has four principal components.

1. **Central control and communication**: Dual computers located in the control room monitor and manage all vehicle movements at all times.
2. **Station and guideway control**: Station computers control local vehicle operations such as switching, stopping, collision avoidance and door operation. Information is transmitted between vehicle-borne antennae and wire loops embedded in the guideway.
3. **Vehicle control and communication**: The vehicle executes commands received from guideway wire loops. The vehicle, however, controls all propulsion and braking internally. Once dispatched, vehicle speed and posi-

Exterior and Interior Views of the Morgantown People Mover Vehicle



Morgantown People Mover Stations

tion are the sole responsibility of vehicle-borne equipment.

4. **Collision avoidance system**: A redundant, fail-safe system of electronic blocks along the guideway insures that vehicles will not run into each other.

The computer manages vehicles on the guideway using a series of imaginary, continuously circulating points, separated by 15-second intervals. Vehicles are dispatched to merge with one of these moving points. Electric power is supplied to the vehicles through specially designed power collectors.

System Performance

By the end of June 1978, after 3 years of operation, the system had carried about 4.5 million passengers and had accumulated over 1.6 million vehicle-miles (2.56 million vehicle-km) in passenger service. The system has a theoretical line capacity of 5040 passengers per hour, but typically carries far fewer passengers. After a football game in October 1976, the MPM did carry about 3200 people in 45 minutes, which compared quite favorably with the design objective.

The average number of vehicles operated rose steadily from 17.6 vehicles in the first year to 21.2 during the third year. Each vehicle travels roughly 16,000-20,000 miles (25,600-32,000 km) per year.

Ridership steadily increased over time, doubling from the first year to the third year. The average weekday ridership in October 1977 was 12,800 passengers per day. The highest single ridership count on one day was 18,228. These ridership figures resulted in an average load factor of 29.2%. This is considerably higher than typical bus and rail transit load factors of 16% to 18%.

Slightly more than two employees per active vehicle were required for operation and maintenance in Phase I, a ratio slightly less than that required for a bus system. This is expected to decrease in the future.

Availability and Dependability

Availability and dependability are two items of major interest in the MPM project, because of the innovative automated nature of the project. As might be expected, the system did have initial problems, but improved steadily after passenger service began in October 1975.

MPM improvements can also be seen in an increase in the average time between breakdowns: first year — 3.3 hours, second year — 6.8 hours, and third year — 8.1 hours. The third year is a 245% improvement over the first year. Similar improvements were made in the time required to restore service after a failure occurs. Initially, it took an average of about 27 minutes to get the system operating again. In the second year this average was reduced to about 22 minutes, and 13 minutes in the third year.

Reliability and maintainability improved each year. By the end of Phase I, the "conveyance dependability," or the probability of a person riding the system without delay caused by a breakdown, was 98.1%.

Costs

The estimated capital cost of the MPM, Phase I, adjusted to 1978 dollars and excluding research and development costs, was $66.5 million. This figure roughly approximates what a similar system elsewhere would have cost to build without additional research and development expenses. Initial operating costs were high, as might be expected with the start-up of a very sophisticated first-of-a-kind system. As a result, operations and maintenance costs for the first year's operation, as reported by the Boeing Aerospace Company, were more than $3.00 per vehicle-mile ($1.90 per vehicle-km) traveled. As the system matured, these costs decreased significantly, and during the operational year, July 1977-June 1978, the cost per vehicle-mile was $2.35 ($1.47 per vehicle-km) at 1978 price levels. This resulted in a 1978 per passenger cost of $0.65.

Public Acceptance

An attitude survey of both riders and non-riders was conducted during April and May 1977. Major results were as follows.

- Both riders and non-riders considered the system to be generally satisfactory. The most frequently cited reason for not riding the MPM was that it did not take people where they wanted to go.
- Neither safety nor personal security appeared to be of concern to passengers.
- Most riders considered the appearance of the guideways and stations to be acceptable, but a sizeable minority did not.
- Vehicle comfort was found to be acceptable.
- The most frequent criticism related to system reliability. Many of the riders have been inconvenienced by frequent failure, but much of the criticism related to problems encountered during the first year of operation.

Safety and Security

The MPM system has experienced an excellent safety record with no fatalities and no major acci-

SUMMARY OF MORGANTOWN PEOPLE MOVER OPERATING STATISTICS

	Sept 1975 thru Aug 1976	Sept 1976 thru Aug 1977	Sept 1977 thru July 1978*
Total System Vehicle Miles	542,644	587,073	479,345
Total System Operating Hours	2,856.3	3,513.2	2,649.2
Active Fleet Size (Vehicles)	29	29	29
Average Operating Fleet Size (Vehicles)	17.6	19.5	21.2
Average Miles Per Operating Vehicle	30,832	30,106	22,611
Average Miles Per Active Fleet Vehicle	18,712	20,244	16,529
Total Passengers Carried	771,756	1,885,095	1,817,093
Total Passenger Miles	1,249,435	3,051,874	2,941,783
Average Load Factor (%)	11.0	24.8	29.2
Average Number of Passengers Carried Per Academic Year Day	2,691	5,730	7,571
Average Number of Passengers Per Weekday Carried in October— A Peak Month Without Holidays	4,071	11,700	12,800
Average Number of Passengers Carried Per Operating Hour	270	537	686
Greatest Number of Passengers Carried in a Single Day	17,116	18,228	16,442

*System operated only 3 days in July 1978, after which it was shut down for Phase II modification.

dents during Phase I. Similarly, no serious security problems or instances of criminal behavior occurred. There were a few incidents with pranksters. Most of these were successfully handled through the use of the close circuit TV or reports by passengers over the emergency telephone. Rerouting vehicles to stations or to the maintenance area allowed WVU campus police to apprehend the offenders in several instances.

MPM Phase I Assessment Conclusions

- The MPM system is expected to satisfactorily meet the University's requirements at the conclusion of Phase II.
- The off-line station type of operation used, while necessary for on-demand service, increases the in-station dwell time when the system is in the scheduled mode.
- For Phase I, the MPM system was programmed to provide on-demand service for off-peak periods (evenings) and scheduled service during peak travel hours. The computer algorithms for on-demand service were not efficient, requiring rewriting.
- System reliability steadily improved during Phase I. The time the system was out of operation was due, in part, to two factors: the severest winter weather experienced in recent history and the failure of ordinary production hardware items such as hydraulic fittings, valves, electrical power pick-up brushes and switches.
- The Phase I fare-gate and fare-card equipment caused more than twice as many maintenance repairs as the next highest problem

area. An improved fare gate was designed for Phase II.

- Overall user and non-user impressions of the MPM system were favorable; safety and security were not major concerns of the passengers.
- Negative attitudes appeared to reflect early experiences of frequent breakdowns during the first months of operation.
- Safety practices for maintenance personnel should also be reviewed. This review should include the adequacy of training regarding maintenance practices and operations in emergency situations.

ROOSEVELT ISLAND TRAMWAY SYSTEM ASSESSMENT

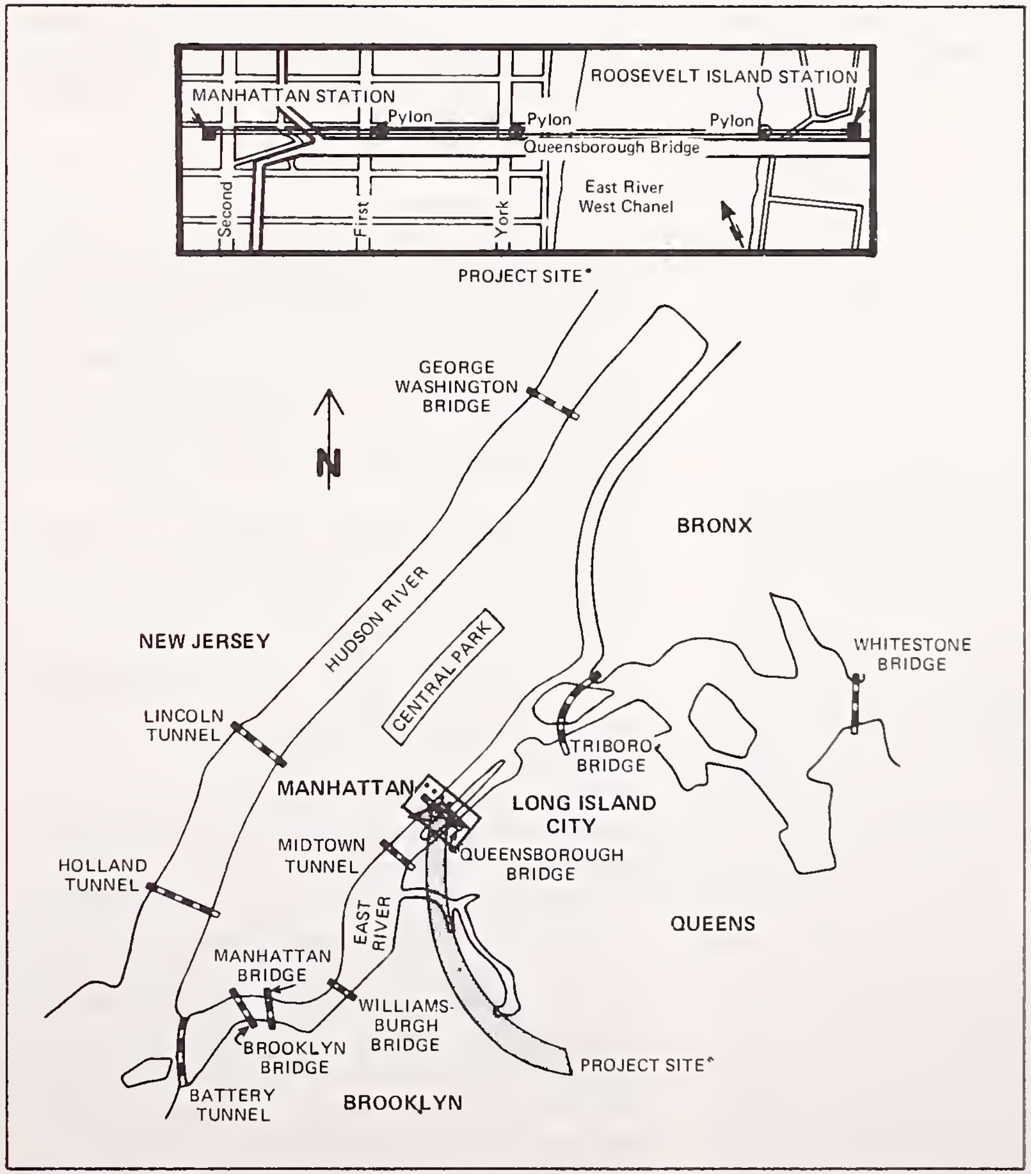
W. Bamberg, C.P. Elms, H.H. Hosenthien, W. Voss; N.D. Lea & Associates, Inc.

August 1979, UMTA-IT-06-0189-79-1, PB 80-129224, 209 pp.

Aerial tramway transportation via cableway is probably familiar to most people from pictures of ski resorts in the U.S. or Europe. In mountainous areas of Europe, cableways have been employed for many years, providing reliable local and even inter-city transport. In this country, cableways, sometimes called gondolas, have been used in ski resorts and other tourist attractions in mountainous areas. Although cables were used for propulsion in many street railway systems during the early part of the 20th century, there was no U.S. application of aerial cableway technology to urban transportation until recently. In 1976, the first such cableway began operation in New York City, providing passenger service between a new urban community on Roosevelt Island, in the East River, and Manhattan. This assessment of the cableway system investigated the technology, performance and passenger reaction, safety, and costs of construction and operation.

Development of the Project

Roosevelt Island is a new community which was developed by the New York State Urban Development Corporation (UDC). Situated on a small island, the project will eventually include about 5000 units of mixed-income housing plus some commercial and industrial activities. The entire is-



Roosevelt Island Tramway Location

land has been carefully planned as a balanced, integrated "new" community. Part of the entire development philosophy is that autos do not circulate on the island. It is small enough that walking is generally sufficient, although a fleet of small electric buses is also available. All autos entering the island must park in a mammoth garage at the bottom of the ramp from the Queensborough Bridge. Access to Manhattan could only be gained, initially, by taking the bridge first to Queens, and then reversing direction to Manhattan. This was difficult to do by either automobile or by the conventional New York City transit system.

A transportation solution, therefore, had to be found which would connect Manhattan directly with Roosevelt Island, would not be excessively expensive, and would be compatible with the somewhat protected environment of the Island. The aerial tramway system best met all of these requirements. It could be built using conventional technology, although urban application of the idea was new to the U.S. Electrically powered, it is quiet and non-polluting. Finally, it did not require extensive capital funds for construction.

A new subway station, connecting Roosevelt Island to the New York subway system, is scheduled to open on the island in 1984. This will eliminate much of the need for the tramway, although it will continue to operate as a tourist attraction.

The tramway was developed and is owned by Roosevelt Island Development Corporation, a subsidiary of UDC. A private firm actually staffs and manages the system. Construction was part of the overall Roosevelt Island project, which was mainly funded with bonds. Operating deficits also come out of the overall project budget. New York State has appropriated some funds which go to this project. The cableway, however, is not part of the New York City Transit Authority system and is not supported directly by UMTA funds.

System Description

The cableway has two stations. One is on Roosevelt Island, the other on Manhattan. The cableway is 3143 feet (1037 m) long, spanning the west channel of the East River. It is parallel with and next to the Queensborough Bridge. As shown in the accompanying map, the Manhattan station is located at the corner of E. 60th Street and Second Avenue.

Two vehicles, each running on a separate, parallel cable, travel back and forth simultaneously in a shuttle service, which operates about 20 hours per day. During peak hours, the vehicles go back and forth every 7.5 minutes, and in off-peak hours, every 15 minutes. Each vehicle has a capacity of 125 people and carries one attendant who controls the vehicle.

Three steel pylons, the middle one being 250 feet (75 m) high, support the cables. The vehicles themselves are 18 feet (5 m) in the air when they cross Second Avenue and are 140 feet (42 m) high when crossing the East River. Loading platforms at the Manhattan station, which is part of a 6-story building, are 18 feet (5 m) above ground level. The Roosevelt Island station is at ground level. This station contains all of the drive machinery and controls, while counter-weights for tensioning the cables are located at the Manhattan station.

Several redundant power sources are provided for the electrically powered cables in case of problems, including an auxiliary drive system and a rescue drive system. Normally, panels in the vehicles provide semi-automatic control; however, the vehicles can be operated, if necessary, from the central control panel located at the rear of the Roosevelt Island station. Telephone communication is provided between both vehicles and the stations.

System Performance

No major problems involving the cableway have been encountered since the start of passenger service in May 1976. The tramway technology utilized is the same as that found in recreational and mountainous areas.

About 5000 passengers ride the cableway each day, or about 1.8 million per year. Much of the ridership is Roosevelt Island residents commuting to Manhattan, although some consists of employees who work on Roosevelt Island. (A large hospital is located there.) A fair number of passengers, particularly on weekends, are tourists who want to ride the tramway, or who are visitors to Roosevelt Island. Ridership shows a fairly normal peaking pattern. System capacity, 1000 passengers per hour in each direction, is currently adequate for the peak demand.

The system is quite reliable. During a 1-year period, it had a total operating time of 7364 hours, and was disabled for only 124 hours. This yielded a system availability statistic of 98.3%. When combined with the possibility of encountering a delay, the average conveyance dependability was slightly lower, 96.7%. These statistics were felt to be well within the range of acceptability.

A variety of conditions were responsible for system breakdowns, when they did occur. The most common problem was bad weather, to which cableways are susceptible because of their exposed nature. Ice and snow accumulations on the cable are always a potential problem, against which most cableways have set up elaborate precautions. Compared to the mountainous areas where most cableways are found, the climate of New York City is relatively mild and this is not a serious problem. High winds can be a problem since the vehicle may be bumped against a pylon. Cableway operation is halted whenever wind velocity exceeds 45 mph (72 km/hr). Lightning is also cause for suspension of operation.

Passenger reaction to the system was not assessed directly, but the overall ride quality is acceptable. Vehicles experience no vibration and little noise, due to the off-vehicle power source. Although many people stand (seating capacity is 10), the trip is only about 3 minutes long. The vehicles are heated but not air-conditioned. Acceleration and deceleration are smooth, and there is little jerking.

Safety

Cable systems have evolved over a long time. Generally, they are considered as safe as other modes. Fire potential on board a tramway vehicle is low and no cases of on-board fires on this system have ever been reported. This is because nonflammable vehicle materials are used and power systems on board the vehicle are absent.

The Roosevelt Island cableway has had no operational accidents. All safety and security incidents, of which there were 11 during the 1-year assessment period, had to do with vandalism, crime, or people falling while using the system. Thus, overall, the system was quite safe.

BUDGETED OPERATING AND MAINTENANCE COSTS FOR THE PERIOD OCTOBER 30, 1977 TO NOVEMBER 1, 1978

Cost Category	1978 Dollars
Labor	725,000
General and Administration (including $800,000 insurance premium and franchise fee of 7% of revenues)	1,150,000
Utilities	110,000
Parts and Supplies	50,000
Repairs and Maintenance	25,000
TOTAL	2,060,000

Economics

As cable systems are "off-the-shelf" items, costs are fairly standard. The Roosevelt Island cableway vehicles and equipment cost $2 million, and constructing the stations and pylons cost $4.25 million, for a total capital cost of $6.25 million. Since the vehicles and equipment will last an estimated 20 years, and the stations and pylons 35 years, the equivalent annual capital cost is $675,600.

Operating costs are about $2 million per year. A substantial portion of the operating cost goes to pay for insurance. A $95 million liability protection policy has been required, which some consider to be excessively high. The total cost per passenger trip (including both capital and operating costs) works out to about $1.49 per trip.

The present fare is $.50, about one-third of the total cost. At current ridership levels, the system could pay for itself if fares were tripled. At current fare levels, the system would be self-supporting if the load factor were increased from 20% to 68.9%.

One unusual aspect of the construction cost was the Manhattan station. Not only was the station built on prime real estate, but special anchors had to be drilled into the rock to support the pulling of the cables. Also, the station was built strong enough to support a 32-story building that is to be built on top of the station. These requirements increased the cost of the station. Most other costs, however, were standard and probably could not be reduced very much.

Potential for Urban Applications

As demonstrated at Roosevelt Island, a cable system is suitable to transport people, under certain conditions, across artificial and natural barriers. This technology allows negotiation of steep grades and long spans at almost any height. Bodies of water, tall construction, expressways, etc., can be bypassed with relatively low construction effort.

Shuttle service between two stations is characteristic of aerial tramways. It is possible to have an intermediate station, but it must be located exactly halfway between the end stations, so that both vehicles can stop at the same time. For longer systems with additional intermediate stations, equal distances must separate all stations. One possible disadvantage is that each vehicle must stop at each station, and dwell time for both vehicles is determined by the vehicle with the longest load and unload time.

Capacity of aerial tramways can only be increased by having larger vehicles or higher speeds. However, speeds are limited. American National Standards Institute specifications allow a maximum speed of only 22 mph (35 km/hr) at clear spans and 17 mph (27 km/hr) when crossing pylons. The largest cable vehicle demonstrated to date holds 140 passengers, which is not much larger than the 125-passenger Roosevelt Island vehicle. Since only two vehicles can be on the system, headways will also increase as system length increases. On the Roosevelt Island system, the maximum line capacity is about 1800 passengers per hour. Thus, cable systems show overall promise in those circumstances where their operating characteristics are congruent with the needs of the application area.

SUMMARY OF CAPITAL AND OPERATIONS & MAINTENANCE COST EXPERIENCE OF AUTOMATED GUIDEWAY TRANSIT SYSTEMS: COSTS AND TRENDS FOR THE PERIOD 1976 - 1979 — SUPPLEMENT II.

Transportation Systems Center, U.S. Department of Transportation, UMTA.
March 1980, UMTA-MA-06-0069-80-1,
PB 80-146483.

The technology of automation can lead to fundamental changes in transit service concepts. Using automation instead of a driver, for example, allows for much smaller vehicles without diluting labor efficiency. Smaller vehicles weigh less and in turn allow narrower, less bulky, less expensive guideways. Maintenance of line capacity with small vehicles requires shorter headways, which can be achieved under automatic control. All these factors can drastically alter traditional transit capital and operations costs. Analysis of these costs will help determine how extensively AGT systems will be built in the future. This report supplements and builds upon the data presented in the original Summary Capital and Operations & Maintenance Experience of Automated Guideway Transit Systems report, published in 1978, and Supplement I, published in 1979.

Overview of AGT Systems

Well over 20 AGT systems have been constructed in the United States. With the exception of the Morgantown People Mover, all are in airports, amusement parks, or similar special-purpose locations. Size, configuration, type and cost vary widely among these AGT systems. Adequate and complete data are not available from all of the systems. The accompanying table shows the characteristics of the AGT systems for which data were available. Note that no two of the systems are exactly the same and that substantial differences do exist.

