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of Transportation
**Urban Mass
Transportation
Administration**

An Analysis of the U.S. Market for Automated Guideway Transit

Volume 1: National Market Estimates

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AN ANALYSIS OF THE US MARKET FOR AUTOMATED GUIDEWAY TRANSIT

VOLUME I--National Market Estimates

Final Report

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16. Abstract

An important component of the Urban Mass Transportation Administration's research and development program involving automated guideway transit (AGT) is the determination of where and under what conditions AGT service characteristics will satisfy the travel needs and socioeconomic requirements of urban areas in a manner that is competitive with or superior to other transportation alternatives. To contribute to this determination, three general activities were undertaken:

- a national markets estimate based on data from 46 urban areas to identify a target implementation potential; reported on in this document, Volume I.
- eleven site-specific alternatives analyses within three representative urban areas; reported on in Volume II.
- a two-phased consumer survey to determine individual preferences toward AGT; reported on in Volume III.

This volume develops estimates of potential US nationwide AGT installations, examining five basic application types: corridors, CBDs, activity centers, medical centers, and airports. The estimates are based on a comparison of anticipated benefits to costs, considering both the local and federal perspective, and forecasting potential passenger demand using actual characteristics of 46 candidate urban areas. Policy implications are analyzed with respect to federal and local funding, economic development, visual and urban design, labor, passenger security and performance characteristics.

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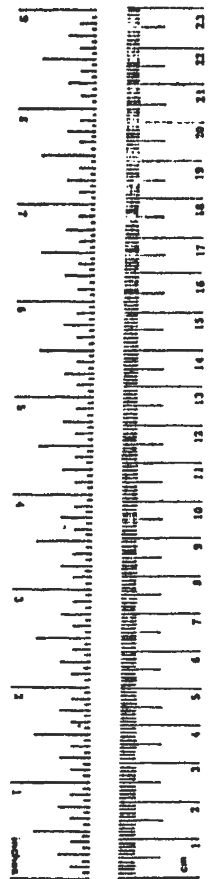
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
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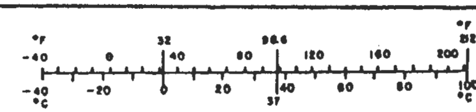
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This study was funded by the US Department of Transportation, Urban Mass Transportation Administration (UMTA), AGT Socio-Economic Research Program. The study team consisted of Cambridge Systematics, Inc.; Skidmore, Owings & Merrill; and National Analysts. In addition to the three volume final report series, an aesthetics handbook has been developed to provide guidance to architects, engineers and planners who are concerned with aesthetic issues of elevated AGT systems.

George A. Kocur of Cambridge Systematics served as director of the project and was responsible for the overall direction and management of the work performed as well as being the primary author of this volume. Co-authors of this national market estimates volume are Daniel Nagin and Pamela Reid of Cambridge Systematics, with additional contributions from John H. Suhrbier, Earl R. Ruiter, and Wendy P. Stern. Principal Skidmore, Owings & Merrill staff were David Smith and Robert Henderson.. The investigation of consumer attitudes toward automated guideway transit and other modes of public transportation, described in Volume III and summarized in this volume, was performed by the Social Science Department of National Analysts. In addition, the firm of Technical Assistance, Inc. provided technical support to the project which contributed importantly to the final results.

The authors wish to express their particular appreciation to the responsible UMTA staff for the guidance and support provided throughout the project. These included Howard Evoy, Robert McCown and Ron Nawrocki.

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SUMMARY

INTRODUCTION

This study investigates the potential of single line automated guideway transit relative to current, non-automated transit technologies to provide transportation in urban areas and to contribute to the revitalization of urban areas. Automated guideway transit (AGT) reflects a class of transportation systems in which vehicles are automatically operated on fixed exclusive guideways. Downtown People Mover (DPM) systems, as one example of AGT, usually are classified as single line systems in which vehicles operating in a simple shuttle system either move back and forth on a single guideway or around a closed loop stopping at any number of stations.

The methodology is based on three associated analyses:

- a two-phased consumer survey to determine individual preferences toward automated guideway transit,
- 11 site-specific alternatives analyses within three representative urban areas,
- a national market estimate based on data from 46 urban areas to identify a target implementation potential.

As illustrated in Figure 1, the consumer survey and the site-specific analyses contribute to the national market estimate, with the results of these two analyses being used to help assess the likelihood of implementation at individual sites in the national market analysis.

The results of each of the inter-related analyses also can be used to assist in the identification and assessment of policy options and financing mechanisms necessary to implement AGT systems and to determine further research, development, and demonstration requirements for AGT systems technology.

CONSUMER SURVEY

The consumer survey examines personal attitudes toward AGT and other transit modes. In addition to meeting with local officials and interest groups to elicit their attitudes and to identify key issues of interest and their likely responses, a more structured set of consumer surveys was carried out. Using a stratified random sample of Atlanta area residents, a series of six in-depth group interviews were conducted in order

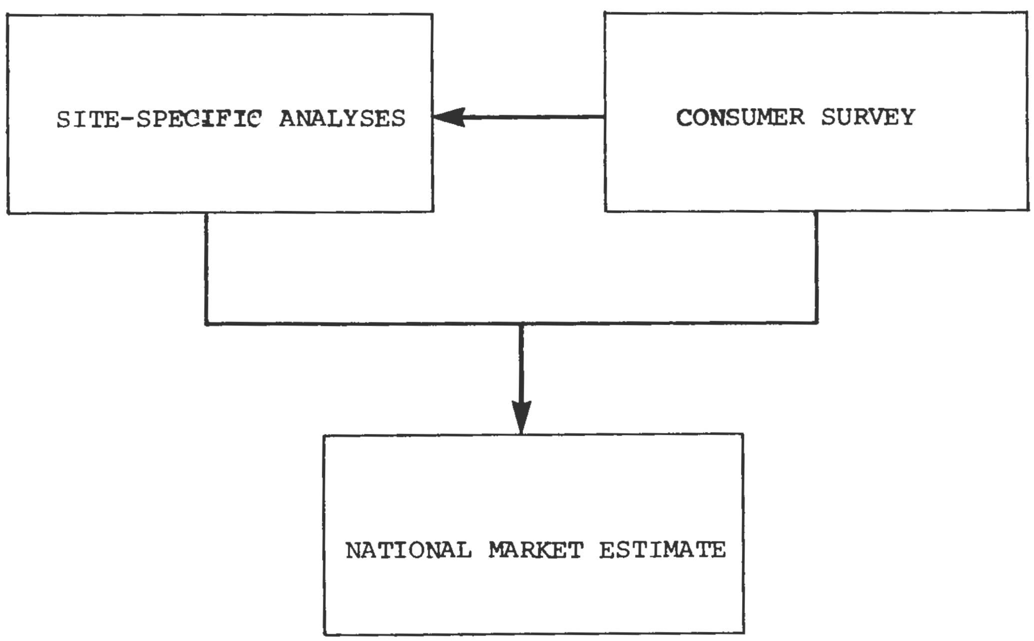

Figure 1 Overview of Analysis Methodology

to identify key factors affecting individual preferences toward an AGT system. Based on the results of these discussions, approximately 550 personal interviews were conducted to identify, using conjoint rating, a quantitative evaluation of the following factors:

- o transit modal image
- o frequency of service
- o vehicle size
- o travel time difference from auto
- o price difference from auto
- o seat guarantee
- o distance to station/bus stop from home
- o distance to destination from station/bus stop of arrival

The survey shows that transit mode is a key factor in individual transportation decisions. On the average, though, transit users rate the four modes about equally. AGT is preferred somewhat less than either rail or express bus, but valued more than local bus. Though the definition of transit mode used in the survey explicitly excludes all other factors considered, transit mode appears to be important because of the perceived effect on other factors. The survey results indicate that consumers are most influenced by travel time, frequency of service, and price. AGT, therefore, can most effectively increase ridership relative to other transit modes if it can provide shorter travel time, more frequent service, or lower price. Factors of less importance which may be potentially influenced by AGT include walk distances, vehicle size, and seat guarantees.

The consumer attitude survey can be stratified to examine the demographic characteristics of potential AGT ridership. AGT is expected to attract primarily riders from other types of transit by offering improved service, although it also will appeal to some non-transit riders. The group of non-transit riders from the sample most attracted to AGT are white males in middle/upper income brackets for work-related travel.

SITE-SPECIFIC ANALYSES

In the site-specific alternatives analyses, Atlanta, Chicago, and Dallas were selected as representative urban areas based on population level, growth, and density characteristics; the availability of necessary data; and interest in participating in an alternatives analysis at the local level. Within the urban areas, 11 candidate local sites were selected that are representative of the following types of potential AGT applications:

- o corridor
- o central business district (CBD)
- o diversified activity center (suburban)
- o medical center

For each site, alternatives were then developed and analyzed for AGT, light rail transit (LRT), bus (local and express), and current base conditions. Key issues, as expressed by local officials, varied substantially across sites, though there is a tendency for consistency within a particular type of site. Potential issues were sometimes of no concern at any site or only of interest at certain types of sites. Also, certain features of AGT were considered to be positive in some sites and negative in others.

Visual Intrusion

In general, visual intrusion from an elevated AGT guideway is considered undesirable, especially in CBDs and residential corridors. In CBDs, an elevated AGT guideway may not be compatible with the existing (usually older) architecture; in corridors, the guideway may not be compatible with residential areas. Opposition from residents in corridors can probably be expected. As for medical centers, the elevated guideway may have positive or negative impacts depending on current architecture. Development of an elevated AGT in suburban activity centers can be expected to have a positive impact. Frequently, the futuristic design of AGT would enhance the modern image most such activity centers desire. Also, the innovative design of AGT can be more easily integrated into ongoing developments at suburban activity centers.

Joint Development

Joint development with an AGT is of primary importance in activity centers and corridors. CBDs tend to be more fully-developed, with joint construction opportunities being correspondingly more complex. Developing activity centers and corridors are particularly good sites for joint development. Not only are they rapidly expanding, the modernistic image of AGT is considered to be an asset.

Benefits deriving from economic development with AGT systems are highly uncertain; however, AGT is expected to enhance economic activity in CBDs, activity centers, and airports. As opposed to these sites, AGT's economic benefits in corridors would most likely be simlar to those from conventional rail systems.

Costs

The most prevelant objection to AGT is the cost. AGT is consistently a lower cost option than rail transit, but more expensive than bus. Since most sites are considering AGT as an alternative to bus rather than rail, the costs of AGT may seem overly high. Only sites with a possibility of substantial economic development or joint development with a regional transit system consider AGT financially viable.

Ridership

Demand levels for AGT are generally higher than for other transit alternatives. Low demand levels are a major concern only in activity and medical centers, sites which usually have minimal current transit service. Thus, a completely new ridership market has to be generated rather than a transfer from other types of transit. Low demand levels are not an issue at those sites already having substantial transit ridership.

Alignment

Alignment selection is a problem primarily in CBDs. Most CBDs are sufficiently developed that system routings, even though they may be within public rights-of-way, become a thorny concern. Another alignment issue concerns flexibility of AGT versus other transit modes. At activity centers which are either newly developing or have multiple owners, the inflexibility of an AGT system may be a concern because of uncertain future growth patterns within new areas or conflicts of interest between owners at some developments.

Disruption

Construction disruptions are a concern in activity centers, medical centers, and some corridors. In activity centers, construction disruption could cause a reduction in retail sales. In medical centers, the noise and vibration from construction are particularly undesirable due to the necessity of a quiet, restful atmosphere. Disruption from construction is also undesirable in residential sections of corridors. Construction disruption, however, is not considered particularly harmful in CBDs due to current high noise and vibration levels. Rerouting of traffic from construction most greatly affects CBDs, but is not considered a major concern by most local officials.

Labor

Labor issues are felt to be unimportant at all sites. Local administrators believe any labor displacements can be absorbed into other jobs.

Personal Security

Personal security proved not to be a major concern in the case studies, except at medical centers. At some sites, personal security is considered low on an automated system, but not lower than current transit. Personal security is a potential risk at medical centers due to the large number of physically impaired riders.

Site Potential

Based on the case study analyses, only certain corridors, CBDs, major diversified activity centers, and medical centers are judged to be likely sites for AGT implementation. Table 1 indicates the key issues by market segment. The following discussion indicates characteristics of each type of site that increase the probability of implementing AGT.

In corridors, the key issues are visual intrusion, disruption of residential areas, costs, and integrated joint development. The probability of successfully implementing an AGT system in a corridor is enhanced by selecting a right-of-way through residential areas that minimizes visual intrusion, operating noise, and construction disruption. Potentially high costs can be mitigated if substantial joint development is possible or if the AGT is a segment of a regional transit system.

In CBDs, the key issues are alignment, visual intrusion, and costs. In addition, integration with current transit systems may be an issue, with some CBDs

Table 1
Potential Key Issues by Type of Application

	Corridors	CBDs	Activity Centers	Medical Centers
Visual Impacts	X	X	X	X
Joint Development	X		X	
Cost	X	X	X	X
Demand Levels			X	X
Alignment Selection		X		
Construction Disruption	X		X	X
Labor Issues				
Personal Security				X

not being potential sites for AGT due to a previous commitment to rail transit. Other CBDs must solve the problem of integrating AGT into existing transit plans. Location of an adequate right-of-way where AGT is compatible with existing architecture is fundamental to development of AGT in CBDs, and some CBDs may contain no viable alignment. Costs of AGT also may be considered to be high unless AGT can enhance economic development in the CBD.

Generally, AGT is viable only in major diversified activity centers with two (or more) retail nodes, two (or more) non-retail nodes, and at least several million square feet of floorspace. These sites are even more promising if they have a single owner and/or are well-established activity centers. High costs and low demand are the key problems in any activity center. These problems can be overcome at some sites, though, through joint development where the areas are growing or through integration with a regional transit system.

Only medical centers that contain single institutions with multiple sites seem appropriate for AGT. In other types of medical centers, each institution is relatively self-contained, with the flow of traffic between institutions being relatively low. Even at medical centers where institutions have multiple sites, the high costs, low demand, and the threat to personal security from an automated system work against successful implementation.

NATIONAL MARKET ESTIMATE

Whereas the site specific alternatives analyses and the consumer market survey can be characterized as looking at issues from a local perspective, the purpose of the market estimate activity is to develop a national forecast of the market for applications of AGT, based on an analysis of global costs and benefits. Local perceptions of a system's cost-effectiveness, however, may differ from the federal perspective due to operating and capital subsidies, economic development opportunities and other issues. Some benefits also may be claimed for AGT which are not true benefits in the framework of a national economic analysis, and accordingly are omitted from the estimate of net benefits. Construction jobs and induced development are two examples where the impact may be primarily distributional. Quantification of other impacts poses difficult problems in measurement or in conversion to monetary equivalents, or both. These include reduction in auto pollution and congestion, visual intrusion, construction disruption, and community development. The estimates also contain an inherent imprecision that is attributable to any methodology that can manageably be applied to large numbers of candidate deployment sites; only detailed design studies could easily reduce this kind of error. Nevertheless, the market estimates are judged to be sufficiently accurate and precise so as to identify the potential magnitude of the market and to inform federal policy. For example, using a measured benefit/cost ratio of .75 as a lower limit for project implementation assumes that unquantified or underestimated benefits may be as much as one-half of the estimated measures in order to bring the total B/C ratio over 1.0.

Using data from the 46 largest urban areas and considering the same four basic application types as in the site specific alternatives analysis--corridors, CBDs, activity centers, and medical centers--plus possible airport applications, estimates of potential nationwide AGT installations are developed. Passenger demand is forecast using actual characteristics of the candidate areas. Capital expenditures are based on typical implementations within each application area, using available unit cost estimates.

- <u>Corridors</u>--The market for corridor applications of AGT appears to be chiefly constrained by the limited number of corridors with sufficient ridership potential for any capital intensive system to be cost-effective. Rail systems have already been deployed in many of the more attractive sites. In corridors where capital intensive systems are potentially attractive, AGT's lower capital and operating costs appear to make it an attractive alternative to conventional fixed guideway technologies. Figure 2 presents the distribution of global benefit/cost (B/C) ratios for corridors. If AGT were deployed in all corridors with global B/C ratios exceeding .99, in 75 percent of the corridors with global B/C's in the interval of .75 to .99 and in 50 percent of the corridors with ratios in the interval of .50 to .74 (Deployment Scenario I), capital expenditures would total about $3.4 billion in 24 corridors. Deployment rates of successively 75, 50 and 25 percent for each of these global B/C ranges (Deployment Scenario II) would generate about $2.4 billion in

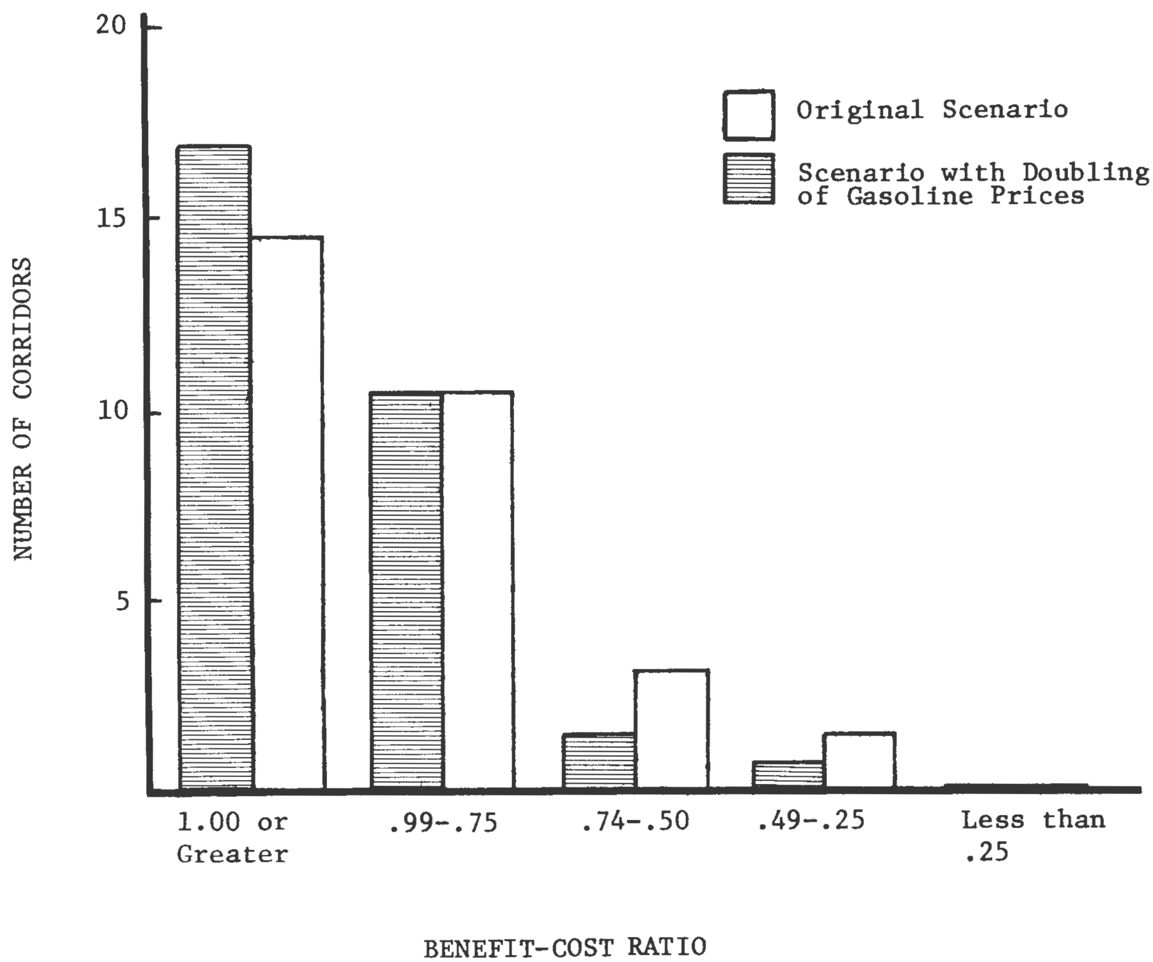

Figure 2 Distribution of Global B/C Ratios for Corridors

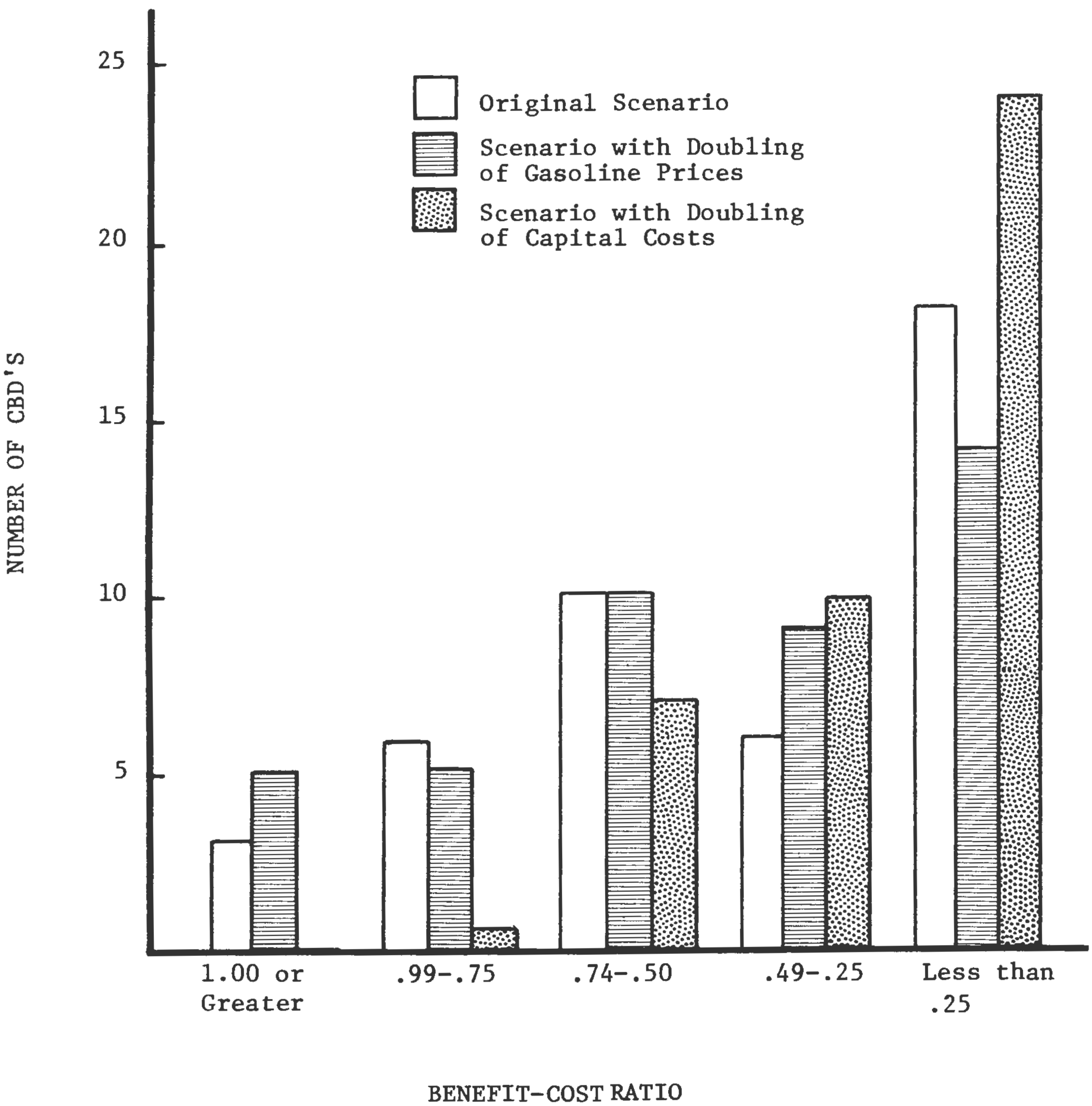

Figure 3 Distribution of Global B/C Ratios for CBDs

expenditures in 17 corridors. If all deployments occurred over a ten-year period, average annual capital expenditures for corridor systems would be between $200 and $300 million.

A doubling of gasoline prices in terms of real dollars would modestly increase the number of attractive corridor applications and total capital expenditures. For Deployment Scenario I, expenditures are estimated to be $3.9 billion in 26 corridors. For Deployment Scenario II, expenditures would be $2.7 billion in 19 corridors.

- <u>Central Business Districts</u>--The analysis of CBD applications of AGT reveals that the largest potential benefit is a savings in bus capital and operating costs from terminating a substantial proportion of CBD-bound bus routes at fringe stations. However, these benefits may not be fully realized because of labor issues and local opposition to route restructuring. Finally, many cities seem unaware of the magnitude of potential bus cut benefits (as shown in the DPM demonstration requests) and may not even try to implement any service cuts. Figure 3 presents the distribution of global benefit/cost ratios for CBDs, based on the assumption of no true urban area or national economic benefits resulting from possible economic development. Assuming deployment in all CBDs with B/C ratios exceeding .74, in 50 percent of the CBDs with ratios in the interval of .50 to .74, and if bus cut benefits are included among system benefits, total capital expenditures in central business districts would be about $990 million (expressed in 1978 dollars) in 14 sites. Without bus cut benefits, estimated capital expenditures with these deployment rate assumptions are about $45 million in a single site. For the former assumption, if the deployments occurred over a ten year period, average annual capital expenditures would not exceed $100 million. The maximum market, assuming both a doubling of gas prices and bus cut benefits, is $1,180 million at 15 sites under the deployment rate assumptions above.

- <u>Shopping Centers and Major Diversified Activitiy Centers</u>--Potential AGT deployments in this market appear to be limited to activity centers with at least two major retail nodes, with the most attractive sites having at least two additional major non-retail nodes. Such sites typically are at least four million square feet in size; with no more than 15 currently existing in the entire United States. However, in view of the rapid growth of some existing diversified activity centers, it is possible that the number above the 4 million foot threshold could increase substantially in the next ten years.

The principal constraint to AGT deployment in this market is capital costs. Reactions of local participants at case study sites suggests that developers are unwilling to spend more than 3 to 5 percent of the development's value on a transportation system. Without subsidies, this constraint will, in general, only be met if the system is a spur connected to a corridor system, and opportunities for such joint deployments are likely to be limited. As a consequence, the market for deployments in this market segment is likely to be limited without substantial subsidies. Assuming systems can be deployed at five centers, total capital expenditures are estimated to be $100 million.

- Medical Centers--The analysis suggests that it is unrealistic to expect many medical centers to follow Duke Medical Center in deploying AGT. The Duke situation is felt to be anomalous in several important respects. It is a single institution located in an environment without a significant crime problem; the system was deployed in the context of a very large addition to the Medical Center; and nearly all its modern architecture is compatible with the system. Few similar opportunities exist.

- Airports already are a proven market for AGT. A continuation of dramatic increases in air travel will undoubtedly necessitate expansion and renovation at large numbers of airports. If 10 to 15 more airports were to deploy a system in the context of an expansion or renovation, capital expenditures are estimated to be in the range of $200 to $400 million.

Table 2 indicates the potential capital expenditure and number of sites estimated for each market segment.

Table 2
Estimated Potential Capital and Number of Sites, 1980-1990 (1978 dollars)

Market Segment	Potential Capital Expenditures (Millions)	Estimated Number of Sites
Corridors	3,400-3,900	24-26
CBDs	45-990	1-14
Activity Centers	100	5
Hospitals	5	0
Airports	200-400	10-15
Total	3,750-5,395+	40-60+

EFFECTS OF FEDERAL R&D OPTIONS

Federal funding of research and development (R&D) for AGT can greatly influence the realization of the potential AGT market.

A "do-nothing" policy is likely to result in only a small fraction of the potential AGT market being realized." Local decision-makers are reluctant to implement what many consider to be an essentially "new" mode, with perceived problems of new system reliability being a particular concern. The total AGT market in this case quite likely would be less than $2 billion.

A R&D strategy aimed at ensuring reliability and operability of current AGT systems in urban environments could have substantial impacts on the market. The total market under this R&D scenario is estimated to be close to $4 billion, or even more, if corridor and CBD deployment scenarios are favorable.

A high performance AGT option does not necessarily expand the AGT markets examined in this study. Market expansion from this R&D strategy, however, could occur if such a high performance system also had substantially lower costs than current AGT designs, or if the more complex routing and switching capability facilitated the implementation of an extensive areawide guideway transit system. In this case, increases in current UMTA funding levels for new starts would be necessary.

If AGT capital and operating costs could be reduced substantially, or at least prevented from escalating, this also would have a marked effect on the number of deployments. This R&D option, however, also would require an increase in the amount of Federal funding available for new starts to fully implement potential AGT deployments. The total AGT market under this R&D option could approach $5 billion.

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

An important component of the Urban Mass Transportation Administration's (UMTA) research and development program involves investigation of the potential of automated guideway transit (AGT), relative to current non-automated transit technologies, to provide mobility to urban residents, and to contribute to the economic revitalization of urban areas. Highly visible aspects of the AGT program have included both the development of new system, subsystem and wayside technology and the implementation of demonstration systems for group rapid transit (GRT) in Morgantown, West Virginia and downtown people movers (DPM) in from four to eight urban areas.

There are, however, a set of market related questions which this largely hardware research contributes, but does not answer directly. It is in this context, then, that the following set of market and socio-economic related issues are examined:

1. Where and under what conditions will AGT service characteristics satsify the travel needs and socio-economic requirements of urban areas in a manner that is competitive with or superior to other transportation alternatives?

2. What is the role of AGT in providing a balanced, total transportation service, and how does it interface with existing services?

3. Where and under what conditions will the public accept automated over conventional transportation systems?

4. Will cities accept the physical presence of AGT guideways? What are the other environmental impacts, pro or con, including air quality, noise, aesthetic, and indirect economic impacts?

5. Is there a potential market for a transportation technology with the characteristics of AGT systems?

To answer these questions, three general activities were undertaken:

- eleven site-specific alternatives analyses within three representative urban areas
- a two-phased consumer survey to determine individual preferences towards automated guideway transit
- a national markets estimate based on data from 46 urban areas to identify a target implementation potential

The work builds upon and uses the results of other studies undertaken by UMTA's AGT Socio-Economic Research Program. These parallel activities include:

- a generic alternatives analysis to identify general sets of urban conditions required for successful AGT deployment, and how AGT systems might be deployed to maximize positive socio-economic impacts or mitigate negative impacts.
- a costs analysis to determine probable costs of AGT development, construction and operation, derived in part from past experience and in part from forecasts of future costs.
- an assessment of the performance and associated social, economic, financial and engineering characteristics from existing domestic and foreign AGT installations operating in public service.

The results of each of these inter-related analyses are to assist in the identification and assessment of policy options and financing mechanisms necessary to implement AGT systems, if warranted; and to determine further research, development, and demonstration requirements for AGT systems technology.

1.2 AGT SYSTEMS TECHNOLOGY

Automated guideway transit reflects a class of transportation systems in which vehicles are automatically operated on fixed exclusive guideways. Using definitions adopted by the US Department of Transportation, four major categories of AGT systems can be defined:

1. Single Line Transit (SLT)

Single line transit is the simplest type of AGT system. The vehicles of a simple shuttle system move back and forth on a single guideway and vehicles in a loop system move around a closed path, stopping at any number of stations. Headways are generally 60 seconds or greater, and vehicles may travel either singly or coupled together. Examples of SLT systems include those in operation at Tampa International Airport and Seattle-Tacoma International Airport.

People Mover or Downtown People Mover (DPM) systems usually are classified as SLT systems. The vehicles used in these DPM systems range in capacity from less than 20 to over 100 passengers. The vehicles generally are constructed of aluminum or fiberglass and are lighter than conventional rapid rail transit cars. Size and weight differences allow for narrower guideways and smaller stations.

SLT (or DPM) guideways may be located on elevated structures, at street level, or below ground and are constructed of steel or reinforced concrete. Power collection is generally accomplished by power rails on the guideway and power collectors on the vehicle.

Where switching is necessary, it is accomplished either by a vehicle mounted mechanism or by moveable beams on sections of the guideway. Operation of the system is under centralized computer control. In general, the complexity of the control system increases as the operational capabilities of the system grow. A staff of employees is used to monitor operations, assist passengers, maintain and service equipment and perform administrative requirements.