Although the systems are not completely comparable, efforts have been made to reduce the system operations and costs to reasonably similar units. For example, the concept of "equivalent elevated lane-miles" is introduced. An at-grade mile (1.6 km) is worth only 0.4 "equivalent elevated miles" (.64 equivalent elevated km), but an underground mile is worth 3.0 "equivalent elevated miles" (4.8 equivalent elevated km). This accounts for the differences in cost between at-grade, elevated and subway construction. Also, "equivalent passenger places" is based on the vehicle interior dimensions, rather than the somewhat arbitrary and widely varying seating arrangements used in the actual AGT systems.

Disclaimers on Cost Data

It is obvious that substantial differences exist between the AGT system settings and the typical urban environment. Morgantown aside, the AGT systems do not reflect many characteristics prevalent in urban application areas. For example, the AGT systems do not have to meet urban work-trip peaking patterns, and, therefore, were not sized for high demand peaks. There is no need for intermodal coordination, such as with buses, requiring additional station construction or station spacing considerations. No park-and-ride lots are needed. There is little, if any, vandalism and crime and few right-of-way acquisition costs. No problems are encountered impacting commercial businesses, disrupting neighborhoods with construction activity, or relocating utilities. All of these factors could come into play in an urban setting and, needless to say, increase costs.

Finally, urban transit construction is subject to delays and/or pitfalls during the institutional and political decision-making process which each project must run. Typical steps include local government concurrence, public hearings, bond issues, environmental impact statements, compliance with state and Federal regulations, labor union approval, and UMTA approval. These steps can add time and cost to AGT construction — costs which were not reflected in the "protected" systems assessed in this report. Thus, although data are available on the technology, many unknowns remain insofar as future AGT deployment in urban areas.

Capital Costs

Capital costs are those needed to construct and implement the system. The promise of AGT has been that lighter-weight guideways would be less expensive than conventional transit structures. Of course, the automation requires technically sophisticated command and control systems which are not needed in conventional transit. The trade-off between these two costs is of particular interest.

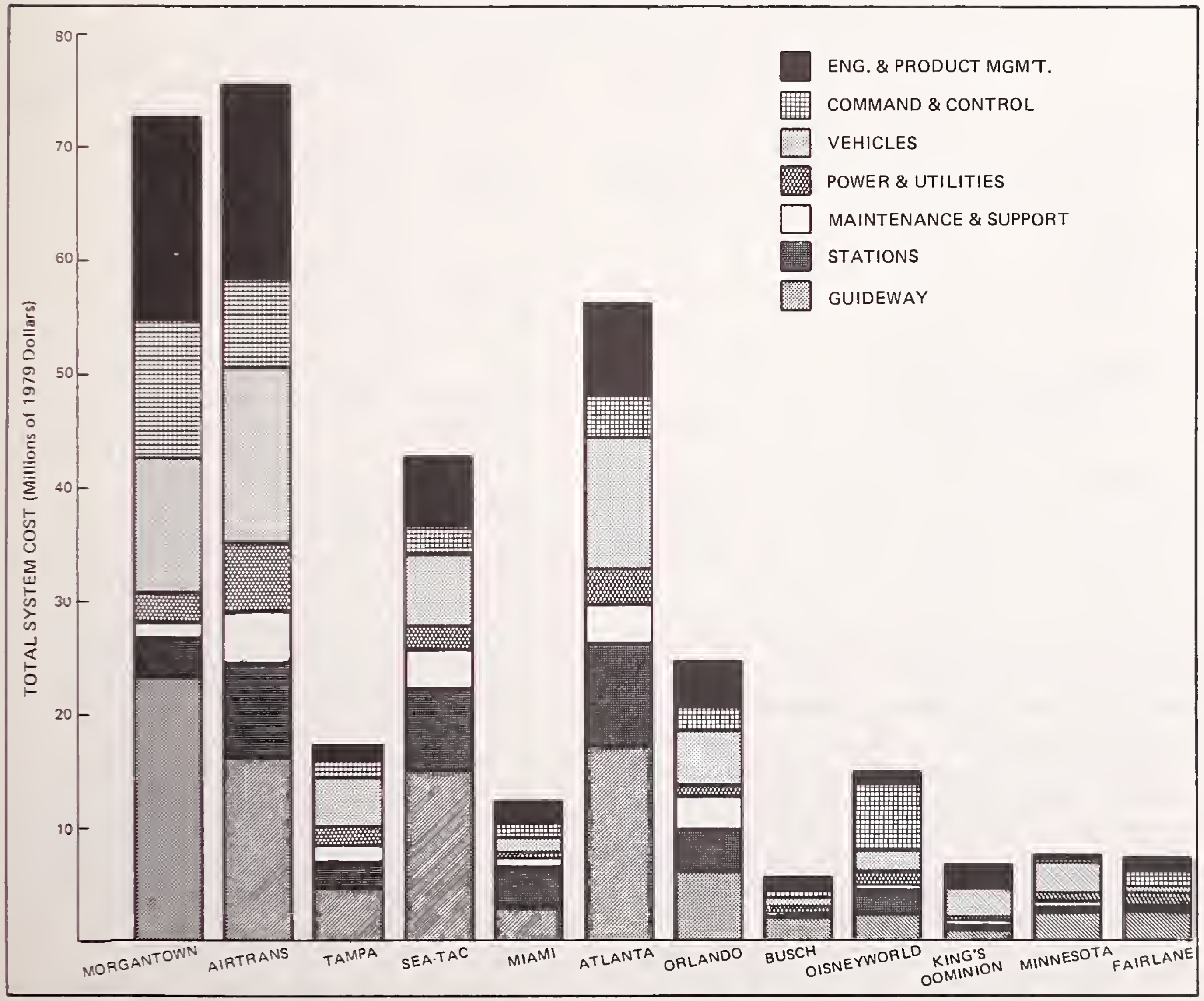
The accompanying chart shows a breakdown of total system capital costs for the AGT systems. Both Morgantown and Airtrans cost over $70 million, while some of the smaller systems cost less than $10 million. Costs have been broken down into the following seven functional areas: guideway, stations, maintenance and support facilities, power and utilities, vehicles, command and control, and

OPERATING AGT SYSTEM CHARACTERISTICS

SYSTEM	LOCATION	SUPPLIER	SITE DESCRIPTION	GUIDEWAY CONFIGURATION	GUIDEWAY LENGTH LANE MILES/* EQUIVALENT ELEVATED LANE MILES	NUMBER OF STATIONS	NUMBER OF VEHICLES	VEHICLE CAPACITY ACTUAL/ EQUIVALENT PASSENGER PLACES	PERIOD OF OPERATIONS	INITIAL SERVICE DATE
MORGANTOWN PHASE I	MORGANTOWN, W. VA	BOEING	COLLEGE CAMPUS	DOUBLE LANE LOOP	5.26/4.52	3	45	21/23	13 HRS DAILY 5.5 WEEKENDS	9/75
AIRTRANS	DALLAS, TX	VOUGHT	AIRPORT	SINGLE LANE MULTI LOOPS	12.8/6.66	28	51	40/42	24 HRS DAY	1/74
TAMPA	TAMPA, FL	WESTINGHOUSE	AIRPORT	DOUBLE LANE RADIAL PATTERN	1.35/1.35	8	8	100/81	18-24 HRS DAY	4/71
SEA-TAC	SEATTLE, WA	WESTINGHOUSE	AIRPORT	2 SINGLE LANE LOOPS SHUTTLE CONNECTION	1.71/5.13	6	12	102/81	20-24 HRS DAY	2/73
MIAMI	MIAMI, FL	WESTINGHOUSE	AIRPORT	DOUBLE LANE SHUTTLE	0.51/0.51	2	4	99/81	24 HRS DAY	UNDER CONSTRUCTION
ATLANTA	ATLANTA, GA	WESTINGHOUSE	AIRPORT	SINGLE LANE SHUTTLE	2.29/6.87	6	17	80/84	24 HRS DAY	UNDER CONSTRUCTION
ORLANDO	ORLANDO, FL	WESTINGHOUSE	AIRPORT	DOUBLE LANE SHUTTLE	1.48/1.48	3	8	100/84	24 HRS DAY	UNDER CONSTRUCTION
BUSCH	WILLIAMSBURG, VA	WESTINGHOUSE	RECREATION CENTER	SINGLE LANE LOOP	1.33/0.84	1	2	90/81	24 HRS DAY	5/75
DISNEYWORLD (WEDway)	ORLANDO, FL	WALT DISNEY ENTERPRISES	RECREATION CENTER	SINGLE LANE LOOP	0.87/0.87	1	30,5 CAR TRAINS	20 TRAIN/ 29 TRAIN	10-17 HRS DAY**	7/75
KING's DOMINION	RICHMOND, VA	UNIVERSAL MOBILITY	RECREATION CENTER	SINGLE LANE LOOP	2.06/0.88	1	6,8 CAR TRAINS	96 TRAIN/ 109 TRAIN	10-12 HRS DAY**	4/75
MINNESOTA ZOO	APPLE VALLEY, MN	UNIVERSAL MOBILITY	RECREATION CENTER	SINGLE LANE LOOP	1.36/1.36	1	3,6 CAR TRAINS	94 TRAIN/ 160 TRAIN	8 HRS DAY**	8/79
FAIRLANE	FAIRLANE, MI	FORD	SHOPPING CENTER	SINGLE LANE WITH DOUBLE LANE BYPASS	0.61/0.61	2	2	24/27	12.5 HRS DAY	3/76

*To convert miles to kilometers multiply by 1.6.

**Annual average



Capital Cost Breakdwon of Selected Operating AGT Systems (1979 $)

engineering/project management. Guideway costs are usually the largest of the seven components, but do not constitute a majority of total capital costs. Due to differing dates of construction, all costs in the chart have been normalized to a uniform 1979 price level by using the consumer, producer, and engineering-construction price indices.

When placed on a per lane-mile basis, AGT system costs still show considerable variation. The underground Sea-Tac AGT was the most expensive – $25,391,000 per mile ($15,869,375 per km). King's Dominion was the least expensive – $3,355,000 per mile ($2,096,875 per km). When placed on an "equivalent elevated lane-mile" or "equivalent elevated lane-kilometer" basis, some, but not all, variation is taken out. Cost ranges from $8.9 to $15.1 million per "equivalent elevated lane-mile," ($5.6 to $9.75 million per "equivalent elevated lane-kilometer") and averages $9.8 million ($6.1).

AGT systems vary in capacity, and it would be expected that capacity would affect costs. When capacity is measured by "equivalent place-miles per hour," there is a fairly linear relationship between total system cost and capacity. The average was $5000 per equivalent place-mile ($3125 per equivalent place-km) per hour.

Guideway costs, the single greatest cost component, do much to determine overall system cost. The AGT guideways varied in dimension, weight, material, construction technique, and other site-specific factors. The analysis found that some factors correlated better with cost than others. Beam shape was important. Longer span lengths led to lower unit costs. Bigger vehicles increased unit costs. Unit costs increased rapidly if overall guideway length was less than 2 miles (3.2 km).

Vehicles also affect costs significantly. The vehicle design, weight, and technology varied among sites and thus affected the cost. Vehicle weights ranged from about 4000 pounds (1800 kg) to over 47,000 pounds (21,150 kg). Most are bottom-supported vehicles propelled by electric motors; however, Disneyworld employed a passive vehicle with a linear induction motor on the guideway. No specific correlations could be calculated for vehicles. Aside from guideways and vehicles, cost differences were due to differing technologies and site-specific situations.

Operating Costs

Operating data were compiled for four of the five major U.S. AGT systems for 1979. (Morgantown was not included because it was shut down for expansion.) These four operated 85% of all U.S. AGT vehicle-miles. The four systems have all been operational over 4 years, thus allowing time-series analysis and confidence in the stabilization of the data. The data have been adjusted to 1979 levels by using the consumer price index to account for inflation.

The accompanying tables summarize the 1979 operating costs for each system and some derivative statistics. For consistency, systems are compared on the basis of "equivalent vehicle capacity," assuming that 67% of all passengers always stand. The average weighted operating cost works out to $.99 per vehicle-mile ($.62 per vehicle-km) of travel. The total 1979 operating costs are broken down into four major cost categories. Most of these costs go into system maintenance, particularly labor, contract services, and materials. Electricity is also a factor. Although 1978 costs are not shown, the 1979 costs per vehicle-mile were actually a bit less than in 1978, when adjusted for inflation.

1979 AGT OPERATIONS AND MAINTENANCE COST BREAKDOWN

	AIRTRANS	SEA-TAC	TAMPA	DISNEYWORLD
LABOR				
Operations	$ 261,510	$ 81,600	$ 4,460	$135,690
Maintenance	1,614,300	410,760	11,140	37,670
UTILITIES				
Electricity	276,300	16,320	76,790	52,660
Other	–	–	–	–
MATERIALS & SERVICES				
Contract Service	–	111,830	466,300	13,330
Spare Parts & Materials	895,665	99,190		46,830
GENERAL & ADMINISTRATIVE	249,225	–	12,770	17,120
TOTAL (1979 Dollars)	$3,297,000	$719,700	$571,500	$303,300

Operating Cost Trends and Comparisons

The accompanying graph plots operating costs per vehicle-mile over time. Both AGT systems and industry averages from conventional transit are shown. Two conclusions can be drawn from this graph. First, AGT operating costs are lower than conventional transit operating costs by a factor of over 50%. Reasons for this include:

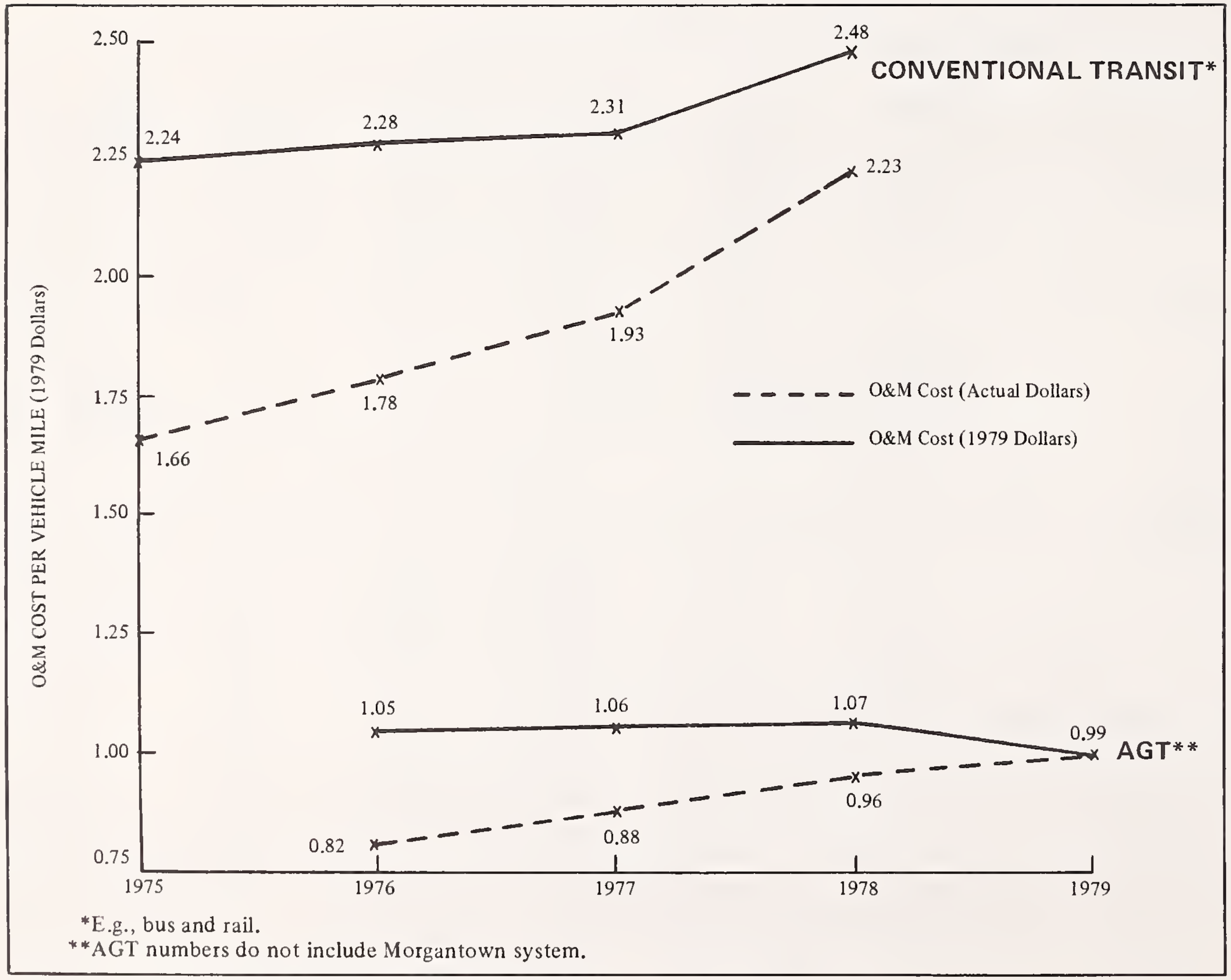
- lower unit vehicle operating costs because more vehicle miles and hours are generated by the relatively small size vehicles;
- lack of on-board drivers;
- the tendency of AGT system wages to be lower than conventional transit wages;
- lower maintenance costs per vehicle-mile travelled; and
- smaller administrative staffing requirements.

Second, AGT operating costs are increasing more slowly than inflation, and conventional transit costs are increasing faster than inflation. Much of this is attributable to the same complex of factors and to increasing maturity and experience with AGT systems.

In summary, this report shows that AGT systems currently cost less to operate than conventional transit services. It is important to recognize,

1979 AGT OPERATIONS AND MAINTENANCE SUMMARY

	Airtrans (A)	Tampa (T)	Sea-Tac (ST)	Disneyworld (D)	4 Systems (Total)	4 Systems (Average)
Total O&M Cost ($)	3,297,000	571,500	719,700	303,300	4,891,500	1,222,875
Vehicle Miles Traveled (VMT)	3,358,000	412,000	528,500	621,100	4,919,600	1,229,900
Active Vehicle Fleet/Equivalent Vehicle Capacity	51/42	8/81	12/81	30/29	101/233	25/58
Active Fleet Capacity (places)	2142	648	972	870	4632	1158
Place Miles Traveled	141,000,000	33,400,000	42,800,000	18,000,000	235,200,000	58,800,000
Passengers Carried	6,745,300	16,356,000	7,011,830	5,017,203	35,130,333	8,782,583
Total No. of Employees	107	7	19	12	145	36
O&M Cost Per VMT ($)	.98	1.39	1.36	.49	N/A	.99
O&M Cost Per Vehicle Operated ($)	64,600	71,400	60,000	10,110	N/A	48,915
O&M Cost Per Unit of Fleet Capacity ($)	1539	882	740	349	N/A	1056
O&M Cost Per Place Mile ($)	.023	.017	.017	.017	N/A	.021
O&M Cost Per Passenger ($)	.49	.03	.10	.06	N/A	.14
O&M Cost Per Employee ($)	30,800	81,600	37,900	25,300	N/A	33,969
Employees Per Vehicle	2.1	.88	1.58	.4	N/A	1.44
Place Miles Per Employee	1,318,000	4,711,000	2,253,000	1,500,000	N/A	1,633,333



Operations and Maintenance Cost Trends for AGT and Conventional Transit

however, when comparing the operating and maintenance costs of AGT and conventional transit systems, that such comparisons are relevant only when all modes provide the same type and level of service. Existing AGT systems provide circulation service in relatively small, specialized activity centers in contrast to conventional transit systems which frequently provide regional or corridor service. The simplified comparisons on a cost per vehicle-mile basis presented in the report indicate an overall contrast between the modes. Site-specific analyses involving an area's individual transportation service requirements would present a more accurate picture of costs at a particular location.

AGT AESTHETICS – A HANDBOOK FOR PLANNING AND DESIGN OF AUTOMATED GUIDEWAY TRANSIT (AGT) SYSTEMS

Skidmore, Owings & Merrill.
February 1980, UMTA-IT-06-0165-79-2,
PB 80-173584, 114 pp.

In spite of its promising technology, whether or not automated guideway transit (AGT) systems become a widely accepted mode in urban areas will depend in part on how they are perceived by passengers and the citizens of communities which surround them. Although AGT systems can be built underground and at grade level, constructing transit systems as elevated structures is usually less costly and less complicated. Consequently, this method is currently receiving the most attention from transportation planners, designers and engineers. Elevated public transportation facilities, such as elevated trains, however, have had devastating effects in some communities in the past. The noise, dirt, and shadows cast by elevated structures, as well as barriers created by them, were destructive to neighborhoods and some business areas, although the transportation they helped provide was a key to economic growth in urban areas. Careful planning of AGT facilities, as well as the advanced design characteristics of AGT itself, can lessen or prevent many of the negative aspects of old elevated transit structures and also at-grade railroad rights-of-way. This handbook provides guidance for architects, engineers, planners and others who are concerned with designing attractive, non-disruptive fixed guideway facilities. The handbook identifies aesthetic issues pertinent to fixed guideway systems and discusses different techniques for solving or minimizing aesthetic problems.

Aesthetics, for the purpose of this handbook, are defined as the result of the interactions of a particular transportation system with its physical and social environment, that is, how it is perceived in relation to the particular area through which it travels. The major aesthetic effects are visual, although other problems, such as noise, are also addressed.