2. Group Rapid Transit (GRT)

   These sytems serve groups of people with similar origins and destinations. The principal differences between GRT and SLT (or DPM) systems are that GRT systems tend to have shorter headways and make more extensive use of switching. GRT stations may be located on sidings off the main guideway (off-line stations), permitting through traffic to bypass. GRT guideways may merge or divide into branch lines to provide service on a variety of routes. Vehicles with a capacity of 6 to 50 passengers may be operated singly or in trains. Headways range from 3 to 60 seconds. GRT systems are in operation at Dallas/Fort Worth Airport and Morgantown, West Virginia.

3. Advanced Group Rapid Transit (AGRT)

   The AGRT system is designed to utilize a fleet of small (12-seat capacity, without standees) vehicles travelling over a guideway network. Vehicle control is automatic and on-board and few personnel are required to operate the system. Stations are off-line so that vehicles can by-pass other vehicles in stations and provide non-stop or few-stop services. Vehicles are capable of travelling at headways of three seconds, thereby allowing lane capacities as high as 14,000 seats per hour to be achieved. The three-second headways are achieved with a no-collision policy, i.e., a following vehicle, through the imposition of reasonable braking rates, will not collide with a leading vehicle assumed to stop instantaneously.

4. Personal Rapid Transit (PRT)

   The term PRT is restricted to systems with small vehicles carrying either one person or groups of up to six usually travelling together by choice. Plans for PRT systems typically include off-line stations connected by a guideway network, providing non-stop, origin-to-destination, demand-responsive service. Under computer control, vehicles switch at guideway intersections so as to follow the shortest uncongested path, without intermediate stops. Most proposed PRT systems call for vehicles to be operated at headways of three seconds or less. Cabintaxi in Germany is a prototype PRT system; however, no PRT system is yet in passenger service.

The analyses described in this report utilize the single line transit (SLT) form of AGT, operating in either a shuttle or loop configuration as is appropriate to the particular application. SLT generally is considered to be readily available technology, but not yet implemented in what can be considered to be uncontrolled public or urban environments. The downtown people mover demonstration program will utilize SLT technology, at least in the first tier of demonstration cities. GRT, AGRT, and PRT are reflective of more sophisticated technologies than SLT and would represent an improvement in the technological state-of-the-art over SLT. Whereas SLT systems are centrally controlled by a master computer system and involve no or little guideway switching, AGRT vehicles would be controlled by individual on-board computers, and generally would be both demand-responsive and involve considerable network switching. Current DOT policy is to first implement a series of SLT systems, before proceeding to more sophisticated GRT and AGRT systems. For purposes of this report, then, the site specific and national market analyses are oriented to shuttle and loop SLT technologies.

The set of socioeconomic impacts and institutional issues addressed, however, would be similar for each category of AGT system. Further, the analysis methodologies employed and the general transportation factors considered are equally applicable to the analysis of more advanced forms of AGT, though specific data values and costs of course would be different.

1.3 OVERVIEW OF APPROACH

The relationships among major project activities is illustrated in Figure 1.1, showing the manner in which site specific alternatives analyses and consumer preference market research contributed to the national market estimate.

In the site specific alternatives analyses, Atlanta, Chicago and Dallas were selected as representative urban areas based on population level, growth, and

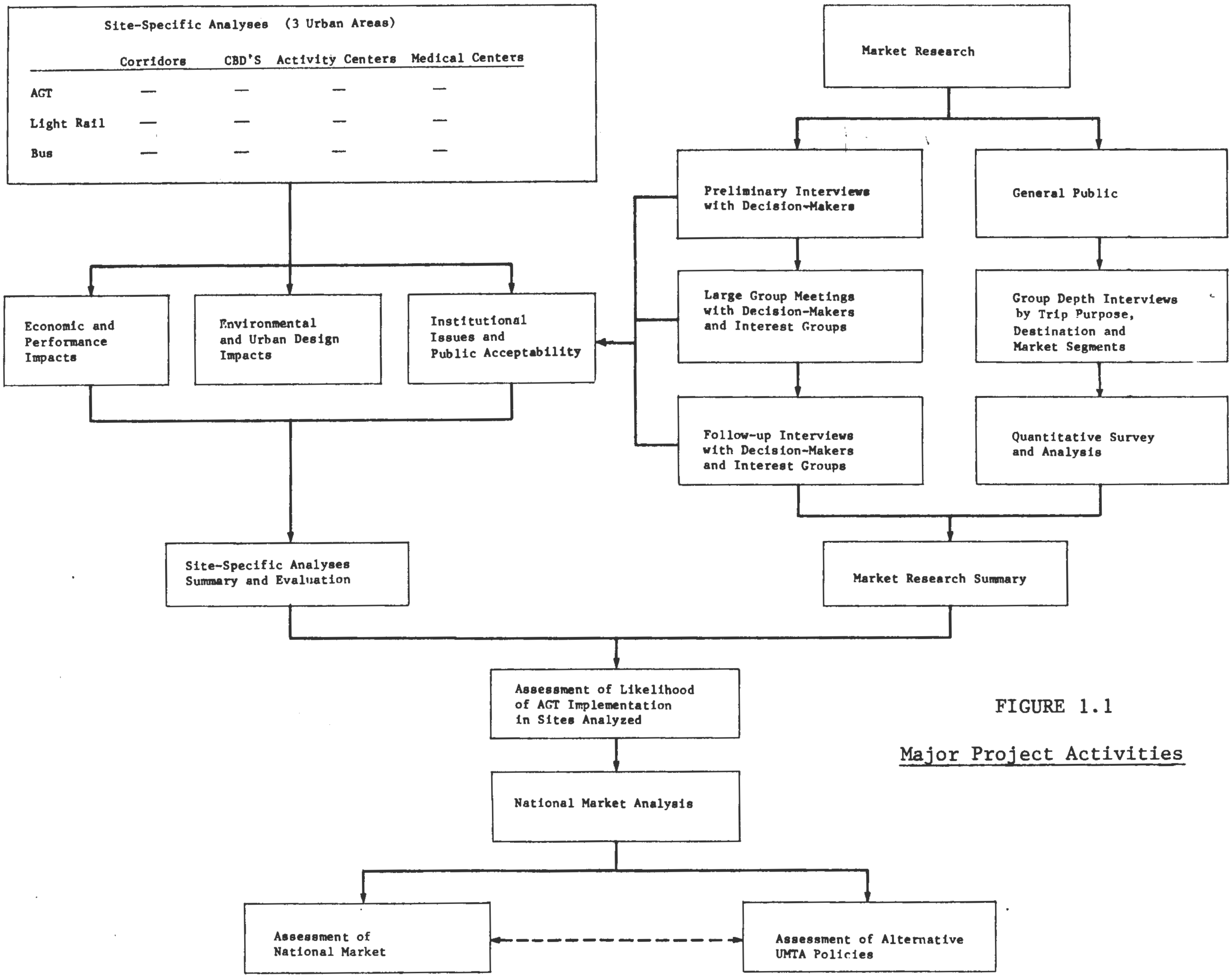

FIGURE 1.1

Major Project Activities

density characteristics; the availability of necessary data; and, interest in participating in an alternatives analysis at the local level. Within the urban areas, eleven candidate local sites were selected that are representative of the following types of potential AGT applications:

- corridor
- central business district (CBD)
- diversified activity center (suburban)
- medical center

For each site, alternatives were then developed and analyzed that were reflective of AGT, light rail transit (LRT), bus (local and express), and current base conditions. The impacts of these alterntive systems were then assessed through use of a set of analysis techniques consisting of:

- sketch planning analysis of travel demand and system performance, based on the use of disaggregate travel demand models

- urban design, economic and environmental assessment analyses

- interviews and small group meetings with urban area decision-makers, agency staff and representative interest groups.

In parallel with the site specific alternatives analyses, a set of market research activities was carried out. In addition to meeting with local officials and interest groups to elicit their attitudes and to identify key issues of interest and their likely responses, a more structured set of consumer surveys was carried out. Using a stratified random sample of Atlanta area residents, a series of six group depth interviews were conducted in order to identify key factors affecting individual preferences towards an AGT system. Based on the results of these discussions, approximately 550 personal interviews were conducted to identify, using conjoint rating, a quantitative evaluation of the following factors:

- transit modal image
- frequency of service
- vehicle size
- travel time difference from auto

- o price difference from auto
- o seat guarantee
- o distance to station/bus stop from home
- o distance to destination from station/bus stop of arrival

Respondents were sampled and classified according to four trip purpose/destination segments:

- o work in the downtown
- o work in a suburban location
- o non-work travel to the downtown
- o non-work travel within the suburbs

Whereas the first two macro-project activities--the site specific alternatives analyses and the consumer market survey--can be characterized as looking at issues from a local or disaggregate perspective, the purpose of the national market estimate activity is to synthesize these local results and to develop a national-level or aggregate forecast of potential AGT implementation prospects. Using data from the 46 largest urban areas and considering the same four basic application types as in the site specific alternatives analyses--corridors, CBDs, activity centers, and medical centers--plus possible airport applications, estimates are developed of potential US nationwide AGT installations. The estimates are based on a comparison of anticipated benefits to costs, considering both the local and federal perspective, and forecasting potential passenger demand using actual characteristics of the candidate areas. Aggregate capital expenditures are based on typical implementations within each application area, using available unit cost estimates.

Based on the results of each of the three major project activities, policy implications then are analyzed with respect to the following areas:

- o funding--Federal & local
- o economic development
- o visual and urban design
- o labor
- o passenger security
- o performance characteristics and costs

1.4 STRUCTURE OF REPORT

The material developed is presented in three reports:

- Volume I summarizes the site specific AGT analyses, presents the national market estimates, and discusses important policy implications.

- Volume II presents the detailed results of the individual site analyses, identifying site characteristics, the alternatives considered, travel demand, potential capital and operating costs, community and urban design, and institutional issues.

- Volume III represents the results of the market research survey of consumer preferences.

One of the important findings is that AGT implementation potential is likely to be dependent on a number of very specific, and occassionaly unique, site characteritics. While important general conclusions are summarized as part of Volume I, a real understanding of these issues can only be developed through examination of the individual case analyses. The complexities, interrelationships and subtleties of how different groups are affected, and which influence actual urban area decision-making, are described as part of the individual site analyses, but largely disappear in the effort to draw general conclusions.

Finally, an important contribution of the project has been the particular analysis methodologies employed. The approach to estimating national market potential is summarized in Chapter 3 of Volume I, and described in more detail in Appendices A and B. Procedures used to analyze potential ridership and other implementation impacts in each of the case studies are described in the appendix provided as part of Volume II. For those interested, it is possible to read the respective analysis findings Chapters, 2 and 4 of Volume I and the main text of Volume II, without an understanding of the analysis methodologies. A knowledge of the underlying methodologies and assumptions, however, is necessary to an in-depth understanding of the site-specific analysis implications and to determine the sensitivity of the analysis findings to alternative assumptions and conditions.

Further, the methodologies can be easily applied by others for the analysis of alternative transit systems, including alternative forms of AGT.

The methods represent a relatively easy, data-efficient approach to analyze the potential of alternative technological programs to contribute to important national and local transportation objectives.

CHAPTER 2
CASE STUDY RESULTS

2.1 INTRODUCTION

The results of a series of site specific analyses of AGT and other alternatives are summarized in this chapter and described in detail in Volume II. The case study approach simulates the alternatives analysis process used for actual transportation investment decisionmaking; however, it uses a reduced, sketch planning level of technical analysis (described as part of Volume II) and limited local participation. The objective of the case study efforts is to surface local reactions to several key AGT issues:

- Are the costs, performance and service levels of AGT appropriate for the study sites examined?
- Is an AGT guideway acceptable to the site?
- Will the public accept an automated system at the site? (As there were no public meetings, the judgments of local planners were used as a basis for addressing this question.)
- Under what circumstances or policies would the local bodies involved in transportation decision-making implement an AGT system?

In addition to examining issues such as the above that are difficult to assess in the abstract, the case studies assess the amount of variability in results across specific site examples of the same class of AGT applications, and validate the technical methods used for the national market projections. As such, the specific case study findings have an important bearing on the total market for AGT and serve as a basis for both the national market estimates and the resulting policy recommendations.

2.2 CITY SELECTION

Three case study cities were selected to provide variety in size, geographical location, density, and institutional setting.

<u>Chicago</u> was chosen as an example of a large, dense metropolitan area with a complex institutional structure. It currently has an extensive rail rapid transit system in almost all major corridors, so consideration of AGT was limited to activity center applications. Chicago is therefore roughly representative of the class of cities including New York, Boston, Philadelphia, Washington, and possibly

others, which have both high densities and existing transit systems. These represent a considerable fraction of the urban population and are considered a potential AGT market. The success of AGT in market areas like these will have a large impact on its market potential. Chicago also serves as a test of issues associated with AGT operation in a cold, snowy climate.

Dallas was the second case study city chosen. It is a large, lower density urban area currently without any fixed guideway transit, although planning for such a system is proceeding. The institutional structure is relatively less complex than Chicago, and a healthy economy and much private development make it an excellent study of private/public participation in potential area projects. AGT is an alternative in CBD and corridor transit applications.

Atlanta was chosen as the third case study city because it is currently constructing a regional rapid transit system. It can provide realistic assessments of many issues involved in the planning and construction of a major new system. There are potential corridor applications for AGT in the region, which has a higher population density than Dallas.

2.3 SITE SELECTION

Within each of the three urban areas, an initial meeting was held with key agency representatives having transportation and planning responsibilities to identify the sites which they felt had potential AGT applications. If possible, sites fitting the general application categories of CBDs, corridors, suburban activity centers, and medical centers were sought, to be consistent with the national market forecast phase of the study. The use of local meetings to choose the specific case study sites is intended to supplement the results of the national market estimate. Given that these are sites in large cities identified by local participants as having considerable potential for AGT and the results of this case study substantiate this potential, then a national market for AGT is likely to exist.

In Chicago, four sites were chosen (Figure 2.1). The North Michigan Avenue area is just north of the Loop (CBD) and has most of the characteristics of a major CBD. It is not currently served by fixed guideway transit, and would be a possible AGT application. A second site was Merrillville, Indiana, which is a growing suburban center serving a market area of over

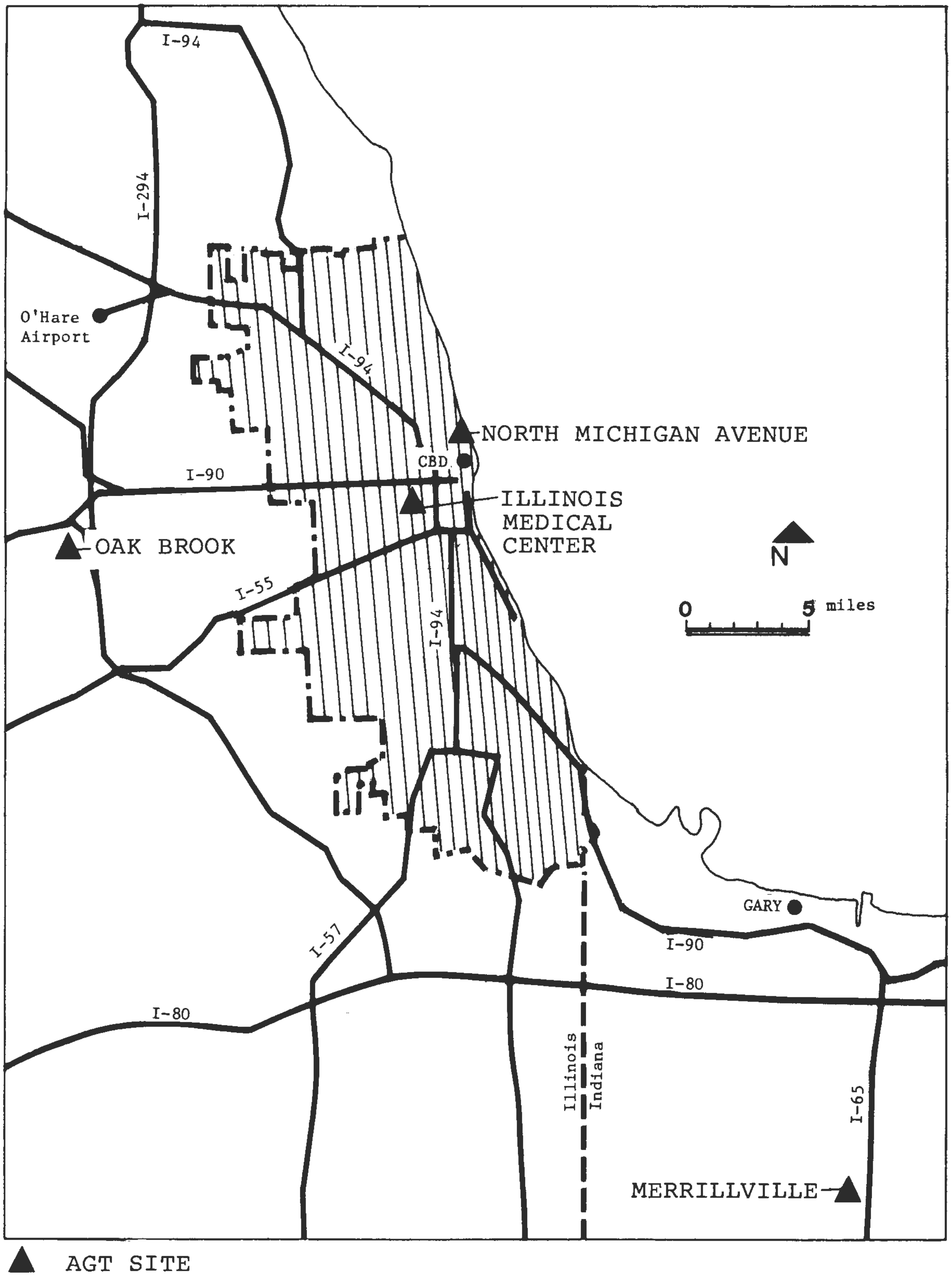

FIGURE 2.1

Site Selection--Chicago

600,000 people. A third site was the Oak Brook shopping and office area west of Chicago. The fourth site was the State of Illinois Medical Center located in Chicago, again a major activity center. Other sites considered but not adopted were a fringe parking concept in the Loop, the South Loop New Town, and other suburban centers. The four sites picked represented those felt to have the most potential for AGT applications in the Chicago area. One corridor (with an AGT alternative) is also under study by local planning agencies, but schedule considerations did not allow it to be used as a case study site. Finally, AGT also has been studied locally for application at O'Hare Airport in Chicago.

In Dallas, two corridors and three activity centers were suggested in the initial meeting with local representatives (Figure 2.2). One of the two corridors is in active planning for a transit system and possible highway improvements; the other is recommended as a primary corridor in the regional transit plan. The CBD, the Northpark shopping and office center, and the Market Center convention/display complex were selected as three primary activity center applications. The City of Dallas had submitted an application to UMTA for a DPM, and both Northpark and the Market Center had considered implementation of AGT systems in the past.

In Atlanta, the local meeting suggested that two corridors containing several major activity centers would be potential AGT application sites (Figure 2.3). These corridors are not included in the regional rail network. Originally, they were to be served by busways; however, the needed highway facilities may not be built.

A summary of the selected sites is provided as Table 2.1. For each site, a range of possible modal alternatives was developed in concert with the local agency representatives.[1] For each alternative, the operating policies, routes and system alignments were reviewed by local participants, for consistency with current transit and urban are objectives; however this report should not be interpreted as a statement of local policies, objectives or actions at any of the case study sites.

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[1]The specific alternatives selected for each site are discussed in Section 2.5 and defined in more detail in Volume II.

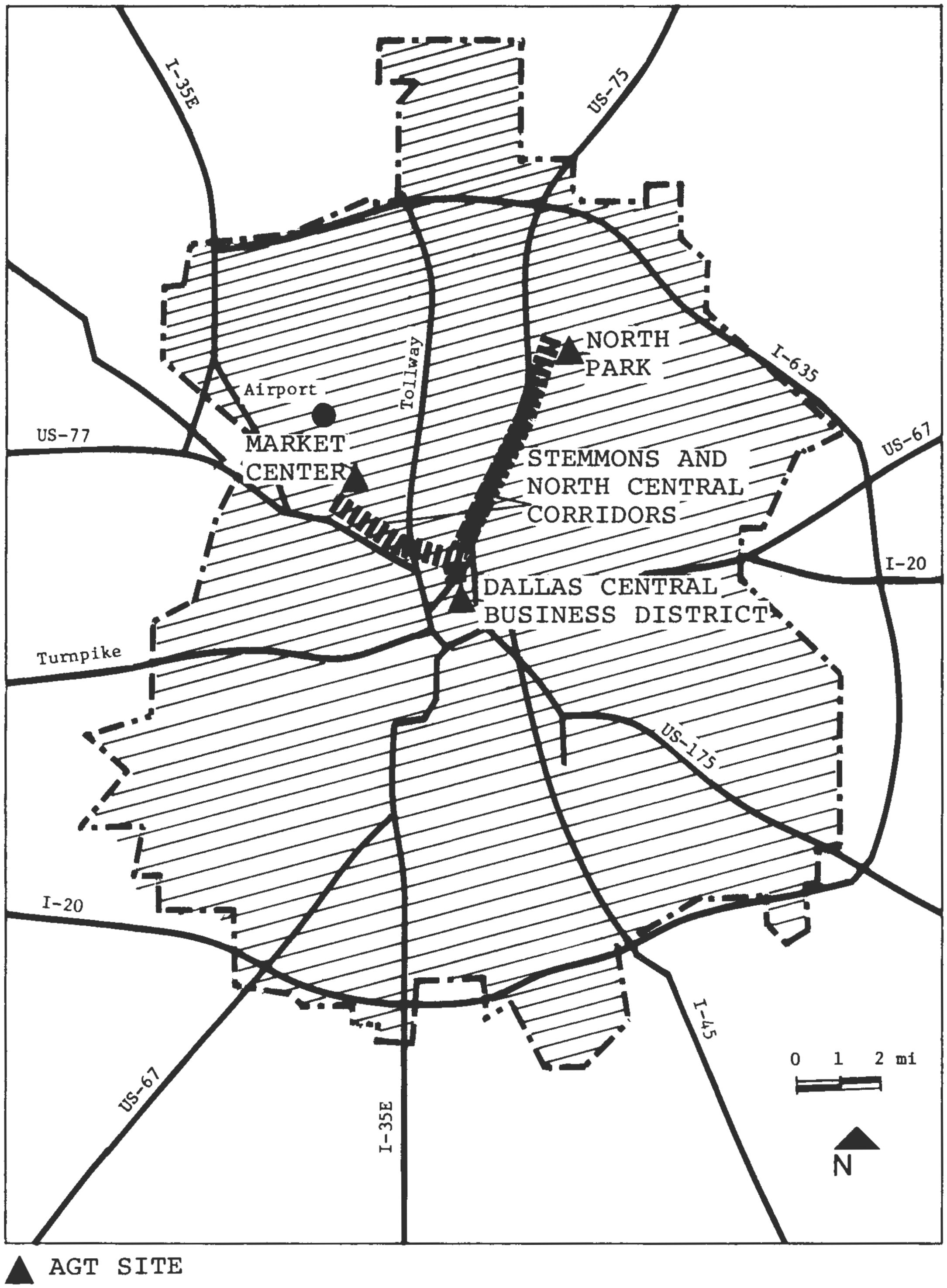

FIGURE 2.2

Site Selection--Dallas

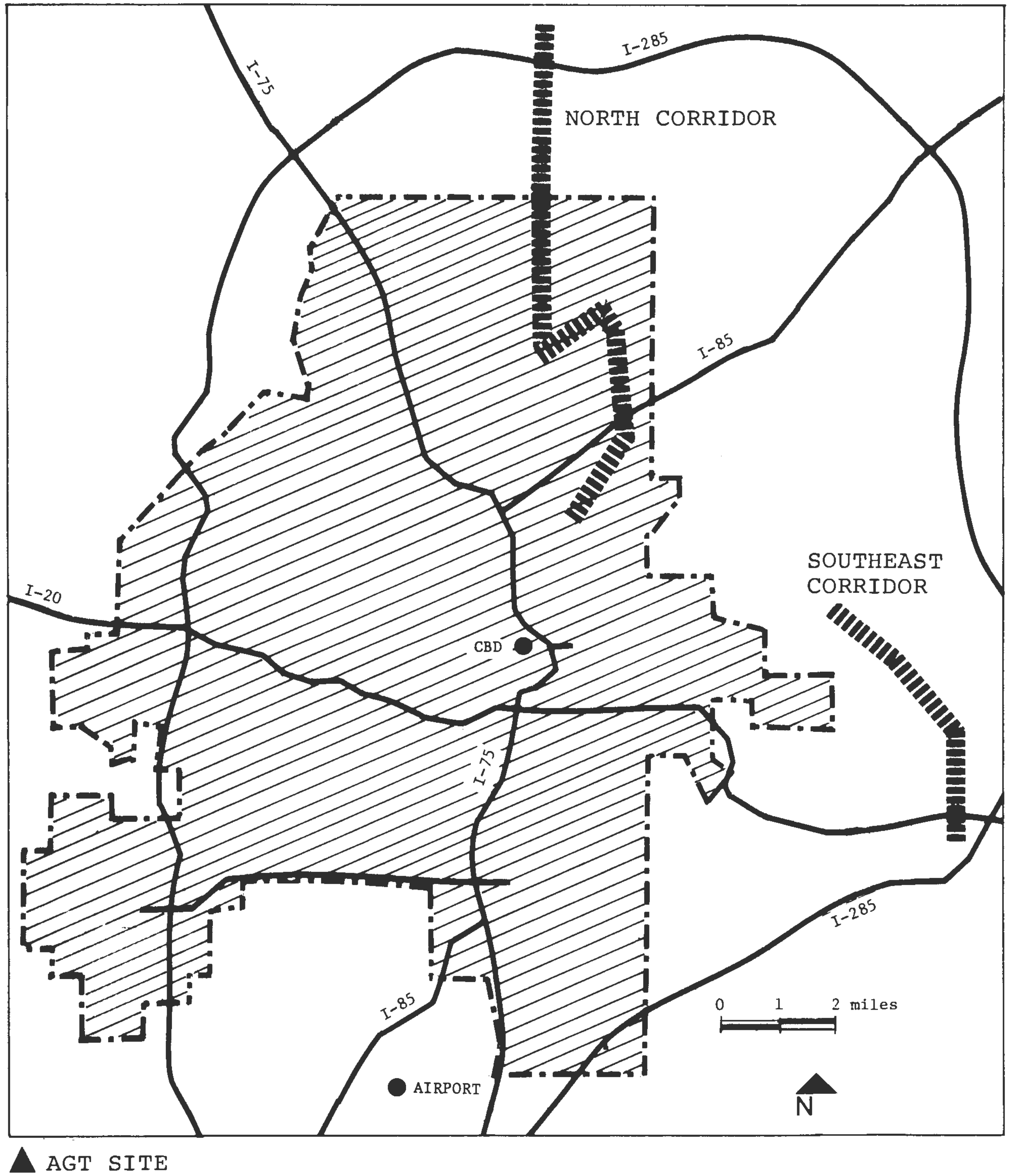

FIGURE 2.3

Site Selection--Atlanta

Table 2.1
Case Study Cities

Corridors	Central Business Districts (CBDs)
Atlanta, North	Chicago, North Michigan Avenue
Atlanta, Southeast	Dallas, CBD
Dallas, Stemmons and North Central	
Major Diversified Activity Centers (MDCs)	**Medical Center**
Chicago, Merrillville	Chicago, State of Illinois Medical Center
Chicago, Oak Brook	
Dallas, North Park	
Dallas, Market Center	

2.4 KEY ISSUES

To provide a realistic basis for exploring potential design, planning, community impact and institutional issues in each of the selected sites, an abbreviated planning, design and analysis process was carried out with the advice and participation of spokespersons of local agencies. Particular attention was given to the following issues felt to be key to potential AGT implementation.

1. Financial:

   The primary financial issue addressed with local officials was the availability of local and Federal funding for the transit alternatives studied. Federal funding is available through two sections of the Urban Mass Transportation Act of 1974: Section 3 provides discretionary capital funding for 80% of project costs, while Section 5 provides capital and operating cost funding on a formula basis. Section 5 funds may be used to cover a maximum of 50% of an operating deficit. Local matching funds must be raised for these Federal grants through property, income, sales or other taxes at local and state levels. Some areas have specific taxes to generate transportation revenues; others do not.

2. Travel Demand Issues:

   Local site representatives were asked to discuss the perceived demand for transit services at the site and were presented with ridership estimates for an AGT system and other transit alternatives for the site as a basis for further discussion of the demand issues. Typical questions considered included the following:

   - Is there currently a perceived or documented need for improved transit services at this site; by whom? Are the agencies involved likely to favor transit services or non-transit improvements (e.g., increased parking capacity, street widening, etc.)?

   - Is the AGT projected ridership sufficiently different from that of other alternatives to merit its consideration on the basis of demand?

   - Does AGT achieve the expectations of a new guideway mode, in terms of service levels or patronage attracted, and other measures?

3. System Performance Issues:

   The performance characteristics of an AGT system compared to that of other modes were discussed with site representatives. These characteristics include speed, capacity, reliability, cold weather performance and other such issues, as relevant to the site. The importance of performance at the particular site and the capability of an AGT system to achieve the desired performance levels were addressed.

4. Economic Development:

   Fixed guideway transportation systems have the potential to influence land use patterns and serve as a catalyst for private sector development. The potential for an AGT system to contribute to or stimulate this development or redevelopment and the priority assigned to this objective by local officials was addressed for each site. The perceived comparison between an AGT system and other transit alternatives for achieving this effect also was addressed.

5. Aesthetic and Urban Design Issues:

   The impact on the urban environment of an AGT system and the relative impact of AGT versus other transit alternatives was addressed with site representatives. To assist in this assessment, assumptions on the size and shape of the AGT guideway and stations were presented. These characteristics were viewed in relationship to the type and intensity of development adjacent to the proposed system especially in the vicinity of stations where the visual impacts may be most severe. Discussion centered on elevated systems, as their acceptability is a key area of uncertainty (Figure 2.4).

6. Labor Issues:

   The labor protection clause of the Urban Mass Transportation Act of 1964 (Section 13c) requires that employees be protected against changes that may adversely affect their conditions of employment. Agencies are required to demonstrate adequate employee protection prior to the receipt of federal funds. Areas considering AGT systems will be required to carefully examine the labor implications of an AGT implementation.

7. Technology Issues:

   Potential personal psychological issues associated with riding in an automated vehicle system, combined with local official's acceptance of a technology whose operation is not yet fully proven in an urban environment are important factors affecting AGT deployment.

8. Personal Security Issues:

   The degree to which issues of personal security are likely to affect AGT implementation were addressed with local representatives. Specific situations, times of day and geographical areas in which issues of personal security appeared to be of greatest concern were explored. The perceived implications about personal security for an AGT system versus other transit alternatives and measures which may be useful in mitigating the specific concerns were discussed.