The impact of a transportation system depends, in part, on its environment. The report describes three general types of areas in which AGT systems could be placed; central business districts or downtown areas; corridors, such as limited access highways, arterial roads and railroad rights-of-way; and activity centers such as campuses, airports, and shopping and office complexes. Discussions on five types of aesthetic effects form a major portion of the handbook.

Visual Compatibility

These issues include both questions of visual congestion, or how cluttered an area looks, and compatibility or how well the system fits into its environment. Compatibility with the environment depends on the size and scale of the system as well as adjacent land use and the compatibility of materials, colors and textures.

Visual compatibility issues are important in all three settings, although the specific problems are different. In downtown areas, streets are frequently crowded with utilities, lights, signs, traffic signals, vehicles and pedestrians. The pre-World War II facades in many older areas may be incompatible in scale and texture with the designs that are currently available.

In corridors, visual compatibility is highly dependent on the physical characteristics of the individual corridor. Construction along rail rights-of-way, for example, would usually result in more visual congestion than construction of AGT facilities along an expressway, because rail rights-of-way are narrower. Visual congestion in corridor areas could be caused by buildings close to the guideway, strip development in the area of the guideway and numerous exit ramps from the corridor itself.

In activity centers, an AGT system may not fit with the older historic image of some college campuses, for example, or with fully developed, landscaped office parks, but can, on the other hand, give a sleek modern look and a special identity to a developing activity center.

Light and Shadows

Two of the most noticeable effects of implementing elevated systems are alterations of light and shadow patterns. These effects include shadows created by the elevated structure and the nighttime lighting on and around the structure. Shadows created by elevated guideways are most likely to be troublesome in older downtown areas with narrow streets and high-rise buildings. Introduction of an elevated system in areas of this type could result in the elimination of all direct sunlight at street level.

Shadow problems are not as significant along corridors as in downtown areas, except in densely urbanized portions. Artificial nighttime lighting, however, could be intrusive in residential areas adjoining a guideway.

Views

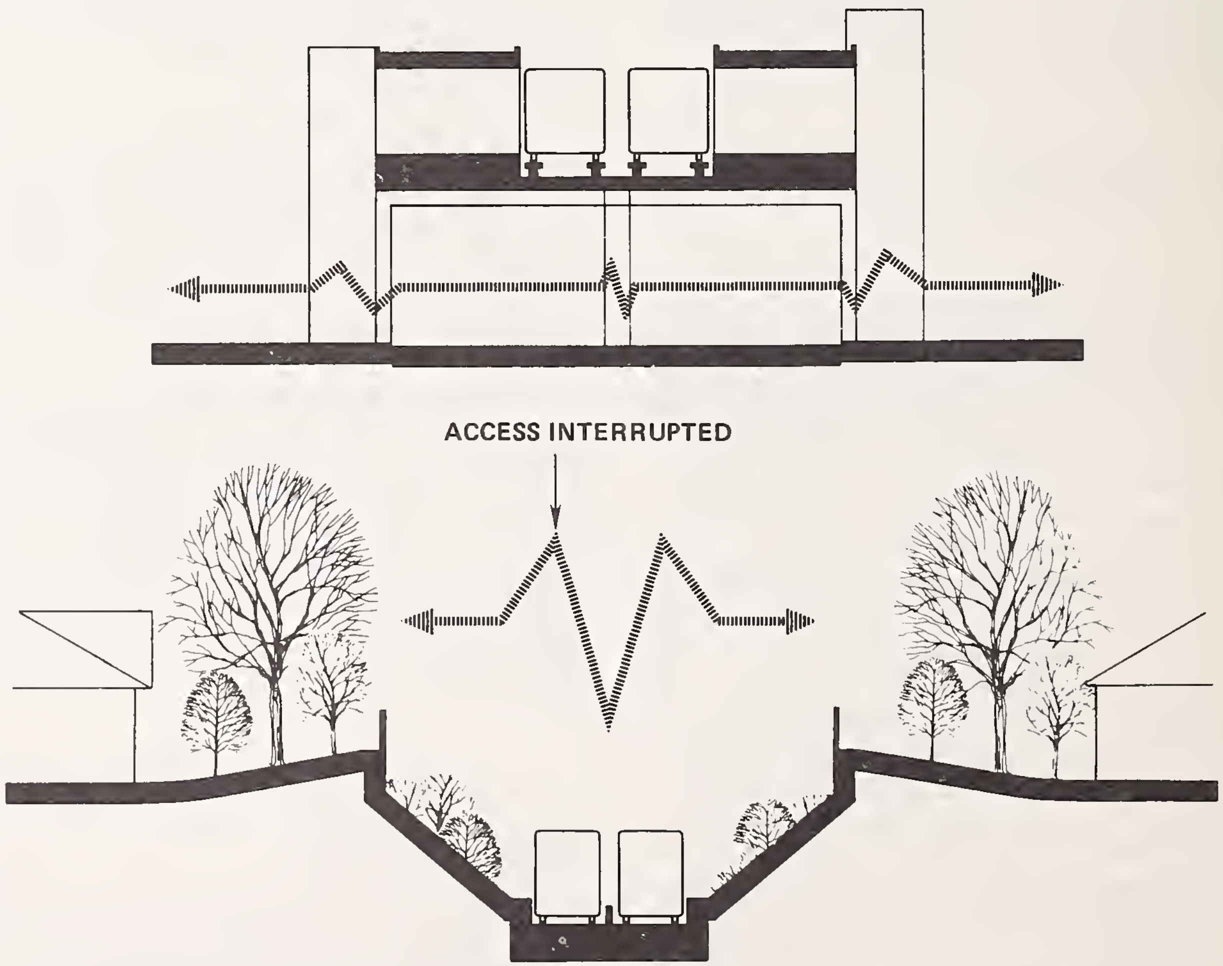
Fixed guideway systems can affect the view of an area by cutting off pleasant vistas or interfering with important sight lines. The effects of the view from a system itself must also be considered. For those in residential areas adjoining a guideway, the system can mean a loss of privacy.

Elevated structures can block views of pleasant surroundings, historic buildings or places, and familiar landmarks. Negative impacts on views and sight lines are more likely to be a problem in downtown areas than in other settings because of the higher population and building densities.

Disruption

Disruption caused by the barrier effects of an elevated or depressed guideway could be a problem in any setting. Elevated structures can create visual barriers while depressed guideways may create physical barriers and access problems across the right-of-way. Significant disruption problems can also be created during construction. Although these problems are temporary, the ripple effects of the temporary disruption can be long term.

In downtown areas, the most serious disruption can occur where elevated structures divide a cohesive residential community or obscure or detract from store fronts. In corridors, guideways can create barriers to pedestrian and vehicular transportation, as well as psychological barriers in communities.



In elevated systems columns and vertical circulation may be barriers to access. When depressed, the open cut becomes a barrier to access.

Barriers Created by Elevated and Depressed Guideway Systems

Development

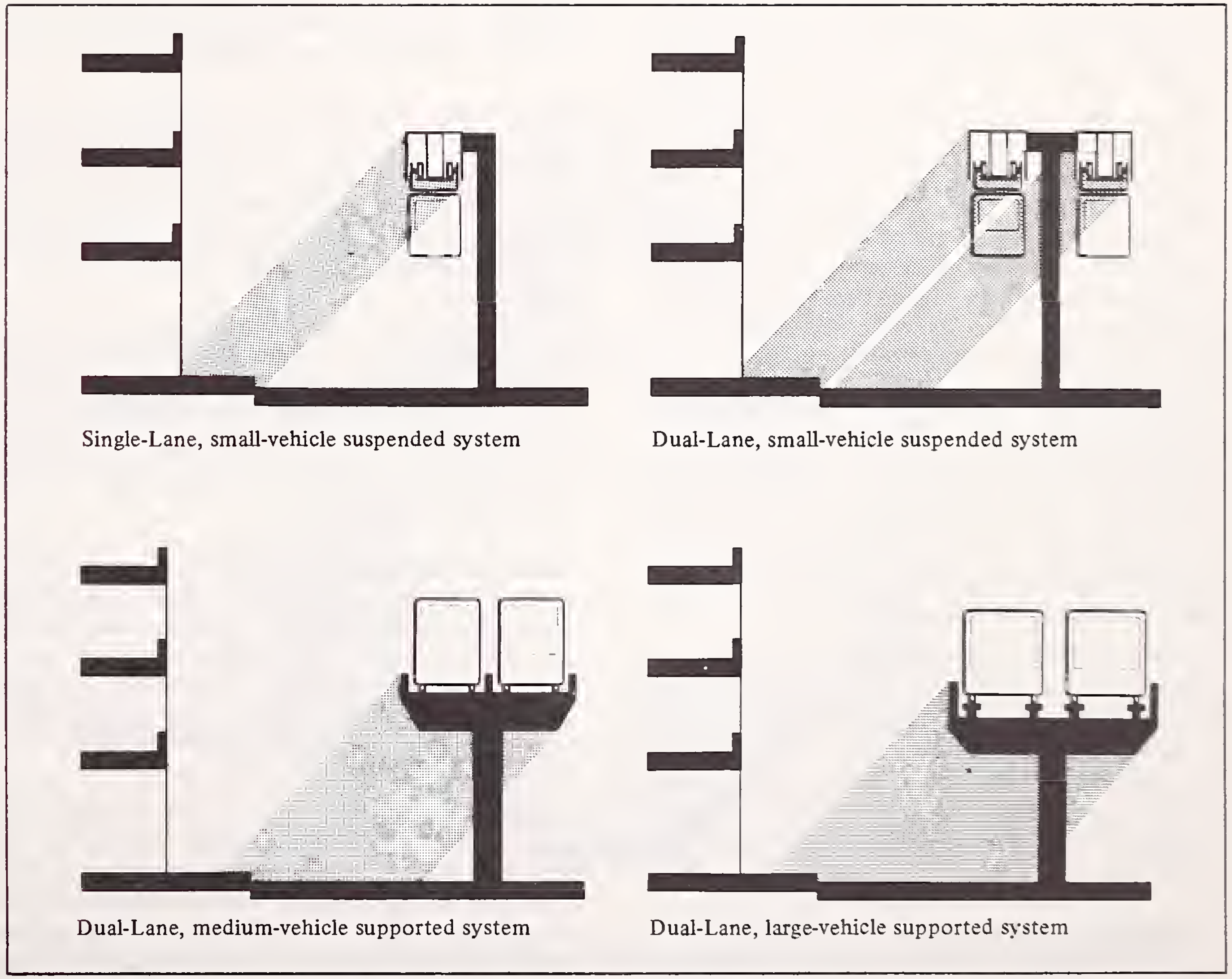
Fixed guideway transit can affect development in all settings. The most significant aesthetic effects on existing development will occur where all or part of the system is incorporated into existing buildings. Joint development, where an AGT system is used as a major feature of new development or where it is integrated into older buildings, is a promising method of making systems work aesthetically. Integration of the system into buildings will not only hide the guideway and support elements of the system but will also ensure that pedestrian access is fast and easy. Development issues also involve the aesthetic effects of necessary parking and pedestrian facilities.

Making the System Work Aesthetically

The handbook defines eight areas in which planners and designers can work to reduce or avoid negative aesthetic impacts caused by fixed guideway system deployments. These eight areas are not mutually exclusive, but overlap. They are:

1. Technology choice;
2. Vertical alignment – will the system be elevated, at grade, or depressed in an open cut or tunnel;
3. Guideway location and design;
4. Station location and design;
5. Parking facilities location and design;
6. Landscaping, lighting, and signage;
7. Street and sidewalk modification; and
8. Joint development.

Technology Choice – How much a fixed guideway system affects its environment depends in large



The Size and Configuration of the Guideway as well as the Number of Lanes will Affect the Amount of Shadow Cast

part on the type of technology which has been selected. Three general types of AGT systems are currently available: suspended or supported small vehicle systems, supported medium-size vehicle systems, and supported large-size vehicle systems. The type of system selected will affect guideway dimensions and station types. Of course, larger, bulkier systems will have a greater impact on surrounding areas than will smaller systems. There are many factors bearing on the choice of technology including climate and safety as well as expected passenger volume and desired level of service.

Vertical Alignment is of major importance when considering the aesthetics of a transit system. The impact of an elevated system is greater than those constructed at grade. (At-grade construction is not discussed in detail in this handbook.) Guideways can also be placed in open cuts, that is, open below-grade guideways. Open cut construction will reduce the visual impact of the system.

Station Location and Design can be varied in response to local conditions even more than the guideway itself. Stations can be located out of important sight lines in less obtrusive areas, balanced with the need to make them visible and accessible to riders. Three types of stations that can be built on two-lane guideways are illustrated. Split station layouts require more space than center platform layouts.

Parking Facilities are an important part of the overall system design, whether they be a multi-storied parking garage in a dense urban setting or a simple at-grade lot in a suburban area. Wherever parking lots are located, they should be designed to cut down noise and visual clutter. In addition, adequate provision for pick-up and drop-off traffic for automobiles, taxis and buses should be made.

Landscaping, Lighting, and Signage – Although guideways and stations are the most prominent components of an AGT system, the overall perception of it is likely to be heavily influenced by the landscaping, lighting, and signage at ground level, where it is exposed to both users and the general public.

Elevated guideways could be used to carry the lighting and signage of a street in a downtown area to reduce the ambient visual clutter, although this might make the guideway seem bulkier. The guideway could carry traffic signs and signals, street lighting, telephone and low-voltage electrical lines and even commercial signs.

Street and Sidewalk Modifications – Installation of a fixed guideway system may make it possible in some areas to limit or even eliminate vehicular traffic, thereby creating pedestrian malls and parks. Other street and sidewalk modifications can make pedestrian traffic in the area of the guideway safer, pleasant, and uncomplicated.

Joint Development – As mentioned earlier, joint development is a highly desirable method of constructing fixed guideway systems. Unfortunately, it requires a high degree of cooperation among public agencies and the private sector that may be very difficult to attain in some areas. The best candidate areas for joint development are in planned new major developments. Activity centers such as airports offer much more joint development potential than downtown or corridor facilities because they usually involve fewer landowners and developers, fewer public agencies and usually a simpler system network.

Analyzing Aesthetic Effects

Because AGT is a new technology that has not, as yet, been deployed widely, transportation planners and designers do not fully understand its aesthetic effects in all possible environments. Several techniques, however, have been developed to assess and evaluate these effects in areas where they might be constructed. Methods for involving the community in the study of the effects and for helping people visualize what systems will actually look like in a particular setting are discussed in the handbook.

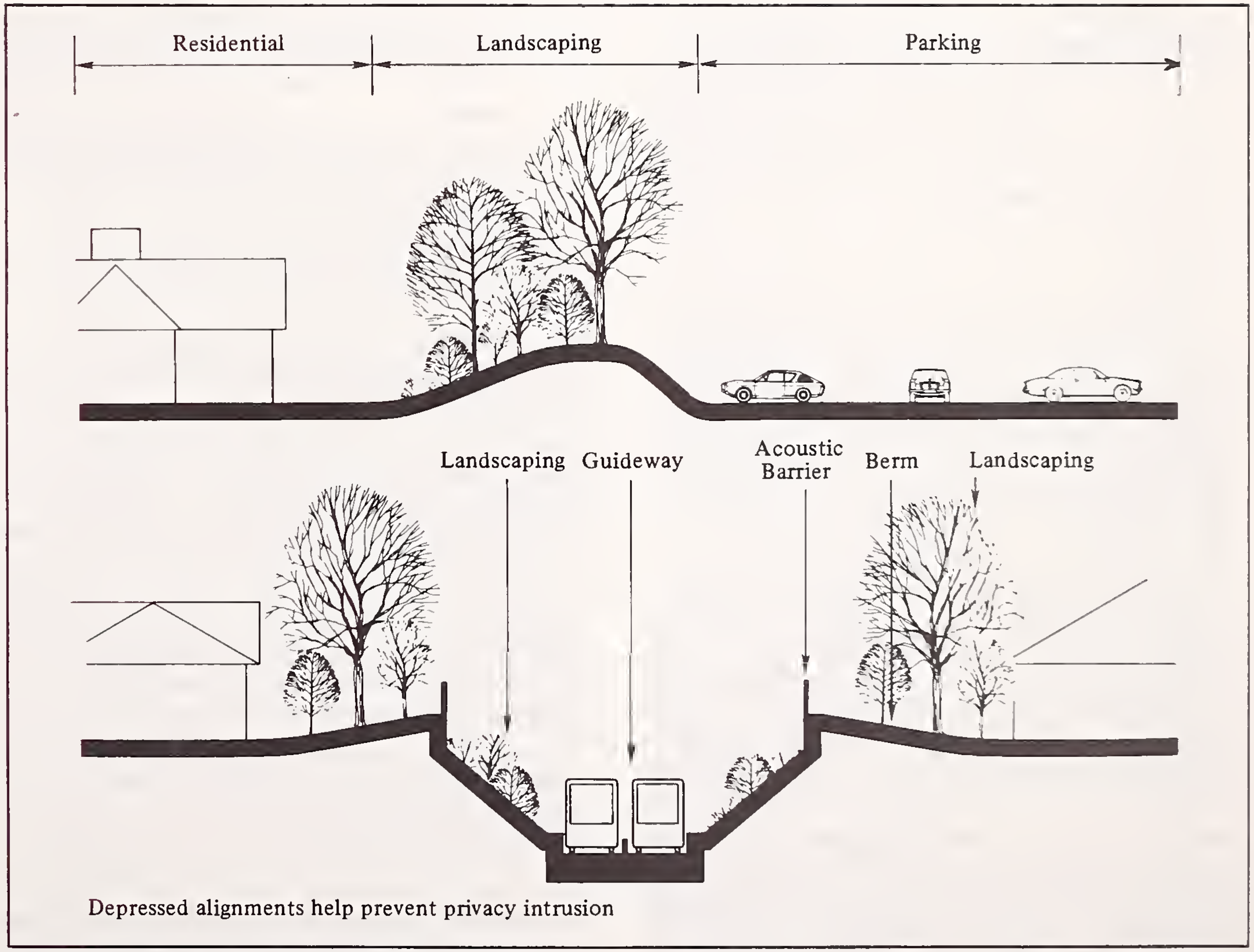
The specific aesthetic analysis techniques are similar to those used in other environmental assessments and urban design studies, such as for a new highway. These methods assume a general familiarity with environmental planning and urban design. The handbook identifies a five-step process for analyzing alternative applications. They are:

1. Assemble data on existing urban design and the proposed system;
2. Identify potential effects;
3. Measure these effects;
4. Evaluate the significance of the effects; and
5. Identify measures to mitigate the negative impacts.

Community Involvement

Community involvement is a major source of information to designers about how the public perceives its environment. Community self-perceptions may be very different from those of transportation planners, and, therefore, community involvement is vital to successful implementation of a transportation system. Both potential users and other residents who would be affected by the system, such as business owners, should be involved in the evaluation of various system proposals.

Methods of displaying various design alternatives to the community and for review by planners for aesthetic issues are also discussed. These methods include scale models, drawings, system mock-ups, photomontages, film, charts and computer graphics.



Landscaping Can Be Used Around Fixed Guideway Systems to Ensure Privacy, Cut Noise, and Block Out Unpleasant Views

AN ANALYSIS OF THE MARKET FOR AUTOMATED GUIDEWAY TRANSIT

G. Kocur, D. Nagin and P. Reid, and D. Smith, R. Henderson; Cambridge Systematics, Inc., and Skidmore, Owings & Merrill and National Analysts.

November 1980, UMTA-IT-06-0165-79-1. (3 Vols.)

Analyses of where and to what extent automated guideway transit (AGT) systems may be effective, feasible, and acceptable to the general public are very useful to those reviewing current and projected urban transportation needs and potential solutions. Answers to these questions are also useful in transportation planning and as a justification for the directions of government transportation research and development activities.

Actual markets for AGT systems are subject to many factors which are difficult to quantify in a research report. These variables often involve local issues and personalities and may be influenced by judgements that are not susceptible to cost-effectiveness analysis. This document reviews a number of potential sites for AGT systems in three diverse cities. The organizations most directly responsible for transportation planning and decision-making in these cities helped choose specific sites and identified issues most relevant to possible AGT deployment. These findings form a basis for national estimates of the potential market for automated guideway systems.

Study Approach

Three general activities were undertaken for the market research performed in this study:

- a national estimate of the potential market for implementation of automated guideway transit (AGT), based on data from 46 urban areas;
- eleven site-specific alternatives analyses within three urban areas: Atlanta, Dallas, and Chicago; and
- a two-phased consumer survey to determine individual preferences toward AGT.

The three case study cities selected provide variety in size, geographical location, density, and institutional structures Chicago, a large dense metropolitan area with a complex institutional setting, is roughly representative of the class of cities including New York, Boston, Philadelphia, and Washington, which have similar densities and established transit systems. Dallas, the second case study city chosen, is a large, lower density city, without an existing fixed-guideway transit system. It has a simpler institutional structure and a healthy economy, which make it an excellent study of joint public and private participation in defined area projects. Atlanta is currently constructing a regional rapid transit system and can provide realistic assessments of many issues involved in planning and constructing a major new transit system.

A series of meetings was held in each case study city involving a number of local groups. These groups often included a metropolitan planning organization, a regional transportation authority, municipal groups and private developers. The general public was not involved in these meetings, although a home survey was taken to obtain public opinions.