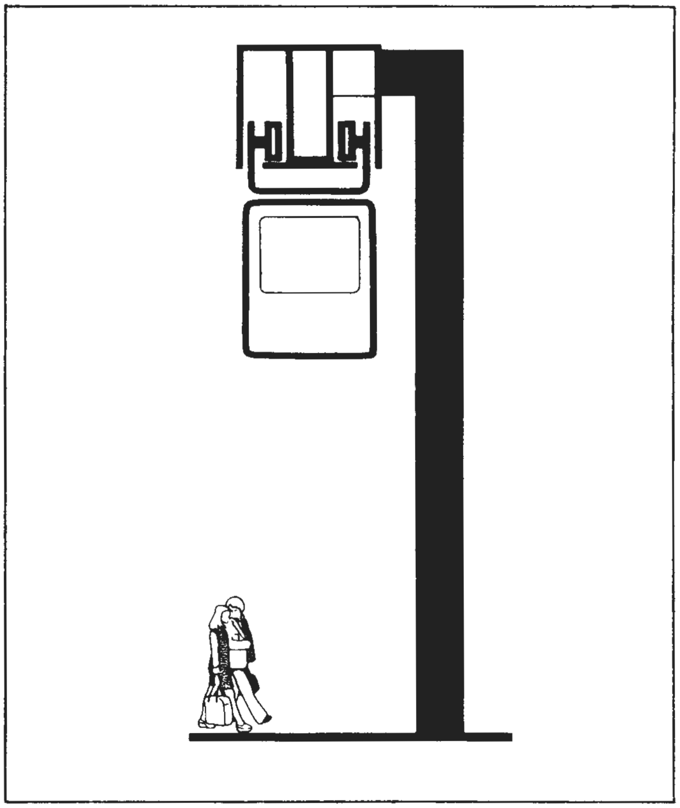

Figure 2.4.a
Single Lane Low Volume
Suspended System

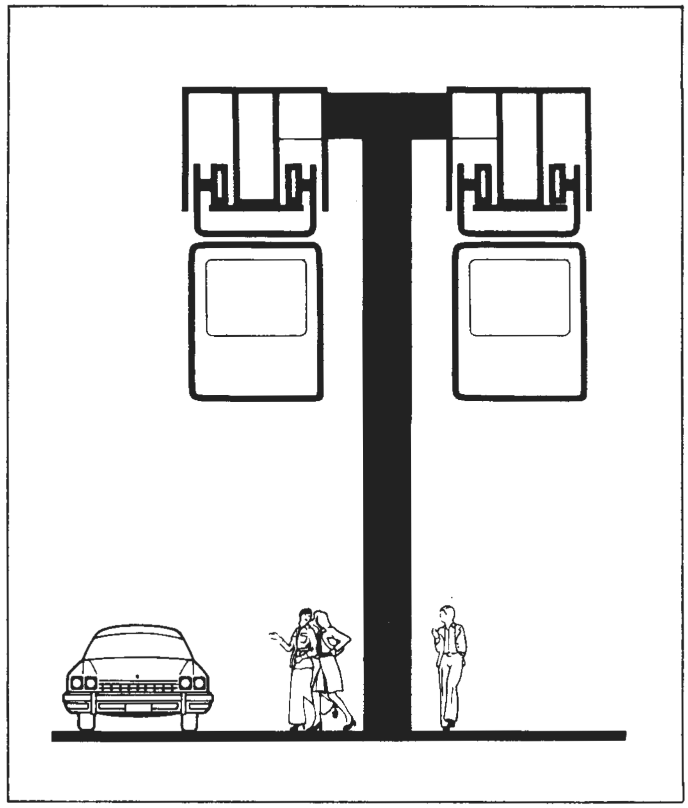

Figure 2.4.b
Dual Lane Low Volume
Suspended System

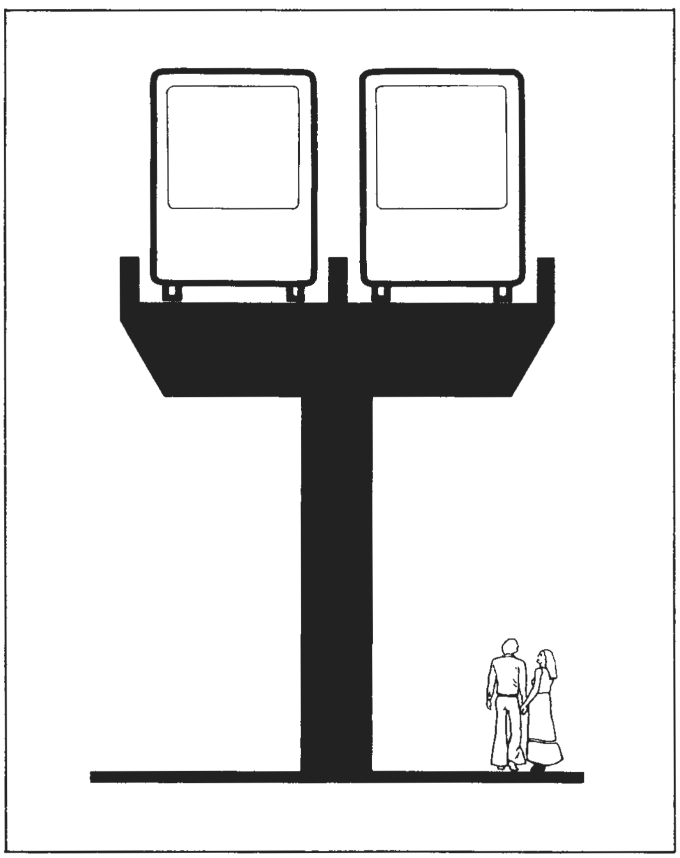

Figure 2.4.c
Dual Lane Low Volume
Supported System

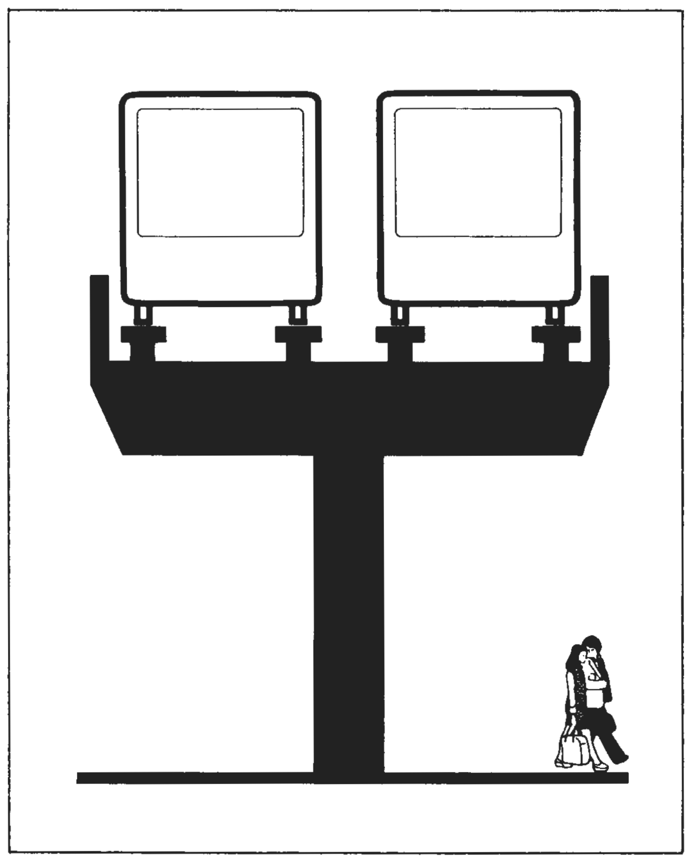

Figure 2.4.d
Dual Lane High Volume
Supported System

2.5 ANALYSIS FINDINGS

The following sections summarize the results of the individual case study analyses. A brief site description, the alternatives studied, community and urban design results, and key issues are given for each site. Tables containing ridership and cost estimates for each site are also given. A fuller discussion of each case study is provided in Volume II.

2.5.1 CORRIDORS

Atlanta, North

The North Corridor is a long corridor consisting of nine miles of concentrated commercial and residential uses. The corridor extends from the proposed Lenox station on the North Line of the Atlanta rail transit system, through the major activity centers of Buckhead, Tower Place, and Lenox Center, then along Roswell Road to Sandy Springs. It is a medium density mixed suburban corridor; however, it is one of the most developed corridors in Atlanta.

The existing transit network consists of a bus system; however, the North Line of the rail system should eventually extend to the corridor and an improved bus alternative is considered as the "base" option. Besides the bus option, AGT and light rail transit (LRT) were considered. A supported type of AGT system was elevated throughout the corridor; LRT was underground, at-grade and elevated in various areas. Heavy rail transit (HRT) was not examined due to operational incompatibility with other planned or existing rail transit. Weekday transit ridership estimates for each alternative are presented in Table 2.2; a revenue and cost summary is presented in Table 2.3. Daily ridership estimates vary from 23,000 with the improved bus option to 30,000 with the AGT.

The disruptive effects of all three alternatives would be slight. The major objections were to the visual intrusion caused by the elevated sections of LRT and AGT. Personal security, economic development, and labor protection were not major issues. There were, however, objections to possible noise levels.

The key issue concerned AGT costs, which were felt to be highly uncertain. Thus, the service levels and demand were not considered sufficiently different from LRT (or an improved bus) to warrant the risk. The participants appeared to have a wait-and-see attitude toward AGT.

Table 2.2
Weekday Transit Ridership
Atlanta, North Corridor

Alternative	Status Quo[2]	Improved Bus	Light Rail Transit	AGT
Daily Ridership:				
Peak[1]	--	9,000	11,000	12,000
Total	15,000	23,000	28,000	30,000
Annual Ridership:	4,500,000	7,000,000	8,500,000	9,000,000
Transit Mode Share:				
CBD	--	25	31	33
Non-CBD	--	4	5	6

1 Peak periods are 7-9 a.m. and 4-6 p.m.

2 1977; all other systems' ridership in 1990.

Table 2.3
Revenue and Cost Summary (1978 Dollars)
Atlanta, North Corridor(1)

Alternative	Improved Bus	Light Rail Transit	AGT
Number of vehicles[2]	80	50	80
Total capital cost: ($ millions)			
Guideway	--	160	81
Stations	--	16	9
Vehicles	8	34	37
Annual capital cost[3] ($ millions)	0.7	12	8
Annual vehicle miles[4]	3,300,000	2,300,000	4,500,000
Annual operating cost	$7,200,000	$ 7,000,000	$ 5,100,000
Annual revenues[5]	$2,000,000	$ 2,500,000	$ 2,700,000
Revenues-operating cost	-$5,200,000	-$ 4,500,000	-$ 2,400,000
Revenues-total annual cost	-$5,900,000	-$16,500,000	-$10,400,000
Change in auto VMT, annual, from Alternative 1	--	10,000,000	14,000,000

1 In an alternatives analysis prepared independently by MARTA shortly after the case study was completed, LRT costs were projected at $121-143 million (guideway and stations only) versus the $176 million, which was based on rough unit costs only. The LRT operating costs differ substantially: $1.9-2.3 million projected by MARTA, versus $4 million (excluding feeder costs) in our study, again based on rough unit costs. The largest discrepancy is in projected ridership: 14,000 (MARTA LRT) versus 28,000 (case study LRT). The most likely estimate is between the two figures, and is probably closer to the MARTA estimate, because of the greater detail used and greater familiarity with the area.

2 Plus 10 buses on secondary or feeder routes.

3 Assuming a 10 percent interest rate and a 6 percent inflation rate.

4 Not including 300,000 annual feeder bus miles.

5 Allocating the entire 30¢ fare to the North Corridor service.

Atlanta, Southeast

The Southeast Corridor is a suburban area with single-family, apartment, and retail uses. It focuses on Decatur, a community directly east of Atlanta. The corridor extends from the Decatur station of MARTAs already operating East Line for six miles to a circumferential expressway. Though the Southeast Corridor is only a medium density area, it is one of the most densely populated corridors in the Atlanta region.

The existing transit network consists of a bus system. The same three basic alternatives were studied as in the North Corridor--improved bus, LRT, and AGT. Both the LRT and the AGT have subway and elevated sections. Weekday transit ridership estimates for each alternative are presented in Table 2.4; a revenue and cost summary is presented in Table 2.5. Daily ridership estimates vary from 21,000 with the improved bus option to 30,000 for both LRT and AGT.

Only AGT and LRT would have major impacts on the corridor. The subway sections would cause a temporary disruption during the construction for as much as two to three years. The elevated sections would block views and be incompatible with the smaller structures along the route. However, both the disruption and visual impacts would be less for AGT due to its smaller size. Personal security and labor protection were not considered to be major issues.

The key issue is the projected split between the residents and businesses along the route. Local spokesmen predicted acceptance and support could be polarized between the residents (who would be against any guideway) and businessmen (who would support a guideway as a form of capital improvement).

Dallas, Stemmons and North Central

The Stemmons and North Central corridors connect the Dallas Central Business District (CBD) with the northwestern and northern parts of the region, respectively. Both corridors are served by major limited-access highways. They are mature, fully developed urban corridors and were built to accommodate the automobile with major buiding complexes typically surrounded by large parking lots.

Table 2.4
Weekday Transit Ridership
Atlanta, Southeast Corridor

Alternative	Status Quo[2]	Improved Bus	Light Rail Transit	AGT
Daily Ridership:				
Peak[1]	--	8,500	12,000	12,000
Total	12,000	21,000	30,000	30,000
Annual Ridership:	3,500,000	6,500,000	9,000,000	9,000,000
Transit Mode Share:				
CBD	--	29	39	39
Non-CBD	--	3	5	5

1 Peak periods are 7-9 a.m. and 4-6 p.m.

2 1977; all other systems' ridership in 1990.

Table 2.5
Revenue and Cost Summary (1978 Dollars)
Atlanta, Southeast Corridor

Alternative	Improved Bus	Light Rail Transit	AGT
Number of vehicles[1]	50[1]	30[1]	50[1]
Total capital cost: ($ millions)			
Guideway	--	195	87
Stations	--	13	7
Vehicles	5	20	22
Annual capital cost[2] ($ millions)	0.5	12	7
Annual vehicle miles[3]	1,900,000	1,300,000	2,600,000
Annual operating cost	$4,800,000	$ 4,600,000	$ 3,500,000
Annual revenues[4]	$2,000,000	$ 2,700,000	$ 2,700,000
Revenues-operating cost	-$2,800,000	-$ 1,900,000	-$ 800,000
Revenues-total annual cost	-$3,300,000	-$13,900,000	-$ 7,800,000
Change in auto VMT, annual	--	8,000,000	9,000,000

1 Plus 16 buses on secondary or feeder routes.
2 Assuming a 10 percent interest rate and a 6 percent inflation rate.
3 Not including 500,000 annual feeder bus miles.
4 Allocating the entire 30¢ fare to the Southeast Corridor service.

In addition, the Stemmons corridor has large rights-of-way and is generally free of the space restraints found in some urban corridors.

The existing transit network consists of a bus system. The primary alternatives considered in addition to the existing system are LRT, express bus, transitway, and AGT. In the North Central corridor, an expressway right-of-way was designated as the transit alignment; in Stemmons, a rail right-of-way was designated. Both the transitway and LRT options used a combination of underground and at-grade alignments. Generally, the AGT used an elevated, supported design. Weekday transit ridership estimates for each alternative are presented in Table 2.6; a revenue and cost summary is presented in Table 2.7. Daily ridership estimates are very similar across alternatives ranging from 62,000 to 69,000. AGT shows a modest operating and capital cost advantage over the other guideway modes.

In general, large right-of-ways and lack of housing in the Stemmons Corridor will tend to minimize the disruptive or intrusive effects of all of the alternatives. All three alternatives will cause some visual intrusion in the North Central corridor. This intrusion will be lessened somewhat, since the guideway is located in the expressway right-of-way. Personal security is a concern along some sections of the guideway. The AGT system will create a number of joint development opportunities throughout the corridor.

Regional transportation objectives are the overriding concerns of planning transit. The region's highest priority is provision of high-level transit service in the designated corridors. The preference for one specific technology was perceived to be of lesser importance.

2.5.2 CENTRAL BUSINESS DISTRICTS

Chicago, North Michigan Avenue

The North Michigan Avenue study site is an area of heavy retail and office activity located in central Chicago. It encompasses part of the residential Gold Coast area to the north and is bounded by the heavily commercial Loop area to the south. The study area contains many large hotels, large retail establishments, office towers, high-rise apartment buildings, and institutional facilities. The area is

Table 2.6
Weekday Transit Ridership
Dallas, Stemmons and North Central Corridors

Alternative	Status Quo	Transitway	Light Rail Transit	AGT
Daily Ridership:				
Peak[1]	9,000	17,000	16,000	18,000
Total	36,000	65,000	62,000	69,000
Annual Ridership:	11,000,000	20,000,000	19,000,000	21,000,000
Transit Mode Share:				
CBD	.24	.30	.28	.31
Non-CBD	.02	.09	.09	.10

[1] Peak periods are 6-9 a.m. and 3-6 p.m.; half the peak ridership is assumed to occur in the single highest hour and is used to compute the load factor. Load factor based on North Central volume.

Table 2.7
Revenue and Cost Summary (1978 Dollars)
Dallas, Stemmons and North Central Corridors

Alternative	Status Quo	Transitway[1]	Light Rail Transit	AGT
Number of vehicles[2]	200	50	25	40
Total capital cost: ($ millions)				
Guideway and Stations	0	155	190	125
Vehicles	20	19	30	32
Annual capital cost[3] ($ millions)	2	10	13	10
Annual vehicle miles[2]	3,200,000	2,800,000	1,100,000	2,800,000
Annual operating cost	$6,300,000	$ 8,900,000	$ 7,600,000	$ 7,500,000
Annual revenues	$3,700,000	$ 6,800,000	$ 6,500,000	$ 7,100,000
Revenues-operating cost	-$2,600,000	-$ 2,100,000	-$ 1,100,000	-$ 400,000
Revenues-total annual cost	-$4,600,000	-$12,100,000	-$14,100,000	-$10,400,000
Change in auto VMT, annual	--	-5.4%	-4.8%	-5.6%

1 So-called "narrow" (34 foot) guideway assumed; at-grade CBD operations.

2 Linehaul only; alternatives 2-4 also require 140 buses in feeder and other corridor service.

3 Assuming a 10 percent interest rate and a 6 percent inflation rate.

highly characteristic of an older, central-city urban environment in the process of continuing development. Much of the recent growth in the area represents a shift of development from the Loop.

The existing transit network is comprised of underground rapid rail transit and bus service. Additionally, two new underground rail lines are in the final planning stages. Two AGT alternative were studied. The exact routes are discussed in Volume II. Both of the AGT systems would be elevated, suspended systems. Weekday transit ridership estimates for each alternative are presented in Table 2.8; a revenue and cost summary is presented in Table 2.9.

The major obstacle for an AGT system is that any streets which would be feasible from a service perspective would be unacceptable due to adverse visual impacts. However, if an acceptable alignment could be identified, an AGT system would have definite service advantages over the existing bus system and compare favorably with a subway system. AGT is expected to support existing economic activity, but not serve as a major catalyst for new development due to the current dense development of the area. Noise and vibration impacts were considered to be minimal. Threat to personal security was important, but was considered no greater than in the current system. It was not felt that opportunities existed for AGT to replace bus services. This minimizes the operating cost advantage of AGT, but eliminated any potential labor problems.

The key issue is the outcome of currently planned projects and identification of a suitable AGT alignment. If these two issues are resolved, AGT would be acceptable at least for some sections of the proposed alignment.

Dallas, Central Business District

The Dallas Central Business District (CBD) is defined by a freeway loop that encompasses over 900 acres. However, the most highly developed and active part of the CBD--which stretches along an east-west axis formed by Main and Elm Streets and a north-south axis defined by Akard Street--covers an area of about 200 acres. Land use in the CBD is similar to that in many large, newer cities developed in the last twenty

Table 2.8
Weekday Ridership Summary
Chicago, North Michigan Avenue/I.C. Air Rights

Alternative	Status Quo	AGT (1) AGT	AGT (1) (Total Transit)	AGT (2) AGT	AGT (2) (Total Transit)
Trip Type					
Internal	364,000				
Pedestrian	355,000				
Transit	8,000	24,000	(24,000)	20,000	(20,000)
Auto	1,000				
External-Internal, short	119,000				
Pedestrian	93,000				
Transit	23,000	6,000	(24,500)	9,000	(26,500)
Auto	3,000				
External-Internal, long	170,000				
Auto	92,000				
Transit[1]	78,000				
Mich. Ave.-North Buses	23,000	0	(23,000)	0	(23,000)
Commuter Rail Buses	14,000	8,250[6]	(15,250)	8,250[6]	(15,250)
East-West & Other Buses	4,000	3,500	(12,500)	3,500	(12,500)
Rail-Grand, Chicago	8,000[2]				
Rail-Lake, Randolph	12,000[3]	9,000	(30,250)	9,000	(30,250)
Commuter Rail-I.C.	10,000[4]				
Mich. Ave.-Loop Buses	7,000[5]				
Total Transit	109,000	50,750	(129,500)	49,750	(127,500)

Source: Derived from pedestrian and person trip table data provided by CATS and line and
station counts provided by CTA; all estimates are approximate; some have been produced using CATS short trip mode split model.

1 Derived from CTA line and station counts. Station counts adjusted for direction of entry/exit; only trips to and from the east or northeast used. Bus estimates expanded from peak period counts.

2 Not including estimated 2,500 transfers to and from the east counted in "other bus."

3 Non-transfer entry/exit to and from the northeast.

4 Total daily ridership 27,000; 10,000 assumed to make trips into study area; 1,000 assumed to use bus currently.

5 Number of transfers at these stations times percent entry/exit to the northeast.

6 Rail/AGT serves Northwestern Station only.

Table 2.9
Revenue and Cost Summary (1978 dollars)
Chicago, North Michigan Avenue/I.C. Air Rights

Alternative	AGT (1)	AGT (2)
Annual Ridership	16,000,000	16,000,000
Number of Vehicles	20	22
Total Capital Cost: ($ millions)	67	52
Guideway	28	25
Stations	30	17
Vehicles	9	10
Annual Capital Cost[1]	$4,000,000	$3,200,000
Annual Vehicle-Miles:	700,000	700,000
Annual Operating Cost	$1,300,000[1]	$1,100,000[2]
Annual Revenues[3]	$ 550,000	$ 250,000
Revenues-Operating Cost	-$ 750,000	-$ 850,000
Revenues-Total Annual Cost	-$4,750,000	-$4,050,000
Change in Auto VMT, Annual	7,100,000	7,100,000

1 Assuming a 10 percent interest rate and a 6 percent inflation rate.

2 A possible savings of 175,000 bus miles or $350,000 (not included above) also results from elimination of bus service to Northwestern Station.

3 Increment over existing revenues due to AGT (including mode-shifted trips on regional transit and commuter rail).

years, with the density in the CBD being much greater than the density of the surrounding areas. Principal land uses are offices, retail, and governmental. The street system is quite regular in layout. Right-of-way width is generous, except for a few streets in the central area.

The existing transit circulation network consists of a shuttle bus system. Only upgrading this shuttle bus system and an elevated, supported AGT system were considered viable alternatives. LRT was initially considered; however, since LRT would necessitate a tunnel due to insufficient street space, it was dropped. Weekday transit ridership estimates for each of the final alternatives are presented in Table 2.10; a revenue and cost summary is presented in Table 2.11. Daily internal trips vary from 14,300 for the shuttle bus alternative to 40,000 for AGT.

The major objection to an AGT system is the visual impacts of the elevated system; however the lack of residential development in the area lessens these impacts. Issues of personal security were of concern for both transit alternatives, though of slightly greater concern for AGT. The AGT system could potentially include part of the regional system, which would boost the economic development of the area.

The costs of AGT are higher than for the bus system; however, they seem feasible to local representatives, since cost-sharing with the private sector can be expected. A particularly well-received option was to develop an increment of the AGT system along the northern part of the CBD. This option would circumvent the urban design incompatibility in the core areas of the CBD.

2.5.3 MAJOR DIVERSIFIED ACTIVITY CENTERS

Chicago, Merrillville

Merrillville is a multi-nodal activity center with several large shopping centers and office complexes. It is in the early stages of development. Current retail and commercial floor space is 2 to 3 million square feet, but projected floor space is about 6 million square feet. There are four distinct sectors in Merrillville. Accessability between sectors is poor and nearly all inter-zonal trips are made by auto. If current growth persists, auto congestion may be a problem.

Table 2.10
Weekday Transit Ridership
Dallas, Central Business District

Alternative	Shuttle Bus (1990)	AGT (1990)
Internal trips[1] by workers (daily):		
Walk	127,000	120,000
Auto	27,000	26,000
Internal transit	4,000	14,000
Internal trips[1] by nonworkers (daily):		
Walk	34,500	33,000
Auto	5,200	5,000
Internal transit	300	2,000
Parking distribution (daily):		
Walk	624,000	616,000
Internal transit	6,000	14,000
Regional transit distribution (daily):		
Walk	246,000	240,000
Internal transit	4,000	10,000
Total internal trips[1] (daily):		
Walk	1,031,500	1,009,000
Auto	32,200	31,000
Internal transit	14,300	40,000

[1] All trips are <u>person</u> trips.

Table 2.11
Revenue and Cost Summary (1978 dollars)
Dallas, Central Business District

Alternative	Shuttle Bus	AGT (with North Spur)
Route length (mi.), two-way	2.6	2.7
Number of vehicles	10	14
Total capital cost ($ millions):		
Guideway	0	30
Stations	0	11
Vehicles	1	7
Annual capital cost[1]	$100,000	$2,800,000
Annual vehicle-miles	200,000	600,000
Annual operating cost	$500,000[2]	$1,000,000
Annual revenues[3]	$300,000	$ 930,000
Revenues-operating cost	-$200,000	-$ 70,000
Revenues-total annual cost	-$300,000	-$2,870,000
Change in CBD auto VMT, annual	--	-200,000

AGT assumed to be operating without a regional system; loop routes (one in each direction) operate at 2 minute headways with the North Spur also operating at a 2 minute headway as a shuttle only.

AGT and shuttle bus assumed to operate 12 hours per day, 310 days/year. If AGT operated longer hours, ridership and costs would be greater.

1 Assuming a 10 percent interest rate and a 6 percent inflation rate.

2 CBD per-mile cost assumed to be $2.50, or 50% greater than the system average.

3 10¢ fare, free transfer for regional transit users.

Currently, no transit system exists. A bus system and a suspended AGT were the two alternatives considered. Both systems follow the same general alignment. The bus system would require construction of roadway, underpasses, and overpasses. The AGT would use an elevated guideway for its entire length. Daily transit ridership estimates are presented in Table 2.12; a revenue and cost summary is presented in Table 2.13. Each of the estimates were computed using 4.8 million square feet and 7.5 million square feet. Estimated ridership for AGT is always more than twice as great as ridership for the bus sytem.

Both alternatives would create some disruption from construction. Personal security is not an issue. The bus system was considered more flexible than AGT; however, AGT may be more compatible with the innovative, futuristic image local planners have for the area. Also opportunities exist for the incorporation of AGT into new architectural structures.

The principal drawbacks of AGT are its inflexibility and cost. Patterns of development are not yet well-defined. Local participants were concerned that patterns of future development would be constrained by the service area of the AGT. Estimated capital cost for the AGT system is over $30 million . Local participants expressed a willingness to spend no more than $5 to $10 million.

<u>Chicago, Oak Brook</u>

Oak Brook is a suburban area with a single retail center and an office park interspersed with other light uses. It is characteristic of many fully-developed post-war suburban complexes throughout the country. Total floor space is about 5 million square feet. Development has reached the saturation point in the last decade and no growth is anticipated in the near future.

Currently, no transit system exists. A bus system and AGT were considered for the area. The AGT system would have an elevated guideway, and either a suspended or supported system could be used. Daily ridership estimates for each alternative are presented in Table 2.14; a revenue and cost summary is presented in Table 2.15. Estimated daily internal ridership for AGT is double the estimated ridership of the bus system (i.e. 4,000 versus 2,000).

Table 2.12
Daily Ridership Summary
Chicago, Merrillville

Alternative	No Internal Transit		Bus		AGT	
Floor space (million sq. ft)	4.8	7.5	4.8	7.5	4.8	7.5
Regional Trips						
Work: Total	23,900	37,600	23,900	37,600	23,900	37,600
Auto	23,300	36,600	23,300	36,600	23,300	36,600
Transit	600	1,000	600	1,000	600	1,000
Shop: Total (all auto)	41,400	60,800	41,400	60,800	42,400	62,100
Internal Circulation						
Workers: Total	4,800	7,500	8,100	12,800	12,400	19,500
Auto	4,800	7,500	3,800	6,000	2,600	4,100
Transit	0	0	4,300	6,800	9,800	15,400
Shoppers: Total	1,700	2,500	2,800	4,100	5,200	7,700
Auto	1,700	2,500	1,300	1,900	900	1,300
Transit	0	0	1,500	2,200	4,300	6,400
Daily Internal Transit Ridership	0	0	6,100	9,500	14,400	22,300
Transit Passengers from 12n-1p.m.			1,400	2,200	1,900	5,100

Table 2.13
Revenue and Cost Summary (1978 dollars)
Chicago, Merrillville

Alternative	Bus			AGT
Floor Space (million, sq. ft.)	4.8	7.5	4.8	7.5
Annual Ridership	1,600,000	2,500,000	4,000,000	6,200,000
Peak Load Factor (12n-1p)[1] (passengers/seat)	.83	1.32	.46	1.22
Number of Vehicles	6(4)		6	9(4)
9				
Total Capital Cost:[2] ($ millions)				
Guideway	3	3	24	24
Stations	0	0	5	5
Vehicles	1	1	2	2
	4		31(15)	
Annual Capital Cost[3]	$ 240,000	$ 240,000	$1,700,000	$1,700,000
Annual Vehicle-Miles:	500,000	500,000	1,200,000	1,200,000
Annual Operating Cost[4]	$ 750,000	$ 750,000	$1,100,000	$1,100,000
Annual Revenues	160,000	250,000	400,000	620,000
Revenues-Operating Cost	-$ 590,000	-$ 500,000	-$ 700,000	-$ 490,000
Revenues-Total Annual Cost	-$ 830,000	-$ 740,000	-$1,800,000	-$1,590,000
Change in Auto VMT, Annual[5]	-225,000	-345,000	-972,000	-732,000

1 Assumes complete loop; loads would be 70% higher with a shuttle only.

2 Suspended capital costs may be approximately three-quarters of supported capital costs.

3 Assuming a 10 percent interest rate and a 6 percent inflation rate.

4 Suspended operating costs may be approximately 3/4 of supported operating costs. Bus operating costs estimated at $1.50/vehicle mile: $0.70/mile fuel and maintenance + $0.80/ mile labor ($9.60/hour at 12 mph).

5 Due to internal transit only; regional transit not included; 0.7 mi. avg. auto trip assumed.

Table 2.14
Daily Ridership Summary
Chicago, Oak Brook

Alternative	No Internal Transit	Bus	AGT
Regional Trips			
Work: Total	38,000	38,000	38,000
Auto	37,500	37,000	37,000
Transit	500	1,000	1,000
Shop: Total (all auto)	50,000	50,000	50,000
Internal Circulation			
Workers: Total	4,000	5,500	7,000
Auto	4,000	3,500	3,000
Transit	0	2,000	4,000
Shoppers:	0	0	0
Total Internal Transit Passengers from 12n-1p.m.	0	600	1,200

Table 2.15
Revenue and Cost Summary (1978 dollars)
Chicago, Oak Brook

Alternative	Bus	AGT
Annual Ridership	600,000	1,100,000
Peak Load Factor (12n-1p) (passengers/seat)	.60	.80
Number of Vehicles	6	11
Total Capital Cost: ($ millions)		
Guideway	0	58
Stations	0	13
Vehicles	1	5
Annual Capital Cost[1]	$ 100,000	$3,600,000
Annual Vehicle-Miles:	66,000	200,000
Annual Operating Cost	$ 130,000	$ 900,000
Annual Revenues	$ 60,000	$ 110,000
Revenues-Operating Cost	-$ 90,000	-$ 790,000
Revenues-Total Annual Cost	-$ 190,000	-$4,390,000
Change in Auto VMT, Annual[2]	- 1,400,000	- 1,500,000

1 Assuming a 10 percent interest rate and a 6 percent inflation rate.

2 Assumes an average trip length of 1 mile for internal trips and 10 miles for external trips.

The AGT system would create a minor amount of disruption during construction. AGT would also create significant visual intrusion. Personal security was not an issue. The potential for joint development with either system is limited.

Three key issues were considered to be most important in influencing transit decisions at this site. These issues are visual intrusion, cost, and demand levels. The design of AGT is not compatible with the area. The capital costs are prohibitive, and the demand levels are low. Some local participants felt AGT might be considered in 10 or 20 years when it is anticipated that Oak Brook may be massively renovated.

Dallas, North Park

North Park is a major regional center near Dallas. It is typical of the large suburban centers which have developed in major metropolitan areas during the past 20 years. Retail shopping, office, and recreation/ entertainment are the three major activities of the area. A total of 3 million square feet of office and retail space exist and 1 million square feet may be added during the next 5 to 10 years. There are four major quadrants of activity. Access to each is good, but access between quadrants is difficult.

Currently, no transit system exists. Three alternative systems were examined in the North Park area--shuttle bus, elevated AGT and a rerouting of the regional AGT system. The proposed AGT alternatives use a supported design. Daily ridership estimates for each alternative are presented in Table 2.16; a revenue and cost summary is presented in Table 2.17. Costs for the regional AGT and the shuttle bus are quite comparable and are significantly lower than the other AGT option.

The AGT construction would cause some disruption, but it was considered to be minor. The elevated AGT structure could also be integrated with current and future architecture. In fact, the modernistic design of AGT was considered an advantage of the system. Personal security was not an issue.

The potential for AGT development at North Park appeared to be quite high. The development of the area is in the hands of a single property owner, so

Table 2.16
Daily Ridership Summary
Dallas, North Park

Alternative	Bus	AGT Circulator	Regional AGT
Internal trips by workers (daily):			
Auto	3,000	2,900	2,700
Internal transit	600	1,000	1,800
Internal trips by nonworkers (daily):			
Auto	9,700	7,500	6,300
Internal transit	1,200	3,400	4,600
Regional transit distribution			
Work	500	500	not required
Nonwork	4,200	4,200	not required

Table 2.17
Revenue and Cost Summary (1978 dollars)
Dallas, North Park

Alternative	Bus	AGT Circulator	Regional AGT
Number of vehicles	8	3	2
Total capital cost ($ millions):			
Guideway	0	7	1.5
Stations	0.5	4	2
Vehicles	0.8	1.5	1
Annual capital cost[1]	$100,000	$ 700,000	$300,000
Annual vehicle-miles	250,000	150,000	75,000
Annual operating cost	$400,000[2]	$ 500,000[3]	$250,000[4]
Annual revenues	0	0	0
Revenues-operating cost	-$400,000	-$ 500,000	-$250,000
Revenues-total annual cost	-$500,000	-$1,200,000	-$550,000
Change in annual internal auto VMT	--	- 564,000	- 900,000

1 Assuming a 10 percent interest rate and a 6 percent inflation rate.

2 Assumes operating cost $1.60 per mile.

3 Assumes operation completely independent of regional system.

4 Assumes central control console operators and station maintenance shared with regional system.

the inflexibility of AGT was not an issue. The elevated structure can be effectively turned into a positive feature. Cost is not a major drawback as long as the AGT is part of a regional network.

Dallas, Market Center

The Dallas Market Center is the world's largest single-site wholesale merchandise mart. It is comprised of six buildings with a total floor space of over 7 million square feet. The market operates only 26 weeks a year, which creates distinctly different ridership requirements. During "market weeks," traffic may exceed 50,000; during "non-market weeks," traffic may drop to half of the previous figure. The Market Center has experienced clear growth trends, which are projected to continue.

The existing transit network is a shuttle bus system. An elevated supported AGT built in conjunction with a regional system is the only alternative to the bus system considered. Daily transit ridership, revenue, and cost estimates are presented in Table 2.18.

Some concerns about AGT were voiced, but were not specific to AGT. Visual intrusion by the AGT guideway is not a problem. Indeed, the elevated guideway is viewed as an asset. Market Center is under single ownership, so the inflexibility of the AGT system is not a major problem.

The key issue is whether AGT could be deployed in conjunction with a system in the Stemmons corridor. If so, the estimated capital costs of about $8 million were not viewed as excessive. There was less enthusiasm for an internal AGT system in the absence of a system in the Stemmons corridor.

2.5.4 MEDICAL CENTER

Chicago, State of Illinois Medical Center

The Illinois Medical Center is situated on a 365 acre site. The complex of 15 million square feet includes 100 health care, research, and educational facilities. Four separate hospitals share the site. In general, the hospitals strive to be self-contained. Shared medical resources among institutions are typically a small proportion of total resources. The functional autonomy of the institutions is in part attributable to different specialties (e.g., children, maternity, eye and ear,

Table 2.18
Daily Transit Ridership, Revenue and Cost Summary (1978 dollars)
Dallas, Market Center

Alternative	Bus	AGT
Internal trips, daily[1]	16,000	16,000
Peak load factor[2] (passengers/seats)	1.00	1.00
Number of vehicles	10	3
Total capital costs ($ millions):		
Guideway	0	3
Stations	0	3[4]
Vehicles	0[3]	1.5
Annual capital costs[5]	0	$450,000
Annual vehicle-miles[6]	25,000	35,000
Annual operating cost[6]	$100,000	$150,000[7]
Annual revenues	0	0
Revenues-operating cost	-$100,000	-$150,000
Revenues-total annual cost	-$100,000	-$600,000

1 Average of 8,000 visitors on market days assumed; all are assumed to make internal trips (two-way), thus creating 16,000 trips.

2 Peak hour assumed to have .20 of daily trips, evenly split between two directions. Shuttle bus and AGT operate at 2 minute headways.

3 Leased vehicles; all costs treated as operating costs.

4 Two stations shared with regional transit.

5 Assuming a 10 percent interest rate and a 6 percent inflation rate.

6 Rough estimate; service charged at $22/hour and provided only during markets.

7 Central console operator and station maintenance costs shared with regional system.

etc.) and to institutional rivalries. However, the predominance of a single (health-related) land use and the presence of a substantial, related residential community adjacent to the Medical Center makes it a characteristic urban community within a community.

The existing transit network consists of two rail lines and a bus system. Additionally, each institution operates some independent transportation services.

An elevated, supported AGT and an equivalent bus system are the alternatives considered. Each of these alternatives are examined under two scenarios--with current parking and with restricted parking. Restricted parking would remove all parking from streets in the Center. Daily ridership estimates for the AGT and all transit are presented in Table 2.19. A revenue and cost summary for AGT and a bus system with equivalent ridership levels is presented in Table 2.20.

The construction of the AGT would cause some temporary disruption. The noise and vibration from construction is particularly undesirable in hospital areas. Some, but not all, of the disruption can be alleviated by prefabrication and other special procedures. The bus system would require no construction. The AGT offers a comfort advantage over the bus system, since the stations can be enclosed for temperature control and physical barriers alleviated. The AGT would create some negative visual impacts, but this could be ameliorated by joint development (especially at stations). Personal security is one of the central issues for the Medical Center area. The bus system is perceived to be much safer than the AGT system. Labor displacement was considered unlikely with AGT.

The key issues at the site are insufficient system demand, high cost, personal security, and institutional factors. Though AGT offered advantages over the bus system in the areas of system performance and land use, these advantages were not felt to outweigh the issues noted above. AGT was felt to generate insufficient demand compared with the cost of the system. Personal security problems could not adequately be overcome due to the absence of vehicle operators and the elevated stations. A lack of interest in AGT by the institutions in the area was anticipated due to their independent operation.

Table 2.19
Daily Ridership Summary
Chicago, State of Illinois Medical Center

Alternative	Status Quo	AGT Current Parking		AGT Restricted Parking	
		AGT	(All Transit)	AGT	(All Transit)
External-Internal Trips					
Work	90,000				
Auto	57,000	1,000	(1,000)	20,000	(20,000)
Pedestrian	8,000	800	(800)	800	(800)
Bus	12,000	200	(12,000)	300	(15,000)
Rapid Transit	13,000	500	(13,000)	600	(16,000)
Nonwork	38,000				
Auto	26,000	450	(450)	10,000	(10,000)
Pedestrian	--	--		--	
Bus	6,000	100	(6,000)	100	(7,000)
Rapid Transit	6,000	200	(6,000)	100	(7,000)
Internal Trips	6,000				
Pedestrian	5,700	--		--	
Bus	300	400	(400)	400	(400)
Total Trips:	134,000	3,650	39,650	32,300	76,200
Trips on Regional Transit:	37,000		37,000		45,000

Table 2.20
Revenue and Cost Summary (1978 dollars)
Chicago, State of Illinois Medical Center

	Status Quo		Restricted Parking	
Alternative	AGT	Equivalent Bus System	AGT	Equivalent Bus System
Annual Ridership	1,200,000	1,200,000	10,500,000	10,500,000
Number of Vehicles	11	17[1]	11	17[1]
Total Capital Cost:[2] ($ millions)				
Guideway	20	0	26	0
Stations	13	0	17	0
Vehicles	4	2	5	2
Annual Capital Cost[3]	$2,100,000	$ 200,000	$2,800,000	$ 200,000
Annual Vehicle-Miles:	630,000	630,000	630,000	630,000
Annual Operating Cost	$ 750,000	$1,300,000	$1,000,000	$1,300,000
Annual Revenues[4]	$ 120,000	$ 120,000	$1,000,000	$1,000,000
Revenues-Operating Cost	-$ 630,000	-$1,180,000	0	-$ 300,000
Revenues-Total Annual Cost	-$2,730,000	-$1,380,000	-$2,800,000	-$ 500,000
Change in Auto VMT, Annual[5]	negligible	negligible	12,000,000	12,000,000

1 Assumes 9 mph average speed.

2 Assumed suspended with 30 passenger vehicles in status quo, supported with 50 passenger vehicles in "restricted parking." Suspended capital and operating costs assumed to be 3/4 of supported costs, as discussed in Merrillville site (Table 2.13).

3 Assuming a 10 percent interest rate and a 6 percent inflation rate.

4 Based on 10¢ fare for parking and internal ridership; 10¢ transfers to CTA.

5 Based on average auto trip length of 5 miles and 1.2 occupancy.

2.6 SUMMARY AND CONCLUSIONS

A summary of projected ridership and cost information for each of the sites and case cities is provided in Table 2.21. The key issues varied substantially across sites, though there is a tendency for consistency within a particular type of site. Potential issues were sometimes of no concern at any site or only of interest at certain types of sites. Also, certain features of AGT were considered to be benefits in some sites and negative in others.

In general, the visual intrusion from an elevated AGT guideway is considered undesirable, especially in CBDs and residential corridors. In CBDs, an elevated AGT guideway may not be compatible with the existing (usually older) architecture; in corridors, the guidway may not be compatable with residential areas. Opposition from residents in corridors can probably be expected. As for medical centers, the elevated guideway may have positive or negative impacts depending on current architecture. Development of an elevated AGT in activity centers can be expected to have a positive impact. Frequently, the futuristic design of AGT would enhance the modern image most activity centers desire. Also, the innovative design of AGT can be more easily integrated into ongoing developments at suburban activity centers.

Joint development with an AGT is of primary importance in activity centers and corridors. CBDs tend to be more fully-developed, with joint construction opportunities being correspondingly more complex. Developing activity centers and corridors are particularly good sites for joint development. Not only are they rapidly expanding, they consider the modernistic image of AGT to be an asset.

Benefits deriving from economic development with AGT systems are highly uncertain; however, AGT is expected to enhance economic activity in CBDs, activity centers, and airports. As opposed to these sites, AGT's economic benefits in corridors would most likely be similar to those from conventional rail systems.

The most prevelant objection to AGT was the cost. AGT is consistently a lower cost option than rail transit, but more expensive than bus. Since most sites are considering AGT as an alternative to bus rather than rail, the costs of AGT may seem overly high. Only sites with a possibility of substantial joint economic development or joint development with a regional transit system consider AGT viable financially.

Table 2.21
Annual Ridership and Costs by Alternative at Each Case Study Site

	Corridors			Central Business Districts	
	Atlanta North Corridor	Atlanta Southeast Corridor	Dallas Stemmons and North Central Corridors	Chicago North Michigan CBD	Dallas CBD
Alternative 1	Improved Bus	Improved Bus	Transitway	AGT(1)	Shuttle Bus
Ridership*	7,000	6,500	20,000	16,000	4,300
Capital Costs*	$700	$500	$10,000	$4,000	$100
Operating Costs*	$7,200	$4,800	$8,900	$300	$500
Capital Cost Per Passenger Trip	$.10	$.08	$.50	$.25	$.02
Operating Cost Per Passenger Trip	$1.03	$.74	$.45	$.08	$.12
Alternative 2	LRT	LRT	LRT	AGT (2)	AGT
Ridership*	8,500	9,000	19,000	16,000	12,000
Capital Costs*	$12,000	$12,000	$13,000	$3,200	$2,800
Operating Costs*	$7,000	$4,600	$7,600	$1,100	$1,000
Capital Cost Per Passenger Trip	$1.41	$1.33	$.68	$.20	$.23
Operating Cost Per Passenger Trip	$.82	$.51	$.40	$.07	$.08
Alternative 3	AGT	AGT			
Ridership*	9,000	9,000	21,000		
Capital Costs*	$8,000	$7,000	$10,000		
Operating Costs*	$5,100	$3,500	$7,500		
Capital Cost Per Passenger Trip	$.63	$.78	$.38		
Operating Cost Per Passenger Trip	$.56	$.39	$.75		
Alternative 4					
Ridership*					
Capital Costs*					
Operating Costs*					
Capital Cost Per Passenger Trip					
Operating Cost Per Passenger Trip					

*Ridership levels and costs in thousands.

Activity Centers				Medical Center
Chicago Merrillville	Chicago Oak Brook	Dallas North Park	Dallas Market Center	Chicago Medical Center
Bus (4.8 miles)	Bus	Bus	Bus	Bus
1,600	600	540	250	1,200
$240	$100	$100	$0	$200
$750	$130	$400	$100	$1,300
$.15	$.17	$.19		$.17
$.47	$.22	$.74	$.40	$1.08
Bus (7.5 miles)	AGT	AGT Circulator	AGT	AGT
2,500	1,100	1,300	250	1,200
$240	$3,600	$700	$450	$2,100
$750	$900	$500	$150	$750
$.10	$3.27	$.54	$1.80	$1.75
$.30	$.82	$.38	$.60	$.63
AGT (4.8 miles)		Regional AGT		Bus (Restricted Parking)
4,000		1,900		10,500
$1,700		$300		$200
$1,100		$250		$1,300
$.43		$.16		$.02
$.28		$.13		$1.24
AGT (7.5 miles)				AGT (Restricted Parking)
6,200				10,500
$1,700				$2,800
$1,100				$1,000
$.27				$.27
$.18				$.95

Demand levels for AGT are generally higher than for other transit alternatives. Low demand levels are a major concern only in activity and medical centers. These types of sites usually have minimal current transit service. Thus, a completely new ridership would have to be generated rather than a transfer from other types of transit. Sites with substantial transit ridership did not indicate concern with low demand levels.

Alignment selection was only a problem in CBDs. Most CBDs are sufficiently developed that easily-accessible rights-of-way are non-existent. Another alignment issue concerns flexibility of AGT versus other transit modes. At activity centers which are either newly developing or have multiple owners, concern was voiced over the inflexibility of an AGT system. The inflexibility was a problem because of uncertain future growth patterns within new areas and conflicts of interest between owners at some developments.

Construction disruptions were a concern in activity centers, medical centers, and some corridors. In activity centers, construction disruption could cause a reduction in retail sales. In medical centers, the noise and vibration from construction are particularly undesirable due to the necessity of a quiet, restful atmosphere. Disruption from construction was also undesirable in residential sections of corridors. Construction disruption was not considered particularly harmful in CBDs due to current high noise and vibration levels. Rerouting of traffic from construction would most greatly affect CBDs, but it was not considered a major concern by most representatives.

Labor issues were felt to be unimportant at all sites. Local administrators thought any labor displacements could be absorbed into other jobs.

Personal security proved not to be a major concern in the case studies. At some sites, personal security was considered low on an automated system, but not lower than current transit. Personal security was a potential risk at medical centers due to the large number of physically impaired riders, but was overriden by other concerns.

Based on the case study analyses, only <u>certain</u> corridors, CBDs, major diversified activity centers, and medical centers are judged to be likely sites for AGT implementation. The following discussion indicates characteristics of each type of site that increases its chance of implementing AGT.

In corridors, the key issues are visual intrusion, disruption of residential areas, costs, integrated joint development, and regional transit planning. To implement AGT in a corridor, a right-of-way through the residential areas that would minimize the visual intrusion, operating noise, and construction would have to be located. Potentially high costs could be mitigated if substantial joint development were possible or the AGT was a segment of a regional transit system.

In CBDs, the key issues are alignment, visual intrusion, costs, and integration with current transit systems. Some CBDs may not be potential sites for AGT due to their previous commitment to rail transit. Other CBDs would still face the problem of integrating AGT into their transit plans. Location of an adequate right-of-way where AGT is compatible with existing architecture is fundamental to development of AGT in CBDs, and some CBDs may contain no viable alignment. Costs of AGT also may be considered to be high unless AGT can enhance economic development in the CBD.

Generally, AGT is viable only in major diversified activity centers with two (or more) retail nodes, two (or more) non-retail nodes, and at least several million square feet of floorspace. These sites are even more promising if they have a single owner and/or are well-established activity centers. High costs and low demand are the key problems in any activity center. These problems can be overcome at some sites, though, through joint development where the areas are growing or integration with a regional transit system.

Only medical centers that contain single institutions with multiple sites seem appropriate for AGT. In other types of medical centers, each institution is relatively self-contained, with the flow of traffic between institutions being relatively low. Even at medical centers where institutions have multiple sites, the high costs, low demand, and the threat to personal security from an automated system may work against successful implementation.

CHAPTER 3
NATIONAL MARKET ESTIMATE METHODOLOGY

3.1 INTRODUCTION

The national market analysis provides guidance on the desirability of pursuing policies to encourage the development and deployment of AGT. The analysis is not intended to predict the actual number of deployments; it is intended to determine whether the number of cost-effective potential applications is sufficient to warrant a Federal effort to encourage their eventual deployment. Cost-effectiveness is UMTA's officially stated criterion for evaluating projects requesting Federal financial support. A project is cost-effective if it achieves a specified set of objectives at minimum cost. Since specific objectives may vary widely between potential AGT sites, a benefit/cost evaluation technique is used to produce comparable rankings of alternatives. Benefit/cost issues, however, are only a subset of the criteria affecting local decision-making on deployment. Other considerations include effects on municipal finances, labor relations, urban/suburban issues, economic development, and others. While the analysis addresses several of these issues, it is neither the intent nor the purpose of this part of the analysis to address the full range of considerations affecting actual local deployment decisions.

Potential applications of AGT vary widely in terms of the scale of the development, the type of transportation demand served, the level of service required, and the type of AGT technology deployed. Accordingly, distinct analysis strategies have been developed to examine the potential size of the various market segments. Separate market analyses are developed for:

1. Corridors
2. Central Business Districts (CBD's)
3. Major diversified activity centers; including shopping centers, airports, and medical centers

Areawide applications are not included; however, deployment in primary and secondary corridors is considered. The methodologies used to analyze the corridor and CBD segments are described in the following sections. Primary emphasis is given to the corridor and CBD markets since these two markets are probably the largest and also are most relevant to UMTA since nearly all Federal policy and financial support for transit service are directed at these two markets.

The national market for AGT in urban corridors and CBDs is analyzed with a combined benefit/cost and revenue/cost methodology. While the analysis is necessarily approximate, it does illuminate the issues affecting the national market. In the corridor analysis, three fixed guideway technologies are explored: AGT, LRT, and busway. In the CBD analysis, AGT is the only fixed guideway alternative considered.

The remaining markets--shopping centers and major diversified centers, airports and hospitals--are analyzed using approaches that are more qualitative than quantitative. For each segment, the principal distinguishing characteristics of a potential application site were identified. The identification of distinguishing characteristics relies heavily on the conclusions of the site specific analyses. The number of potential applications in each market segment are estimated on the basis of the number of existing sites that currently or may soon meet the necessary criteria.

3.2 IDENTIFICATION OF POTENTIAL MARKET

Deployment of AGT was investigated for selected corridors of cities listed in Table 3.1, i.e., all urbanized areas over 500,000 population that do not already have extensive rail systems. Cities marked with an asterisk already have or are likely to deploy a non-AGT fixed guideway system of limited extent. National deployment estimates are made with these cities included as potential deployment sites. These two categories of cities are distinguished because the likelihood of an AGT deployment in a corridor without fixed guideway transit is likely to be reduced if a non-AGT technology has already been deployed in another corridor. Integration of different system technologies often imposes added costs. Operators and management must familiarize themselves with the problem of operating and maintaining a new technology. This cost would not be incurred if the same technology were deployed. Also possibilities for system integration are reduced when different technologies are deployed. However, as an initial analysis, these issues are not analyzed.

Table 3.1
Potential Metropolitan Areas for a Corridor Deployment of AGT**

St. Louis	San Antonio
Baltimore*	Kansas City
Miami*	Syracuse
Dallas/Ft. Worth	Honolulu*
Houston	Akron
Milwaukee	Birmingham
Minneapolis/St. Paul	Dayton
Pittsburgh*	Indianapolis
San Diego	Norfolk
Seattle	Oklahoma City
Buffalo*	Phoenix
Cincinnati	Portland
Columbus	Sacramento
Denver	Tampa
Memphis	Toledo
New Orleans***	Albany
Providence	Hartford
Rochester	Los Angeles
Detroit*	

* Limited rail systems are already in place or will soon be deployed.

** New York, Boston, Cleveland, Chicago, Atlanta, Philadelphia, the San Francisco Bay Area, and Washington, D.C. are not included on this list due to the extensiveness of their existing or planned fixed guideway systems. Ft. Lauderdale, which has considered an AGT, was not included because sufficient data for doing an analysis of this site was unavailable.

*** Right-of-way judged not to be available for construction in major corridors.

The candidate cities for CBD systems include:

1. All cities listed for corridor applications

2. All cities with extensive rail systems, i.e., New York, Boston, Philadelphia, San Francisco, Cleveland, Washington, DC, Atlanta, and Chicago.

3. Two cities considered by UMTA as candidate sites for DPM deployment; i.e., Anaheim, California and Jacksonville, Florida.

3.3 SELECTION OF RIGHT-OF-WAY AND CONSTRUCTION TYPE

The right-of-way (ROW) category assumed for each candidate project substantially affects both the relative and absolute benefit/cost ratios for each system alternative.

The benefits of reduced time and auto ownership costs are functions of system ridership which is in turn influenced by ROW. Likewise, operating and maintenance costs are functions of system ridership. The unit cost for guideway and station construction vary markedly by construction type which is in turn determined by ROW.

Assignment of ROW categories in corridors is guided by the rule that if an abandoned or lightly used rail ROW is available, a rail ROW is assumed. Corridors with both expressway and rail ROW options are frequently encountered. In these instances, a rail ROW is generally assigned because at-grade contruction is considerably less expensive than elevated construction and visual intrusion is also considerably reduced. Arterials are used when convenient rail or expressway ROW's are not available.

The unit capital costs for guideways and stations are dependent on construction type with at-grade construction the least expensive and subway construction the most expensive. Thus, in terms of direct monetary cost, at-grade construction is most preferred and subways least preferred. The decision on which type of construction is chosen is determined by numerous considerations, among the most important of which are the costs of visual intrusion and the space constraints of the chosen right-of-way. Generalizing about the preferred construction type for the different ROW categories is difficult but necessary. Table 3.2 defines the assumptions for the preferred construction type for each mode and ROW category.

Table 3.2
Construction Type and Right-of-Way for Corridor Analyses

ROW		Guideway Location	
		Outside CBD	In CBD
Rail:	AGT	50% elevated, 50% at-grade	elevated
	LRT	50% elevated, 50% at-grade	subway
	Busway	50% elevated, 50% at-grade	no guideway - circulation on city streets
Expressway:	AGT	elevated	elevated
	LRT	elevated	subway
	Busway	elevated	no guideway
Arterial:	AGT	elevated	elevated
	LRT	subway	subway
	Busway	not feasible	--

These judgments derive primarily from consideration of space limitations and direct monetary costs.

In the non-CBD portion of a corridor application, rail rights-of-way may offer the opportunity to build much of the system at-grade, but some elevated structures are required for grade crossings and maintenance of rail freight service. In constrast, expressway ROW frequently does not have sufficient residual space for at-grade construction. Development along the expressway may further constrain space. Thus, an elevated construction type for expressway ROW is assumed. Arterial ROW's typically pose the most severe space limitations. Elevated structures for LRT are typically too massive for an arterial ROW and the most expensive subway alternative is assumed necessary for an LRT deployment along an arterial. In contrast, AGT elevated structures are less massive than LRT elevated structures and conceivably could be fit into many arterial settings. Since guideway and station costs for an elevated AGT guideway are about one-fourth those for LRT subway construction, arterial settings have been argued to be a prime market for AGT. Finally, elevated busways are assumed infeasible in an arterial ROW both because of the massiveness of the guideways and the noise and pollution impacts. A variety of cost, operational and environmental factors tend to make bus subways less attractive than alternative systems in virtually all settings. Therefore, they are not considered in the analysis.

The choice of construction type for the CBD applications of AGT reflects similar reasoning. Space constraints prohibit an elevated LRT structure and thus subway construction is assumed. In view of the infeasibility of subways for buses, for the busway alternative the buses are assumed to circulate on the city streets. The AGT guideway is assumed to be elevated.

3.4 TIME HORIZON AND DISCOUNT RATES

Benefits and costs, except for the initial capital costs, are assumed to accrue annually, with a 30-year time horizon adopted for the analysis. To compute the system benefits over the 30 year horizon, annual benefits for each of the 30 years are brought back to a present value through use of an assumed interest rate. Costs are computed by assuming all capital costs are incurred in the first year, and that all operating costs are converted to present value through the interest rate.

Future costs and benefits are discounted using a 10 percent interest rate and a 6 percent inflation rate. This interest rate is the one currently suggested by the Office of Management and Budget (OMB) for Federal projects,[1] and the 6 percent inflation rate is a conservative characterization of experience at the time of the analysis. All money values are computed in constant 1978 dollars.

3.5 ALTERNATIVE SCENARIOS

In an analysis such as this it is important to analyze the sensitivity of the results to key assumptions. Two such scenarios are analyzed:

1. A Doubling of Gasoline Prices--Recent experience with gas prices suggests that the possibility of a doubling in the real cost of gasoline from $0.75 to $1.50 is quite high.

2. Doubling of the Capital Costs of a DPM System--Recent estimates for DPM systems are nearly double the cost estimates used in this study.

3.6 CORRIDOR ANALYSES

The decision to deploy an AGT in a corridor is considered as a two stage process. First, a decision is made on the relative merits of AGT and other fixed guideway technologies. If AGT is considered the superior technology, then a second decision on the merits of AGT relative to non-guideway bus service (possibly with some major improvements in level of service) is required. The first is a decision among capital intensive fixed guideway systems; the second is between a capital intensive alternative and a low capital alternative. The fixed guideway technologies in addition to AGT that are analyzed are light rail transit (LRT) and busway.

3.6.1 BENEFITS AND COSTS

The potential benefits of a fixed guideway technology in a corridor application are numerous. The most important are:

1. Reductions in travel time to persons using the system.

2. Reductions in auto ownership. The reduction in transit travel time may induce a reduction in average auto ownership levels. Viewing auto ownership as a demand for mobility, a reduction in auto ownership is a benefit.

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[1] OMB Circular A-94.

3. Reduction in bus operating costs. Deployment of any fixed guideway technology will generally permit a reduction in bus operating costs in the corridor where the system is deployed.

4. Reductions in auto-related externalities, such as pollution, congestion, and accidents.

5. Economic development.

Savings in auto operating costs of new transit users frequently are mentioned as benefits of any improvement in transit service. However, it is incorrect to regard these as a user benefit. The ridership on a transit system will be a function of the inclusive cost of travel on the system, which consists of both the time and the out-of-pocket cost of the trip. An analogous price also exists for other potential modes of travel. Any improvement in transit level of service will reduce the inclusive cost of transit use. The full benefits of the reduction will accrue to the existing transit ridership, and half the reduction to new transit users attracted from other modes.[1] Since an improvement in transit service does not in general affect the inclusive cost of travel by other modes but rather improves transit's competitive position, the benefits in terms of travel cost savings should only be measured in terms of the incremental reduction in the inclusive cost of transit use.

The second element of benefits due to a guideway system is reduced auto ownership and auto related externalities. The former measures a long term effect of improved transit service, since improved transit service allows a reduction in investment in alternative modes of transportation--the most important being automobiles.[2] The latter benefit, reduced auto externalities, is also appropriately included because the cost of auto use is not solely born by the users, pollution and congestion costs are imposed on society at large.

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[1]This is the concept of consumer's surplus, which measures benefits to users as the difference between their willingness to pay for a service and what they actually pay.

[2]Some may disagree with this as a benefit, claiming that it is merely part of the inclusive cost of travel by auto, and thus should be treated in the same manner as auto operating costs, which are excluded from the benefits.

Costs of a fixed guideway system include:

1. Capital and operating costs
2. Visual intrusion of guideways
3. Noise and pollution from transit vehicles
4. Construction disruptions
5. Displacement of residents and businesses

In this analysis, only the first three benefits and system capital and operating costs are quantified.[1] Quantification of the remaining costs and benefits poses difficult problems in measurement or in conversion to monetary equivalents, or both. While the benefits and costs to be quantified fall considerably short of being exhaustive, they are sufficiently inclusive for a qualitative analysis of the impact of remaining benefits and costs.

3.6.2 RIDERSHIP FORECASTS

An essential ingredient for estimating benefits and costs is system ridership on each of the fixed guideway technologies and the existing bus system. Ridership estimates for the fixed guideway technologies are necessary for estimating vehicle capital costs, operating costs and each of the user benefits. Ridership data on the existing bus system in the service area of the alternative fixed guideway systems are necessary for estimating the savings in bus operating and capital costs and total user benefits.

Ridership on the Existing Bus System

First, ridership on all central business district (CBD) bound bus routes is estimated. CBD trip ends are estimated as a function of CBD employment or floor space. CBD bound transit ridership is estimated as the product of CBD trip ends and CBD transit mode share, which is derived from census data. This estimate is further scaled to account for ridership on CBD bound buses with destinations outside the CBD. The estimate of ridership on CBD bound buses is finally multiplied by the proportion of all ridership originating from the service area of the fixed guideway alternative, as described below.

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[1]Appendix A gives a detailed description of the models used to quantify the benefits and costs.

Ridership on the Fixed Guideway Alternatives

Fixed guideway transit service typically attracts substantially larger ridership than the standard bus alternative. A fixed guideway system generally has more frequent service, greater operating speeds and better physical amenities (e.g., ride quality, noise). The first two service dimensions can be measured with assumptions on average operating speeds and service frequencies (headways) on each alternative. In Table 3.3 the assumed average speeds and headways for each system considered are shown.

The greater operating speeds and service frequencies of the fixed guideway alternatives relative to the existing bus alternative translate into reduced in-vehicle travel time (IVTT) and out-of-vehicle travel time (OVTT). The magnitudes of the changes are substantially dependent on the accessibility of transit stations (assumed one per guideway mile) to the population of potential riders. Persons within walking distance of a station will benefit most from deployment of a fixed guideway system. For AGT and busway, OVTT is reduced by 6 minutes and for LRT by 4.5 minutes.[1] IVTT is reduced by more than 50% for all systems. For persons not within walking distance of a station, level of service improvements are less dramatic because feeder bus service must be used. OVTT for AGT and busway is reduced by only 1 minute; for LRT, OVTT increases by a half minute. Savings in IVTT are also reduced because a smaller proportion of the trip length is on the faster fixed guideway system. In the analysis, persons within one quarter of a mile are assumed to walk to a station and the remaining ridership are assumed to use a feeder service.[2] Average trip length, which determines the total saving in IVTT, is estimated with a relationship relating this quantity to metropolitan population. A one mile average trip length on the feeder service is assumed.

The average changes in IVTT and OVTT are computed as the weighted sum of the changes for these two segments of system ridership; the weights are the proportion of the population in each group. These proportions will vary with system location. Locations considered in

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[1]Average wait time is assumed one-half the headways.

[2]Walk times to a station, feeder bus stop for the fixed guideway alternative or to a bus stop for the current bus system are assumed to be the same.

Table 3.3
Average Speed and Headways for Alternative Corridor Systems

	System		Feeder Bus	
	Average Speed (mph)	Headways* (min.)	Average Speed (mph)	Headways* (min.)
Current Bus Service	12	15	--	--
AGT	25	3	12	10
LRT	25	6	12	10
Busway**	25	3	12	10

* Headways are for an average route in peak periods. Headways in the off-peak will typically be twice the peak period headways. Annual ridership and costs are computed assuming 500 3-hour peak periods and 1600 3-hour off-peak periods per year.

** Stations along the busway are assumed. If no stations are assumed, speeds can be higher, but trips to intermediate points on the busway cannot be served.

this analysis are arterial, expressway and rail rights-of-way (ROW). Expressway ROW will typically traverse areas of higher population density than rail ROW and population densities along an arterial ROW will typically be still larger than expressway ROW. As a consequence the segment proportions are varied depending on system location. Level of service improvements are largest for arterial locations and least for rail locations.

To compute system ridership, the increase in CBD bound transit mode share attributable to the level of service improvements is first estimated. In making this estimate, an additional "modal image" factor is included to account for level of service improvements not captured by the reduction in IVTT and OVTT such as improved physical amenities.[1] The modal image effect can be put into a quantitative perspective by estimating the savings in IVTT (about 10 minutes) that would produce a ridership increase of equal magnitude. CBD transit ridership from the fixed guideway system's service area is the product of estimated transit mode share, CBD trip ends and the estimated proportion of the CBD trip ends originating from within the system service area. This final factor is a function of the number of major corridors in the metropolitan area, their relative vehicular volumes and the system length. This product estimates CBD bound transit ridership from within the system service area. The CBD bound ridership estimate is next factored up to account for non-CBD trips. The factor for non-CBD trips is a function of the relative frequency of non-CBD trips in the central city to CBD bound trips. As the relative frequency of non-CBD trip destinations increases, the scale factor increases.