At the first meeting specific sites within each of the cities were selected. A total of eleven sites representing a variety of potential application areas were chosen: four in Chicago, five in Dallas, and two in Atlanta. Together, the sites represented a wide range of potential application areas.

The case study techniques used were similar to those actually used in transportation planning but with a reduced level of technical analysis and limited public participation. The objective of the case study effort was to obtain local reactions to these key AGT questions:

- Are AGT costs, performance and service levels appropriate for the sites examined?
- Are automated transit and the guideways themselves acceptable to the local public, labor, and government?
- Under what circumstances or policies would local bodies involved in transportation decision-making implement an AGT system?

A series of transit alternatives were defined for each case study. In activity centers, the alternatives were typically the existing transit service, shuttle bus systems, and AGT. In corridors, alternatives were existing transit services (usually bus), AGT, light rail, and sometimes exclusive busways. Operating policies and route alignments were designed to conform with actual operating policies of the region being examined.

The AGT mode considered in the market analysis could best be described as a shuttle loop transit (SLT) system. The service was presumed to have online stations, minimum headways of 60 seconds or longer, vehicle capacities of between 20 and 50 passengers. and maximum speeds of 40 mph (64 km/hr) in most applications.

Enough data were collected at each site to model the cost and travel demand for each alternative. Data which were collected at each site included zonal trip and socio-economic data, transit and auto network data, and current ridership and cost figures. A sketch-planning technique using models and parametric levels of demand was then used to generate estimates of service level, ridership, revenues. costs, and selected environmental impacts.

The results of these case studies were used to determine local reactions to the estimated impacts and to discuss deployment potential at the case study sites. These findings provided guidance in establishing more abstract national market estimates. Cost and benefit analyses provided the basis of these estimates which also considered impacts of the less quantifiable issues.

The AGT market was estimated in three different categories: central business districts (CBDs); corridors; and major diversified centers (MDCs) including shopping centers, airports, and medical centers. Area-wide applications were not specifically included because it was felt that the possibility of such deployments is remote in the near-term future. A 15-year time horizon was adopted, yielding a relatively short-term market estimate.

In each site, an analysis was made of the existing travel patterns via transit and automobile, and possible ways in which an AGT system might be constructed. Varying alignments were studied and compared with conventional bus service. Based on existing land use and densities, opportunities for future joint development projects were studied. Also, aesthetic and institutional aspects of the problem were investigated. Demand and costs were estimated and an overall evaluation of AGT potential was made.

Chicago Case Studies

Four sites in the Chicago area were considered:

The North Michigan Avenue/Illinois Central Air Rights site is a busy retail and office area in central Chicago. It encompasses part of the residential Gold Coast in the north side and touches the northern edge of the Loop. Currently, it is not served by a fixed guideway transit system.

Merrillville is an expanding suburban center located in northwestern Indiana. It includes low-density, "office-park"-type buildings including hotel, medical, office, and retail facilities.

Oak Brook is another suburban center located about 20 miles (32 km) west of downtown Chicago. It includes a shopping mall complex and an office park interspersed with hotel, medical, office, and retail facilities.

The State of Illinois Medical Center contains 100 health care, educational and research facilities. It is located on the west side of the city of Chicago.

The North Michigan Avenue site was found to have the highest potential for AGT because of its high density land use and resultant high travel demand. However, the visual impact of an elevated guideway running north and south conflicts with the character of existing neighborhoods and buildings. Possibilities for replacing existing bus service are low because there is little incentive for the transit operator to switch. An east-west alignment would provide potential for future joint development in currently under-utilized land.

At the Merrillville site, bus service proved to be more feasible than AGT service under existing conditions. Although the area is still expanding, demand for internal circulation did not justify the cost of AGT. Neither the private developer nor the local town officials could fully support the costs. An AGT system, however, could be more feasible in the future due to its higher level of service.

The Oak Brook site was considered inappropriate for AGT. There is only a single retail center at the site, and consequently little internal travel flow. The need for AGT is therefore absent. Also, the layout of Oak Brook is linear and a fixed guideway was felt to be visually incompatible.

AGT was found to be inappropriate at the Medical Center site because of the high costs of the system, low ridership under current parking policies, personal security concerns and anticipated lack of interest by medical institutions due to their independence. As in the Oak Brook site, there is relatively little internal circulation and the system costs could not be supported by the medical institutions.

Atlanta Case Studies

In Atlanta, two high-density corridors with several major activity centers not included in the current regional rapid rail transit network were chosen.

The North Corridor goes from Atlanta to the suburb of Sandy Springs. It is 9 miles (15.4 km) long, contains concentrated residential and commercial activities, and connects to the proposed Lenox station on the MARTA rapid rail system.

The Southeast Corridor is in a medium-density suburban area with single-family, apartment and retail uses. It focuses on Decatur, a community east of Atlanta.

The same analytic approach was followed here as in the Chicago case studies. The only difference was that these case studies were corridors with travel patterns markedly different from those in activity centers studied in Chicago.

In the North Corridor, AGT ridership did not differ significantly from the other alternatives. Most of the travel is CBD-oriented, and passengers are expected to use the future MARTA rail line. Thus, the alternatives considered – AGT, light rail transit, and improved bus – did not differ markedly because their relative differences in service level for a downtown trip were small. Improved bus was the least expensive alternative, and it attracted almost as much ridership as AGT and light rail transit. Also, the bus alternative would have the least effect on the community's physical character.

In the Southeast Corridor, it is unlikely that AGT or any other fixed guideway system will be implemented for some time. Due to the low level of corridor employment and lack of appropriate rights-of-way, an AGT system would not fit easily in this corridor. Most of the region's resources are concentrated on the task of finishing the MARTA rail system, which will go to Decatur. In addition it was felt the elevated AGT would not be acceptable to the residents of this corridor.

SUMMARY OF RESULTS FOR POTENTIAL AGT USE IN CHICAGO CASE STUDIES

	ANNUAL RIDERSHIP	ANNUAL CAPITAL COST* (1978 Dollars)	ANNUAL OPERATING COST (1978 Dollars)	ANNUAL REVENUES (1978 Dollars)
North Michigan Ave. (Alt. 1)	16,000,000	4,000,000	1,300,000	550,000
Merrillville (4.8 mil. ft^2)	4,000,000	1,700,000	1,100,000	400,000
Oak Brook	1,100,000	3,600,000	900,000	110,000
State of Illinois Medical Center				
Status Quo	1,200,000	2,100,000	750,000	120,000
Restricted Parking	10,500,000	2,800,000	1,000,000	1,000,000

*Assuming a 10% interest rate and a 6% inflation rate.

Dallas Case Studies

In the Dallas region, five separate case study sites were selected; two corridors and three activity centers.

The Stemmons Corridor connects the central business district to the northwest. It is an older, fully-developed corridor, 4.5 miles (7.2 km) long, containing a freeway (I-35E), a 7,000,000 square foot (630,000 square meter) wholesale center, four major hospitals, and many hotels.

The North Central Corridor, focused on U.S. Highway 75, connects the central business district to the north. It is 6 miles (9.6 km) long and has diversified land uses, but is a predominantly multi- and single-family residential area.

The Central Business District covers about 200 acres (80 hectares) and is almost entirely devoted to office buildings. There are also government, retail and hotel facilities.

North Park is a major regional activity center, typical of many large suburban centers. It is served by two major expressways. Retail shopping is the main reason people travel to North Park (100,000 trips on peak days), followed by trips to offices and recreational facilities.

COMPARISON OF TRANSIT ALTERNATIVES IN ATLANTA CASE STUDIES

	ANNUAL RIDERSHIP	ANNUAL CAPITAL COST* (1978 Dollars)	ANNUAL OPERATING COST (1978 Dollars)	ANNUAL REVENUES (1978 Dollars)
North Corridor				
AGT	9,000,000	8,000,000	5,100,000	2,700,000
LRT	8,500,000	12,000,000	7,000,000	2,500,000
Improved Bus	7,000,000	700,000	7,200,000	2,000,000
South Corridor				
AGT	9,000,000	7,000,000	3,500,000	2,700,000
LRT	9,000,000	12,000,000	4,600,000	2,700,000
Improved Bus	6,500,000	500,000	4,800,000	2,000,000

*Assuming a 10% interest rate and a 6% inflation rate.

The Dallas Market Center is the world's largest wholesale merchandise mart at a single location. It contains 6 buildings on a 135-acre (54-hectare) site.

The Stemmons and North Central Corridors were treated together, being served by one system. Alternatives considered were the current public transit system (local bus), AGT, light rail transit (LRT), and exclusive busway. In each case, alignments in the two corridors joined and entered the Central Business District. In general, these two corridors need transit service, and all of the proposed fixed guideway alternatives were beneficial when compared to the present system. AGT was considered to be a feasible option, inasmuch as the corridor has appropriate rights-of-way and land use to allow elevated guideways.

The alternatives analyzed for the Central Business District were designed to provide internal trip circulation. AGT appeared to be capable of accomplishing this task acceptably, although some questions were raised about the visual effects of the elevated guideway. Costs were felt to be acceptable and an AGT system could also be linked up to a regional transit system.

At the Market Center, an AGT system was viewed positively. Its high level of service outranked the bus alternative, and the guideway was viewed as a positive "futuristic" aesthetic image. At North Park, an AGT system was also viewed favorably. The AGT alternative provided a higher level of service than bus and was expected to contribute more to economic development. Aesthetic issues were not expected to be a serious problem.

National Market Estimates

The purpose of the market analysis was to estimate the potential national market and indicate potential cost-effective research and urban deployments. Since cost effectiveness has been UMTA's officially stated criterion for awarding capital grants, the methodology used in this study relied heavily on benefit/cost (B/C) analysis.

Any national market estimate necessarily requires some assumptions and a systematic methodology. In this study, separate market estimates were made for three categories: corridors; CBDs; and MDCs including shopping centers, airports, and medical centers. Benefits which were considered included travel time reductions, auto ownership reductions, bus operating cost reductions, reductions in auto-related problems and economic development. Costs included capital and operating costs, visual intrusion, noise and pollution.

Thirty-seven U.S. cities were considered as possible sites for a corridor AGT. This included all cities over 500,000 which do not have or currently plan to have a rapid rail system. Ridership estimates were based on assumed level-of-service variables. Benefits were calculated from the ridership and from consideration of consumer surplus theory. Quantification of the major benefits and costs was accomplished through modeling. Essentially the same technique was used in assessing potential CBD AGT systems. MDCs were analyzed using more qualitative techniques. Results were as follows.

Corridors: The market for corridor applications of AGT is constrained because there are few available corridors in which high ridership could be generated which do not now have a rail transit system. Where capital intensive systems are attractive, AGT's lower costs make it a potential alternative to conventional technology. If AGT were deployed in all corridors with global B/C ratios exceeding .99, in 75% with global B/C ratios from .75 to .99 and in 50% with global B/C ratios from .50 to .75, capital expenditures would total about $3.4 billion in 24 corridors. Deployment rates of successively 75%, 50% and 25% for each of these global B/C ranges would generate about $2.4 billion in expenditures in 17 corridors. If all deployments occurred over a 10-year period, average annual capital expenditures for corridor systems would be between $200 and $300 million. Extending the evaluation horizon or doubling the price of gas would increase the market estimate but total expenditures would still remain modest.

Central Business Districts: Analysis reveals that the largest benefit of CBD AGT accrues from a cutback of bus routes which enter the downtown area. The practical possibility of realizing these benefits is in

COMPARISON OF TRANSIT ALTERNATIVES IN DALLAS CASE STUDIES

	ANNUAL RIDERSHIP	ANNUAL CAPITAL COST[1] (1978 Dollars)	ANNUAL OPERATING COST (1978 Dollars)	ANNUAL REVENUES (1978 Dollars)
Stemmons and North Central Corridors				
Existing Transit	11,000,000	2,000,000	6,300,000	3,700,000
Transit Way	20,000,000	10,000,000	8,900,000	6,800,000
LRT	19,000,000	13,000,000	7,600,000	6,500,000
AGT	21,000,000	10,000,000	7,500,000	7,100,000
CBD				
Shuttle Bus	4,290,000	100,000	500,000[2]	300,000
AGT	12,000,000	2,800,000	1,000,000	930,000
Dallas Market Center				
Shuttle Bus	4,800,000	0[3]	100,000	0
AGT	4,800,000	450,000	150,000	0
North Park				
Shuttle Bus	540,000	100,000	400,000	0
AGT	1,320,000	700,000	500,000	0

[1]Assuming a 10% interest rate and a 6% inflation rate.
[2]CBD per-mile cost assumed to be $2.50, or 50% greater than the system average.
[3]Leased vehicles, all costs assumed as operating costs.

question due to institutional constraints, such as the 13(c) provision of the UMT Act.

If, however, AGT systems were deployed in all CBDs with B/C ratios greater than .74 and in half of all the CBDs with B/C ratios of between .50 and .74 and if the savings realized from cutting bus service are included, then the total market is about $990 million in 14 CBDs. If bus service is not eliminated, estimated capital expenditures are about $45 million in a single site.

Major Diversified Centers: Potential AGT deployment appears to be chiefly limited to MDCs with at least two major shopping areas. The most attractive sites would also have at least two other major uses, such as offices. These criteria typically require at least 4 million square feet (360,00 square meters) of space, and it is unlikely that at present there are more than 15 such MDCs in the U.S. The principal constraint on deployment is capital cost, which is typically far beyond the reach of private developers. Assuming systems can be deployed at five centers, total capital expenditures were estimated to be $100 million.

Medical Centers: This analysis suggests that it is unrealistic to expect many medical centers to deploy an AGT system. There does not appear to be enough need for internal circulation at large medical centers. Uncertain funding and security are also important issues in these studies.

Airports: Airports are proven markets for AGT because of their growing size, lengthy distances, and high passenger volumes. Many airports have already carried out expansion plans, however. If 10 to 15 more airports added AGT systems, capital expenses would range from $200 to $400 million.

The total estimate for all markets is approximately $4 billion or about $400 million per year if implementation of all systems were evenly spread out over a 10-year period. Less than half of the funds would be for vehicles and control equipment, since much of the money goes for guideway and station construction. This market is not large, when placed on a yearly basis. Both the bus and rail transit car industries have larger markets, yet have had difficulty attracting domestic manufacturers. Thus, it is unclear if potential manufacturers would make the required investments to meet the market.

AGT Implementation Issues

Several issues are of interest in attempting to evaluate the future market for AGT. There are limitations on UMTA Section 3 capital grants. Only about 20% of these discretionary funds are used for new rail starts; AGT would have to compete with conventional technology for these funds. Operating expenses are also of concern. Other issues, such as personal security and visual intrusion on communities, could affect AGT implementation, but these are issues which affect all fixed-guideway systems. Economic development is often perceived as a major result of AGT and, therefore, a justification for its construction. The exact relationship between better mobility and economic development, however, is uncertain.

Labor is another important institutional issue. AGT's potential to reduce labor costs and increase productivity is a distinct advantage, though this advantage could be reduced in areas where UMTA labor protection laws would apply.

Other major factors affecting AGT's potential markets are the public's willingness to ride in unmanned, automated vehicles and local officials' acceptance of a technology that is largely untested in urban environments.

SECTION II

Summaries of Transit Technology Evaluation Program Documents

ASSESSMENT OF OPERATIONAL AUTOMATED GUIDEWAY SYSTEMS – AIRTRANS (PHASE I)

R. Kangas, M. Lenard, J. Marino et al.; Transportation Systems Center, U.S. Department of Transportation.

September 1976, UMTA-MA-06-0067-76-1, PB 261-329, 294 pp.

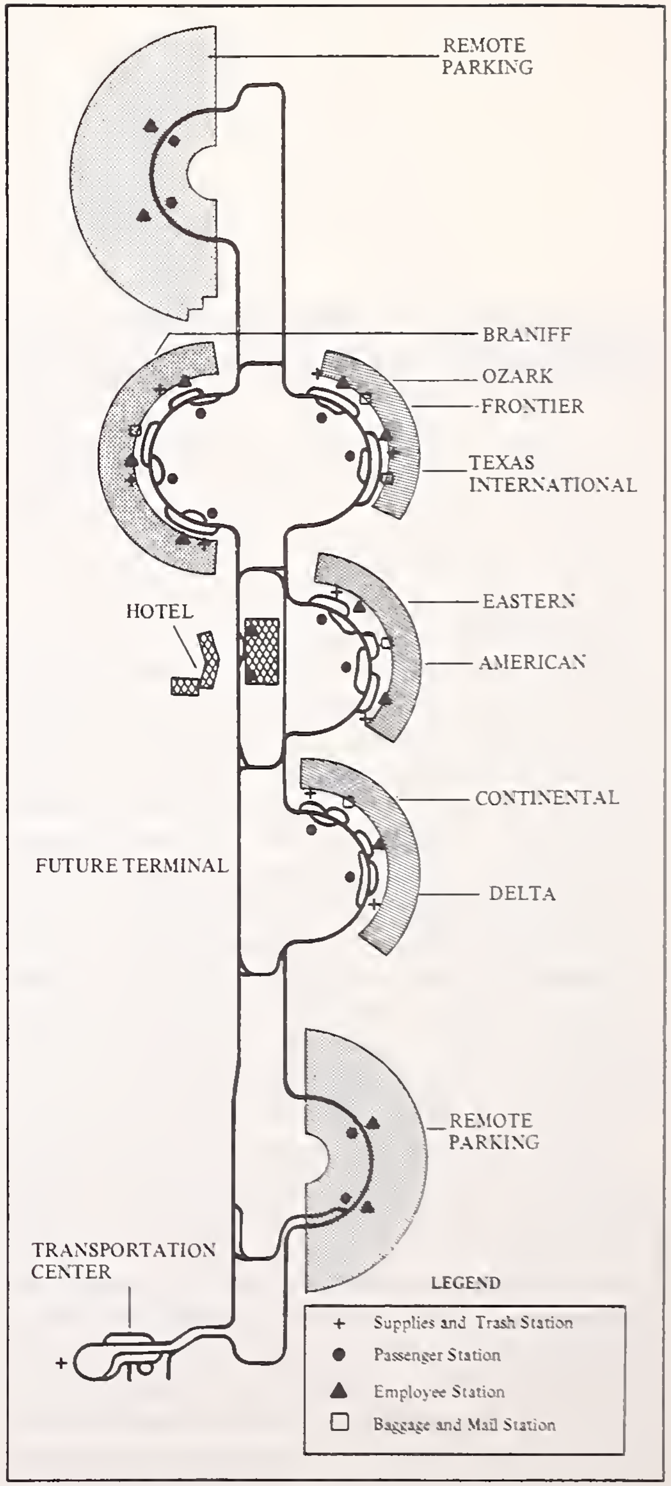
One of the largest, most sophisticated automated guideway transit (AGT) systems in the world is an inter-terminal transportation system located at the Dallas/Fort Worth Regional Airport. Airtrans consists of 13 miles (20.8 km) of single-lane guideway connecting 53 stations (14 passenger, 14 employee, and 25 utility) throughout the airport and 68 vehicles (51 personnel and 17 utility), plus 13 gasoline-powered service tugs. The layout encompasses five separate service routings for passengers, four for employees, two for trash, and two for commissary supplies. Additional routes were originally planned for baggage and mail distribution, but have not been implemented.

Airtrans and the Dallas/Fort Worth Regional Airport both began operations on January 13, 1974. Because of a hasty construction schedule, the system was "broken in" only after operations began. The manufacturer, Vought Corporation, had a work force of 800 people assigned to troubleshoot during the initial months of operation. This "trial by fire" approach resulted in a rapid decrease of equipment and operational problems. By April 1976, the system had carried 5.6 million passengers over 6.4 million vehicle-miles (10.2 million vehicle-kilometers). Airtrans is now operating successfully, 24 hours per day, 7 days per week.

The electrically-powered, rubber-tired Airtrans vehicles are fairly small, seating 16 people, with a total capacity of 40. The vehicles are automatically steered using eight guidance wheels fixed to a guide bar in the guideway. Although all vehicles are constantly monitored from a central control, they are fully automated. Headways as low as 18 seconds are possible. Frequency of service on each of the various routes is about 5 minutes, yielding a maximum trip time of 20 minutes between terminals and 30 minutes to remote parking lots. There are 14 passenger stations, 10 of which are off-line.

It cost about $64.5 million (1971 dollars) to build the system. Operating and maintenance costs for 1975 were about $.68 per vehicle-mile ($.43 per vehicle-kilometer) and were expected to decrease. Overall reliability and maintainability of the system are now good.

The assessment documents the system through 1976. A detailed technical description of the system is given, including project evolution and the performance specifications. The assessment also covers operating data and statistics, passenger trip times, system dependability, ride quality, and safety and security. The different freight and utility subsystems planned for Airtrans are also described. A discussion of economics, cost, and management leads to a general evaluation as well as suggestions and recommendations for the future.



Airtrans Guideway and Station Layout

ASSESSMENT OF OPERATIONAL AUTOMATED GUIDEWAY SYSTEMS – AIRTRANS (PHASE II)

C.W. Watt, D. Elliott, D. Dunoyé et al.; Transportation Systems Center, U.S. Department of Transportation, and Ministere des Transports (France).

January 1980, UMTA-MA-06-0067-79-1, PB 80-182538, 347 pp.

This assessment covers the Airtrans operations from September 1976 through July 1979, in which services were expanded beyond those in Phase I. The level of passenger service was almost as high as originally planned. The system reached maturity, ridership and availability were up, and operating costs were down. Several changes which were introduced included computer redundancy in central control, improved ability to reset vehicle functions automatically, improved station stopping accuracy, improved traction, and successful testing of an obstacle detection system. Preventive maintenance was improved, allowing the total maintenance force to drop from 125 in 1975 to 86 in 1978.

This report presents in detail the availability, reliability, maintenance, and operational safety aspects not documented in the Phase I report. Most of these measures had improved substantially, showing a classic case of reliability growth through design changes and system maturity. System availability, defined as the percentage of scheduled time in which the whole system was operational, was 98.5%. The average vehicle operated about 82 hours between malfunctions. The average malfunction lasted only about 3.9 minutes. Fifty-eight accidents were recorded; six related to passengers, one of whom was injured. Airtrans proved to have lower passenger accident rates than conventional rail and bus systems.

Airtrans Vehicles at the Dallas/Fort Worth Regional Airport

The Phase II report concludes with a series of recommendations for future AGT implementations. These include guidelines for smoother construction and design work, better planning, caution in requiring multi-use capability, additional safety measures, and better and more systematic record-keeping. Appendices include sampling data on malfunctions, reliability data, and cause and nature of malfunction in the two key accidents. Also described is the Airtrans Urban Technology Program, an UMTA research effort to improve Airtrans for future urban service that was conducted from late 1976 to late 1979.

ASSESSMENT OF OPERATIONAL AUTOMATED GUIDEWAY SYSTEMS — JETRAIL

G. Anagnostopoulos, P. Wlodyka, I. Mitropoulis et al.; Transportation Systems Center, U.S. Department of Transportation.

December 1977, UMTA-MA-06-0067-77-1, PB 278-521, 280 pp.

Jetrail was the first operational, completely automated demand-responsive, group rapid transit (GRT) system in the country. It operated successfully from April 1970 to January 1974, connecting the Braniff International Airlines terminal at Love Field in Dallas, Texas to a parking lot .75 mile (1.2 km) away. Passenger service was discontinued when Braniff moved to the new Dallas/Ft. Worth Regional Airport. The system was designed and partially constructed by the Stanray Corporation; Braniff completed construction and operated it.

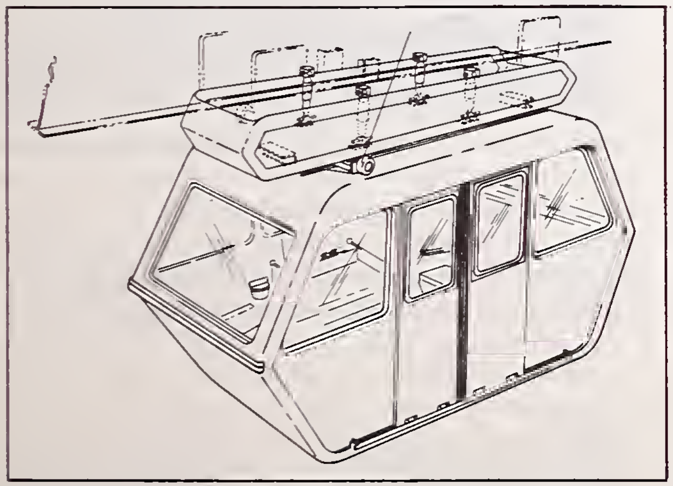
During the 4-year period of operation, over 6 million passengers were carried over 1.3 million miles (2.1 million km) without a fatality or a major mishap. Jetrail operated 24 hours per day, 7 days per week, and high levels of overall system availability and reliability were reported. Problems with the propulsion and control components were experienced.

Jetrail was an elevated, suspended monorail system with three on-line stations and storage, maintenance, and bypass facilities. Each of the 10 vehicles in the system was powered by 2 single-speed, three-phase electric motors.

The assessment found that Jetrail technology, with some modifications, would be suitable for applications in other types of areas. Necessary modifications include the addition of fire safety features, development of a capability to operate under snow and ice conditions, and changes in the vehicle propulsion and control components to improve reliability and maintainability.

The study found that insufficient time and effort were spent in the initial design, development and testing phases of Jetrail. This led to cost overruns later on. The operating costs of the system, however, were found to be acceptable.

The Jetrail system has, after 1974, been used as a testing ground for a prototype linear induction motor propulsion system. This new system, called Astroglide, has improved on some of the less successful elements of the Jetrail system and is also briefly discussed in the report.



Some Details of Jetrail Vehicle and Suspension

ASSESSMENT OF THE AUTOMATICALLY CONTROLLED TRANSPORTATION (ACT) SYSTEM AT FAIRLANE TOWN CENTER

A.M. Yen, C. Henderson, M. Sakasita et al.; SRI International.

December 1977, UMTA-IT-06-0135-77-2, PB 286-524/AS, 120 pp.

Another in the automated guideway transit (AGT) assessment series, this report documents the automatically controlled transportation system at Fairlane Town Center at Dearborn, Michigan. The system is a shuttle operating two vehicles on an elevated guideway between a large shopping center and a hotel about .25 mile (.4 km) across the parking lot. The design was an integral part of the center/hotel development, which began in 1970. The ACT system itself began in 1973, and was the second prototype demonstration of Ford Motor Company's AGT system, first displayed at TRANSPO '72. Each car holds 24 people and travels at about 20 mph (32 km/hr) maximum. The guideway is a single lane, except for the double-lane bypass area located midway between the two stations. Overall, the system is technologically sophisticated, using state-of-the-art "intelligent" vehicles which control and switch themselves.

The report gives a technical description of the system, describes its operational performance, and analyzes the costs and economics. The development process is also reviewed. As a whole, the system works well and is popular with passengers. The report concludes that the engineering aspects of the system have potential applications to more advanced AGT systems.

ASSESSMENT OF THE BUSCH GARDENS AUTOMATED ANHEUSER-BUSCH SHUTTLE SYSTEM

H.A. Theumer and C.P. Elms; N.D. Lea & Associates, Inc.
November 1979, UMTA-IT-06-0188-79-4, PB 80-127384. 166 pp.

A single-loop, two-station automated guideway transit (AGT) system has been in operation since 1975 at the Busch Gardens theme park in Williamsburg, Virginia. A two-car train carries passengers from the park to an Anheuser-Busch brewery and hospitality center a mile (1.6 km) away. Westinghouse Electric Corporation designed and constructed the system.

About one-third of the guideway is elevated and has fairly steep slopes of 10% in three locations in order to provide a more exciting ride. There is no provision for guideway ice and snow removal because of the seasonal nature of the park. Each vehicle can carry up to 96 passengers and can travel up to 30 mph (48 km/hr).

The system is reported to have cost $4,320,000 (1975). The estimate of annual operations and maintenance cost is about $166,000. This works out to about $60 per vehicle-hour and $.11 per passenger based on an estimated annual ridership (in 1977) of 720,000. Load factor is .314.

The system performance has been quite acceptable for the park's purposes, but is modest compared to other AGTs. Overall system availability in 1977 was established as .915 and the mean time between failures was only 2.2 hours. This low performance is due, in part, to the operating and management philosophy of the park. For example, the AGT system is closed whenever a thunderstorm approaches. Safety and security have been handled by the park security patrol with little problem. Passengers react well to the system since it is quite comfortable and air conditioned. The system is completely accessible to elderly and handicapped persons via ramps.

ASSESSMENT OF THE MUELLER AEROBUS SYSTEM: THE SYSTEM INSTALLED AND OPERATED FOR THE BUNDESGARTENSCHAU 1975, MANNHEIM, GERMANY

W. Bamberg, C.P. Elms, H.H. Hosenthien, and W. Voss; N.D. Lea & Associates, Inc.
September 1979, UMTA-IT-06-0189-79-2, PB 80-130636. 262 pp.

The Mueller Aerobus Cable System was installed and operated for about 6 months in 1975 in Mannheim, Germany, specifically to serve the 1975 Bundesgartenschau (Federal Garden Show). The Aerobus shuttled visitors back and forth between the two sites, which were about 2 miles (3.2 km) apart and separated by the Neckar River. The Aerobus was an experimental application of a cable technology that was originally constructed and tested in Switzerland. Important in the decision to use the Aerobus was the fact that there would be little disruption of existing urban structures; it would use existing rights-of-way, and would bridge the river. As a result of operational evaluations made during this test, the manufacturer is to improve the design for future applications.

The Aerobus system consisted of an elevated, double cableway supported by pylons with fixed-rail sections in curves and at switches. The cableway passed over a variety of urban barriers without interference. Eight articulated vehicles with capacity for 100 persons provided fixed-schedule service at roughly 3-minute headways. The electrically powered vehicles were not automated, but were controlled by an attendant located in the center of the vehicle.

Ridership on the Aerobus system was quite high. Passenger waits often averaged 20 minutes in the peak periods. Line capacity was only about 1440 passengers per hour. This is low for urban applications, but capable of being increased with system redesign. The system achieved an overall availability of 98%. There were no accidents, and passenger safety and security were exemplary. Capital costs were about 13 million German marks (DM).* Operating costs for the 6-month period were about 2 million DM.

The assessment report gives a complete system description, including technical and engineering details on the vehicles, the cableways and stations, controls, steering, propulsion, and power. System performance is evaluated based on data on operating energy consumption, reliability and maintainability, and safety and security. Costs are listed in detail and the system development process is discussed.

*To avoid inaccuracies caused by fluctuating currency exchanges and inflation rates, costs are presented in 1975 German marks.

Mueller Aerobus System

Improvements in system design and technology would be required before the system could be used successfully in urban areas. These include higher speed and capacity capabilities, accessibility features and a more comfortable ride. The basic concept, however, of point-to-point service in urban areas with special natural or man-made barriers with minimal environmental impact is a sound one.

ASSESSMENT OF THE PASSENGER SHUTTLE SYSTEM (PSS) AT TAMPA INTERNATIONAL AIRPORT

A.M. Yen, C. Henderson, M. Sakasita et al.; SRI International.

December 1977, UMTA-IT-06-0135-77-4, PB 285-597. 109 pp.

The Tampa airport has a modern design which includes one central terminal for passenger baggage, ticketing, and ground access, and four "airside" terminals, handling actual aircraft boardings. To provide passenger access from the central terminal to each airside terminal, the passenger shuttle system (PSS) was installed. It is an elevated, fully automated guideway transit (AGT) system, very much like a two-stop horizontal elevator on wheels. The guideway "legs," or sections between the central and each of the airside terminals, range from 779 to 1002 feet (234 to 301 meters) in length. There are eight vehicles, two for each shuttle. Each pair occupies two lanes; movements are automatically synchronized so that the two vehicles leave the opposite terminals simultaneously and pass each other in the middle. Average dwell time is about 30 seconds, and travel time about 40 seconds.

The simplicity of the design has helped to create a good record for reliability. The per-lane availability was .995 in December 1976. Even if one vehicle is down for some reason, the adjacent vehicle can easily be used as a shuttle by itself. Thus, although the Tampa airport has one of the first AGTs in regular operation, there have been no major problems with it.

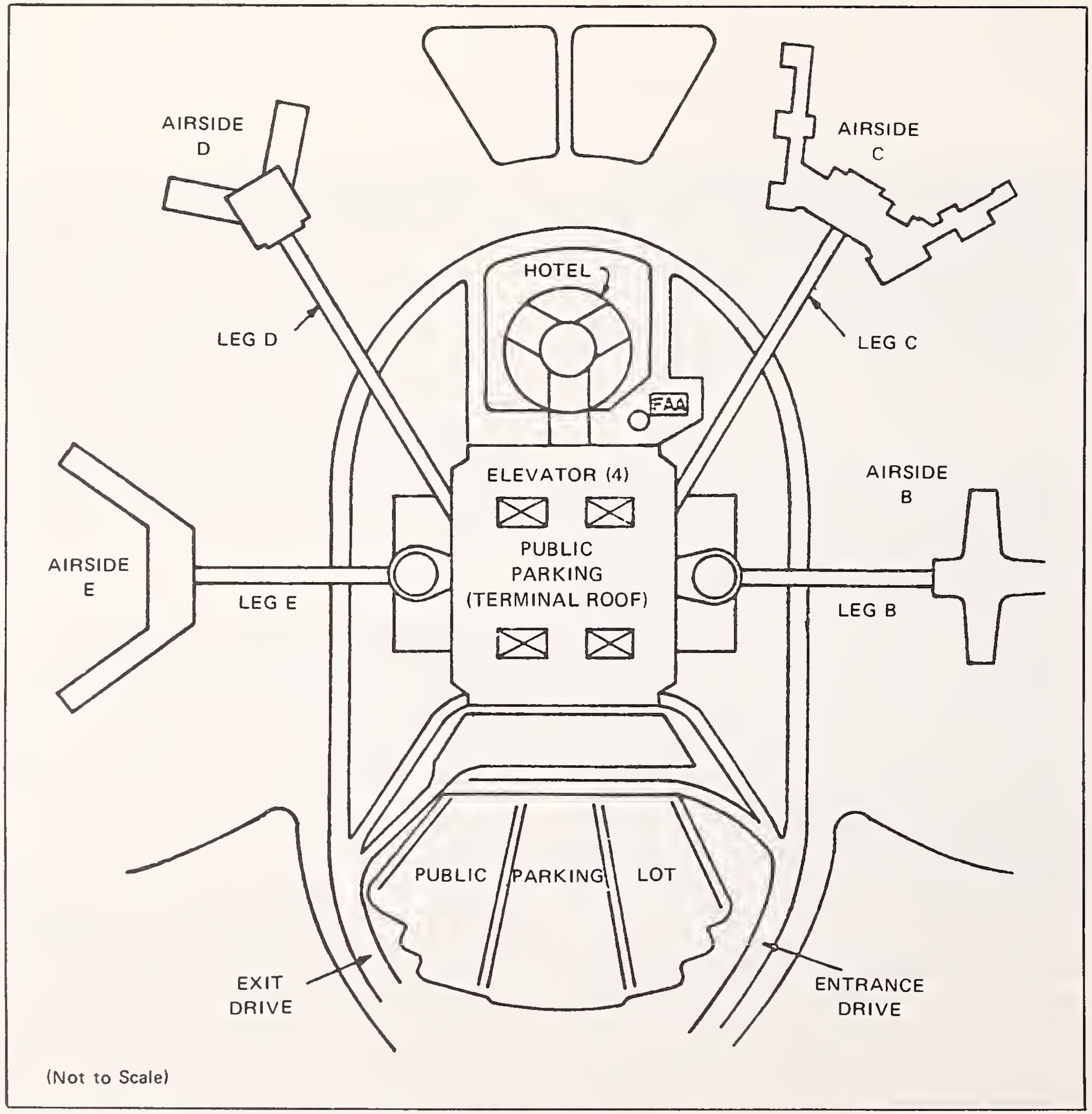
Each vehicle has a capacity of about 100 standees and travels at about 30 mph (48 km/hr). Because of the mild climate, no weatherization measures were built into the guideway. Simple stations are integrated into the terminals. In 1976, the PSS logged about 400,000 vehicle-miles (640,000 vehicle-km) and carried about 14.5 million passengers. The estimate of annual passenger-miles of travel was about 2.47 million (3.952 million passenger-km), yielding an average load factor of .061. This indicates a large amount of excess capacity, which is desirable for handling sudden influxes of people whenever several planes land similtaneously.

ASSESSMENT OF THE SATELLITE TRANSIT SYSTEM (STS) AT THE SEATTLE-TACOMA INTERNATIONAL AIRPORT

A.M. Yen, C. Henderson, M. Sakasita et al.; SRI International.

December 1977, UMTA-IT-06-0135-77-1, PB 281-820. 132 pp.

Since 1973, an automated guideway transit (AGT) system has been operating at the Seattle-Tacoma International Airport between the central terminal building and each of two satellite terminals. It was built by the Westinghouse Corporation and is called the Satellite Transit System. The 9007-foot (2729-meter) guideway is completely underground and consists of two loops, one for each satellite terminal, and a connecting shuttle path. The system is the only link among the terminals,



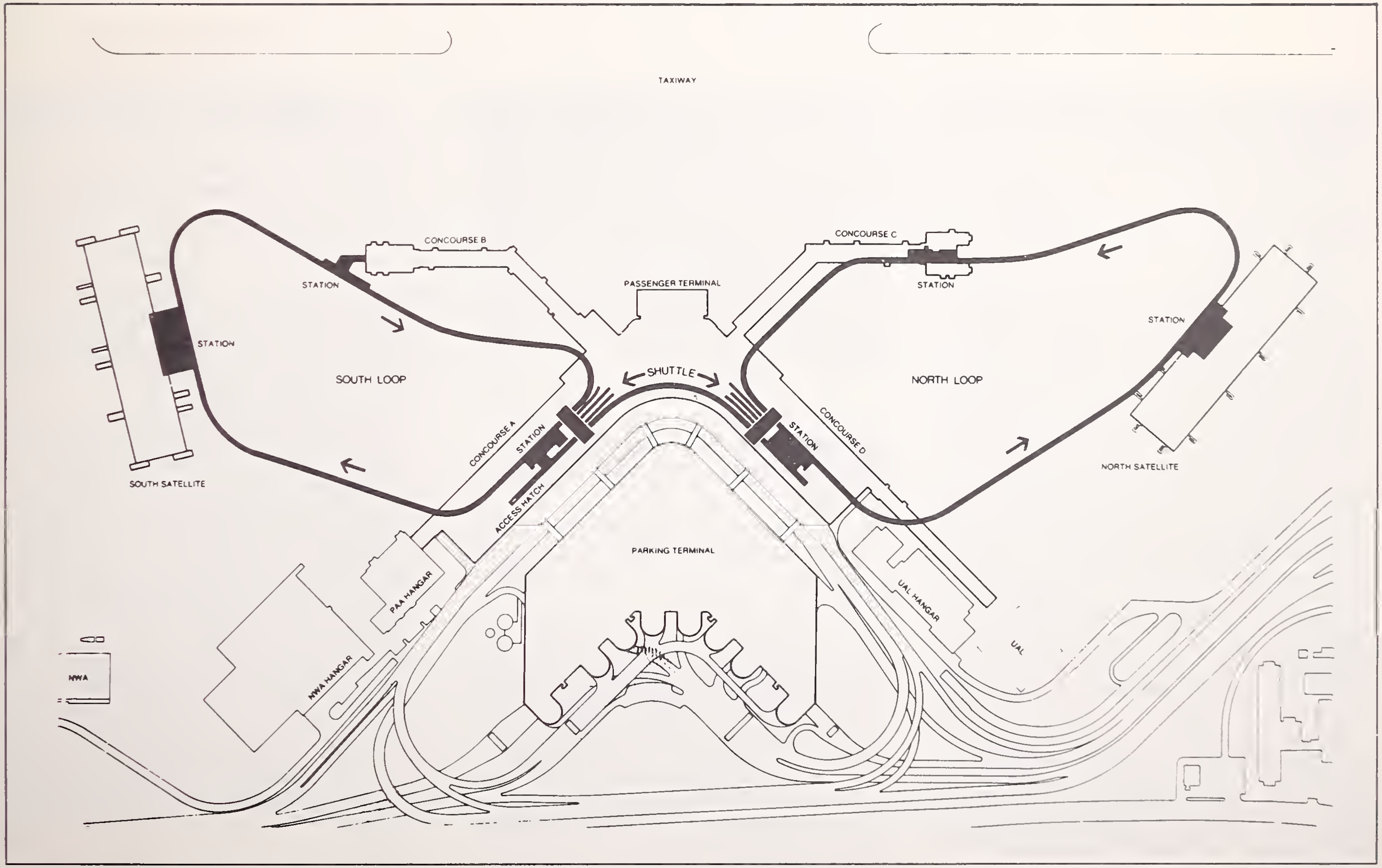
Plan View of Tampa International Airport

since the latter are surrounded by aircraft loading and unloading areas where it would be unsafe to walk.

Since there is no other access to the satellite terminals, except for a narrow emergency walkway in the AGT tunnels, primary emphasis and major resources are directed toward maintenance and reliability. This strategy has been successful; system availability in 1976, for example, was about .998. When an interruption does occur, it takes less than 3 minutes, on the average, to restore service.

Vehicles travel around the loops in a clockwise direction, but can reverse direction if some point becomes blocked so that service is not interrupted. The system contains 12 vehicles which can travel both singly and entrained. They can carry up to 102 passengers each and travel along the guideway at speeds over 20 mph (32 km/hr) between the system's 6 stations. The maximum capacity of the system is about 8000 to 9000 passengers per hour per loop. Yearly ridership was 10.1 million passengers in 1976.

The costs of the Sea-Tac AGT were high because of the required tunnel construction and were difficult to gauge because the system was built in conjunction with an airport expansion program. It is estimated that a duplicate system would cost over $22 million to build. Operating costs are about $500,000 per year, resulting in a cost per vehicle-mile of about $1.83 ($1.14 per vehicle-km) in 1976.



STS Routes and Stations: Sea-Tac

ASSESSMENT OF THE TUNNEL TRAIN SYSTEM AT HOUSTON INTER-CONTINENTAL AIRPORT

A.M. Yen, C. Henderson, M. Sakasita et al.; SRI International.