3.6.3 BENEFIT CALCULATIONS

Saving in the Inclusive Cost of Travel

Transit ridership is determined by the inclusive price of transit measured relative to competing modes. In

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[1]Transit mode share for the fixed guideway alternatives is estimated with a technique called incremental logit. The necessary parameters, including the image factor, are derived from the results of the survey reported in Volume III and are consistent with the Dallas and Atlanta mode choice models used in the case studies. Incremental logit predicts changes from existing ridership based on changes in service level.

Figure 3.1 the relationship of transit ridership to the inclusive price of transit use is shown. The term TC measures the change in average price per trip resulting from deployment of a fixed guideway system. Note that the benefits of this reduction are different for the ridership on the existing bus system, R_B, and the new ridership, $R_F - R_B$, attracted by the level of service improvements. Annual benefits to the former group is simply the product of TC and R_B where benefits to the latter are estimated as one half the product TC $(R_F - R_B)$. Annual benefits are estimated by the sum of these two quantities. The change in price, ΔTC, is estimated using the estimated changes in OVTT and IVTT, converted to dollar units. The typical value of ΔTC is about $1.30 per round trip.

Reduced Auto Ownership

A model developed by Lerman and Ben-Akiva[1] which relates automobile ownership to transit level of service is used to estimate the annual benefits from reduced auto ownership. Specifically, the reduction in average auto ownership level resulting from the improved level of service is estimated. Assuming the average annual cost of owning and operating an automobile is about $3800 per year,[2] benefits are distributed among previous and new transit riders by an analogous relationship to that shown in Figure 3.1.

Reduced Bus Operating and Capital Costs

Typically deployment of a fixed guideway system permits a reduction in bus operation in the service area of the fixed guideway system. The reduction, however, cannot be 100 percent because feeder service must be provided. It is assumed that the realignment of routes from a radial CBD-oriented configuration to a configuration suitable for feeder service allows an estimated one-third reduction in operations in corridors. Achieving this benefit for the AGT alternative, however, may pose a legal and labor issue since Section 13c of the Urban Mass Transportation Act provides that Federal aid may not result in displacement of transit workers without significant

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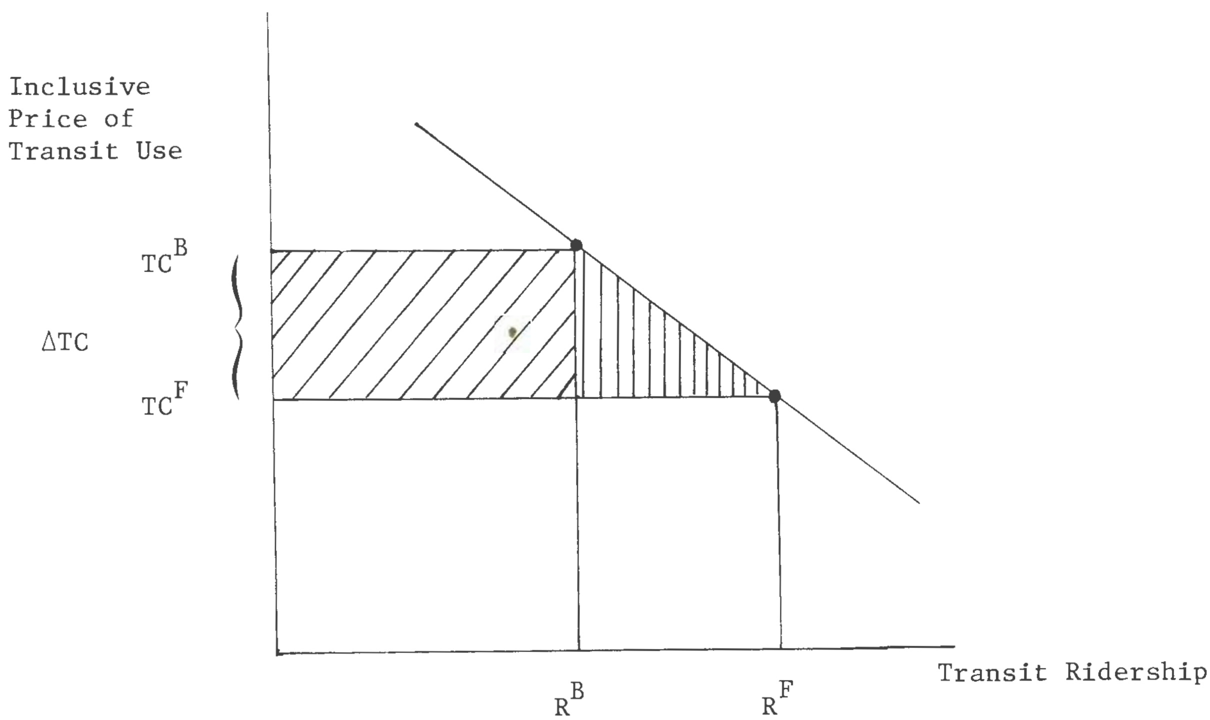
[1]"A Disaggregate Behavioral Model of Automobile Ownership," S.R. Lerman and M. Ben-Akiva, Cambridge Systematics, Inc., 1975.

[2]An upper bound value was chosen deliberately; this benefit turns out to be quite small anyway.

FIGURE 3.1

The Travel Cost Benefits

of a Fixed Guideway System



Area of ▱ (diagonal hatching) $= \Delta TC \cdot R^B$

Area of ▯ (vertical hatching) $= \frac{1}{2}\Delta TC(R^F - R^B)$

R^B = ridership on the current bus system

R^F = ridership on a fixed guideway system

TC^B= average inclusive price of travel on the bus system

TC^F= average inclusive price of travel on the fixed guideway system compensation. For the LRT and busway alternatives, operators displaced by the reduction in existing bus operations can be re-assigned to operate guideway vehicles. Since vehicles are automated for the AGT alternative, this possibility is not available. Thus, there is some uncertainty as to whether the bus capital and operating savings can be achieved for the AGT alternative.

3.6.4 COST CALCULATIONS

Table 3.4 shows the unit costs that are applied to estimate system capital and operating costs. Costs for LRT, busway and feeder bus service are drawn from different sources than the AGT estimates. The difference in their functional form reflects the difference in source. Whereas the relationship defining AGT operating and maintenance costs includes many terms, operating and maintenance costs per vehicle mile for AGT are lower than for the other alternatives because of labor savings.

When predicted ridership is greater than the system capacity under the assumed headways and vehicle capacities, system headways are decreased and trains may be operated (LRT and AGT only). Demand is then recomputed at the new, improved service level. Vehicle capital and operating costs also reflect the greater service level being provided.

3.7 CBD ANALYSES

For the CBD analysis, AGT is the only fixed guideway alternative considered. Alternative technologies, light or heavy rail, would require subway construction; whereas for the reasons discussed in the previous section, construction of elevated AGT guideway is feasible in many CBD's. Due to the direct cost savings of elevated structures, construction of an AGT would be appreciably less expensive than a subway for a rail transit system. Thus the choice is between building AGT or doing nothing. (Operation of bus shuttles is included as a part of the status quo or do-nothing alternative.)

3.7.1 BENEFITS AND COSTS

The principal benefits of AGT considered are:

1. Reduction in the time cost of travel in the CBD-This benefit will accrue if AGT provides a better level of service than the existing bus system.

Table 3.4
Unit Costs of Alternative Modes (1978 dollars)

	Operating and Maintenance Costs
Feeder Bus*:	$2.00/veh. mi.
LRT:	$2.80/veh. mi.
Busway:	$1.50/veh. mi.
AGT:	$270,000 + $.57/veh. mi. + $60,800/2-way guideway mi. + $19,800/station + $3,100/veh.
	Vehicle Capital Costs (Seats Per Vehicle)
Feeder Bus*:	$100,000 (50)
LRT:	$650,000 (75)
AGT:	$450,000 (50)
	Guideway and Station Costs**
LRT:	at-grade - $5.8 mil./2-way mile
	elevated - $19.1 mil./2-way mile
	subway - $47 mil./2-way mile
Busway:	at-grade - $5.4 mil./2-way mile
	elevated - $15.5 mil./2-way mile
AGT:	at-grade - $2.6 mil. + 7.1 mil./2-way mile
	elevated - $2.6 mil. + 12.0 mil./2-way mile

* Unit cost used to estimate bus operating and capital costs. Capital costs estimated assuming a 12 year vehicle life.
** Assumes one station per guideway mile in corridors and five stations per guideway mile in CBD.

Note that operating costs reported in case studies are total transit operating costs at the site, both guideway and feeder. Likewise, capital costs include feeder bus costs as well. AGT and LRT vehicles assumed to have 15 year life; guideways assumed to have 40 year life.

Source: AGT Costs: Memoranda and personal communications from Transportation Systems Center, USDOT, 1978.
Other Costs: Kaiser Engineers, memoranda prepared for Barton-Aschman Associates in conjunction with AGT Socio-Economic Research Program: Generic Alternatives Analyses.

2. Reduction in parking costs--If fringe parking lots are provided at AGT stations on the CBD periphery, park 'n ride patrons will generally save on parking costs.

3. Reduction in bus operating cost--This benefit will be realized if CBD bus operations are reduced.

4. Reduction in bus related externalities, pollution and congestion.

5. Economic development in the CBD.

The principal costs are:

1. AGT capital and operating costs.
2. Parking lot construction costs.
3. Visual intrusion from the elevated guideway.
4. Construction disruptions.

The list of benefits and costs differs in some important respects from that in the corridor analysis. Included among the benefits is reduced parking costs. An AGT deployment in a CBD provides an excellent oppportunity to institute a viable fringe lot parking operation. By locating lots at fringe stations, unsubsidized parking rates can typically be charged that are substantially less than those in the CBD center. Fringe lot patrons can ride the AGT to their final destination. The incremental cost of carrying the additional ridership will be small. Without an AGT, the cost of providing distribution service with a shuttle bus would typically be at least as great as the parking revenues, and the shuttle service would often not be attractive enough to induce people to park at the fringe lot.

A reduction in auto ownership costs and auto related externalities is not included in the analysis. The analysis of the reduction in the time cost of CBD travel suggests that the change is not sufficient to induce even a moderate increase in overall regional transit ridership. Thus, it is unlikely that a deployment would affect regional auto ownership levels and usage rates. Moreover, it is conceivable that fringe parking lots with their associated reduction in parking costs and accessibility to the CBD center by AGT could even <u>increase</u> total regional auto trips.

Benefits of economic development, reduced bus externalities, costs of visual intrusion, and costs of construction disruption are not quantified. As is the case with the corridor analysis, quantification of the other benefits and costs is sufficiently inclusive to discuss the influence of the remaining unmeasured benefits and costs.[1]

3.7.2 BENEFITS CALCULATIONS

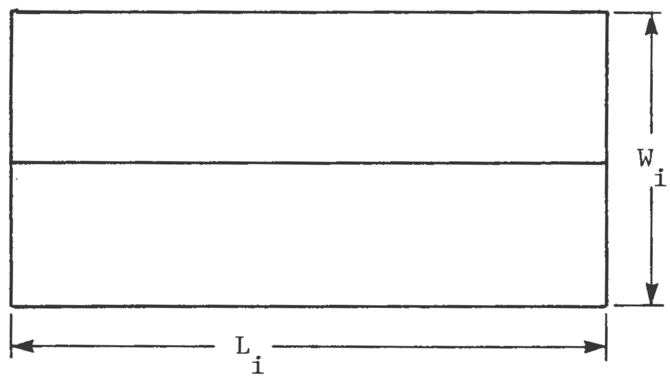
Time Cost Reductions

The deployment of an AGT and any accompanying changes in the CBD leg of bus routes continuing to enter the CBD will differentially affect the time costs of CBD travel for transit users. The change in time costs, however, is dependent upon each individual's destination and the proximity of transit service to that destination before and after deployment. To estimate the change in the time costs of CBD travel in each candidate city, the average time cost of travel in that city's CBD if an AGT were deployed is estimated. Next, the average cost of CBD travel in the city with its existing bus system is estimated. The difference in these two costs, ΔC, estimates the change in the average time cost of CBD travel resulting from deployment of an AGT. The annual benefits (or costs) from the change in the time costs of CBD travel is the product of this difference, ΔC, and CBD transit ridership.

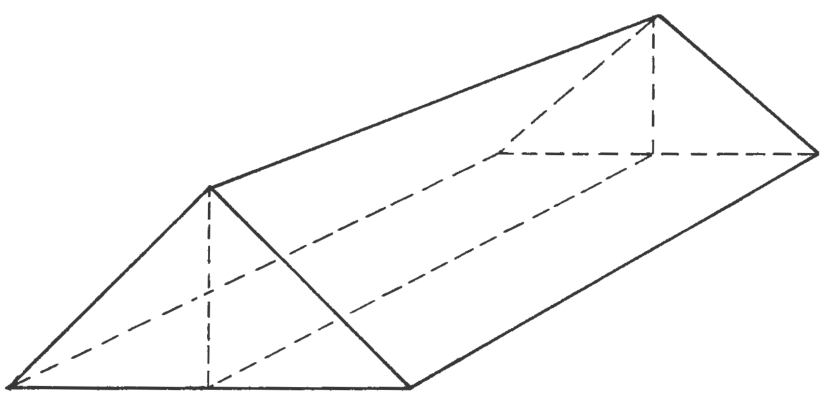
CBD transit ridership is assumed to include both persons using the AGT and those using only the residual buses continuing to enter the CBD. The latter group is included because deployment of an AGT typically will require a reconfiguration of bus routes; since the reconfiguration of bus routes is a consequence of the AGT deployment, its effect on all transit users should be taken account.

Ideally, the change in the time cost of CBD travel for the candidate cities would be estimated using sketch planning techniques like those used in the local case study cities. Such an effort is infeasible since more than forty candidate cities are examined. Instead, a far more abstract approach was used. The CBD of the candidate cities is assumed to be rectangular with dimensions L_i and W_i (Figure 3.2). The CBD dimensions for each candidate city are estimated from maps and published statistics on CBD areas. Further, a linear decline in the density of destinations from

[1]Appendix B provides a detailed description of the procedures used to quantify the benefit/cost calculations for the CBD analyses.



(a)



(b)

FIGURE 3.2

Prototypical CBD

the CBD spine (the L axis) to the CBD periphery is assumed.[1] For reasons discussed in the next chapter, this assumption of distribution of destinations probably results in optimistic estimates of time savings.

System Configuration

The assumed system configuration is a straight-line shuttle system running down the spine of the CBD, Figure 3.3. All remaining bus service runs on the axis perpendicular to the AGT alignment. The other possible general configuration is a loop system with buses routed down the CBD spine. For the loop system, buses provide service along the spine of the CBD, and the AGT to points more distant from the spine. Each system is, of course, an abstraction of systems that might actually be constructed.

This analysis considers only the shuttle or spine configuration. Analyses of loop systems suggest that such a configuration would produce comparable benefits. However, operating and capital costs for the loop system would be 3 to 4 times greater than those of the shuttle system because the guideway length for the loop is 3 to 4 times that for the shuttle. While variations that were not considered would certainly affect the relative desirability of these two systems, differences in benefits would have to be sufficiently large to justify the differences in cost.

Estimating the Change in Time Cost per Trip, ΔC

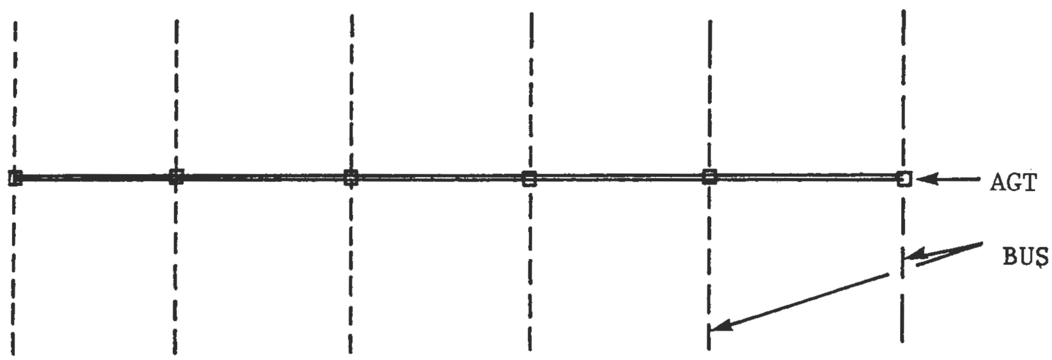
The change in time cost ΔC is measured by the difference in the time cost of CBD travel for the shuttle AGT/bus system shown in Figure 3.3a and the bus system shown in Figure 3.4. For the configuration of bus routes in Figure 3.4, routes entering from the east or west run on the CBD spine and routes entering from the north or south intersect the spine at its midpoint.

Whereas it would be more realistic to assume that buses not entering on the spine enter the CBD radially, the simplifying assumption of N/S routes is

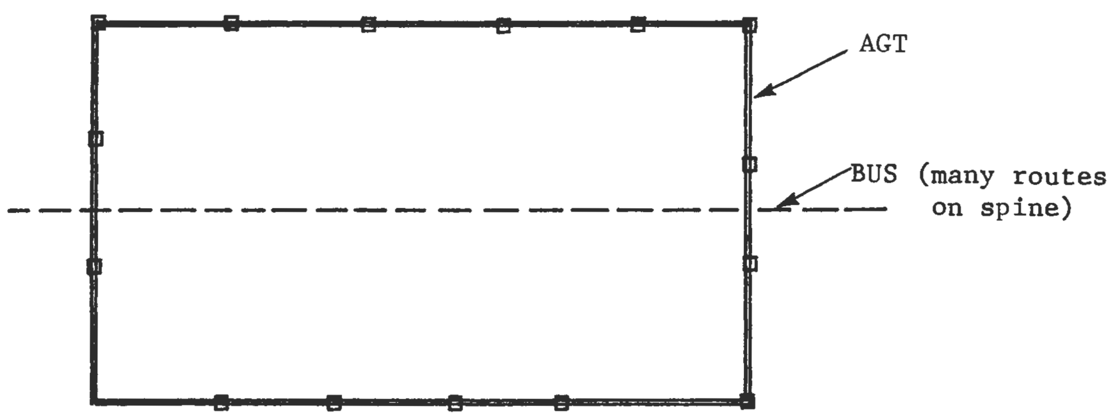
[1]An alternative assumption on the density of CBD destinations is a pyramid distribution with the apex of the pyramid at the CBD center. For certain CBDs in the list of candidate cities this may be a closer approximation to reality. For reasons discussed in the next chapter, analyses under this alternative were not done.

FIGURE 3.3

Bus/AGT Alignments



a. Spine CBD AGT



b. Loop AGT or DPM

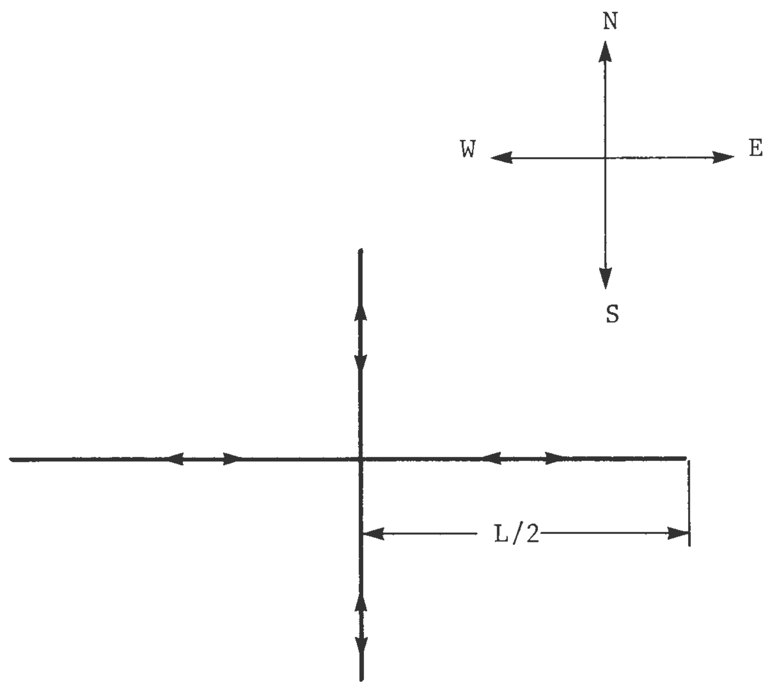


FIGURE 3.4

Typical Bus Configuration

probably not an unreasonable "first order" approximation. The error in this assumption is further mitigated by introducing a variable P, the proportion of routes entering on the CBD spine. Since most buses will be routed to run along the densest parts of a CBD to maximize service quality, P will typically be large. In the analysis we assume P is assumed equal to .75.

Passengers on an AGT/bus system belong to one of four groups:

1. Regional bus riders who transfer to the AGT (distribution);

2. Regional bus riders entering the CBD who do <u>not</u> transfer to the AGT (distribution);

3. Park 'n ride passengers; persons driving to the CBD, parking at lots located at fringe AGT stations and transferring to the system (distribution);

4. Intra-CBD trips (circulation).

In computing the time cost of CBD travel for the AGT/bus system, time cost for park 'n ride patrons is not considered. Typically, park 'n ride patrons will not be attracted to using the system because of a savings in the time cost of CBD travel. Indeed, it is probably true that their time cost savings are negligible or non-positive. Rather, their motivation for using the system is the savings in parking costs, and this benefit is estimated separately from time costs. Additionally, the sketch planning analyses of AGT systems in Chicago and Dallas and an AGT ridership analysis done by Zupan[1] both reveal that the largest proportion of an AGT's ridership are persons using the system for distribution purposes. Thus, to simplify the analysis, time costs for CBD travel on the AGT/bus system are estimated using the time cost for distribution passengers. However, circulation ridership is counted among the transit ridership benefitting from the change in time costs.

The estimate of time costs is the weighted average of time costs for the first two groups. The relative weighting is determined by the rate at which regional

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[1]Zupan, Jeffrey, <u>Aggregate DPM Demand Estimation</u>, Regional Planning Association, New York, NY, 1978.

bus passengers transfer to the AGT. The second group, the non-transfers, are included in the estimate because the necessary re-routing of CBD-bound buses affects all transit users regardless of whether they transfer to the AGT.

Ridership on the existing bus system is composed of passengers (1) completing a trip originating outside the CBD (Distribution) and (2) making intra-CBD trips (Circulation). Since circulation bus ridership is nearly always small in comparison to distribution ridership, time costs are estimated for the average distribution trip; the error involved in this approximation is small.

The estimates of the change in the time cost of travel vary with CBD area. Not surprisingly, the larger the CBD the greater the savings in time costs. Nonetheless, even for the largest CBD's in the sample (e.g., Los Angeles), the savings are moderate--about 8 to 10 cents per ride.[1]

Estimating System Ridership

Annual time savings benefits are equal to the product of ΔC and annual system ridership; because time savings for park 'n ride patrons is assumed negligible, the estimate of ridership used in computing benefits includes regional bus riders entering the CBD and circulation patrons. Regional ridership to the CBD is estimated using the same approach described in the previous section for estimating CBD bus ridership. Circulation ridership is assumed to be 5 percent of CBD bound regional transit ridership, based on case study results.

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[1]The estimates are derived from the following assumptions:
1) an average CBD bus speed of 6 mph
2) an average AGT speed of 8 mph
3) an average walk speed of 2.5 mph
4) AGT headways of 2 minutes in the peak and 4 minutes in the off-peak
5) time cost for walking is 10¢/min.
6) time cost for transit-in-vehicle time is 4¢/ min.
7) time cost for waiting (transfers) is 6¢/min.

The AGT speed (item 2) is conservatively low; it was chosen for consistency with aggregate analyses in the DPM Planning Manual.

Parking Cost Benefits

The Zupan analysis cited previously examines the decline in CBD parking rates as a function of the percent of maximum CBD density. This analysis suggests that parking rates at peripheral CBD lots would be about 50 percent of the average daily CBD parking rate. Using models developed by Cambridge Systematics, the analysis suggests that this saving in parking costs coupled with the distribution capabilities of the AGT could attract a large park 'n ride patronage.[1] The Zupan analysis is consistent with this finding. Indeed for many of the larger CBDs, the demand would far exceed any conceivable estimate of parking supply at stations on the CBD periphery. In this analysis, two fringe parking lots constructed at the termini station are assumed, each with a 2000 vehicle capacity. For each candidate city, if the predicted demand exceeds the supply constraint, then the supply constraint is used to define park 'n ride ridership.

Annual benefits to park 'n ride patrons are estimated assuming an average savings of one-half the average daily parking rate. Average daily parking rates are estimated by a relationship in the Zupan analysis relating this rate to CBD floor space.

Reduction in Bus Operating and Capital Costs

One of the most substantial potential benefits of an AGT deployment within a CBD is a reduction in bus operating and capital costs. In principle, an AGT deployment permits a substantial reduction in CBD bus operation. While the CBD leg of most bus routes is a small proportion of the total route length, the time spent in the CBD is a larger proportion of total route running time. As a consequence, if the CBD leg of a substantial portion of the CBD bound routes can be terminated at a fringe station, large reductions in bus operating costs can be achieved. The operating cost savings are further increased from the VMT reduction because operating costs per vehicle mile are higher in the CBD than outside the CBD since average

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[1]The Cambridge Systematics models are the DPM Planning Manual models, also used in the Dallas and Chicago case studies.

speeds are less in the CBD.[1] Additionally a reduction in system VMT would permit a reduction in fleet size.

Bus cost savings, as discussed in the corridor methodology, however, may not be fully achievable. Section 13c effectively prohibits a reduction in a transit authority's labor force under many situations, and it may be difficult to find alternative job assignments for operators freed by the reduction in system VMT. Labor is likely to require an expansion in non-CBD service sufficient to absorb these employees. Unless this expansion in non-CBD service would have been undertaken in the absence of the AGT deployment, no real savings will be achieved. Because the bus cut savings are uncertain, all analyses are done both with and without bus cut savings.

Estimates of bus cut savings are made assuming that 50 percent of all CBD bound bus routes could be terminated at fringe stations. To estimate the number of buses affected, CBD bound bus ridership is used to estimate the number of buses entering the CBD.

3.7.3 COST CALCULATIONS

AGT Capital and Operating Costs

Capital and annual operating and maintenance costs are estimated with the AGT costs shown in Table 3.4. Guideway and stations are estimated with unit costs for elevated construction; these estimates, though, may be optimistic because construction costs in a CBD are typically greater than elsewhere. Where predicted ridership is greater than system capacity for the assumed headways and vehicle capacities, vehicle capital and operating costs are estimated under the assumption that capacity will be increased to accommodate the predicted ridership.

Parking Lot Capital Costs

Capital costs for the fringe parking lots are comprised of two components--land costs and construction costs. Land costs are estimated with a relationship developed by Zupan which relates CBD land costs to

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[1]Bus operating costs in the CBD are calculated as $3.30 per vehicle mile, reflecting a 6 mph speed versus a 12 mph speed outside the CBD, and an average system cost of $24.00 per bus hour.

gross leasable floor space in the CBD. Construction costs are assumed proportional to the number of spaces constructed; a unit cost of $1500 dollars per space is assumed. This is low for a CBD, and reflects the possibility that existing spaces at stadiums, convention centers, etc., that are often located at the fringe of a CBD may be used. Parking capacity is assumed to be sufficient to meet predicted demand except where demand exceeds the 2000 space per lot constraint.

System Revenues

An AGT generates additional revenues directly from fare box receipts and indirectly from the parking revenues. Annual fare revenues are estimated for a ten cent fare; free transfers from the regional buses are assumed. Parking revenues are assumed to be one-half the estimated average daily parking rate in the CBD, which is the rate estimated for the fringe lots.

3.8 NON-BENEFITS

A wide variety of benefits may be claimed for both CBD and corridor systems which are not true benefits in the framework of an economic analysis, and accordingly are omitted from this analysis.[1] These effects may occur due to AGT construction, but they are not proper economic benefits.[2]

All economic benefits are net benefits, or the difference in value (after deducting the costs of the project) between the "after" situation and the "before" situation. Benefits therefore arise from better use of resources, or producing more outputs from the same inputs, than was previously the case. Government actions can produce benefits when there are social or external benefits that a private market does not account for, or when there are failures in the private market, by creating the proper incentives (or directly undertaking actions) to improve the use of resources.

Benefits should be carefully distinguished from transfer payments. A transfer payment is simply a

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[1]See, for example, Economic Benefit Assessment Report, Los Angeles Downtown People Mover Program, prepared by Community Redevelopment Agency, City of Los Angeles, November, 1978.

[2]The issues discussed should not be considered benefits for competing transportation systems either.

transaction from one party to another with no attendant net benefit. The gain of the party receiving the payment is exactly offset by the loss to the party making the payment. Some of the "benefits" typically claimed for transportation systems are actually transfer payments.

For example, construction jobs created are a cost of the project, not a benefit. This is a pure transfer payment, with every dollar of wages paid out being offset by a dollar of taxes paid in by some taxpayer. To a region obtaining a Federal project, these jobs have a real impact on the local economy; however, from a national perspective, these effects are distributional only.

Taxes are another example of a transfer payment. While a municipality receiving the added taxes sees a gain, it is exactly offset by the loss seen by those who pay the taxes.

Induced development is another example where the impact of transportation is primarily distributional, and has little impact on total development. In the CBD economic assessments, much is made of AGT increasing the CBD's "capture rate" of regional office space. This is an explicit recognition that only distributional issues are involved--the gain in the CBD is offset by a loss in suburban areas.

While there may be true economic development impacts due to AGT, they are difficult to assess and much smaller than the gross "benefits" typically reported.

CHAPTER 4
NATIONAL MARKET RESULTS

4.1 INTRODUCTION

The results of the national market analysis are presented in this chapter. Using the methodology described in Chapter 3 and Appendices A and B, benefit-cost and financial ratios were calculated for corridors and central business districts (CBDs) in selected cities. These results, then, are used in conjunction with the case study findings summarized in Chapter 2 and reported in detail in Volume II to estimate the national market for AGT in corridors and CBDs. Estimates of the national market for AGT in major diversified activity centers, medical centers, and airports are based on the case study results. The findings for each market segment are presented in the following five sections. The final section gives the national market projections for all segments. Also, implications of the market projections for AGT suppliers are examined in the final section.

4.2 CORRIDORS

4.2.1 CANDIDATE CITIES

Table 4.1 lists all cities initially considered for corridor deployments of AGT. Detailed analysis, however, was done on only a subset of the cities initially considered. This subset consists of three groups of cities: all cities estimated to have annual CBD-bound transit ridership greater than 20 million, all cities known to be actively considering a fixed guideway system, and ten of the twelve "representative" cities in the AGT *Generic Alternatives Analyses* report. Atlanta and Chicago are the two remaining "representative" cities. They are not included because both already have extensive rail systems. Table 4.1 lists all cities initially considered and their estimated CBD-bound transit ridership. Cities selected for detailed analysis are indicated with a single asterisk.

The 12 *Generic Alternatives Analyses* representative cities span a wide range of city sizes, with several cities having relatively small transit riderships (e.g., Rochester, Providence, and Denver). The results for these cities indicate that AGT is not likely to be cost-effective in these sites. Since

Table 4.1
Annual CBD Bound Transit Ridership in Candidate Cities

City	Annual CBD Ridership (millions)
Akron	2.8
Albany	11.0
**Baltimore	36.0
Birmingham	3.7
* Buffalo	20.9
* Cincinnati	19.1
Columbus	11.6
* Dallas	29.6
Dayton	7.4
* Denver	12.0
* Detroit	42.9
Hartford	11.7
* Honolulu	9.4
* Houston	19.2
Indianapolis	12.5
Kansas City	12.0
* Los Angeles	40.7
Memphis	8.1
* Miami	17.0
* Milwaukee	29.0
* Minneapolis	20.5
Norfolk	4.6
Oklahoma City	2.7
Phoenix	1.5
* Pittsburgh	46.5
* Portland	17.7
* Providence	14.6
* Rochester	12.9
Sacramento	2.8
* St. Louis	29.3
San Antonio	11.0
* San Diego	4.8
* Seattle	26.4
Syracuse	9.1
Tampa	2.8
Toledo	5.4

*Selected for detailed analysis
**Data necessary for analysis was not available.

these cities have an annual CBD-bound transit ridership of less than 20 million, the general criterion of limiting analysis to cities with annual CBD-bound ridership of more than 20 million should not affect the market estimate.