December 1977, UMTA-IT-06-0135-77-3, PB 286-641. 98 pp.

The Houston airport consists of two separate terminals, a hotel, and a parking facility laid out in a linear fashion. Because of the long walking distances, an entirely underground automated guideway transit (AGT) system, a Rohr P-Series Monotrain, loops 6080 feet (1842 meters) through all four facilities. Each of the three-car trains traverses the loop in an unscheduled mode at an average speed of about 3.7 mph (6.2 km/hr), slightly faster than an average walker. Since the trains travel alongside an underground pedestrian walkway, use of the AGT is not mandatory, but is more of a convenience for those with baggage or longer trips. All stations are on-line and there is no fare. Each car holds 12 passengers, producing a normal line capacity of 480 passengers per hour, too low for direct urban applications. The slow speed and resultant high headways are primarily caused by the system design and the fairly narrow tunnel.

Because the AGT is not an absolute necessity, very high availability is not required. Consequently there is no comprehensive preventive maintenance program. Mean time to restore service is 2 hours, which is high compared to other AGT systems. This is due to design; however, the system has met most of the functional requirements stipulated before construction.

Records show that in 1976 the system traveled 366,000 vehicle-miles (585,600 vehicle-km). The annual ridership is estimated at 1.2-1.4 million passengers. The exact cost of the Rohr Houston AGT is not known because of the lack of historical data. In 1976, the airport reported about $328,000 in operations and maintenance costs, resulting in a per-passenger cost of about $.25.

The Rohr system has since been removed from the Houston Airport and is being replaced with another AGT system manufactured by Walt Disney Productions.

ASSESSMENT OF THE UMI TYPE II TOURISTER AGT SYSTEM AT KING'S DOMINION

A.M. Yen, C. Henderson, M. Sakasita et al.; SRI International.

December 1977, UMTA-IT-06-0135-77-6, PB 286-513/AS. 65 pp.

The King's Dominion Amusement Park, near Richmond, Virginia, operates an unscheduled, 2-mile (3.2-km), largely at-grade, loop automated guideway transit (AGT) system through its Lion Country Safari. Passengers are carried through the habitat area to view the animals in 9-vehicle trains. Each train contains a passengerless lead vehicle with controls and equipment, and 8 passenger vehicles carrying 12 people each. There is an operator on board who describes the animals and avoids collisions with them.

Although designed to go 15 mph (24 km/hr), the maximum operating speed employed is 6.5 mph (10.4 km/hr). This yields a fairly low line capacity of 1800 passengers per hour, even with all 6 trains operating. A round trip takes about 20-25 minutes. The system only operates in the summer and is, thus, not winterized. Estimates were that the system traveled 228,000 vehicle-miles (364,800 vehicle-km) in 1976, which when combined with the estimated fee-paying ($1.50) ridership of 872,700, yielded a load factor of .74. Of course, this high ridership statistic is a result of the fact that this is an amusement ride and trains are always held at the station until reasonably full.

System reliability is fairly good, and there have been few shutdowns. The overall availability can be calculated at .993. Comfort and convenience are also quite good because of the tourist orientation of the ride. Safety and security have not been problems, in part because of the presence of operators, park attendants, and security police. One incident occurred when lightning damaged a length of track and several trains were stranded among the lions for several hours.

Cost data are not readily available since the system manufacturer considers the information to be proprietary. However, the estimated capital cost is around $5.5 million (1976 dollars). Operations and maintenance costs are about $156,000 per season (1976 dollars), yielding a per trip cost of about $.18. It is not possible to ascertain the ability of the tourister AGT system to be transferred to urban environments because of the unusual operating environment.

ASSESSMENT OF THE WEDWAY PEOPLEMOVER AT WALT DISNEY WORLD

A.M. Yen, C. Henderson, M. Sakasita, M. Roddin; SRI International.

December 1977, UMTA-IT-06-0135-77-5, PB 268-935. 108 pp.

The WEDway PeopleMover is located at the well-known Walt Disney World recreational complex in Lake Buena Vista, Florida. It consists of a single 4600-foot (1380-meter) loop with one station. Its function is not transportation; rather, it is one of many attractions at the Magic Kingdom Theme Park. Located near the park entrance, the 10-minute ride allows passengers to view a number of exhibits, such as the Space Mountain and the Flight to Mars.

The WEDway PeopleMover systems are constructed by the Walt Disney Corporation, and are used in several areas. WEDway is a passive vehicle system. The vehicles have neither motors nor electronic guidance elements; they have only limited suspension, and no lighting, climate control, or communication equipment. Propulsion is through single-sided linear induction motors (LIMs) with the active elements mounted in the guideway. LIMs are placed along the guideway at about 10-foot (3-meter) intervals, and determine the vehicle acceleration and deceleration as the vehicles pass over them. The speed profile for the entire loop is wired into the system. Since each vehicle receives the same commands when in the same area, collisions are unlikely.

The travel time is 10 minutes. Speeds vary from 2 mph to 6.8 mph (3.2 to 11 km/hr). Passenger loading is also unique. The vehicles travel around a revolving platform through an arc of 300° at about 2 mph (3.2 km/hr). Thus, the vehicles and rotating platform are synchronized for about 1.5 minutes, ample time for the average passenger to board or alight safely.

The system is heavily used, and carried about 4.66 million passengers in 1976. The average load factor was about .28. Both system safety and reliability have been quite good. For example, in a 20-month period there were only 49 failures, totaling about 20 hours of downtime. Downtime has consistently averaged less than 1% per month. There have been no accidents or other incidents.

The capital costs of the system have been estimated at slightly over $10.5 million (1976 dollars). Annual operations and maintenance costs were about $350,000 in 1976. This works out to about $.07 per passenger trip. The overall transferrability of the technology to the urban environment was not addressed in this assessment.

DESCRIPTION AND TECHNICAL REVIEW OF THE DUKE UNIVERSITY AUTOMATED PEOPLE/CARGO TRANSPORTATION SYSTEM

H.A. Theumer and C.P. Elms; N.D. Lea & Associates, Inc.

July 1979, UMTA-IT-06-0188-79-2,
PB 80-159734. 139 pp.

The first automated guideway transit (AGT) system using an air levitation feature as part of its suspension system recently began operation at the Duke University hospital complex in Durham, North Carolina. This is also the first commercial application of an Otis Elevator Company AGT design. This report describes the design, technical subsystems, and performance, reliability and maintainability specifications of this system. No performance evaluation, however, is contained because the people/cargo transportation system began operation in May 1980—after this study had been completed.

The system was designed to satisfy transportation needs of patients, visitors and personnel between two hospital buildings and a parking area at the Duke University Medical Center. Cargo is also carried on the system. A 1207-foot (368-meter), double-lane concrete guideway connects the hospital buildings with one another and a 560-foot (171-meter) single-lane guideway connects one of the hospital buildings with the parking facility. The guideway contains elevated, at-grade, and below-grade sections and a drawbridge which was installed as the lowest cost alternative for crossing an existing railroad spur.

On-line stations are located at each of the hospital buildings and at the parking area. One of the hospital buildings also has an off-line cargo station. The stations are incorporated into the buildings they serve and the station doors are coordinated with the vehicle doors.

The system operates with three passenger vehicles and one cargo vehicle which can also be used to transport passengers when necessary. The passenger vehicles can carry up to 37 people and can be attached to form two-vehicle trains. The system is automated and under the supervision of one dispatcher.

Duke University People/Cargo Vehicle

The report suggests that this technology could be adapted for use between buildings in an office or shopping center, or, in an expanded form, in a central business district. It recommends that an energy-efficient way of removing snow and ice from emergency braking surfaces may be required in northern climates and that larger vehicles may be needed for urban applications.

DESCRIPTION AND TECHNICAL REVIEW OF THE MIAMI INTERNATIONAL AIRPORT SATELLITE TRANSIT SHUTTLE SYSTEM

H.A. Theumer and C.P. Elms; N.D. Lea & Associates, Inc.

September 1979, UMTA-IT-06-0188-79-3, PB 80-158892. 115 pp.

The Miami International Airport installed a shuttle automated guideway transit (AGT) system in the late 1970's, connecting the International Satellite Building with the main terminal one-fifth mile (320 meters) away.

The 1358-foot (407-meter), double-lane elevated guideway simply extends between the two buildings, entering the upper floors of the terminals where the stations are located. The system can carry up to 16,000 passengers per hour, based on regular 1.5-minute headways.

The vehicles can accommodate about 100 passengers each, mostly standing, and are joined in two-car trains, one train for each guideway lane.

The shuttle is a relatively simple operation; basically a horizontal elevator, it has some features that make it especially suited to its environment. Through an interlock and door control feature, the system can separate free passengers from "sterile" passengers who are headed for the Customs and Immigration Service at the main terminal. There is a part-time central control supervisor, but otherwise the system is completely automatic.

The 1976 adjusted capital cost of the system was $9,883,000. The most expensive components were the guideway, the stations, and the engineering and project management. Since the assessment took place before operations began, no operating data were available.

DEVELOPMENT/DEPLOYMENT INVESTIGATION OF CABINTAXI/CABINLIFT SYSTEMS

V.J. Hobbs, W. Heckelmann, N.G. Patt, J.H. Hill; Transportation Systems Center, U.S. Department of Transportation, and the Federal Ministry of Research and Technology, Federal Republic of Germany.

December 1977, UMTA-MA-06-0067-7702, PB 277-748. 432 pp.

This report, a joint U.S./German effort, presents the results of an investigation of the Cabintaxi/Cabinlift automated guideway transit (AGT) systems under development in the Federal Republic of Germany. The Cabintaxi/Cabinlift program was developed by two manufacturers, DEMAG Fordertechnik and Messerschmitt-Bolkow-Blohm (MBB), and the German government. The program is developing the components which can make up a variety of AGT systems. The program is still evolving; while most component subsystems have reached a high level of maturity, others are only in the early stages of development. Although the Cabintaxi/Cabinlift system is not fully operational, there is one prototype development using this technology in a shuttle configuration at a hospital in Ziegenhain, West Germany. A large, sophisticated, and unusually extensive test facility operating in Hagen is an important element in the program.

The system has three types of vehicles: a 3-passenger vehicle; a 12-passenger vehicle; and a slightly larger vehicle which will, unlike the other models, accommodate standees. The vehicles are propelled by linear induction motors. The guideway is typically elevated and can be constructed to carry two-way traffic on the same beam utilizing both suspended and supported vehicles.

The report focuses on a description of the technical concept, the degree to which various systems and major subsystems have been developed, the experience gained in design refinement through realistic testing, and theoretical and feasibility studies. The report concludes that this type of concentrated ongoing research may yield long-term benefits for future AGT deployment and that the design philosophy to fabricate AGT modules has resulted in a system that can potentially be applied in a wide variety of locations.

Cabintaxi/Cabinlift 12-Passenger Supported Vehicle


Cabintaxi/Cabinlift Prototype in Ziegenhain, West Germany

DEVELOPMENT/DEPLOYMENT INVESTIGATION OF H-BAHN SYSTEM

L. Silva, T. Comparato, C. Watt and W. Heckelmann; Transportation Systems Center, U.S. Department of Transportation, and the Federal Ministry of Research and Technology, Federal Republic of Germany.
January 1981, UMTA-MA-06-0069-81-1, PB 81-214991. 362 pp.

This report presents the results of a joint U.S./German technical assessment of the H-Bahn automated guideway transit (AGT) system under development in the Federal Republic of Germany. The assessment focused on technology tested and observed on the 0.84-mile (1.4-km) loop system at the Erlangen test facility. Although not yet deployed in revenue service, the H-Bahn system is currently under construction at Dortmund University, and installation of a demonstration system in Erlangen is planned. In addition to a detailed description of the H-Bahn system and a technological assessment of the system maturity and design, this report presents information about system, capital, and operation costs.

The H-Bahn is an automated transit system comprised of various sized vehicles suspended from running gear units (bogies) which travel inside a narrow, slotted box track beam. At a headway of 60 seconds, lane capacities ranging from 1000 passengers/hr with the smallest vehicle to 15,000 passengers/hr with large articulated vehicles can be obtained. The closed track beam arrangement shelters the internal hardware, critical to safe and reliable automatic operation, from environmental effects. It is suspended from columns, steel or concrete, which are spaced at about 100-foot (30-meter) intervals at a normal height of 30 feet (9 meters). A significant cost-saving feature of the H-Bahn guideway system is the ability to prefabricate the track beam sections and columns. The fabricated guideway components can then be transported to the construction site, where they are assembled and erected on concrete foundations. This time-saving feature reduces overall guideway cost as well as urban disruption and traffic congestion during construction.

H-Bahn System Test Facility in Erlangen, West Germany

In contrast to extending the state-of-the-art in automated systems through innovative concepts and new hardware, the H-Bahn approach has been one of utilizing existing technology, with emphasis on simplicity, flexibility, and extensive testing. The developers, Siemens and DüWag, have relied heavily on an extensive test program in order to evolve and mature their system design. With such a high level of dependence on conventional technology, the emphasis has been and is anticipated to continue to be focused on the integration of hardware into applications representative of revenue operation.

LIFE CYCLE COST MODEL FOR COMPARING AGT AND CONVENTIONAL TRANSIT ALTERNATIVES

C.A. Graver and J.F. Jenkins-Stark; General Research Corporation.

February 1976, UMTA-CA-06-0090-76-1, PB 259-529. 86 pp.

In implementing any kind of transit system, capital acquisition costs must be balanced against future operating costs. For example, high-quality, high-cost equipment may require less maintenance and could last longer than less expensive products. On the other hand, higher initial costs are not always offset by lower operating costs. Government procurement regulations which place sole emphasis upon low capital costs sometimes result in purchases which have unusually high operating costs or short lives. Life cycle costing attempts to address this question and determine the lowest total cost of a product by adding all expected operating costs to the capital costs and distributing these costs over time.

Accurately comparing automated guideway transit (AGT) systems with non-automated systems requires the use of a life cycle cost model because AGT systems replace labor or operating costs with capital costs. For example, high automation costs, which would include computerized command and control and possibly a higher number of vehicles, are offset by lower labor costs because drivers are not required.

The computerized model calculates the total life cycle cost of an AGT system, based on a series of input assumptions regarding the time-value of money, inflation, and discount rates. The model predicts the future timing of costs, and shows the impact of alternative courses of action, such as delayed purchase of an AGT system. Since different types of costs are increasing at different rates, results of the cost analysis can change significantly depending on when the AGT purchase is made. That is, a cost-effective purchase in 1975, might not be so in 1985. The study did not reach any overall conclusion on the cost merits of AGT systems; rather, the model can be used in other situations to evaluate AGT proposals.

SUMMARY OF CAPITAL AND OPERATIONS & MAINTENANCE COST EXPERIENCE OF AUTOMATED GUIDEWAY TRANSIT SYSTEMS

F.A.F. Cooke, C.P. Elms, T.J. McGean, H.W. Merritt; N.D. Lea & Associates, Inc.

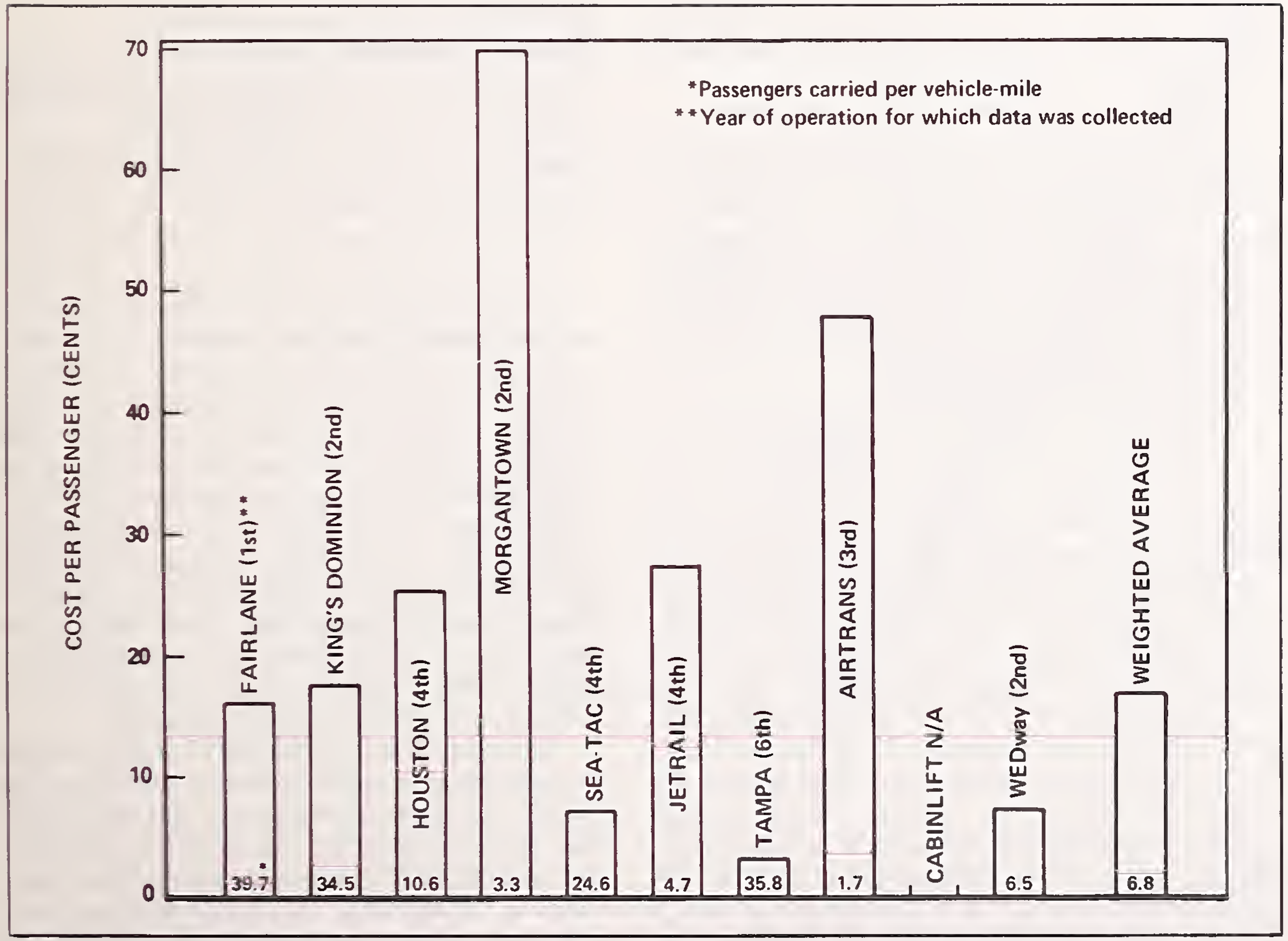
June 1978, UMTA-IT-06-0157-78-2, PB 294-306. 66 pp.

This report summarizes cost data on 10 different automated guideway transit (AGT) systems at Morgantown, Dallas/Fort Worth Regional Airport, Love Field (Dallas), Ziegenhain Hospital (West Germany), Tampa Airport, Seattle-Tacoma Airport, Houston Intercontinental Airport, Fairlane Town Center, Disney World, and King's Dominion. The capital, operations, and maintenance costs are described and related to the AGT characteristics. Also, performance measures are developed. Unit cost data are calculated and cost trends are extracted.

The total cost of all 10 systems was about $203 million (1976 dollars). Operating costs plus the time value of the capital yields about $30 million per year. About 44 million passengers were carried in 1976, averaging about $.70 per passenger trip. Of this, operating cost was about $.17 and capital about $.53. This reveals the capital intensive nature of AGT systems. Total cost ranged from $.03 per trip in Tampa (where the trip is quite short), to about $.72 in Morgantown.

There were, of course, wide variations in costs, depending on system capacity, size, length, technology, site factors, etc. Rough orders of magnitude are $7.3 million per lane-mile ($4.56 million per lane-km) of guideway and $215,000 per vehicle, again in 1976 dollars. Costs for research and development and right-of-way acquisition were excluded.

The report also compares certain AGT information with data from conventional transit service. The average AGT cost of $1.13 per vehicle-mile ($.71 per vehicle-km) is less than the comparable cost for bus or rail transit. The comparison, however, should be treated with caution because of the differing environments in which AGT and conventional transit are now found and differing vehicle sizes.



1976 O & M Cost Per Passenger Carried

SUMMARY OF CAPITAL AND OPERATIONS & MAINTENANCE COST EXPERIENCE OF AUTOMATED GUIDEWAY TRANSIT SYSTEMS: COSTS AND TRENDS FOR THE PERIOD 1976-1978 —SUPPLEMENT I

F.A.F. Cooke, C.P. Elms, D.U. Muotoh et al.; N.D. Lea & Associates, Inc.

October 1979, UMTA-IT-06-0188-79-1, PB 80-146483. 60 pp.

This report extends the information reported in the first cost summary. Operating and maintenance costs for 1976-78 are analyzed for five systems: Airtrans, Morgantown, Sea-Tac, Tampa, and Disney World. Capital cost is reviewed for the above and for the following: the people mover under construction at the Atlanta Airport, and existing automated guideway transit (AGT) systems at Busch Gardens (Williamsburg, VA), the Miami Airport, Fairlane Town Center, and King's Dominion.