For each of the cities selected for further analysis, major CBD-oriented corridors were identified. The Generic Alternatives Analyses report identified all major corridors in the representative cities. For the remaining cities, corridors were identified from local transit plans and maps. CBD-bound trips were then estimated for all corridors. In each city the corridor with the maximum number of trip ends was analyzed. In several of the larger cities, other corridors were included in the analysis because estimated trip ends originating from these corridors were sufficient to warrant further analysis.

The geographic limits of the corridors are not specifically identified; the analysis is sufficiently general and aggregate that no useful purpose is served by identification. Instead the corridors with maximum trip ends are referred to as principal corridors. Non-principal corridors included in the analysis are referred to as major secondary corridors.

4.2.2 VERIFICATION OF RIDERSHIP ESTIMATING METHODOLOGY

In designing the methodology for estimating system ridership, every effort was made to incorporate the key considerations that would guide a more detailed analysis. The necessity for developing a manageable approach, though, inevitably introduces errors of unknown magnitude. In an attempt to verify the study methodology, estimates of ridership in principal corridors were compared with counterparts calculated with a methodology developed by Zupan.[1] Both estimates reflect initial system ridership. The results are shown in Table 4.2. With several exceptions the alternative estimates of LRT ridership per system mile (the modal type most common to both methodologies) are quite comparable.

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[1]Zupan, Jeffrey, Aggregate DPM Demand Estimation, Regional Planning Association, New York, NY, 1978.

Table 4.2
LRT Ridership Per System Mile: A Comparison of Methodologies[1]

City	Annual Ridership per System Mile in Principal Corridor: Zupan Methodology	Study Methodology
Los Angeles	1.1	1.1
Honolulu	2.1	1.6
Houston	1.1	.5
Detroit	1.0	1.2
Dallas	1.0	1.1
Seattle	1.7	.8
Pittsburgh	.9	1.0
St. Louis	1.4	.6
Milwaukee	1.2	1.3
Minneapolis	.5	.5
Buffalo	.7	1.6
Denver	.5	.5
San Diego	.5	.3
Providence	.8	.5
Cincinnati	.5	.4
Portland	.5	.7

[1]The correspondence is not good for Houston, Seattle, St. Louis, and Buffalo. The Zupan estimate for Houston appears to be unduly optimistic in view of current ridership levels. In contrast, the Zupan estimate for Buffalo is probably understated. An alternatives analysis done for this corridor predicts a ridership per system mile even greater than the estimate from the current study.

4.2.3 QUANTIFIED BENEFITS AND COSTS

Table 4.3 lists summary statistics for each corridor analyzed. Included are estimates of a global benefit/cost (B/C) ratio, a local benefit/cost ratio, and a financial ratio. These ratios are computed as follows:

$$\text{Global B/C} = \frac{B_1 + B_2 + B_3 + B_4}{(C_1 + C_2 + C_3)}$$

$$\text{Local B/C} = \frac{B_1 + B_2 + .5B_3 + .2B_4}{.2C_1 + .2C_2 + .5(C_3 - F)}$$

$$\text{Financial Ratio} = \frac{F + .5B_3 + .2B_4}{.2C_1 + .2C_2 + .5(C_3 - F)}$$

Where:

B_1 = Long Term Reduction in Inclusive Price of Travel to Transit Users (Current and New)
B_2 = Long Term Auto Ownership Benefits
B_3 = Long Term Bus Operating Costs Savings
B_4 = Long Term Bus Capital Costs Savings
C_1 = Guideway and Station Capital Costs
C_2 = Vehicle Capital Costs
C_3 = Long Term Operating Costs
F = Long Term Increase in Fare Revenues[1]

All benefits, vehicle capital costs, and long-term operating costs are in net present value. Guideway and station costs are assumed to be incurred in the present time period.

The global B/C is simply the ratio of all benefits to all costs. While fare revenues may be pivotal in financing the system, they are not included in the B/C ratios because fare revenues are neither an economic cost nor benefit. The local B/C ratio is included as a measure of benefits and costs accruing directly to the local area. While this ratio may be more pertinent to local decisionmakers than the global ratio, the global ratio is more relevant to informing federal policy. In the local B/C ratio, all computed costs are factored by approximate current federal subsidy rates: 80 percent of capital costs and about 50 percent of operating deficits.

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[1] Computed at current fares

Table 4.3
Summary Benefit and Financial Statistics for Corridors Analyzed

City	Type[1]	ROW[2]	AGT				LRT				Busway			
			Ridership[3]	Global B/C	Local B/C	Financial Ratio	Ridership[3]	Global B/C	Local B/C	Financial Ratio	Ridership[3]	Global B/C	Local B/C	Financial Ratio
Los Angeles	1	E	13.9	1.01	2.41	.54	12.9	.52	1.30	.31	12.9	.65	1.45	.34
	2	E	13.3	.99	2.38	.53	5.7	.51	1.28	.31	5.7	.64	1.44	.34
Pittsburgh	1	A	8.4	1.16	2.98	.58	8.1	.36	1.17	.25	-	-	-	-
	2	E	8.1	1.11	2.90	.55	7.7	.57	1.57	.32	7.7	.77	1.86	.38
	2	R	6.9	1.26	3.08	.57	6.6	.76	1.86	.37	6.6	1.08	2.20	.44
Dallas	1	E	7.4	1.30	3.39	.57	6.8	.63	1.83	.34	6.8	.92	2.26	.42
	2	R	5.6	1.39	3.48	.61	5.1	.79	2.11	.39	5.1	1.29	2.71	.50
Detroit	1	E	15.3	1.09	2.66	.51	14.5	.56	1.38	.38	14.5	.69	1.53	.31
	2	A	13.5	1.03	2.56	.49	12.8	.34	1.03	.21	-	-	-	-
	2	A	9.3	.83	2.22	.43	8.8	.26	.86	.18	-	-	-	-
	2	R	8.4	.96	2.39	.45	7.9	.60	1.43	.29	7.9	.78	1.60	.33
Seattle	1	R	10.1	1.01	2.61	.37	9.5	.61	1.44	.22	9.5	.77	1.61	.25
	2	R	6.4	.78	2.16	.31	6.0	.51	1.30	.20	6.0	.67	1.60	.23
Buffalo	1	A	19.7	1.21	2.80	.55	18.6	.41	1.14	.24	-	-	-	-
	2	R	10.3	1.03	2.47	.48	9.7	.61	1.39	.30	9.7	.78	1.55	.33
	2	E	9.6	.81	2.17	.43	9.0	.41	1.13	.24	9.0	.54	1.31	.28
	2	R	7.7	.88	2.23	.44	7.2	.54	1.31	.28	7.2	.72	1.49	.32
Miami	1	R	6.3	1.28	3.10	.61	5.9	.73	1.85	.40	5.9	1.14	2.29	.50
Honolulu	1	E	24.9	.87	2.12	.39	22.7	.42	.99	.20	22.7	.51	1.07	.22
Milwaukee	1	A	13.9	1.14	2.64	.61	13.1	.37	1.08	.27	-	-	-	-
	2	E	8.1	1.02	2.42	.54	7.6	.62	1.43	.35	7.6	.82	1.63	.40
	2	A	7.1	.75	2.03	.47	6.7	.22	.77	.19	-	-	-	-
Rochester	1	R	3.4	.65	1.75	.43	3.1	.40	1.12	.29	3.1	.60	1.34	.35
Providence	1	R	5.7	.79	2.12	.38	5.3	.50	1.30	.25	5.2	.68	1.52	.29
Portland	1	E	3.9	.79	2.37	.42	3.6	.39	1.29	.24	3.6	.59	1.67	.31
Houston	1	E	5.8	.50	1.47	.34	5.2	.26	.81	.20	5.2	.35	.97	.23
St. Louis	1	R	7.0	.79	2.14	.32	6.6	.50	1.27	.21	6.6	.66	1.46	.24
Denver	1	E	4.7	.65	1.94	.36	4.3	.33	1.06	.21	4.3	.47	1.34	.27
San Diego	1	E	4.1	.32	.98	.30	3.7	.16	.54	.18	3.7	.22	.64	.22
Minneapolis	1	E	5.8	.66	1.99	.32	5.4	.34	1.05	.19	5.4	.46	1.28	.23
Cincinnati	1	E	4.9	.47	1.50	.22	4.6	.25	.82	.13	4.6	.33	.99	.16

[1] Type: 1 = Principal Corridor
2 = Major Secondary Corridor

[2] ROW: R = Rail
E = Expressway
A = Arterial

[3] Annual Ridership in millions.

The final statistic is included to measure the effect of deployment on municipal finances. If this ratio is greater than one, then over the 30-year time horizon, fare revenues and local savings on bus operating costs will exceed the local share of capital and operating costs. No user benefits are included in this ratio because they do not directly effect municipal finances.

Inspection of Table 4.3 reveals that these ratios vary widely across cities and among corridors within cities. The ratios are consistently largest for AGT and smallest for LRT. Also, the local B/C ratios are substantially larger than the global B/C ratios. This difference is attributable to the 80 percent capital subsidy and 50 percent operating deficit subsidy. Notably, the financial ratios never exceed .75.

Table 4.4 shows the distribution of global B/C ratios for each system. The frequency of B/C ratios greater than .74 is largest for AGT; 25 corridors or 80 percent of the sample meet this criterion. The .49 level is exceeded for 93 percent of the sample. For busway, the .74 and .49 levels are exceeded respectively in 36 and 80 percent of the sample. LRT exceeds the .74 level in only one corridor and the .49 level in 16 corridors for 6 and 51 percent of the sample, respectively.

The variations in the distribution of global B/C ratios among modes is in part attributable to AGT having larger estimated riderships and lower operating costs but is principally attributable to AGT's lower capital costs. At-grade construction guideway costs are about equal for all systems; but for elevated construction, AGT's costs are about a third less than an elevated LRT and busway. Additionally, the general necessity for subway construction in the CBD for the LRT alternative greatly increases its capital costs relative to the other alternatives. The lowest global B/C ratios for LRT are generally for arterial corridors where subway construction is assumed for the entire system length.

Table 4.5 lists all corridors where AGT's global B/C ratio exceeds .74 and compares the AGT global B/C ratio with the global B/C of LRT or Busway, whichever is larger. A Review of Local Alternatives Analyses

Table 4.4
Distribution of Global Benefit/Cost Ratios for 30 Year Forecast Horizon

Mode	Global B/C[1] Greater than or equal to 1	.99 - .75	.74 - .50	.49 - .25	Less than or equal to .24	Total[2]
AGT	.45 (14)	.35 (11)	.13 (4)	.06 (2)	.00 (0)	1.00 (31)
LRT	.00 (0)	.06 (2)	.45 (14)	.42 (13)	.06 (2)	1.00 (31)
Busway	.12 (3)	.24 (6)	.44 (11)	.16 (4)	.04 (1)	1.00 (25)

[1]Number in parentheses is number of corridors in cell.

[2]Due to rounding, percentages may not sum to one. Exact figures can be obtained from the actual number of corridors given in parentheses.

Table 4.5
Comparison of AGT Global B/C with Next Best Alternative

City (type)	AGT Global B/C	Best Alternative Global B/C	Best Alternative Technology
Rail ROW			
Pittsburgh (2)	1.26	1.08	Busway
Dallas (2)	1.39	1.29	Busway
Detroit (2)	.96	.78	Busway
Seattle (1)	1.01	.77	Busway
Seattle (2)	.78	.67	Busway
Buffalo (2)	1.03	.78	Busway
Buffalo (2)	.88	.72	Busway
Miami (1)	1.28	1.14	Busway
Providence (1)	2.12	.68	Busway
St. Louis (1)	.79	.66	Busway
Expressway ROW			
Los Angeles (1)	1.01	.65	Busway
Los Angeles (2)	.99	.64	Busway
Pittsburgh (2)	1.11	.77	Busway
Dallas (1)	1.30	.92	Busway
Detroit (1)	1.09	.69	Busway
Buffalo (2)	.87	.54	Busway
Honolulu (2)	.87	.51	Busway
Milwaukee (2)	1.02	.82	Busway
Portland (1)	.79	.59	Busway
Arterial ROW			
Pittsburgh (1)	1.16	.36	LRT
Detroit (2)	1.03	.34	LRT
Detroit (2)	.83	.26	LRT
Buffalo (1)	1.21	.41	LRT
Milwaukee (1)	1.14	.37	LRT
Milwaukee (2)	.75	.22	LRT

Type:
1 - Principal
2 - Major Secondary

involving AGT[1] concludes that two of the major impediments to acceptance of AGT is concern about the reliability of a largely untested technology and uncertainty about actual operating and capital costs. This concern suggests that AGT will have to be appreciably more attractive than alternative proven technologies if it is to be adopted. In rail ROW's AGT's comparative advantage is modest; the AGT global B/C ratios generally are about 20 percent larger than their counterparts for a busway. The difference is more substantial in expressway ROW, where the AGT ratios are generally about 40 percent larger than those for busways.

In arterial ROW the only alternative to AGT considered is LRT. AGT's global B/C ratios are consistently a factor of three larger than their counterparts for LRT. The difference is principally attributable to assumptions on construction type for the two systems in an arterial ROW. Subway construction is assumed for LRT and elevated for AGT. Unit costs for AGT elevated construction are about one-fourth those for LRT subway construction.

In summary the results in Table 4.5 suggest that AGT is distinctly more cost-effective than alternative technologies in expressway and arterial ROW and moderately more cost-effective in rail ROW. However, the number of corridors where AGT might be considered cost-effective relative to the existing bus system is relatively small. Twenty-five corridors have global B/C ratios exceeding .74, and, in four of these corridors, plans for deploying rail technologies are currently in advanced stages. For a .50 cut-off level, the potential market increases modestly; twenty-nine corridors exceed this cut-off.

4.2.4 UNQUANTIFIED BENEFITS AND COSTS

Using a measured B/C ratio of .75 as a lower limit for project implementation assumes that unquantified benefits are unlikely to be more than half of quantified measures to bring the total B/C ratio over 1.0. Assessing the effect of the non-quantified benefits and costs, however, is difficult. The

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[1]Urbitran, Review of Local Alternatives Involving AGT, prepared for AGT Socio-Economic Research Program, Report No. UMTA-NY-06-0057-78-1, 1978.

obstacles to their quantification permit great differences in interpretation of their potential magnitude and importance, especially to local decision makers who ultimately will determine the market for AGT. It is also probably correct that assessments of the magnitudes of these benefits and costs will in part be determined by the emphasis specific locales place on accruing the unquantified benefits and avoiding the unquantified costs. The remainder of this section discusses the principal unquantified benefits and costs and factors that may influence their saliency to different locales.

i) Economic and Community Development

In recent deployments of fixed guideway systems, considerable emphasis has been given to encouraging joint development in and around guideway stations. Such development can include shopping malls, office space and residential housing. In some instances the transit authority or municipality will be direct participants in the development with the proceeds from the projects augmenting the authority's or municipality's general revenues. Alternatively, privately-held developments will indirectly increase municipal revenues through taxes.

The achievability and desirability of economic and community development will vary across communities. The emphasis a community places on the attraction of new retail and commercial business or the expansion of existing concerns is a key local policy issue. It is unlikely that many communities would actively discourage economic development (except possibly for heavy industry), but differences in concern for some of the negative externalities of economic development will importantly affect the pursual of economic development opportunities. Also, community development is valued by nearly all communities, but its saliency varies among communities. Guideway stations can provide a focal point for development of high density housing. Such housing will generally be most attractive to moderate income households and persons who are transit dependents. The attractiveness of such housing developments, though, will necessarily be influenced by the adequacy and quality of the housing stock for moderate income households and the estimated size of the transit dependent population.

The desirability of economic and community development should be distinguished from its achievability. Ironically, some of the communities most desiring development may be the communities least likely to achieve it. Many, but certainly not all, communities most desirous of economic and community development are those with a declining economic base and deteriorating housing stock. Both of these trends reflect larger social and economic problems that a fixed guideway system may help to mitigate but will certainly not resolve.

Though differences in the potential of each modal alternative to stimulate economic and community development exist, it is clear that AGT and LRT are superior to busways. AGT and LRT are appreciably less noisy than buses and additionally are not direct sources of exhaust emissions. Both the noise and pollution immediately surrounding a busway would considerably detract from the attractiveness of locations in and around the stations for development. Also busway's noise and pollution problems must also be counted as costs to residents and businesses situated near the guideway.

The differences in the economic and community development potentials of AGT and LRT are probably modest. AGT may have some advantages because it is less noisy than LRT, has a potentially larger ridership, and a modernistic image for joint development.

ii) Reduction in Auto Pollution and Congestion

Among the principal externalities of auto use are pollution and congestion. The promise of fixed guideway transit to reduce reliance on automobiles must be counted among its most important benefits. Moreover, the increasing dependence on expensive and sometimes unreliable foreign sources of oil has further enhanced the desirability of reducing auto usage.

Table 4.6 shows estimates of the reduction in annual auto vehicle miles travelled (VMT) attributable to each mode. Also shown are annual estimates of the gallons of gasoline saved and the net increase in transit VMT.[1] While deployment of a fixed

[1]The net increase in transit VMT is system VMT minus the reduction in bus VMT from their realignment to provide feeder service.

Table 4.6

Annual Auto VMT and Gas Reductions and Net Change in Annual Transit VMT by Corridor[1]

City	AGT			LRT			Busway		
	Auto VMT (mil)	Gas[2] (mil gal.)	Transit VMT (mil)	Auto VMT (mil)	Gas[2] (mil gal.)	Transit VMT (mil)	Auto VMT (mil)	Gas[2] (mil gal.)	Transit VMT (mil)
Los Angeles	-128.9	-8.6	8.8	-113.9	-7.6	3.7	-113.9	-7.6	8.1
	-123.4	-8.2	8.4	-109.9	-7.3	3.6	-109.9	-7.3	7.7
Pittsburgh	- 30.9	-2.1	2.8	-27.9	-1.9	.8	- 27.9	-1.9	-
	- 28.2	-1.9	2.7	-24.2	-1.6	.7	- 24.2	-1.6	2.5
	- 21.8	-1.5	2.2	-18.8	-1.3	.6	-18.8	-1.3	2.0
Dallas	-21.9	-1.5	1.6	-17.4	-1.2	.2	-17.4	-1.2	1.4
	-14.9	-1.0	1.1	-11.3	-.8	.1	-11.3	-.8	.9
Detroit	-109.1	-7.3	9.2	-97.7	-6.5	3.7	-97.7	-6.5	8.6
	-101.6	-6.8	8.2	-91.1	-6.1	3.3	-91.1	-6.1	-
	-70.5	-4.7	5.6	-63.0	-4.2	2.3	-63.0	-4.2	-
	-57.0	-3.8	5.0	-49.5	-3.3	2.0	-49.5	-3.3	4.6
Seattle	-45.3	-3.0	5.6	-36.3	-2.4	2.0	-36.3	-2.4	5.1
	-28.7	-1.9	3.6	-22.7	-1.5	1.2	-22.7	-1.5	3.2
Buffalo	-123.2	-8.2	10.5	-108.1	-7.2	4.0	-108.1	-7.2	-
	-57.3	-3.8	5.4	-49.0	-3.3	1.9	-49.0	-3.3	5.0
	-57.4	-3.8	5.1	-49.1	-3.3	1.9	-49.1	-3.3	4.6
	-42.6	-2.8	4.0	-35.7	-2.4	1.5	-35.7	-2.4	3.7
Miami	-23.4	-1.6	1.5	-20.4	-1.4	.4	-20.4	-1.4	1.3
Honolulu	-214.8	-14.3	18.0	-176.3	-11.8	7.2	-176.3	-11.8	16.1
Milwaukee	-74.9	-5.0	6.5	-64.9	-4.3	2.3	-64.9	-4.3	-
	-37.8	-2.5	3.7	-31.6	-2.1	1.2	-31.6	-2.1	3.3
	-38.6	-2.6	3.3	-33.6	-2.2	1.2	-33.6	-2.2	-
Providence	-24.1	-1.6	2.5	-19.1	-1.3	.8	-19.1	-1.3	2.3
Portland	- 9.8	- .7	.8	- 7.5	- .5	.1	- 7.5	- .5	.8
St. Louis	-46.6	-3.1	4.2	-40.6	-2.7	1.6	-40.6	-2.7	3.6

[1]List only includes cities where AGT global B/C exceeds .74.

[2] Assumes 15 mi./gal.

guideway system in a single corridor may result in only a small percentage change in areawide VMT, the absolute reductions are large and would result in large absolute reductions in emissions and gasoline consumption. Since the net increases in transit VMT are small relative to the reductions in auto VMT, the total reductions in combined VMT are large. The savings in total VMT are the largest for AGT because system ridership is largest for this alternative.

iii) Visual Intrusion

In both rail and expressway ROW, all systems suffer about equally from problems of visual intrusion by guideways. Visual intrusion may be greatest in expressway ROW because a greater proportion of the system is likely to be elevated than in a rail ROW; however, the fact that rail ROW's sometimes traverse residential areas may make intrusion an issue there as well. In both these settings, AGT may have a moderate advantage over the alternative systems because its guideways are less massive. Nonetheless, when elevated construction is being considered, the principal issue will be whether elevated structures are acceptable, whatever the technology.

In arterial ROW's where it is assumed AGT would be elevated and LRT would be underground; there are substantial trade-offs between modal alternatives. The principal reason for the difference in AGT's and LRT's global B/C ratios is attributable to the relative construction costs of elevated and subway construction. Despite the cost difference some locales (e.g. Berkeley and Buffalo) have opted for underground construction to avoid the costs of visual intrusion. From the local perspective the financial burden of subway construction is eased by the 80 percent federal subsidy for capital costs. Thus, the apparent dominance of AGT over LRT in an arterial ROW may be overstated by the global B/C measures, due to the implicit high cost of visual intrusion as shown by the Berkeley and Buffalo decisions.

iv) Construction Disruptions

Generalizations about the magnitude of construction disruption across cities or among corridors within cities are difficult, but some are possible. The magnitude of the disruption will necessarily increase with the length of the construction period. At-grade construction can generally be built quickest and underground construction least quickly. This suggests that in an arterial setting where the alternatives are an elevated AGT or an underground rail system, AGT would be the dominant alternative with respect to construction disruption.

The construction disruptions attributable to construction of any fixed guideway system on an expressway ROW will be greatly reduced if the roadway itself is undergoing a major renovation. Since the age of many urban expressways will necessitate major renovation in the next decade, the opportunities for joint renovation/deployment projects could be numerous. Such an approach also is likely to reduce construction costs.

4.2.5 ALTERNATE SCENARIOS

The prospect for a doubling in the real price of gasoline within the next few years is real. While Federal policy toward gasoline pricing is not directly controlled by UMTA, a doubling of gas price whether by a direct policy intervention or simply because of market forces would greatly increase transit ridership. Since high transit usage rates are necessary to justify the capital cost of a fixed guideway system, the implications of a doubling in real gas prices from $0.75 to $1.50 per gallon for the AGT market was examined. The results are summarized in Table 4.7, showing an increasing attractiveness of deployment for all technologies. For AGT, the .75 and .50 thresholds are met by 90 percent and 96 percent of the sample. For LRT, the respective percentages are 13 percent and 55 percent; and for busway, 48 percent and 88 percent. The previously noted pattern on AGT's relative advantage by ROW is unchanged.[1]

4.2.6 POTENTIAL CAPITAL EXPENDITURES

Table 4.8 shows estimates of total capital expenditure for AGT for varying assumptions on deployment rates in corridors with B/C ratios exceeding a specified level. Panel (a) shows expenditures for the 30-year evaluation horizon without gas price increases. The maximum estimated

[1]It is estimated that doubling gasoline prices combined with an associated level of service improvement of a fixed guideway system necessary to carry the additional demand would also more than double the auto VMT reduction shown in Table 4-6. The reduction attributable only to the system itself, however, is nearly equal to the estimates in Table 4-6.

Table 4.7
Distribution of Corridor Global Benefit/Cost Ratios for Doubling of Gas Prices

Mode	Global B/C[1] Greater than or equal to 1	.99 - .75	.74 - .50	.49 - .25	Less than or equal to .24	Total[2]
AGT	.55 (17)	.35 (11)	.06 (2)	.03 (1)	.00 (0)	1.00 (31)
LRT	.00 (0)	.13 (4)	.42 (13)	.42 (13)	.03 (1)	1.00 (31)
Busway	.16 (4)	.32 (8)	.40 (10)	.12 (3)	.00 (0)	1.00 (25)

[1]Number in parentheses is number of corridors in cell.

[2]Due to rounding, percentages may not sum to one. Exact figures can be obtained from the actual number of corridors given in parentheses.

Table 4.8
Potential Capital Expenditure for Corridor AGT ($ Billions)

a) 30-Year Evaluation Horizon

	Deployment Rate			
	100%	75%	50%	25%
	Global B/C			
≥ 1	1.9	1.4	.9	.5
≥ .75	3.6	2.7	1.8	.9
≥ .50	4.0	3.0	2.0	1.0

b) Doubling of Gas Prices

	Deployment Rate			
	100%	75%	50%	25%
≥ 1	2.6	1.9	1.3	.6
≥ .75	4.2	3.2	2.1	1.1
≥ .50	4.6	3.4	2.3	1.1

market of corridors with global B/C ratios exceeding .99 is $1.9 billion. Total capital expenditures required for deployments in all corridors with global B/C ratios exceeding .74 is $3.6 billion and for the .50 cut-off the total is $4.0 billion. Since the possibility of a 100 percent deployment rate is remote, actual capital expenditures is likely to be a proportion of these maximum estimates. Therefore, estimates of total expenditures for differing deployment rates are also shown in the table. Since the cities with lower current population and transit ridership included in the analysis had relatively low B/C ratios, the exclusion of other small cities from the sample is unlikely to have a large effect.

Panel (b) shows estimates of potential capital expenditures for the thirty year evaluation horizon with a doubling in gas prices. With a 100 percent deployment rate and a B/C ratio greater than .5, capital expenditures are estimated not to exceed $4.6 billion.

The estimates in Table 4.8 suggest that annual capital expenditures for AGT deployments in corridor settings may not be large. If the expenditure were equally spaced over a ten year period, annual expenditure would never exceed $460 million and more realistically would probably not exceed $200-250 million. The results in the table also suggest that capital expenditures for AGT deployments in corridors may be insufficient to sustain potential suppliers of AGT based on this market alone.[1] The principal reason for the scarceness of the market is that, in many cases, rail systems have already been deployed in corridors where fixed guideway transit is most attractive. Consequently, there are relatively fewer remaining corridors where fixed guideway transit would be cost-effective.

There also are important implications of an AGT deployment for municipal finance. Inspection of the local B/C ratios in Table 4.3 reveals that all exceed 1.0. This finding suggests that in most moderately sized metropolitan regions, local authorities may be enthusiastic about deploying an automated guideway system. Inspection of the financial ratios, though, reveals that municipal finances could be a disciplinary counter-force. Table 4.9 shows the joint

[1]Expenditure for hardware and engineering assistance is unlikely to exceed 40 percent of total capital costs.

Table 4.9
Joint Distribution of Global B/C Ratios and Financial Ratios for Corridor AGT

		Financial Ratio[1]				
		.99 - .75	.74 - .50	.49 - .25	.24	Total[2]
	1	(0) (0)	.35 (11)	.10 (3)	.00 (0)	.45 (14)
Global B/C	.75-.99	.00 (0)	.03 (1)	.32 (10)	.00 (0)	.35 (11)
	.75	.00 (0)	.00 (0)	.16 (5)	.03 (1)	.19 (6)
	All	.00 (0)	.39 (12)	.58 (18)	.03 (1)	1.00 (31)

[1]Number in parentheses is number of corridors in cell.

[2]Due to rounding, percentages may not sum to one. Exact figures can be obtained from the actual number of corridors given in parentheses.

distribution of AGT's global B/C ratios and financial ratios. In no instance is a financial ratio greater than .75, which implies that all systems would have a funding deficit even with a federal subsidy. Thus, additional revenues would have to be found to fund system construction and operation. Joint development ventures are a potential source but are unlikely to produce sufficient revenues to finance the deficits. Other possibilities are subsidies from state or local government, bond issues, or special taxes.

4.3 CENTRAL BUSINESS DISTRICTS

4.3.1 INTRODUCTION

Central business districts (CBDs) and corridors comprise the two largest potential markets for AGT. The results of the previous section suggest that one limitation to the corridor market may not be necessarily attributable to shortcomings with AGT but to previous deployment of other technologies in most corridors where fixed guideway transit is attractive. For the reasons discussed in Chapter 3, the smaller physical scale and automated features of a downtown people mover (DPM) may make such systems competitive with bus systems for providing distribution and circulation within central business districts.

4.3.2 QUANTIFIED BENEFITS AND COSTS

For each CBD analyzed, Table 4.10 lists the following cost ratios summarizing the analysis results. In all cases, the particular form of automated guideway transit assumed is a downtown people mover (DPM).

Global B/C

$$\text{With Bus Cuts} = \frac{B_1 + B_2 + B_3 + B_4}{C_1 + C_2 + C_3}$$

$$\text{Without Bus Cuts} = \frac{B_1 + B_2}{C_1 + C_2 + C_3}$$

Local B/C

$$\text{With Bus Cuts} = \frac{B_1 + B_2 + .5B_3 + .2B_4}{.2C_1 + .5C_2 + .5C_3}$$

$$\text{Without Bus Cuts} = \frac{B_1 + B_2}{.2C_1 + .5C_2 + 5C_3}$$

Table 4.10
Summary Ratios and Ridership Estimates for Candidate CBD's[1]

City	Global B/C		Local B/C		Financial Ratio		DPM Ridership
	Bus Cuts	No Cuts	Bus Cuts	No Cuts	Bus Cuts	No Cuts	(annual, millions)
Los Angeles[2]	1.36	.58	2.99	1.84	2.26	1.12	37.2
Dallas	.93	.29	1.79	.89	2.37	1.47	28.1
Houston	.77	.30	1.55	.89	2.26	1.60	20.3
Detroit[2]	1.04	.25	1.90	.77	2.34	1.20	37.6
Cleveland	1.00	.15	1.68	.46	2.41	1.19	42.4
Atlanta	.94	.40	2.07	1.27	1.75	.96	21.3
St. Louis	.85	.21	1.56	.65	2.07	1.16	26.9
Baltimore	.76	.05	1.14	.14	2.29	1.29	31.9
Pittsburgh	.62	-.18	.57	-.54	2.49	1.38	39.8
Seattle	.62	.03	.91	.10	2.26	1.44	24.5
Milwaukee	.88	.24	1.66	.74	1.97	1.05	26.4
Indianapolis	.65	.28	1.42	.88	1.41	.88	13.9
Kansas City	.40	.08	.67	.22	1.95	1.51	13.5
Minneapolis[3]	.56	.07	.89	.21	1.98	1.29	19.8
Cincinnati	.53	.06	.83	.18	2.00	1.35	18.8
Miami[2]	.54	.10	.91	.30	1.81	1.20	17.1
Denver	.41	.07	.67	.22	1.82	1.37	13.3
Portland	.55	.10	.93	.30	1.82	1.19	17.6
Buffalo	.60	.09	.98	.26	1.81	1.09	20.0
Columbus	.60	.25	1.28	.77	1.29	.78	13.0
New Orleans	.60	.13	1.08	.41	1.61	.94	17.5
Honolulu	.24	-.02	.29	-.04	1.85	1.51	11.3
Providence	.29	-.09	.26	-.27	1.78	1.26	14.2
San Diego	.23	.08	.48	.26	.78	.55	6.1
Dayton	.18	-.03	.21	-.09	1.18	.88	7.9
Phoenix	.06	.02	.13	.06	.77	.70	3.5
San Antonio	.33	.01	.52	.02	1.13	.63	10.1
Louisville	.33	.05	.53	.13	1.72	1.33	12.0
Memphis	.17	-.06	.15	-.18	1.23	.90	8.4
Rochester	.26	-.10	.21	-.30	1.54	1.03	12.4
Syracuse	.18	-.08	.14	-.25	1.18	.79	8.8
Akron	.06	-.02	.06	-.06	.81	.69	3.8
Birmingham	.10	-.01	.13	-.02	1.15	1.01	5.5
Ft. Lauderdale	.06	-.03	.03	-.10	.59	.46	3.3
Norfolk	.08	-.05	.05	-.16	.65	.44	4.5
Oklahoma City	.12	.04	.22	.12	1.41	1.31	6.2
Sacramento	.06	-.02	.06	-.06	.81	.69	3.8
Tampa	.07	-.01	.09	-.02	.98	.87	4.4
Toledo	.11	-.05	.08	-.15	.90	.66	5.7
Albany	.22	-.09	.18	-.27	1.41	.97	10.7
Hartford	.23	-.11	.16	-.34	1.26	.76	10.6
Anaheim	.01	.00	.01	-.01	.49	.48	1.5
Jacksonville	.09	-.05	.05	-.18	.67	.44	4.9

[1]Cities not included that are likely to have ratios comparable to Los Angeles, Detroit, and Cleveland are: New York, Chicago, Boston, Philadelphia, Washington, D.C., and San Francisco.
[2]Cities currently participating in UMTA's DPM demonstration program.
[3]Minneapolis' sister city of St. Paul also is participating in the DPM demonstration program.

Local Financial Ratio

$$\text{With Bus Cuts} = \frac{PR + F + .5B_3 + .2B_4}{.2C_1 + .5(C_2\ F) + .5C_3}$$

$$\text{Without Bus Cuts} = \frac{PR + F}{.2C_1 + .5(C_2\ F) + .5C_3}$$

Where

B_1 = Change in time costs of CBD travel
B_2 = Parking cost savings
B_3 = Reduction in bus operating costs
B_4 = Reduction in bus capital costs
C_1 = DPM capital cost
C_2 = DPM operating cost
C_3 = Capital costs for the fringe parking lots
PR = Parking lot revenues
F = Fare revenues

All benefits, vehicle capital costs, DPM operating costs, and parking lot costs are in net present value. Guideway and station costs are assumed to be incurred in the present time period.

The global B/C ratios are simply the ratio of the sum of all benefits to the sum of all costs. In computing the local B/C and financial ratios, DPM operating and capital costs and savings in bus operating and capital expenditures are factored to reflect current federal subsidy policy. It is assumed the Federal government will pay for half the parking lot costs.

Probably the most important potential benefits and costs that are not quantified are economic development and visual intrusion by guideways. For CBD deployments, these may be pivotal in determining the potential market. Accordingly the B/C ratios in Table 4.10 should be interpreted with this caution.

Inspection of Table 4.10 reveals that all ratios are very sensitive to whether the bus cut benefits are included. The analysis reveals that the potential savings from a 50 percent reduction in CBD bus operations are consistently the largest benefits of a DPM deployment. Indeed without the bus cut benefits, global B/C ratios are negative in some cities. The negative B/C ratios occur in cities where the analysis suggests that a DPM deployment will increase time costs for CBD travel. This occurs in cities with very small CBDs where in-vehicle time savings are not sufficient to compensate for transfer costs. These transfers are forced for regional transit users whose bus routes are cut back to the CBD fringe, requiring them to use DPM to their destinations. The results confirm the principle that DPM's time benefits will be largest in CBDs of large area with a relatively low density of destinations.[1]

Table 4.11 shows the distribution of global B/C ratios with and without bus cuts. With bus cut savings included, global B/C's exceed .99 in three cities. The .74 level is exceeded in nine cities and a .49 level is exceeded in nineteen cities. Without bus cuts the .49 level is exceeded in only one CBD. These distributions, however, understate the number of potential CBDs with highest B/C ratios. The CBDs of New York, Boston, Philadelphia, Washington, D.C. and San Francisco are not included because of difficulties in estimating ridership in the system's service area. All would probably have global B/C ratios comparable to Los Angeles, Detroit and Cleveland. Thus, for the benefits and costs included, about 12 to 14 CBDs in the entire country would have global B/C ratios including bus cuts benefits exceeding .74. Without bus cut benefits, the number exceeding .49 would probably be three or four.

The results in Table 4.11 suggest that, from a cost-effectiveness perspective, the achievability of the bus cuts could be pivotal in determining the DPM market. As discussed in Chapter 3, Section 13c personnel issues are a significant issue to successfully achieving these cuts. No doubt unions will demand that operators freed by terminating CBD bound bus routes at fringe stations be re-assigned to non-CBD routes. If such an expansion in non-CBD bus service would have occurred without a DPM deployment, then the bus operating and capital benefits will be realized because additions to the fleet and labor

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[1] In Chapter 3, analysis of the implications of a pyramid distribution of destinations is discussed. Destinations are more densely located in the pyramid distribution than the assumed linear decline distribution. Thus, if a pyramid distribution is assumed, time benefits would be reduced. Since the B/C ratios are already generally considerably less than 1.0, an analysis with the pyramid distribution would not have greatly affected the conclusions.

Table 4.11
Distribution of Global B/C Ratios With and Without Bus Cuts for CBDs

	Global B/C[1]					
	Greater than or equal to 1	.99-.75	.74-.50	.49-.25	Less than or equal to .24	Total[2]
With Bus Cuts	.07 (3)	.14 (6)	.23 (10)	.14 (6)	.42 (18)	1.00 (43)
Without Bus Cuts	.00 (0)	.00 (0)	.02 (1)	.14 (6)	.84 (36)	1.00 (43)

1 Number in parentheses is number of corridors in cell.

2 Due to rounding, percentages may not sum to one. Exact figures can be obtained from the actual number of CBDs given in parentheses.

force would have been necessary without the deployment. It is more likely, however, that this expansion will be forced by the 13c issue. In this event user benefits will accrue from the improvement in non-CBD bus service but the full benefits of the CBD bus cuts will not be realized; none of the financial savings from the cuts to the authority will be realized, though the added non-CBD services will generate additional revenues. Even if 13c issues prove not to be an obstacle in some sites, there may be opposition by the current riders of bus routes to be terminated at the fringe DPM stations. If there is substantial opposition, the transit operator may choose to continue operating all routes into the CBD, and not achieve the bus cut benefits. A final issue is that many cities do not perceive the bus cut benefits as significant, and may not even attempt to restructure service to obtain these savings. For all these reasons, baseline DPM market projections are made assuming no bus service cuts take place in the CBD.

Without achieving the bus cuts, the market of cost-effective DPM deployments appears to be quite limited. This observation, however, conflicts with the response to UMTA's DPM competition; almost forty cities responded with proposals. In part the general enthusiasm is attributable to DPM's promise of contributing to economic development in the CBD, and this benefit is not included among the quantified benefits. Examination of Table 4.10, though, reveals another explanation. In 33 cities, the local financial ratio <u>without</u> bus cuts exceeds .74 and in 23 cities the .99 level is exceeded.

In the corridor analysis, many corridors had very favorable local B/C ratios but it was noted that the large deficits implied by the low financial ratios might discipline local enthusiasm. Inspection of the financial ratios for DPM reveals a very different pattern than for corridors. Even without the savings from bus cuts, nearly all financial ratios are larger than one and in many of the larger CBDs financial ratios are substantially greater than one. The financial ratios thus suggest a DPM deployment will <u>increase</u> municipal revenues. This finding is principally attributable to the revenues from the fringe parking lots. In an era when municipal finances generally are deteriorating, the prospect of improving city transit services and providing a focus for CBD revitalization without increasing the burden on general revenues or increasing taxes would be very enticing. It is noted, however, that the financial ratios may not be entirely accurate due to the cost assumptions.

4.3.3 UNQUANTIFIED BENEFITS AND COSTS

The quantitative analysis results suggest that without consideration of the bus cut benefits the market for DPM is severely reduced from a strict cost effectiveness perspective even though current federal subsidy policy may still make DPM attractive to large numbers of municipalities. However, as previously noted, certain potential benefits and costs that may be particularly important in determining the DPM market have not been quantified.

i) Economic Development

The potential promise that a DPM would serve as a catalyst for economic development was among the principal motivations for many cities submitting proposals for the DPM competition. Making an objective judgment of DPM's potential for stimulating economic development, though, is difficult. If DPM stimulates development only if it improves transit level of service, then a significant stimulus is doubtful. Both abstract analysis of time savings and the results of the site specific case studies suggest that the level of service improvements are modest. However, the assumption that DPM will only stimulate development if it improves transit service may not be entirely valid.

A DPM may serve as a compelling symbol of a city's commitment to economic development. Coupled with appropriate tax incentives, a DPM might serve more as a catalyst than a stimulus to economic development. This more optimistic perspective, however, should be tempered by the observation that transit service can only mitigate but not alleviate the forces that are the principal causes of the deterioration in the vitality of many CBDs.

To provide perspective on the magnitude of economic benefits required for a DPM to be an attractive investment, the development benefits required to increase global B/Cs to unity were calculated for each of the candidate cities.[1] The range of required benefits per city varies between $25 and $50 million

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[1]Global B/Cs without bus cut benefits were used.

but typically are less than $40 million. There is, however, no systematic relationship between the required development benefits and the global B/C ratios. This lack of correspondence is attributable to a correlation between the system costs and the global B/C ratios. Cities with higher ratios are also the candidate cities with the larger capital and operating cost requirements. This relationship is due to these cities having the largest projected riderships. Increases in ridership are typically associated with both increased costs and benefits.

It should be noted that there is, in general, no direct equivalence between development benefits and the value of a development that can be attributed to deployment of the system. Development requires the use of land, materials and labor, and the value of these resources is a cost, not a benefit. DPM's development benefits include any savings in the cost of development that the system's deployment may permit. For example, such savings may evolve from DPM's contribution to improving accessibility within the area of its deployment.

In many large U.S cities, large tracts of land in or adjacent to the CBD are unused or underdeveloped. Such tracts are typically warehouse or manufacturing districts and abandoned or underused railroad yards. Development of such underused land may be hindered because their accessibility to foci of activity in the CBD is poor. A properly aligned DPM may sufficiently improve accessibility to encourage development of this land.

It is important to note, therefore, that the $25 to $50 million in benefits required to bring the B/C ratio of many DPM's to unity is <u>not</u> simply the value of induced CBD development. Under general conditions, economic benefits can be measured by increases in land values in the CBD which would be brought about by a DPM; these benefit increases will typically require a substantially larger investment than $25 to $50 million in new development.

ii) Reduction in Bus Related Externalities

Even if the reduction in CBD bus operations is used to augment the non-CBD bus service, non-pecuniary benefits will be achieved. In cities with extensive transit service, buses are often major contributors to CBD pollution and congestion. By terminating a substantial proportion of CBD bound bus routes at fringe stations, CBD pollution and traffic congestion may be measurably reduced. Particularly for large CBDs without rail transit, this benefit is likely to be given considerable emphasis.

iii) Visual Intrusion by Elevated Guideways

Problems with visual intrusion may be particularly acute in CBDs because the possibilities for obstructing vistas or for the elevated guideway being incompatible with surrounding architecture is greatest in this setting. The magnitude of this potential problem, though, is very dependent on site specific characteristics. Consequently, generalizations on the importance of visual intrusion considerations on the potential market are not easily made. Nonetheless, the response to the DPM competition is evidence that in principle the visual intrusion problem is not considered overriding. Local authorities, however, could feel differently after seeing preliminary plans and citizens have the opportunity to voice their concerns.

iv) Construction Disruptions

As with visual intrusion, the costs of construction disruptions are likely to be greatest in CBDs. Per unit of area more businesses and persons will typically be affected by construction in a CBD than in any other potential setting for AGT. However, the potential inconvenience to CBD visitors and the possibility of temporary reductions in retail activity did not dissuade the large number of cities who submitted proposals in the DPM competition.

4.3.4 ALTERNATE SCENARIOS

Tables 4.12 shows the distribution of CBD global B/C ratios for the doubling in real gas price scenario. Without the bus cut benefits, the distribution does not differ markedly from that shown in Table 4.11 for the baseline scenario. Only one CBD has a ratio exceeding .49. As noted previously, though, New York, Chicago, Boston, Philadelphia and San Francisco are not included, and each should probably be counted among those cities with the highest ratios. Nonetheless, even with their inclusion, without the bus cut savings the potential CBD market for AGT deployments is small, if based only on national

Table 4.12
Distribution of CBD Global B/C Ratios For Alternate Scenarios

	Global B/C[1]					
	Greater than or equal to 1	.99-.75	.74-.50	.49-.25	Less than or equal to .24	Total[2]
a) Doubling of Gas Prices						
With Bus Cuts	.12	.12	.23	.21	.33	1.00
	(5)	(5)	(10)	(9)	(14)	(43)
Without Bus Cuts	.00	.00	.02	.16	.81	1.00
	(0)	(0)	(1)	(7)	(35)	(43)
b) Doubling of Capital Costs						
With Bus Cuts	.00	.02	.16	.23	.59	1.00
	(0)	(1)	(7)	(10)	(24)	(43)
Without Bus Cuts	.00	.00	.00	.04	.96	1.00
	(0)	(0)	(0)	(2)	(41)	(43)

[1] Number in parentheses is number of corridors in cell.

[2] Due to rounding, percentages may not sum to one. Exact figures can be obtained from the actual number of CBDs given in parentheses.

cost-effectiveness. While economic development considerations could substantially increase the global B/C ratios in these cities, the impact would have to be large enough to increase the ratios to one and increases in land values of $25 to $50 million would generally be required.

Inclusion of bus cut savings substantially increases the number of global B/C ratios exceeding .74 and .99. For the doubled gas price scenario, though, the frequency of ratios exceeding .74 is only one greater than that for the baseline scenario. This is because time cost savings are only modest.

The current unit construction cost estimates for the cities currently implementing DPM range from $17.5 to $36 million per two-way mile. These costs are approximately double the unit costs in Table 3.3, which were used in the analysis. To adjust for this cost difference, B/C ratios were calculated with a doubling of capital costs. In this case, the number of cities having a global B/C ratio greater than .49, considering bus cut savings, is reduced from 19 to 8.

4.3.5 POTENTIAL CAPITAL EXPENDITURES

Estimates of capital expenditures for DPM for varying assumptions on deployment rate and minimum B/C cutoffs are shown in Table 4.13. Without the bus cut benefits, total capital expenditures for systems meeting a .50 cut-off are an estimated maximum of $90 million. For the alternative scenarios the comparable estimates are somewhat larger, and if the bus cut benefits can be achieved, the potential capital expenditures increase appreciably. Maximum estimated capital expenditures in this case for a .50 cut-off is $937 million for the baseline scenario and $1.065 billion with a doubling in the real cost of fuel. For a .75 cut-off, maximum expenditures range from $518 to $643 million. These results suggest that if a cost-effectiveness criterion is strictly used to define the potential market for DPM, capital expenditures would be relatively limited without the bus cut benefits but significantly larger when bus cut benefits are included.

Table 4.13

Potential Capital Expenditures for DPM ($ Millions)[1]

		With Bus Cuts		Without Bus Cuts	
a: 30-Year Evaluation Horizon					
Deployment Rate:		100%	50%	100%	50%
Global B/C	.75	518	259	--	--
	.50	937	468	90	45
b: Doubling Gas Prices					
		100%	50%	100%	50%
	.75	643	321	--	--
	.50	1,065	533	104	52
c: Doubling Capital Costs					
		100%	50%	100%	50%
	.75	141	72	--	--
	.50	766	383	--	--

1 The Global B/C ratio for Los Angeles is assumed for New York, Chicago, Boston, Washington, D.C., and San Francisco. The combined capital cost for a DPM deployment in these 5 cities is assumed to be 250 million.

4.4 MAJOR DIVERSIFIED ACTIVITY CENTERS AND SHOPPING CENTERS

4.4.1 INTRODUCTION

The chief attraction of AGT for major diversified activity centers (MDCs) and shopping centers is its capability to provide the best level of service of any transit alternative for internal circulation. AGT's level of service advantages can contribute to the attractiveness of such activity centers by increasing effective "retail density," the number of retail opportunities within a given access time. This potential to increase effective retail density is a particularly important asset to an MDC or shopping center whose size has reached sufficient proportions that access distances among nodes in the center are too long for walking or when physical barriers (such as busy roads) limit walk access among nodes. In MDCs and shopping centers, non-AGT fixed guideway technologies are not attractive because their capital and operating costs generally are prohibitive and their physical scale is typically too imposing.

Assessment of the market for AGT in this segment relies chiefly on the conclusions of the case studies of Merrillville, Oak Brook, the Dallas Market Center and Northpark. Chapter 2 summarizes the findings of the case studies at these sites; detailed results are presented in Volume II.

4.4.2 NATIONAL MARKET POTENTIAL

The case study analyses suggest that an AGT is most attractive for multi-nodal activity centers where there are substantial barriers to walk access among high activity nodes. Table 4.14 shows a matrix of activity center types. Its dimensions are number of retail nodes and number of non-retail nodes. Each cell includes an indication of whether AGT would typically be attractive for activity centers characterized by the cell. These indications are, of course, generalizations and specific characteristics of an activity center may make it an exception.

In general, activity centers without major retail activity are not attractive sites for an AGT deployment. In centers with only one major node of non-retail activity, there is no need for an internal guideway system. In centers with two or more non-retail nodes, internal circulation is typically very low and too diffuse to justify an internal guideway system. Transit mode shares to the center typically also will be too small to generate

Table 4.14
Activity Center Type and the Attractiveness of AGT

		Number of Retail Nodes		
		0	1	2
Number of	0	0	0	?
Non-Retail	1	0	0	?
Nodes	2	0	0	X

0= Unlikely candidates for AGT
X= Likely candidates for AGT
?= Possible candidates for AGT

Each node assumed to contain approximately 1,000,000 ft^2 of gross leasable area.

sufficient ridership for a distribution oriented system. A two million square foot office complex will generally have about five thousand workers.[1] If the transit mode share is ten percent, which is very high for the typical activity center, daily ridership would be only about one thousand trips.

All centers with a single shopping node are also judged to be generally inappropriate for an AGT deployment. Even the largest shopping centers are typically designed to allow easy walk access to most locations internal to the center. Thus, internal circulation systems typically will be unnecessary. Where there are adjacent office complexes, a possible application is to link the offices to the shopping center with an AGT. Internal trip-making rates by office workers, however, are unlikely to be sufficient to warrant such a system. A large office complex of one million square feet typically houses about 2500 employees. If half of these employees use the system daily, annual ridership would be about three quarters of a million. For a one mile system offering a level of service similar to that assumed in the case studies, the cost per rider is over 2 dollars. Cost per rider in Northpark is about 28 cents, which has projected retail and non-retail floorspace of 4 million square feet. With an 80 percent capital subsidy, cost per rider is about 23 cents in Merrillville, which has projected retail and non-retail floorspace of 6 million square feet. Since Northpark and Merrillville (with an 80 percent capital subsidy) expressed considerable interest in AGT, the cost per rider in these two study sites provides a rough indication of the necessary threshold for a system to be attractive in an activity center context. It is estimated that over seven million square feet of office space along the system serving a single retail node is necessary for the cost per rider to be comparable to Northpark or Merrillville.[2]

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[1]Assuming one worker per 400 square feet. Also assume two trips per day, either internal or distribution from regional transit, which is a generous assumption.

[2]A system serving 7 million square feet of office space would generally have to be considerably longer than one mile. Thus, using the costs per passenger at Northpark and Merrillville as the threshold standard, even 7 million square feet may not be sufficient.

Cost-effective applications appear to be chiefly limited to activity centers with at least two major retail nodes. In sites without major retail nodes or with only one such node, the desirability of AGT is unclear. The principal difficulty in making a more conclusive judgment about such sites is the difficulty of estimating ridership on the system segment linking the shopping nodes. Inter-retail node trip making rates are very dependent on the comparative quality and types of shopping opportunities at the retail nodes, the geography of the activity center, and the distance separating the nodes and barriers to access among nodes. Table 4.15 shows different estimates of ridership and costs per rider for varying estimates of inter-nodal trip-making between two shopping nodes. One million square feet of retail floor area is assumed at each node. Inter-nodal trip-making rates are estimated as different proportions of trip attractions per thousand square feet of retail space. Eighty percent of all inter-nodal trips are assumed to be made by AGT.[1] For an inter-nodal trip-making rate of seven per thousand square feet of retail space, cost per rider for the two activity center types is between forty and fifty cents. Cost per passenger in Merrillville without the capital subsidy is within this range and local participants expressed reluctance to support the system without the subsidy. The reaction of the Merrillville participants, however, suggests that the inter-nodal trip-making rate must be substantially higher than seven per thousand square feet for AGT to be attractive without a subsidy. A rate of fourteen per thousand square feet reduces cost per passenger to a range that is attractive to Merrillville and Northpark.

The likely activity center candidates for AGT deployments, thus, are sites with two or more retail nodes and two major non-retail nodes. This conclusion chiefly derives from the site studies at Merrillville and Northpark; both sites are of this type. However, major obstacles to AGT deployments remain even at sites of this type. The studies at Merrillville and Northpark suggest that capital costs are in general an important obstacle to deployment and that inflexibility of a fixed guideway system may be a problem in many sites.

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[1]In Merrillville, an estimated 80 percent of all internal trips would be made by AGT, and this is considered to be a reasonable upper bound. In Northpark, AGT's estimated share of internal trips is 40 percent.

Table 4.15
Ridership and Cost Per Rider in Activity Centers with Two Retail Nodes and Either Zero or One Non-Retail Node[1]

Inter-Retail Node Trip Making Rate[2]	No Non-Retail Nodes		One Non-Retail Node[3]	
	Annual Ridership (mil)	Cost Per Rider (cents)	Annual Ridership	Cost Per Rider
7/1000 sq. ft.	3.4	52	4.2	42
14/1000 sq. ft.	6.8	26	7.6	23

[1] Cost per rider is estimated for a one mile system. Estimated annual capital and operating cost for such a system is 1.75 million dollars.

[2] Assuming a trip attraction rate of 22 trips per 1000 square feet of retail space, the inter-nodal rates are respectively about one-third and two-thirds of the total attraction rate.

[3] The non-retail node is assumed to be 1 million square feet. If half the employees used the system about 1,250 round trips would be made daily.

Developers appear to be willing to invest no more than three to five percent of the total development value for an internal transportation system. For both these sites, this translates into an investment of no more than six to ten million dollars. At Merrillville this maximum local expenditure can only be achieved with an eighty percent or more subsidy of capital costs. At Northpark the maximum is achievable if a regional system were deployed with a spur entering the activity center. Otherwise a fifty percent subsidy is necessary. The possibility of a spur deployment is also viewed positively at the Market Center.

The apparent constraint on total capital expenditure may greatly restrict the potential market. Suburban developments are not likely to receive Federal subsidies under current UMTA priorities and opportunities for joint deployment with regional systems will not generally be available.

The inflexibility of fixed guideway systems may also limit AGT's attractiveness in activity centers in early stages of development. The initial alignment may place undesirable constraints on future development plans. Concerns about inflexibility were voiced in Merrillville. Inflexibility is not an issue at Northpark because no significant shift in development is envisioned.

Activity centers with two or more retail nodes and two or more non-retail nodes will typically have a total floorspace in excess of four million square feet. Smaller centers are unlikely to have sufficient activity to warrant a deployment. In the Generic Alternatives Analyses, all major shopping centers and MDCs in twelve representative cities are identified, and total over sixty in number. Only three of these, though, had gross leasable areas in excess of four million square feet--City Post Oak and Greenway Plaza (Houston) and Century City (Los Angeles). Greenway Plaza is a multi-node office complex with no major retail activity. A review of the Greenway Plaza site plans and statistics suggests that possibilities for an AGT deployment at this site are remote[1] and a conclusion that is consistent with the generalization that centers without major retail activity are unlikely candidates for AGT. Century City has one major shopping center and one major office complex.

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[1]Harvey, Thomas, E., et.al., The Academic Medical Center Study, Rice University School of Architecture, Houston, Texas, 1976.

There are also several smaller office complexes. The major office and retail complexes are separated by about one-quarter of mile and are already connected by a covered walkway. An AGT deployment at this site is also considered to be unlikely. Only City Post Oak appears to be a potential candidate for AGT. City Post Oak is strikingly similar to Merrillville, and is growing at an extraordinary rate. Between 1969 and 1976 retail floor area doubled and non-retail area increased eight-fold. By 1976, total area was over eight million square feet. Several major shopping and office complexes are separated by major highways. If attitudes of developers at City Post Oak are similar to those at Merrillville, then an AGT deployment would be viewed as attractive but only if sufficient subsidies to reduce capital expenditures to an acceptable level are available.

Current data are not available on the number of activity centers with at least two retail nodes, two or more non-retail nodes and total floorspace of at least four million square feet. However, it is unlikely that more than 5 to 10 centers like Merrillville, Northpark, City Port Oak, and the Market Center exist. In view of the extraordinary growth of City Post Oak, though, this number could increase substantially in the next ten years. Assuming an average system cost of twenty million dollars, the maximum capital expenditures from the current market is probably in the order of $200 to $300 million. However, without substantial subsidies or opportunities for joint deployment with a regional system only a small fraction of this estimate is likely to be realized.

4.5 MEDICAL CENTERS

Large medical centers are typically a conglomeration of medical and parking facilities. Because the largest medical centers have generally evolved over an extended period in an ad hoc fashion from small institutions, accessibility among facilities is frequently poor. An AGT deployment could potentially facilitate movement among medical facilities or improve access between the parking and medical facilities or both.

The approach to estimating the market for AGT at medical centers relies chiefly on the findings of the case study at the Illinois Medical Center and an examination of the motivations for the deployment of an AGT currently under construction at Duke Medical Center, the only such system in the country.

Duke Medical Center is located in Durham, North Carolina, on the campus of Duke University, and is situated on a 120 acre site. Duke Hospital is an extraordinarily large institution in view of its location. Durham's population is about 100,000. Measured by admissions or average daily in-patient census, it is the second largest teaching hospital in the country. Virtually all large medical centers include teaching hospitals.

The principal function of the AGT system currently under construction is to provide circulation between two large medical facilities. While it will also link a parking garage to the medical facility, the chief motivation for the deployment is to improve access between the medical facilities.[1]

Several important features distinguish Duke from the Illinois Medical Center. Duke Medical Center is a single institional entity. The principal reason for deploying the AGT system is to link the older facility with the new facility, Duke Hospital North, which is currently under construction. Because neither facility will be self-contained, considerable circulation between the facilities is expected. Ridership between facilities is estimated to be at least six thousand per day. Personal security is not a major issue because crime rates are relatively low in the areas surrounding Duke and a major portion of the system is isolated from surrounding areas. Visual intrusion is not a problem for several reasons. Only a portion of the system is elevated but more importantly the system is not incompatible with either the existing or new construction. The existing construction in the hospital complex is very modern. Noise from the construction is not an issue because the system is being deployed concurrently with the addition of Duke North.

[1]Information about the Duke system is from communications with Jane Elchepp, M.D., Ph.D., of Duke Medical Center.

Table 4.16 shows summary statistics characterizing seven large medical centers.[1] The statistics in the table and the details given in the report suggest that the Illinois Medical Center is more typical of medical centers than Duke. Other than Duke, only the Johns Hopkins Medical Center is a single institution. A multi-node complex within a single institution may be the most important requirement for an AGT to be attractive to a medical center. Such a deployment will directly contribute to a principal mission of the medical center, delivery of medical care. The system will provide greater accessibility to medical resources shared by the complex. Facilitation of patient, staff and material flow was the primary motivation for the AGT deployment at Duke. While the Illinois Medical Center study revealed that substantial ridership from parking garages to medical facilities may be achievable, such a function does not produce the direct benefits to service delivery that internal circulation systems can generate. The justification of AGT through benefits to the delivery of medical services is the only one that is able to attract financial support from an institution.

Several of the medical centers listed in Table 4.16 are also similar to Illinois Medical Center in other important respects. Most are located in deteriorating neighborhoods (including Johns Hopkins) which makes personal security a significant obstacle to deployment. Also many are comprised primarily of older buildings and thus incompatibility between the guideway and existing architecture may be a problem.

While analysis of the medical center market segment is not sufficiently detailed to allow strong conclusions on the potential market for AGT in this segment, there appear to be few attractive deployment opportunities. Duke Medical Center is anomalous on several dimensions that will affect the attractiveness of an AGT deployment at a medical center. Duke's decision to deploy an AGT is unlikely to signal deployments at a large number of other large medical centers.

4.6 AIRPORTS

Airports already are a developed market for AGT. Systems are in operation at airports in Dallas-Ft. Worth, Seattle-Tacoma, Houston, and Tampa,

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[1] Except for Duke, data are from Harvey, Thomas, E., et.al., The Academic Medical Center Study, Rice University School of Architecture, Houston, Texas, 1976.

Table 4.16
Major Medical Centers

	Johns Hopkins (Balt.)	Longwood (Boston)	Illinois (Chicago)	Detroit	Texas (Houston)	NYU-Bellevue-VA (NY)	Washington University (St. Louis)	Duke (Durham)
Location from CBD (Miles)	3E	2.5W	2.5W	1N	3SW	--	4W	2SW
Total Acreage	30.6	150	365	240	337	30	69.5	120
Medical Acreage	22	81	214	150	200	30	50.3	∿40
Total Beds	1125	2003	3777	2301	3484	3243	1885	1008
Employees (hosp. only)	4472	10333	13850	8135	10641	10832	5579	∿4000
No. of Med. Schools	1	1	3	1	2	1	1	1
No. of Other Schools	2	0	11	0	4	1	0	1
No. of Hospitals	1	3	4	3	4	3	2	2
No. of Specialty Hospitals	1	4	6	3	5	1	1	0
No. of Rehabilitation Centers	1	0	2	1	1	1	1	0
No. of Clinics	0	2	7	1	2	0	1	1
Inpatient Census/Day	829	1719	3070	1986	2796	2686	1636	∿800
Outpatient Visits/Day	1233	1523	4000	899	2866	NA	708	∿900
Visitor Population	NA	9100	7000	NA	18505	NA	4000	NA
Total Users/Day	NA	22000	64000	NA	40000	NA	20000	6000

and under construction in Atlanta, Miami, and Orlando. Federal intervention in the airport market to facilitate deployments appears to be unnecessary. As a consequence, only a limited analysis of this market segment has been performed, with the principal interest of determining the additional capital expenditures in this market as an element of the total potential expenditures for AGT. An estimate of this total is necessary for making judgments on whether the total market for AGT is sufficient to support suppliers.

AGT's have been deployed in airports principally to facilitate circulation among major terminals (e.g., Dallas-Ft. Worth) or between a major terminal and a satellite terminal (e.g., Miami). Provision of some type of motorized ground transportation is becoming increasingly necessary as the physical dimensions of airports grow or space constraints require that additional terminals be constructed in inaccessible locations. These changes in the scale and design of airports have been necessitated by rapidly increasing passenger volumes, and continued growth in passenger volumes is likely for the foreseeable future.

Table 4.17 shows forecasted passenger volumes in thirty major airports. Airports with operational or planned AGT deployments are marked with an asterisk. Airports that have recently undergone major reconstruction or have added major new facilities without making provisions for an AGT deployment are marked with a double asterisk. Airports in both categories are equal in number and span a wide spectrum of passenger volumes. Without more detailed information on the design of airports in these two categories, it is not possible to generalize on the distinguishing characteristics of airports deploying AGT. The only generalization that can be made with some confidence is that it would be extremely difficult to deploy an AGT connecting terminals unless provisions for a deployment had been included in the original design. Space constraints in most airports likely would make unplanned deployments very difficult.