The first five systems listed above are the major U.S. AGT systems in terms of ridership. In 1978, the average operations and maintenance cost was $.17 per passenger trip, considerably lower than that of the conventional transit industry. The systems, however, are not completely comparable because of the differences in trip length and operating environments. Overall, the systems perform quite well. Over 5.7 million vehicle-miles (9.12 million vehicle-km) were operated successfully in 1978.

Despite automation, labor is still a major component of AGT operations and maintenance costs.

By and large, labor is dedicated to maintenance and management. The AGT systems use about 1.6 employees per vehicle operated, which is less than the transit industry's figure of 2.6 employees. Capital costs are roughly comparable to light rail installations, about $25 million per route-mile ($15.6 million per route-km).

REVIEW OF DOWNTOWN PEOPLE MOVER PROPOSALS: PRELIMINARY MARKET IMPLICATIONS FOR DOWNTOWN APPLICATIONS OF AUTOMATED GUIDEWAY TRANSIT

N.B. Mabee and B. Zumwalt; The MITRE Corporation.

December 1977, UMTA-IT-06-0176-77-1, PB 281-068. 137 pp.

The Downtown People Mover (DPM) program was initiated by UMTA in April 1976, to demonstrate the urban applicability of people movers. Letters of interest were originally submitted by 65 U.S. cities, 38 of which later submitted formal proposals. A three-step site selection process was then undertaken to determine the four cities which would be awarded the first grants. After the first step of the evaluation, which involved a preliminary review and site visits, 19 of the cities were selected as preliminary final candidates. Cleveland, Houston, Los Angeles, and St. Paul were announced in December 1976 as the ultimate selections, although two of these cities later withdrew and were replaced by other cities. Also, a second tier of cities was granted Federal funds to continue preliminary studies.

This report contains brief summaries of each of the 38 DPM proposals. The proposals are broken into two groups: the 19 final candidates and the 19 remaining proposals. Each proposal is described exactly as submitted in each city's original documentation. Included for the final candidates is a sketch of the route alignment, quantitative data on the DPM's characteristics, narrative on expected demand, related transportation and land use information, and possible institutional considerations.

Profiles of all proposals are presented based on the individual city summaries to provide an overview of the various ways that the cities had approached the DPM subject. Generally, the finalists had better documentation and justification, which was one reason for their selection. Route lengths for finalists ranged from 4.7 miles (7.5 km) in Memphis to 1.09 miles (1.7 km) in Houston. Estimated weekday ridership varied from 61,700 in New York City to 12,560 in Bellevue, WA. Capital cost ranged from $167 million in Los Angeles to $25 million in Baltimore. Other aspects included functional purpose of circulation, peak-to-base ridership ratios, system capacity, operating cost, value capture, social acceptability, access to the handicapped (12 of the 19 finalists included elevators in all stations), security, safety and labor issues. The evaluation process also considered the amount of citizen input in preparing the DPM proposal, the likely environmental impact on downtown, energy consumption, downtown revitalization, and the degree to which the DPM could be integrated with the regional transportation system.

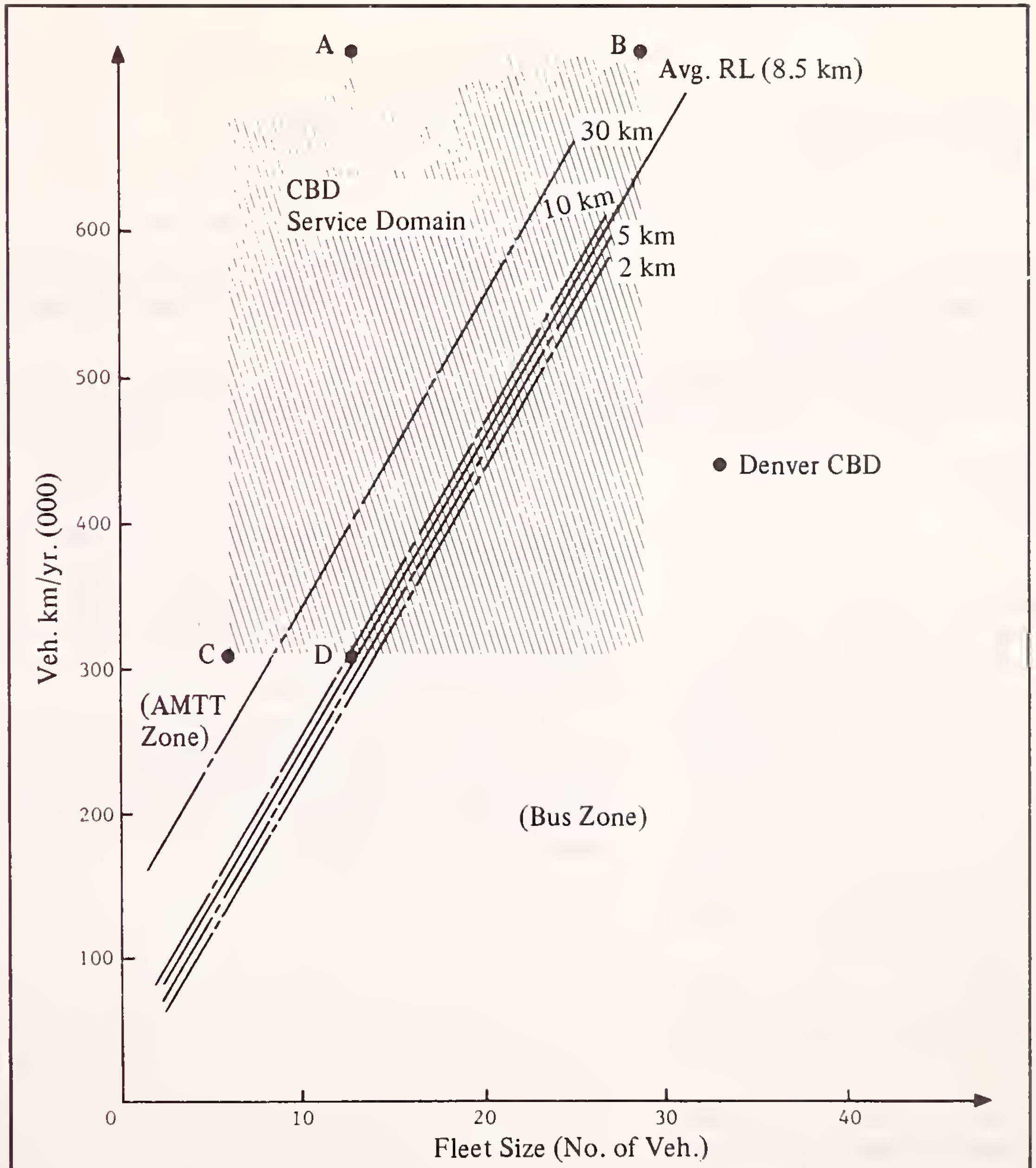
AUTOMATED MIXED TRAFFIC TRANSIT MARKET ANALYSIS

C. Chung and T. Anyos et al.; The MITRE Corporation and SRI International.

September 1980, UMTA-VA-06-0056-80-3, PB 81-105801. 194 pp.

Although automation of vehicle operator functions can result in significant operating cost savings, the high cost of the exclusive guideway and station structures associated with conventional automated guideway transit (AGT) systems has limited their application. A need was thus perceived for a less capital-intensive automated vehicle mode that could utilize existing rights-of-way with relatively minor modification. This system concept, Automated Mixed Traffic Transit (AMTT), refers to a system of driverless electric vehicles which move safely at low speeds over surfaces shared by pedestrians, and (possibly) move at higher speeds on a pedestrian-free path protected by suitable side barriers.

The development of the AMTT system reached the stage where it became necessary to examine and identify the potential market for this technology. This report examines the characteristics and associated costs of AMTT vis-a-vis its conventional transportation alternatives. Parametric analyses were performed between electrically powered driverless AMTT and internal combustion conventional bus transit to identify appropriate service and operating conditions for AMTT. An examination of potential application areas and the results of economic analyses indicated that AMTT would be less costly on a total annual cost basis than conventional bus transit in areas where fleet requirements are relatively low and a high amount of service, as measured in vehicle-kilometers, is desired. This can best be illustrated by the analyses of airports and medical centers. The information gathered and the analyses performed during this study indicate that AMTT may also find potential application in selected central business district malls, some universities and colleges, new towns, large shopping centers, and in a number of recreation areas and amusement parks.



A – high service level, high speed
B – high service level, low speed
C – low service level, high speed
D – low service level, low speed

Isocost Lines between Near-Term AMTT and Bus (Large-Sized Vehicles) —CBDs Market Analysis

AUTOMATED GUIDEWAY TRANSIT SOCIO-ECONOMIC RESEARCH PROGRAM FINDINGS 1976-1979

R. Nawrocki and B.A. Zumwalt; The MITRE Corporation.

February 1980, UMTA-IT-06-0176-80-1, PB 80-184633. 96 pp.

This report summarizes findings from the AGT Socio-Economic Research Program. Begun in response to a Senate recommendation in 1976, the program addressed performance, social, economic, institutional, and environmental issues associated with AGT technology to determine where and under what conditions AGT would prove to be a feasible urban public transportation mode. The program included feasibility studies of AGT; assessments of existing AGT systems, recommending hardware and technology improvements; and planning and analysis techniques.

The report summarizes 3 years of research which resulted in over 35 reports on AGT systems. The Research Program comprised four substantive areas:

- **Assessments** of many existing AGT systems, including engineering, system, and human factors data;
- **Costs** of AGT systems, both capital and operating;
- **Generic Alternatives analyses,** which examine the relative ability of different modes – auto, rail, AGT, etc. – to meet different types of urban travel needs; and
- **Market studies/local alternatives analyses,** which consider AGT deployment potential in cities.

Using data from the assessments, this report compares many of the features in the different AGT settings, operating characteristics, and public perceptions. This yields a useful summary reference source which cuts across all of the systems, highlighting the most relevant data and conclusions. Summaries of the national markets and generic alternatives project are presented. Although no new conclusions can be reached save those in the individual reports, this synopsis of findings provides a useful reference on AGT impacts.

The report's principal conclusions are that AGT has potential for urban applications. The final determination on AGT's usefulness, however, must await additional implementation of AGT systems in actual urban environments.

SECTION III

Summaries of Related Documents

Automated Guideway Transit

AUTOMATED GUIDEWAY TRANSIT – AN ASSESSMENT OF PRT AND OTHER NEW SYSTEMS

Office of Technology Assessment, Congress of the United States.
June 1975, PB 244-845.

In 1975, the Congressional Office of Technology Assessment undertook a comprehensive assessment study of automated guideway transit (AGT). Buttressed by several panels of experts, the study documented the status of AGT development, problems, research and development and possible governmental approaches for fiscal year 1976. Substantial supporting panel reports documented international developments, the economics of AGT, its social acceptability, and technological developments in the AGT field. The report serves as a good explanation of government AGT policy decisions made at that time.

The major findings of this assessment concerned UMTA's research and development program as it was then structured. The report found that shuttle-loop transit (SLT) deserved careful consideration as a solution to urban transportation problems, but that the UMTA research and development program did not sufficiently emphasize evolutionary improvements in SLT technology. Also, UMTA was found not to match its technical research and development with a corresponding program to study the economics and public acceptance of AGT. An urban demonstration of SLT was urged, as well as a mechanism for transferring research and development results to the capital grant program.

In assessing the status of group rapid transit (GRT), the report found that some cities had shown interest in GRT but existing installations had shown serious technical problems. The report urged a market and economic research program on GRT, and suggested monitoring Airtrans and Morgantown. The report stated that expansion funds for Morgantown should be withheld (this conclusion is now dated) and that UMTA's High Performance Personal Rapid Transit (HPPRT) program (later changed to the Advanced Group Rapid Transit program) seemed unjustified. Also, further preliminary studies of PRT and cooperation with foreign governments were recommended.

The report also assessed the overall management of the UMTA research and development program and analyzed four different budget alternatives for fiscal year 1976.

GUIDEWAY TRANSPORTATION, A BIBLIOGRAPHY WITH ABSTRACTS

Edith Kendon, editor.
National Technical Information Service.
May 1978, NTIS/PS-780402.

The National Technical Information Service (NTIS) of the U.S. Department of Commerce is a central repository for U.S. Government-sponsored research reports. The collection exceeds 800,000 titles. This document is a bibliography of research on automated guideway transportation (AGT) placed in NTIS between 1964, and April 1978. There are 157 abstracts of about one page each which list bibliographic data and give a brief summary of each report's contents. The types of subjects covered in these abstracts include almost all possible aspects of AGT, such as technology, demand, design, urban impact, etc. A variety of government sponsors, not limited to UMTA, are included here.

The bibliography includes PRT, dual-mode, general AGT, monorails, high-speed ground transportation, magnetic levitation and palleted systems, among others. (Air cushion vehicles are excluded.)

IMPACT OF ADVANCED GROUP RAPID TRANSIT TECHNOLOGY

Office of Technology Assessment, Congress of the United States.
U.S. Government Printing Office, Number 052-003-00736-3, PB 80-153323.

The simplest form of automated guideway transit (AGT), shuttle-loop transit (SLT), has been demonstrated and has been in use for several years. A second generation, called group rapid transit (GRT), is operating at Morgantown, WV, and at the Dallas/Fort Worth Regional Airport. A third generation, called advanced group rapid transit (AGRT), is currently being developed by a large UMTA research program. This document assesses proposed changes in the scope and cost of UMTA's AGRT program and also addresses three major issues:

- the need for more advanced automated systems;

- prototype development; and
- government-industry relationships.

The report briefly discusses the history of the AGRT research program, the needs of urban areas related to AGT, various transportation options which are available, and the impact of AGRT technology. Aside from these system-oriented aspects, the report also delves into government-industry relationships, barriers to innovation, and foreign trade aspects of AGT. (The U.S. no longer has a technical lead in AGT technology.) Several market scenarios are put forth.

The report concludes that automation still has untested potential and that more study is needed. Development of multiple prototypes is suggested to avoid the possibility of choosing the wrong technology. The introduction of innovative systems is somewhat constrained by institutional factors and an alternative arrangement for managing transit research and development is worth consideration. The report also analyzes four different options for future AGT research. These include:

1. Emphasis on short-run improvements in SLT and GRT technology;
2. Long-range development of critical subsystems;
3. Subsystem validation in an integrated system environment; and
4. Development of prototype AGRT systems.

The report recommends that the first policy is appropriate as a continuing objective; that policies 2 and 3 are the best way to ensure orderly long-term development; and that policy 4 is premature at this time.

AGT GUIDEWAY AND STATION TECHNOLOGY; VOL. I, EXECUTIVE SUMMARY

R.D. Stevens, C.W. Dolan, R.J. Pour et al.; DeLeuw Cather & Co. and ABAM Engineers, Incorporated.

July 1979, UMTA-IT-06-0152-79, PB 299-553. (8 vols. in complete study.)

The main objective of the AGT Guideway and Station Technology studies was to develop guideway, station, and weather protection concepts which would reduce the cost and implementation time of future AGT construction. There are eight volumes in the series, of which this is the executive summary. The other seven volumes are:

Volume 2, Weather Protection Review;

Volume 3, Guideway and Station Review;

Volume 4, Design Guidelines;

Volume 5, Evaluation Models;

Volume 6, Dynamic Model;

Volume 7, Guideway and Station Concepts; and

Volume 8, Weather Protection Concepts.

According to the conclusions reached in the study, it is possible to reduce the costs associated with building AGT systems. For example, optimizing guideway designs is estimated to save 15% over existing designs, mainly by increasing the span length. Other suggested modifications could cut costs even more such as by eliminating off-line facilities and using at-grade alignments or joint development.

Weather protection is one of the most critical issues in AGT design. Despite the fairly large number of U.S. AGT systems, experience with severe weather conditions is limited because most AGTs are placed in southern climates or in amusement parks operating only in the summer. After assessing existing data, the project made recommendations in three most significant weather problem areas: icing of signal and power rails; loss of traction due to ice, etc.; and freezing of guideway switches. Solutions include pavement heating, abrasives, chemicals, and traditional snow removal methods.

The project also analyzed and discussed guideway components and arrangements; structure weight and cost relationship; optimal cross-sectional designs for guideways; station schematic layouts; escalation of construction costs; evaluation of potential designs; factors influencing ride comfort; and other data on materials and vehicle/guideway relationships. Methods for modifying existing AGT guideways are also described.

PEOPLE MOVER PROFILE

Transportation Systems Center, Technology Sharing Program Office, U.S. Department of Transportation.

May 1977.

This report, introductory in nature, is a general interest publication designed to aid the reader in gaining a basic familiarity with and understanding of people movers, one of the categories of automated guideway transit (AGT). The profile consists basically of three sections. The first section defines and differentiates the various types of AGT systems, including: people movers, or shuttle and loop transit; group rapid transit; and personal rapid transit. In addition, the physical components of a people mover system – vehicles, guideway, stations, and control system – are described.

The second section provides detailed technical data and photographs of operational people mover systems, including: Boeing's Morgantown system; the DEMAG/MBB Cabinlift; Ford Motor Company's ACT System; the Rohr Industries, Inc., P-Series Monotrain (Houston Tunneltrain); the Universal Mobility, Inc., Unimobil Type II; the Vought Corporation's Airtrans; Walt Disney Community Transportation Services Company's WEDway People Mover System; and the Westinghouse Electric Transit Expressway.

The third section contains supplementary material on UMTA's efforts and involvement in people mover research and development and a glossary of terms used in the document.

Dual Mode Systems

DUAL MODE TRANSPORTATION

Special Report 170, Proceedings of a Transportation Research Board Conference held in May 1974.

Transportation Research Board, National Academy of Sciences.

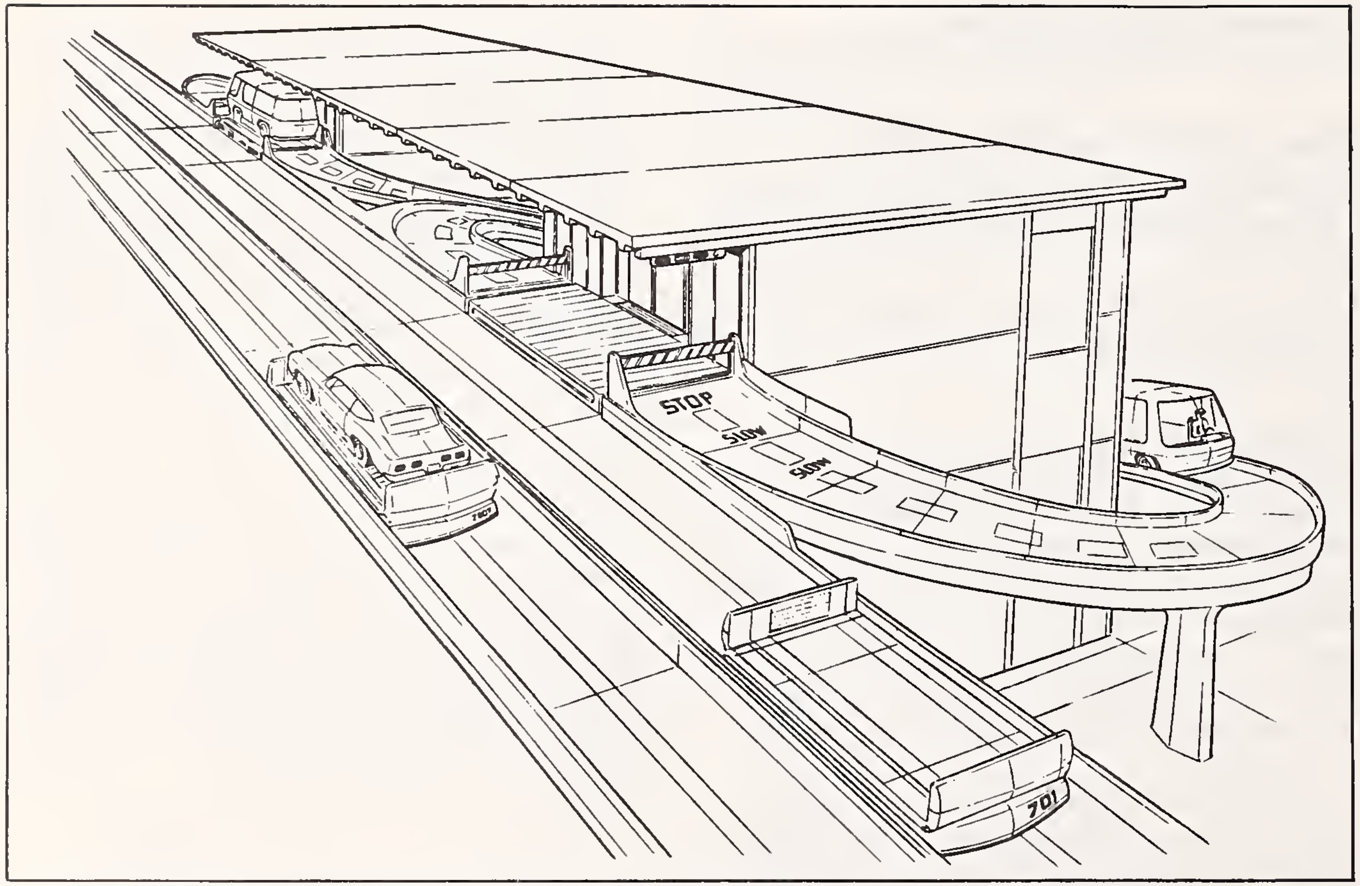
1976, PB 262-257.

Dual mode transportation employs vehicles which operate manually on existing streets and automatically on special purpose guideways. Vehicles may be either privately-owned "autos" or common carrier "buses." Collection and distribution of passengers off the guideway may be either fixed-route or demand-responsive, and guideways may have on-line or off-line stations. Vehicles can also be driven onto pallets which are in turn transported on the guideway.

Dual mode is a theoretical system which has received research attention because its attributes appear favorable compared to the automobile. Research began in the 1960's with a series of conceptual studies. In 1974, the first general conference on dual mode was sponsored by the Transportation Research Board. This document presents papers, abstracts of papers, and speeches by participants of that conference.

Taken as a whole, the report is an excellent overview and summary of the body of knowledge available on dual mode at that time. The authors presented in this document include the most knowledgeable researchers, planners, and government officials. Specific topics which were covered in the conference include a broad range of engineering, architectural, conceptual, and behavioral aspects.

Several papers give broad overviews of the current status of dual mode research and discuss potential urban applications. (Since little research in the area has been done recently, much of what is reported here is still current.) A description of the government's overall research program is given, as well as several different promising conceptual approaches. Several authors address the question of potential user reactions to dual mode. Many separate engineering aspects are also addressed, such as command and control, lateral control, station planning, reliability and maintenance, longitudinal control, propulsion and energy, capacity, safety, and guideway design. Thus, the document is a useful reference work to substantive areas of interest regarding dual mode transportation.



Dual Mode Transit System Using Pallet Transporters (Otis/TTD)

DUAL MODE PLANNING CASE STUDY-MILWAUKEE

Volume 1: Executive Summary and Planning Analysis

G. Kocur, E. Ruiter, and D. Stuart; Cambridge Systematics, Inc., and Barton-Aschman Associates.

August 1977, UMTA-MA-06-0056-80-1, PB 80-193956. 428 pp. (3 vols. in complete study.)

This study analyzes the operations, economics, and impacts of alternate dual mode transit systems for Milwaukee, WI. The dual mode systems employ public vehicles capable of automated operation on the guideway and manual operation on streets. The three different dual mode concepts in the study use hardware suggested by three manufacturers. Different network configurations and operating policies were tested to address a variety of system design issues. The three different modeling elements used were a supply procedure model, a demand model, and an evaluation model.

Three different networks were tested in conjunction with four potential operating strategies. Networks varied the extent and spacing of guideway coverage. Operating strategies included fixed-route, fixed-schedule, demand-responsive, nonstop, and subscription services. Combination of networks and operating policies yielded five "best" dual mode systems which could be considered as cost-effective candidates for development and demonstrations. The report analyzes the cost, demand, economic benefit, environmental impact, and many other aspects of all five "best" systems. The range of uncertainty around the estimates is also calculated.

The report concludes that both the fixed-schedule and the demand-responsive policies are inappropriate for a dual mode system as an "end-state." The reason is that with the presence of many stations in the design, over 90% of all passengers will make at least one transfer, and the dual mode capability is not effectively utilized. Other conclusions involved the 10 to 15% decrease in driver utilization due to guideway automation, transfer policy, mixed fleets, and system capacity. Apparently, most other potential system users (i.e., goods delivery) would not be able to remove the driver at both ends of the trip and would, therefore, not utilize the full dual mode capability.

DUAL MODE PLANNING CASE STUDY – ORANGE COUNTY

Volume 1: Executive Summary and Planning Analysis

P. Costinett, W.G. Hansen, J. O'Doherty; Alan M. Voorhees & Associates, Inc.

June 1977, UMTA-VA-06-0030-80-1. (3 vols. in complete study.)

In this report, a full scale planning study of dual mode was carried out for Orange County, CA. Based on existing and projected population, land use, and socio-economic data for 1990, a basic network of dual mode service was designed and evaluated. Both bi-modal and pallet systems were included, and different levels of network coverage were also tested. Using modal split models from other urban areas, local trip distribution patterns, and manufacturers' assumed service characteristics, a set of baseline demand forecasts was made. Costs were also based on manufacturers' estimates, as well as policy fare levels.

Results of the study showed that while dual mode had considerable potential for attracting more trips than conventional transit, it could not compete with the auto. Optimistic forecasts yielded an overall transit mode split of 8%, up from today's 1%. Local collection and distribution proved to be the most important single component of the system. During peak periods, fixed-route collection and distribution proved more effective than demand-responsive collection and distribution. Maintaining high operating speeds proved to be important. Only in certain areas did off-guideway operation of dual mode vehicles appear fruitful. Only about 25% of the peak-period trips did not involve transfers. Larger vehicles offered the potential for lower costs without serious effect on service levels.

Overall potential benefits were judged to be substantial but uncertain. A total operating cost reduction of 15 to 20% could be achieved with only a 10% increase in capital cost to account for the automation. These data, however, assumed that dual mode reliability can be assured. The bi-modal vehicle concept was superior to the pallet vehicle concept in both cost and performance. Overall, the dual mode studied in this case could be more attractive than either conventional rapid rail or busway systems.

There are two additional volumes to this report. Volume II (appendices) describes the methodology and background data used. Volume III describes the quasi-manual initial screening procedure, which can be used as a sketch planning model in other applications.

ANALYSIS OF DUAL MODE SYSTEMS IN AN URBAN AREA

Volume I: Summary

P. Benjamin. J. Barber, R. Favout et al.; Transportation Systems Center, U.S. Department of Transportation.

April 1973, DOT-TSC-OST-73-16 A,I, PB 236-425. 40 pp. (4 vols. in complete study.)

This report summarizes one of the earliest attempts at analyzing the costs, impacts, and benefits of dual mode transportation. The objective was to assess overall dual mode potential by simulating several different dual mode systems in a case study city – Boston. Three dual mode technologies were tested and compared against the official 1990 plan for the Boston region as it existed at that time. The technologies tested were a pallet system, an automated highway vehicle system, and a new small vehicle system. The latter system included specially deisgned, system-owned, electric 4-passenger vehicles and 12-passenger minibuses. This system incorporated a dial-a-ride function for off-guideway collection and distribution, while the other two systems utilized fixed routes and schedules.

One dual mode network of roughly 250 miles (400 km) of guideways was designed for the Boston region. It provided access throughout the region and was integrated to serve the existing public transportation system. Results of the simulation showed that all three dual mode technologies had the potential to be comparable with the officially anticipated investment in new highway and transit scheduled by 1990. Dual mode provided better accessibility to desired locations, reduced travel time and highway congestion, increased energy consumption (due to greater speeds), and reduced pollution in the small vehicle system. Revenues were found to meet or exceed system operating costs, but fairly large capital subsidies, ranging from $1.6 to $4.2 billion, were needed. The report also suggested that total regional benefits of dual mode were roughly twice the costs, and that there were no equipment areas considered to be technically infeasible. Dual mode systems with private vehicles and public buses were evaluated as more effective than systems consisting of either type exclusively.

Accelerating Walkway Systems

ACCELERATING MOVING WALKWAY SYSTEMS – EXECUTIVE SUMMARY

J. Fruin and R. Marshall, Port Authority of New York and New Jersey.

November 1978, UMTA-IT-06-0126-78-1, PB 290-682, 31 pp. (7 vols. in complete study.)

Variable-speed, accelerating walkway systems (AWS) resemble conventional, constant-speed moving walkways in appearance. However, they accelerate after a passenger enters the walkway to speeds four to five times that of conventional systems and slow down again as the passenger leaves the walkway.

Five AWS developers had systems at or near the prototype state of hardware development and testing at the time this document was written. These include:

1. The Speedaway system by Dunlop;
2. The TRAX system by Regie Autonome de Transports Parisiens (Paris Transit Authority);
3. The Applied Physics Laboratory system by Johns Hopkins University;
4. The Boeing system by Boeing Aerospace Corporation; and
5. The Dean system by Dean Research Corporation.

This report summarizes the results of a series of six feasibility studies on these five systems and on the potential of AWSs in general. These studies were the first phase of a program leading to a demonstration of an accelerating walkway system.

Accelerating walkways could be useful in moving pedestrians faster through high-traffic areas where vehicular transit may be undesirable. Potential markets for these systems include airports, transit systems, and other urban activity centers. Under certain conditions AWSs offer lower life cycle costs and lower energy requirements than vehicular systems providing a similar level of service. In high-volume pedestrian corridors these systems are shown to be cost effective. A safety evaluation, done as part of this study, concludes that the five systems could operate at acceptable safety levels.

The reports in the AWS series include:

Accelerating Moving Walkway Systems – Technology Assessment, UMTA-IT-06-0126-78-2;

Accelerating Moving Walkway Systems – Safety and Human Factors, UMTA-IT-06-0126-78-3;

Accelerating Moving Walkway Systems – Market, Attributes, Applications, Benefits, UMTA-IT-0126-78-4;

Accelerating Moving Walkway Systems – Demonstration Plan, Procurement, UMTA-IT-06-0126-78-5;

Accelerating Moving Walkway Systems – Demonstration Plan, UMTA-IT-06-0126-78-6; and

Accelerating Moving Walkway Systems – Safety Seminar Proceedings, UMTA-IT-06-0126-78-7.

ACCELERATING WALKWAY SYSTEMS
TECHNOLOGY ASSESSMENT – COMPARATIVE SUMMARY

ITEM / MODEL	DUNLOP SPEEDAWAY	RATP TRAX	JOHNS HOPKINS A.P.L.	BOEING	DEAN RESEARCH
1. System Type and Current Status	One directional, abutting pallet treadway; fully tested prototype, near production.	Two directional loop, intermeshing pallet treadways; partially tested full scale prototype.	One directional, intermeshing leaf treadway, partially tested, reduced scale prototype.	Two directional loop, intermeshing leaf treadway, reduced scale prototype under construction.	One directional, abutting roller treadway, prototype segement partially tested.
2. Siting Characteristics	"S" shaped alignment, 30 ft. wide ends, 57 in. subgrade, level sites.	Linear 14-16 ft. width throughout, 7.4 ft. subgrade at ends, 20 in. on line, some grade and alignment variability.	Linear, 6 ft. approx. width throughout, 15-24 in. subgrade, some grade and alignment variability.	Linear, 14 ft. width throughout, above grade installation, some grade and alignment variability.	Installation envelope not defined, linear, 6 ft. approx. width, promising grade and alignment variability.
3. Passenger Service Characteristics (all systems continuous)	Motions treadway and handrail should be acceptable to public based on tests.	Motions treadway acceptable based on tests, handrail undergoing tests.	Motions treadway acceptable based on tests, handrail designed but not tested	No testing at time of report.	Treadway motions reported as acceptable based on limited tests.
4. Estimated Total Costs (Equipment, Site Construction and Installation) per lineal foot or route installed, based on 1000 ft: grade	$3474/LF*	$4430/LF	$2560/LF	$3030/LF	$2860/LF
bridge	$4194/LF	$5650/LF	$3440/LF	$4250/LF	$3740/LF
subway	$5864/LF	$7020/LF	$4530/LF	$5620/LF	$4830/LF
5. Developer Qualifications	Fully qualified moving way system manufacturer.	U.S. licensee, possible consultant assistance required.	U.S. licensee, possible consultant assistance required.	Qualified transportation system manufacturer, possible consultant assistance required, moving way passenger systems.	Industrial conveyor manufacturer, possible consultant assistance required, moving way passenger systems.
6. Safety and Human Factors Potential Problem Areas	Handrail proximity at wide entrance and exit, multiple handrails, pallet movement beneath balustrade.	Bunching, treadway meshing, handrail synchronicity with treadway, handrail detailing under test.	Bunching, treadway meshing, handrail not tested.	Bunching, treadway meshing, handrail detailing not known or tested.	Treadway rippling, vibration and other affects, handrail detailing not known or tested.

*LF – linear foot.

ACCELERATING WALKWAY SYSTEM TIMES SQUARE – GRAND CENTRAL STATION ANALYSIS

C. C. Chung; The MITRE Corporation.

December 1978, UMTA-VA-06-0041-78-3, PB 80-181795. 40 pp.

An accelerating walkway system (AWS) is a high-capacity, continuously available mode of transportation. Potentially, it can fill the gap between walkway and conventional vehicular systems. Its potential seems greatest in cases of very high, short-distance demand. A prime example of this is the distance between Times Square and Grand Central Station, in New York City. These locations, only about 2500 feet (750 meters) apart, draw heavy crosstown traffic, as well as transfers between various subway lines. Today, there is a subway shuttle between the two points which carries about 90,000 passengers per day. Also, a second through subway connects the two points one level further down, as do two surface bus routes.

The report works out the cost and service characteristics of accelerating walkway systems as built by five different manufacturers, if placed between Times Square and Grand Central Station. With a treadway width of 3.3 feet (1 meter), the practical capacity is about 7200 passengers per hour. This is adequate for current peak loads. Costs are speculative only, and assume that accelerating walkway systems could be placed inside the existing subway shuttle tunnel. Equipment costs range from about $2800 to $5700 per lane-meter, excluding site preparation costs. Total capital costs range from $5,000,000 to $13,000,000. Total operating costs for power, maintenance and insurance would range from $500,000 to $750,000 per year. Life cycle costs work out to about $.04 to $.08 per passenger. The accelerating walkway's system level of service is approximately equal to today's transit alternatives. One major advantage is the complete elimination of waiting time. The report did not, however, evaluate the effectiveness of replacing the existing subway shuttle, with its costs, with an accelerating walkway system.

HIGH-SPEED PEDESTRIAN CONVEYORS – A REVIEW

A. Naysmith; Transport and Road Research Laboratory, Department of the Environment, Department of Transport, England.

1978, ISSN 0305-1293. 33 pp.

This report summarizes 10 years of research on high-speed pedestrian conveyors in England. The high-speed conveyors, known in the U.S. as accelerating walkways, were reviewed in terms of technology, design constraints, and comfort. Specific safety problems relating to boarding, acceleration, passengers moving from one belt to another on the walkway, among others, were also discussed.

The market in the United Kingdom for accelerating walkways was assessed and it was concluded that there are few areas where they would be cost-effective and feasible.

Automated Mixed Traffic Transit

AUTOMATED MIXED TRAFFIC VEHICLE CONTROL AND SCHEDULING STUDY

T.K.C. Peng and K. Chon; Jet Propulsion Laboratory, California Institute of Technology.

December 1976, UMTA-RD-CA-06-0088-76-1, N77-14945. 65 pp.

An Automated Mixed Traffic Vehicle (AMTV) is a driverless transit vehicle designed to share its guideway with pedestrians and other vehicles. It is designed to carry passengers from one station to another following an electrical guidewire buried in the street or right-of-way while automatically slowing down or stopping to maintain safe distances from objects in its path. Collisions are avoided through use of proximity sensors, automatic control mechanisms and wayside signals. AMTV systems are thought to have some potential for urban applications since they require neither human operators nor exclusive guideways and therefore could have a cost advantage over conventional transit systems.

A low-speed, experimental AMTV system is currently operating at the Jet Propulsion Laboratory in Pasadena, CA. Although its top speed is 7 mph (11 km/hr), this could be suitable for use in public malls, shopping centers, and some industrial parks. A higher-speed model 15-20 mph (24-32 km/hr) is mentioned, but no prototype has yet been produced. Substantial development work is required before a prototype higher-speed AMTV system is possible.

This study gives a brief history and background of AMTV systems, analyzes their operation, and evaluates the expected performance of a transit system using low-speed AMTVs. A simulation model developed to compare passenger waiting times and system load factors for various headway and control policies is described.

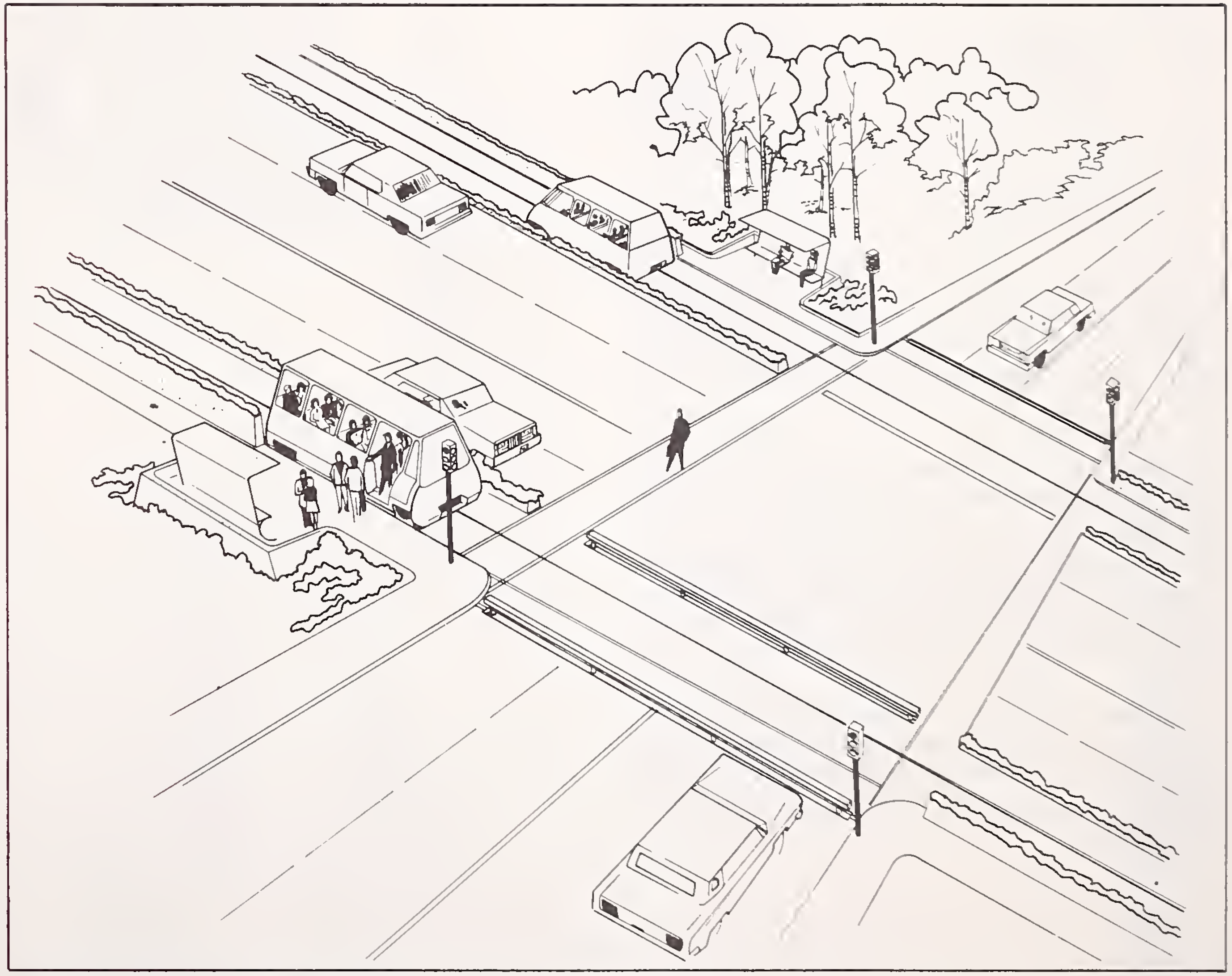
The report concludes that a high level of service and efficiency can be provided through effective scheduling and control policies. It also reports optimum speed control parameters for safety and comfort and recommends ways to minimize interference from pedestrains and other vehicles.

AUTOMATED MIXED TRAFFIC VEHICLE – AMTV – TECHNOLOGY AND SAFETY STUDY

A.R. Johnston, T.K.C. Peng, H.C. Vivian, P.K. Wang; Jet Propulsion Laboratory, California Institute of Technology.

February 1978, UMTA-CA-06-0088-78-1, N78-25257. 126 pp.

This report discusses current Automated Mixed Traffic Vehicle (AMTV) technology and safety issues related to implementation of an AMTV system. Also identified are specific areas where further



Potential High-Speed AMTT Application Along a Corridor Area

development is needed before a low-speed (7 mph or 11 km/hr) AMTV system can be demonstrated, which is possible within 3 to 5 years of this study. A low-speed AMTV system could be demonstrated in a pedestrian mall or recreation area, and subsequently used in shopping areas, campuses, and other special types of urban centers.

Hybrid AMTV systems are also discussed. These are designed to operate at low speeds in mixed traffic areas and at high speeds (20 mph or 32 km/hr) in protected rights-of-way. Hybrid systems may be used, after much further development, as shuttles or where longer distances are a factor in the service area.

The physical elements of an AMTV system, both moving and stationary, are described in terms of system requirements and subsystem specifications. The reasons for hardware failure and other safety concerns unrelated to hardware failures are analyzed. The study recommends both design modifications and improvements, and operational procedures to remedy or prevent potential safety problems.

Urban applications of AMTV technology, beyond the initial demonstration, will require engineering, development and long-term research. The specific subsystems that require this work are enumerated.

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