Eight airports on this list have recently undertaken major construction without making provision for AGT, and it is unlikely that any of these airports would deploy an AGT in the next five to ten years. Eight of the airports have already deployed or will soon deploy

Table 4.17
Daily Passenger Forecast for 30 Major Airports

Airport		Average Daily Passengers, Enplaned and Deplaned (000) 1975	1985
** 1.	O'Hare--Chicago, IL (ORD)	116	200
2.	Los Angeles International, CA (LAX)	125	160
* 3.	Atlanta International, GA (ATL)	83	186
** 4.	Kennedy International, NY, NY (JFK)	78	132
** 5.	San Francisco International, CA (SFO)	61	113
6.	La Guardia, NY, NY (LGA)	57	107
* 7.	Miami International, FL (MIA)	48	89
* 8.	Dallas, Ft. Worth, TX (DFW)	51	112
** 9.	Washington National, DC (DCA)	41	63
**10.	Logan International, Boston, MA (BOS)	41	85
11.	Stapleton International, Denver, CO (DEN)	37	99
12.	Metro Wayne, Detroit, MI (DTW)	35	77
**13.	Philadelphia International, PA (PHL)	31	67
*14.	Newark--Newark, NJ (EWR)	34	86
**15.	Pittsburgh, PA (PIT)	29	64
16.	Honolulu International, HI (HNL)	28	58
17.	St. Louis International, MO (STL)	30	66
18.	Minneapolis International, MN (MSP)	24	54
19.	Hopkins, Cleveland, OH (CLE)	23	49
*20.	Houston International, TX (IAH)	22	47
*21.	Seattle-Tacoma, WA (SEA)	23	48
22.	New Orleans International, LA (MSY)	18	38
*23.	Tampa International, FL (TPA)	16	34
24.	San Juan International, PR (SJU)	16	33
25.	McCarran International, Las Vegas, NV (LAS)	18	40
**26.	Kansas City International, MO (MCI)	18	40
27.	San Diego International, CA (SAN)	17	38
28.	Sky Harbor Municipal, Phoenix, AR (PHX)	16	38
29.	Memphis International, TN (MEM)	14	32
30.	Baltimore-Friendship, MD (BAL)	14	38
***	Bradley Field, Hartford, Conn.	-	-
*	Orlando, FL	-	-

Source: Terminal Area Forecast, 1975-1985, Department of Transportation, Office of Aviation Economics, Aviation Forecast Division, July 1973.

* AGT in operation, deployment included in planned expansion, or capability for a future deployment designed into facility.

** Recently expanded without AGT deployment or plans for expansion do not include AGT.

*** AGT deployed but not in operation.

Note: Indications of plans for an AGT deployment developed from a literature search of architectural trade journals.

systems.[1] Additional capital expenditures on AGT over the next five to ten years at these airports should be small.

The remaining 15 to 16 airports are potential candidates for an AGT deployment. Nearly all of these are among the smaller airports on the list. However, the deployments at Tampa and Orlando suggest that an AGT may be attractive at even relatively small airports. Assuming an average cost of twenty million dollars per system, the maximum total expenditure from the airport market over the next ten years is estimated to be in the range of $200 to $400 million.

4.7 SUMMARY AND CONCLUSIONS

The results of the national market analysis need to be considered within the context of the basic perspective of the analysis, mainly to estimate the market for cost-effective applications of AGT rather than the actual number of possible deployments. Cost-effectiveness is among the chief criteria used by the Federal government in making subsidy decisions, whereas the effects of deployment on municipal finance are likely to be among the chief considerations of local agencies. In addition, local perceptions of a system's cost-effectiveness are likely to be very different from the federal perspective due to operating and capital subsidies. This analysis has focused almost entirely on the global cost effectiveness criteria to which subsidy policy is not relevant.

The estimates of cost-effective applications also contain an inherent imprecision that is attributable to developing a methodology that could manageably be applied to large numbers of candidate deployment sites. Only detailed design studies conducted in a controlled manner could easily reduce this kind of error. However, a more important element of imprecision may be attributable to the absence of quantitative estimates of key benefits and costs, with the more important of these being economic and community development benefits and visual intrusion by guideways. Nonetheless, the measures are judged to be sufficiently accurate and precise so as to identify the potential magnitude of the market and to inform federal policy.

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[1] Atlanta, Miami, Ft. Worth-Dallas, Houston, Seattle-Tacoma, Tampa, Orlando, and Hartford. Newark Airport is designed to permit an AGT deployment but the system will not be deployed for at least several years.

The results of the analysis of each market segment are summarized below:

- <u>Corridors</u>--The market for corridor applications of AGT appears to be chiefly constrained by the limited number of corridors with sufficient ridership potential for any capital intensive system to be cost-effective. Rail systems have already been deployed in many of the more attractive sites. In corridors where capital intensive systems are potentially attractive, AGT's lower capital and operating costs appear to make it an attractive alternative to conventional fixed guideway technologies. If AGT were deployed in all corridors with global B/C ratios exceeding .99, in seventy-five percent of the corridors with global B/C's in the interval of .75 to .99 and in fifty percent of the corridors with ratios in the interval of .50 to .74 (Deployment Scenario I), capital expenditures would total about $3.4 billion in 24 corridors. Deployment rates of successively seventy-five, fifty and twenty-five percent for each of these global B/C ranges (Deployment Scenario II) would generate about $2.4 billion in expenditures in 17 corridors. If all deployments occurred over a ten year period, average annual capital expenditures for corridor systems would be between $200 and $300 million.

  A doubling of gasoline prices in terms of real dollars would modestly increase the number of attractive corridor applications and total capital expenditures. For Deployment Scenario I, expenditures are estimated to be $3.9 billion in 26 corridors. For Deployment Scenario II, expenditures would be $2.7 billion in 19 corridors.

- <u>Central Business Districts</u>--The analysis of CBD applications of AGT (DPM) reveals that the largest potential benefit is a savings in bus capital and operating costs from terminating a substantial proportion of CBD-bound bus routes at fringe stations. However, these benefits may not be fully realized because of Section 13c rules and local opposition to route restructuring. Finally, not all cities may be aware of the magnitude of potential bus cut benefits (as shown in the DPM demonstration requests) and thus may not try to implement any service cuts. Assuming a DPM is deployed in all CBDs with B/C ratios exceeding .74, in 50 percent of the CBDs with ratios in the interval of .50 to .74, and if bus cut benefits are included among system benefits, total capital expenditures for DPM would be about $990 million in 14 sites. Without bus cut benefits, estimated capital expenditures with these deployment rate assumptions are about $45 million in a single site. For the former assumption, if the deployments occurred over a ten year period, average annual capital expenditure would not exceed $100 million. The maximum market, assuming both a doubling of gas prices and bus cut benefits, is $1,180 million at 15 sites under the deployment rate assumptions above.

- Shopping Centers and Major Diversified Activity Centers--Potential AGT deployments in this market appear to be limited to activity centers with at least two major retail nodes, with the most attractive sites having at least two additional major non-retail nodes. Such sites typically will be at least four million square feet in size, with probably no more than 15 existing in the entire United States. However, in view of the rapid growth of some existing diversified activity centers, it is possible that the number above the 4 million foot threshold could increase substantially in the next ten years.

  The principal constraint to AGT deployments in this market is capital costs. Reactions of local participants at case study sites suggest that developers are unwilling to spend more than 3 to 5 percent of the development's value on a transportation system. Without subsidies, this constraint will in general only be met if the system is a spur on a corridor system, and opportunities for such joint deployments are likely to be limited. As a consequence, the market for deployments in this market segment is likely to be limited without substantial subsidies. Assuming systems can be deployed at five centers, total capital expenditures are estimated to be $100 million.

- Medical Centers--The analysis suggests that it is unrealistic to expect many medical centers to follow Duke Medical Center in deploying AGT. The

Duke situation is felt to be anomalous in several important respects. It is a single institution located in a neighborhood without a significant crime problem; the system is being deployed in the context of a very large addition to the Medical Center; and nearly all its modern architecture is compatible with the system. Few similar opportunities exist.

- <u>Airports</u> already are a proven market for AGT. A continuation of dramatic increases in air travel will undoubtedly necessitate expansion and renovation at large numbers of airports. If ten to fifteen more airports were to deploy a system in the context of an expansion or renovation, capital expenditures are estimated to be in the range of $200 to $400 million.

Summary estimates of capital expenditures in each market segment are shown in Table 4.18. The total baseline estimate for all markets is approximately $4 billion or about $400 million per year if all systems were deployed over a ten year period. Somewhat less than half these expenditures would be for vehicles and off-vehicle control equipment. Typically at least half the capital costs of a deployment are for basic construction materials and on-site labor. Expenditures on conventional buses provide some perspective on the size of the AGT market. In 1975 total deliveries of new buses in the United States was about 5300 units.[1] At an average cost of about 100,000 dollars per unit, total expenditures for new buses exceeded $500 million (in 1978 dollars). In comparison, estimated annual expenditures are less than $200 million for AGT vehicles and off-vehicle control equipment.

These capital expenditures of $500 million for buses are currently supporting two major U.S. suppliers: General Motors and Flexible. A third firm recently left the market. Annual total expenditures are projected to be no more than $400 million in the AGT market for vehicles, stations and guideway. While strong conclusions can not be drawn on the number of firms that can be supported with this size market, the comparison with the bus market indicates that their number may be limited. Changes in Federal policy on

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[1]<u>Transit Fact Book</u>, American Public Transit Association, Washington, D.C. (1975-76 edition).

Table 4.18
Summary Estimates of AGT Capital Expenditures, 1980-1990

Market	Number of Potential Sites	Potential Capital Expenditures (millions)		Number of Sites Meeting B/C Criteria	
		Baseline	Maximum	Baseline	Maximum
Corridors	39 cities	3400	3900	24	26
CBD's	48	45	990	1	14
MDC's	approx. 15	100	NE	5	NE
Hospitals	approx. 15	5	NE	0	NE
Airport	23	300	NE	15	NE
Total		3850	more than 5290	45	more than 57

NE: Not Estimated.

Criteria Used in Construction of Table:

Potential Site:

Corridor: SMSA's over 500,000 without extensive rail.

CBD: All SMSA's over 500,000 plus two smaller areas which submitted DPM proposals.

MDC: Area over 4,000,000 ft^2 with at least two retail nodes.

Hospital: Medical centers with significant hospital, teaching, research, and support facilities.

Airport: Over 14,000 daily enplaned passengers (1975).

Site Meeting B/C Criteria, Baseline Case:

Corridor: AGT assumed to be deployed in all sites with B/C over .99; 75% of sites with B/C between .75 and .99; and 50% of sites with B/C between .50 and .74.

CBD: AGT assumed to be deployed in all sites with B/C over .75, and 50% of sites with B/C between .50 and .75. No bus cost reductions are included.

MDC: AGT assumed to be deployed in one-third of potential sites; only a minority of potential sites are likely to implement AGT due to cost reasons.

Hospital: No sites except Duke assumed to implement AGT.

Airport: All potential sites which have not recently expanded without consideration of AGT. (Airports which already have AGT's are also excluded.)

Site Meeting B/C Criteria, Maximum Case:

Corridor: AGT assumed to be deployed as in baseline, but with doubled gas prices.

CBD: AGT assumed to be deployed as in baseline, but with bus cut benefits included.

evaluation criteria and subsidy policy might double or perhaps triple capital expenditures but expenditures are likely to remain modest.

The rail transit car industry also offers evidence that the AGT supplier industry may face significant difficulties due to a limited market size. Several carbuilders have left the field recently, due to lack of standardization, lack of a steady flow of orders, foreign competition, and other issues. The size of the rail car market on an annual basis has been significantly larger than that projected for AGT systems.

CHAPTER 5
POLICY AND IMPLEMENTATION ISSUES

5.1 INTRODUCTION

The results of the national market analysis, combined with the findings of the individual city case studies and the consumer survey, indicate that the following eight policy issues are critical in affecting the deployment of AGT systems:

- performance capabilities
- costs
- personal security
- labor
- aesthetic acceptability
- economic development
- federal funding
- local funding

Their successful resolution consequently must be an important component of federal AGT-related policy making.

5.2 PERFORMANCE CAPABILITIES

The choice of a target AGT performance level is an important question of federal policy, involving fixed versus dynamic scheduling, vehicle size, vehicle speed, network configuration, and system reliability. Choosing too high a level of service could lead to higher development and implementation costs, without corresponding increases in ridership and system acceptability.

For the case city analyses, baseline assumptions were made for the study of AGT's operating capabilities, and were then reviewed with the local participants for each site to determine whether they were appropriate to the needs of each site. In corridors, AGT was assumed to have a maximum speed of 40 mph, and an average speed between 25 and 30 mph, depending on station spacing. While off-line stations with express operating strategies were tested in several sites, all the networks were small enough that the resulting time savings were minimal; thus, on-line stations were eventually chosen as the best configuration in all sites studied. Minimum headways of 60 seconds between vehicles were assumed; these were assumed to be possible with fixed block control. Vehicle size varied from 20 to 50 passengers at the sites. Once the on-line station strategy was chosen, and route headways of two to four minutes were established as maximum service levels required, a vehicle size of 30 to 40 passengers was assumed in the activity center settings, and trains of vehicles carrying between 100 and 200 passengers were required in corridors. Trains were assumed to be fixed, rather than dynamically entrained. Hourly line capacity, the product of train size and number of trains per hour, varied from a low of 600 passengers per direction per hour (30 single-passenger vehicles, 2 minute headways) to 6,000 passengers per hour (200 passenger trains, 2 minute headways). Some routing and switching capabilities were assumed in all sites; simplified terminals were designed, avoiding stub-end operations if possible. Demand-responsive operations were analyzed at several sites during certain periods, though most operations were assumed to be fixed schedule. AGT reliability was not addressed explicitly, but it was assumed sufficient to operate systems of moderate length (20 or 30 single lane miles) at close headways (60 seconds) with acceptable reliability, at least equal to a busway or rail system providing the same service.

In the 31 corridor settings analyzed for the national market estimate, the peak, two-way hourly volumes ranged from 1,000 to 7,000 passengers. At three minute headways, these volumes could be handled by 40 to 280 passenger trains; at two minute headways, the corresponding train sizes are 25 to 180 passengers. Ridership is virtually insensitive to headway at these levels (the difference in average wait time between 2 and 3 minute headways is only 30 seconds), and AGT operating costs are also fairly insensitive; their automated nature implies that costs will be more sensitive to vehicle- than to train-miles. Thus, a combination of headway and train or vehicle size should be chosen in this range that allows for stable and reliable operations.

In the case study cities, a maximum speed of 40 mph was adequate, although a small increase to 50 or 60 mph would make AGT more attractive. Routing and switching capabilities were generally useful in corridor systems to interface with CBD and other activity center AGT systems, and for operation with multiple corridors. Demand-responsive operation, however, was generally not necessary. Finally, some concerns over reliability with a system of the extent proposed for most of the corridors were expressed by the case city participants.

In CBD's and other activity centers, a maximum speed of 25 mph was assumed, producing an average speed of 10 to 14 mph including stops and speed restrictions. This was felt to be adequate in all sites. The assumed CBD base headway was two minutes in the peak (including noon periods) and four minutes in the offpeak. For activity centers, similar or slightly longer headways were used. Two-vehicle trains of 50-passenger cars were used in CBD's, while single 30-50 passenger vehicles were used in most other sites. Thus, two-way capacity is between 1,800 and 6,000 passengers per hour. This proved adequate in all suburban sites and in most CBD's, but was not adequate in approximately 15 of the larger CBD's if half the bus routes entering the CBD were terminated at a fringe station. In most of these cases, either operation of trains capable of holding 100 to 150 pasengers on 1 minute headways is required, or another DPM line must be built. The peak ridership would occur during the usual morning and afternoon peaks, though a substantial amount of ridership would be carried in the noon period as well. Thus, AGT capacity is an issue only in the largest CBD's.

Most cities appear to favor relatively simple alignments for DPM's, requiring little switching or routing flexibility. The ability to interface or expand a DPM into an areawide system was viewed with mixed emotions. While the service level would be excellent and the capital costs fairly low if a regional AGT used a DPM network in the CBD for collection and distribution, concerns over the possible increased size of guideways and stations and the increased complexity to users were also expressed. Demand-responsive operation was not necessary for general operations.

Airports and other activity centers also appear to view current AGT performance capabilities as adequate. In summary, most activity centers are interested in a fairly simple, reliable system with sufficient capabilities to serve as a useful extension to the circulation pattern at the site. The overriding concern expressed is cost rather than performance.

5.3 CAPITAL AND OPERATING COSTS

Major benefits of AGT are projected to result from a lower construction cost for AGT relative to alternative fixed guideway systems, as well as lower operating costs resulting from their automated nature. To be successful, these AGT cost savings must actually be achieved and not lost to cost increases.

AGT unit capital costs of $11 million per elevated two-way guideway mile, $1.4 million per station, and $0.45 million per 50 passenger vehicle were used as a rough baseline in all the analyses. Ranges were developed for each site using more site and system-specific estimates, but the numbers reported above are fairly representative of the average estimates. Operating and maintenance costs of $0.80 per vehicle mile were typical for corridor systems, with smaller activity centers often costing double that amount due to the lower number of vehicle-miles over which to spread fixed operating costs such as central control, station and guideway maintenance and operation.

In corridors, both AGT capital and operating costs generally showed an advantage over LRT and busway costs. There were some doubts expressed by local agencies, though, that AGT capital costs would be substantially lower than those for LRT. As expected, there was also much uncertainty over AGT's projected operating costs. Local areas differed in their willingness to trade off these anticipated cost savings against the risks of a new technology in a corridor setting, so no general response can be reported. Given the relatively small differences in ridership, visual issues, and economic development stimulus of the alternative corridor modes, a cost advantage is likely to be AGT's strongest competitive edge against other systems. The cost issue was also ranked as the most important in many local alternatives analyses, and thus it appears critical that AGT's advantages in this area be documented and proven if a market is to be developed.

In CBD's, costs proved not to be an overriding issue. The estimated costs of $20 million to $80 million are within the resources of most areas, assuming 80 percent federal funding is available; and several CBD's appear willing to raise the local share of DPM capital costs if the benefits can justify the system's construction. The ongoing operating costs appeared to be of greater concern, however, and satisfactory methods to cover any deficits are important. As revenues derived from DPM fares will usually not cover its operating costs, two alternative sources for funds that can be applied to the deficit are the DPM fringe parking revenues and the savings from cuts in CBD bus operations. Even in the absence of these, however, deficit funding may still be possible, perhaps through public and private cooperation. In summary, costs do not appear to be a major deterrent to CBD applications.

A very different picture emerges in suburban activity centers, where costs are an overriding concern. Developers appear willing to spend perhaps up to 5 percent of the value of a site on a circulation system, but an AGT system sufficient to link all the elements of a site cannot be built for this amount at the unit costs assumed. Typically, a reduction in costs by a factor of 2 to 5 is required. An 80 percent UMTA capital grant would provide the needed reduction in costs but is viewed by local actors as extremely unlikely given UMTA's current priorities. Operating and maintenance costs also are a concern to these sites, many of whose representatives had hoped that AGT would be less expensive to operate than an equivalent bus system. At the relatively low levels of operation appropriate to suburban centers (generally near 500,000 vehicle-miles per year), AGT does not appear to show an operating cost advantage over bus, and may in fact be more expensive. Thus, cost emerges as a key issue and, in fact, the key barrier to suburban center implementations. Most other AGT impacts, such as visual, security and development impacts, were generally viewed favorably.

Airports, which often implement AGT as part of a larger development or expansion effort, appear to be finding current AGT costs acceptable. Use of AGT allows the airport design to be more flexible, and enough cost savings and other benefits can occur through this to justify the AGT system. As airports grow larger, the use of AGT or other circulation systems is likely to increase to keep walking distances at a reasonable level within the terminal areas. Current experience shows that AGT costs are acceptable to airports.

For hospitals and medical centers, costs are often a barrier. Many hospitals require their transportation facilities (such as parking garages) to be self-supporting for capital and operating costs; it is very difficult for an AGT system to meet this requirement. If it cannot be self-supporting, the other potential justification for absorbing its costs is that the AGT improves the quality or improves the efficiency of health care at the facility. This condition is likely to exist only at a single, multiple-building institution which shares functions across its set of buildings. Few such sites exist; thus, in most sites, the cost of AGT cannot be borne by the medical institution. In summary, financing the cost of AGT in medical applications appears to be a significant barrier in most, though not all, sites.

5.4 PASSENGER SECURITY

5.4.1 BASIC ISSUES

AGT's automated features have raised concern about passenger security. Issues of basic concern are the security implications of:

- unattended stations
- unattended vehicles
- off-peak operations
- elevated platforms

While substantial security problems could be encountered in operating an AGT system with potentially disastrous impacts on ridership, in several important respects security problems are no different in AGT systems than in other guideway systems. Certain features of all fixed guideway technologies make them potentially conducive environments for crime.

Transit station security problems are principally attributable to their design and isolation from the external environment. Offenders can strategically locate themselves for easy escape while simultaneously blocking the victim's avenues of potential flight. Also, by choosing lightly patronized stations their potential victims have no security in numbers. The deterrent effect of an attendant is probably only marginal. Attendants are nearly always physically isolated from passengers, often do not have a full view of the station and in any event are not regularly scanning the platform. Moreover, attendants are not intended to provide security and indeed they are chief targets of robbers operating in transit stations. AGT is not the only system to use unattended stations; several current and planned rail systems use unattended stations in many areas, especially during evening off-peak hours when security concerns are the greatest. Also, closed circuit television systems are a potential security device at unattended stations. Thus, the issue of unattended stations is neither central nor unique to AGT.

Security problems on unattended AGT vehicles, particularly those with small capacity, are likely to be greater than on attended vehicles, but the difference may be small. Operators on rail vehicles are typically separated from passengers and can only view one or two cars in a multiple car train. Moreover, operators often are not trained in policing tactics. Robberies of bus fare box receipts, which were the principal motivation for exact change fare systems are evidence of an operator's vulnerability. One distinct security advantage of attended vehicles is that if an operator witnesses a criminal incident, a radio call can be made for police assistance at the next station. For this advantage to be realized, however, the operator must witness the incident and police must respond quickly. The operator rarely intervenes directly. In some cases, a passenger-operated emergency call system may provide the same level of security as an operator by summoning police to the next station.

Attended vehicles and stations might provide a sense of security to potential users even if attendants do not substantially improve actual security. Such a purely psychological effect is likely to be short term. If a system operates without serious security problems, anxiety about security is likely to diminish. If security problems do arise, attendents are unlikely to reduce anxiety. The New York subway system's serious criminal problem is evidence of the ineffectiveness of attendants alone in deterring criminal activity.

Passenger vulnerability to crime is greatest during off-peak operating hours because fewer persons are in stations and vehicles. Isolating the potential victim is an obvious strategical consideration in committing a crime. Security problems during off-peak hours are specifically relevant to AGT because its automated features can make late night operations economically feasible whereas if an alternate non-automated technology were deployed, such operations would not be practicable. One potential solution to this problem is deployment of a security force during offpeak operations. Such an action, however, might jeopardize the economic viability of off-peak operations.

A final issue of basic concern is passenger security on elevated platforms. Elevated (and subsurface) stations are particularly conducive environments for criminal activity. The problem, however, is not specific to AGT; all fixed guideway technologies using elevated or subsurface stations suffer from the problem that such stations attract criminal activity. Research on designing elevated and subsurface stations to minimize passenger vulnerabilty to criminal activity has been done and is still underway. The results of this research deserve careful scrutiny.

5.4.2 CASE STUDY RESPONSES

Personal security emerged as an issue of principal concern at only one case study site, the State of Illinois Medical Center. This medical center is situated near a neighborhood with a significant crime rate, and the local participants' concern about passenger security is likely to be well founded. Some concerns about passenger security were also voiced at the Dallas Market Center and North Michigan Avenue in Chicago, but security considerations were not viewed as significant obstacles to deployment at either site. Problems at these sites were regarded as the typical ones found in a CBD environment, which both of these sites are near. The North Michigan Avenue site was viewed by some participants as a serious security problem due to its use of elevated stations. In the remaining case studies, security was not an issue.

The results of the case studies suggest that passenger security will only be a substantial issue if the system is deployed in a high crime rate location where threats to passenger safety are real. Only in Merrillville was there some concern about an AGT generating criminal activity in an otherwise low crime rate area.[1] It is unlikely that such a phenomenon would occur; a transit system may affect the distribution of crime but it is unlikely to induce additional crime.

In summary, AGT's security problems do not differ substantially from those of other fixed guideway systems. The presence of operators on unautomated technology may provide some deterrent to crime but the effect, though unknown, is likely to be small. Operators are neither trained nor equipped to provide security, nor is passenger security their function. Security problems are best addressed with appropriate station designs and, if necessary, with a transit security force. The latter necessarily increases operating costs but incremental increases will not differ appreciably among alternative technologies.

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[1]Merrillville has a problem with property crime but violent crime which includes robbery is virtually non-existent.

5.5 LABOR COSTS AND PRODUCTIVITY

5.5.1 SECTION 13(c)

AGT's promise to both reduce labor costs and increase productivity is among its chief potential benefits. Labor costs typically are over 60 percent of a transit system's operating expenses. Not surprisingly, any technology having the potential for increasing labor productivity is greeted with keen interest.

A major issue in realizing labor savings benefits from investments subsidized by UMTA grants is Section 13(c) of UMTA's enabling legislation. Section 13(c) makes a condition of nearly all UMTA financial assistance "that fair and equitable arrangements are made...to protect the interests of employees affected by such assistance." Employees displaced by a project receiving UMTA funds must be made "whole." In practice, their being made "whole" requires transferring them to positions equivalent to their prior function or creating such a position. Equivalence implies at least equal remuneration. If remuneration is less, the grantee is required to make up the difference. If retraining is necessary, the grantee is expected to provide the training at no expense to the employee. If the employee is laid off, the grantee is expected to make up the difference between the employee's previous salary and unemployment benefits for a period of time.

The key restrictions in the scope of Section 13(c) are that it applies only to UMTA funded projects and in effect does not apply to projects that <u>only</u> extend existing service. If UMTA grants are not used in funding a project, 13(c) has no legal force. It is also not intended to prohibit use of federal funds for investments in labor saving technologies that solely extend existing service. While such investments will typically reduce long term labor requirements, they do not threaten the interest of current employees.

If a grantee's employees are unionized, Section 13(c) requires that an arrangement for satisfying the provisions of 13(c) be negotiated between the grantee and the union. Such contracts have been negotiated in St. Paul, Detroit, Los Angeles and Miami in anticipation of DPM deployments in these cities. The principal provisions of the contracts are:

1. Displaced employees will be given first opportunity for employment in any new jobs created as the result of the DPM project. New job selection will take place one year before the DPM project is to begin operation.

2. If an employee fails to find a job and is still adversely effected, the person is entitled to a "displacement allowance." The allowance provides the employee with last year's average pay for up to six years, depending upon seniority.

3. A displaced employee may accept a lump sum payment separation allowance of between three and twelve months pay.

The intent of 13(c) is not to reduce productivity or to institutionalize inefficiency. While 13(c) will not necessarily jeopardize the productivity gains or cost efficiencies of the specific project initiating the 13(c) agreement, it can inhibit system-wide improvements in productivity and cost efficiencies. The requirements for making displaced employees "whole" require, at the minimum, that the employees be given a lump sum termination payment; however, in virtually all instances where employees are displaced, they have been transferred to positions made available by attrition or by expanding service. To the extent that transferred employees lack the qualifications for effectively meeting the demands of the position or the position is created chiefly to "make work" for the displaced employees, system-wide improvements in efficiency are likely to be largely negated.

5.5.2 POTENTIAL AGT IMPLICATIONS

Section 13(c) provisions have differing implications for the various AGT market segments, with the airport, suburban center, and hospital markets largely unaffected. None of the airports that have constructed or plan to construct AGT's have received UMTA funding; 13(c) is thus not applicable. Moreover, even if UMTA were to fund an airport AGT, 13(c) would typically have no legal force because current transit system employees still would not be affected. Similarly, 13(c) provisions are unlikely to have any significance for suburban center and hospital AGT deployments. In many such sites, there is no existing transit service. Thus, even if UMTA supported the deployment, 13(c) provision would not be relevant. If a transit system were in place and UMTA funded the deployment, then 13(c) provisions would have to be honored, but typically the displaced employee could easily be absorbed because the systems are generally small.

Section 13(c) requirements are, however, significant to the CBD and corridor markets. The national markets analysis suggests that 13(c) will have the greatest impact on the CBD market, since the potential savings in bus operating and capital costs from terminating a substantial proportion of bus routes at fringe stations are among the largest benefits of a DPM deployment. Section 13(c) agreements may provide a barrier to fully realizing these benefits. The great proportion of operators freed by terminating CBD bound bus routes at fringe stations are likely to be used to expand service on routes not entering the CBD or to create new routes. If such expansions in service would have occurred without a DPM deployment or are otherwise cost-effective, the bus operating and capital benefits will be realized because additions to the fleet and labor force would have been necessary without the deployment. It is perhaps more likely, however, that the expansion will be forced by the 13(c) agreement. Unless this service is cost-effective, the full benefits of the reduction in CBD bus operations will not be realized.

The 13(c) clause also is relevant to the corridor market for AGT but its significance in affecting the attractiveness of AGT in this market is markedly less than in the CBD market. A corridor deployment of a fixed guideway system will typically permit a reduction in corridor bus service, but not all bus service can be cut because extensive bus feeder service is still a necessity. However, the realignment of corridor bus service from a CBD orientation to a route structure suitable for feeder will generally permit an appreciable reduction in corridor bus operations. If a non-automated technology is deployed, operators and maintenance personnel displaced by the reduction in bus operations can typically be usefully reassigned to new positions created by the system deployment. If an AGT is deployed, reassignment to positions associated with its operation may be difficult. If vehicles are unattended, operators cannot be reassigned to the system. Reassignment of maintenance personnel may also be difficult without extensive retraining.

While 13(c) may reduce the potential benefits from reductions in corridor bus operations, the analysis of the national market for corridor deployments of AGT reveals that the bus cut savings are small relative to other benefits. The number of cost-effective corridor deployments of AGT is unlikely to be greatly affected by 13(c) provisions and AGT's relative desirability with respect to alternative fixed guideway technologies is also unlikely to be appreciably altered.

5.6 VISUAL AND URBAN DESIGN CAPATIBILITY

Several findings of the case studies and market analysis bear on the aesthetic acceptability of AGT. While the sample and the level of detail on which these findings are based are too small to generalize, they do point out some interesting possibilities.

In corridor settings, the bulk of the potential sites appear to have rail and expressway rights-of-way that will not pose severe visual problems for any transit technology. System designs in rail or expressway corridors can be very similar for rail, busway, and AGT; thus the issue of AGT's acceptability in an elevated configuration in areas where other modes require tunnelling does not exist in most of the corridors studied. Only if a fairly extensive transit system is envisioned will it be necessary to build along arterials for significant sections.

It was found that station location within corridors did not affect system patronage strongly. The bulk of trips on a corridor system are CBD-oriented, and few people are within walking distance of stations no matter where they are located in the corridor. Since most of the riders thus need to use feeder service as well, the exact station locations in the corridor are less important. Only a small fraction of the transit trips will be intracorridor trips where stations located at the primary nodes would be critical. These results point to the use of rail or expressway rights-of-way even if they are somewhat removed from the axis of development in a corridor, suggesting that stations can be located with a large amount of flexibility and maximizing the opportunity to lessen their visual impacts. Again, this applies to all modes.

This ability to have flexible station locations could be an aid to AGT systems. The case studies indicated that there could often be significant opposition to stations in residential areas, and there are typically greater opportunities for designing stations in commercial areas because the scale and activity of the transit station are more compatible with existing activity patterns. Providing large amounts of parking appears to be difficult at most potential locations; thus, feeder services will generally be a more acceptable means of providing access to stations. In summary, for corridor systems, the elevated versus subway issue may not be encountered directly in most candidate corridors, as rail lines and expressways may provide the lower cost, lower impact rights-of-way without sacrificing much ridership. Stations along these rights-of-way in commercial areas, without major parking facilities, are most likely to be acceptable on a variety of visual and community issues.

In CBD's, visual issues in the denser areas with narrow rights-of-way appear to be potentially quite significant. In fringe areas of possible redevelopment, visual issues generally are not a problem. In all areas of a CBD, joint development that masks or de-emphasizes the guideway appears to be a goal of all interested parties. Station sites are particularly sensitive areas due to their size.

A possible offsetting factor to an elevated guideway's visual impacts is the possibility of reducing CBD bus volumes substantially. In addition to the cost savings attendent to such a change, there is a significant reduction in noise and vehicle volume. In some cases one or two lanes of the street may be closed without affecting traffic flow, or conceivably the entire street can be closed, if buses are removed. The amenities of wider sidewalks and a quiet environment may make the overall impacts of a guideway acceptable and even desirable. If traffic is removed, centerplatform stations which are less massive than sideplatform stations can also be used. As in corridors, the AGT system is more likely to be acceptable in commercial areas than residential areas, where opposition is likely unless the design of the AGT is well integrated with other structures.

In suburban centers, visual issues often will not be a problem. While there may be strong concerns over aesthetic issues at most sites, solutions appear to be generally available. These include the location of as much of the system as possible along existing visual barriers (primarily expressways along which most candidate suburban sites are located); incorporating stations either into buildings or making their design very similar; and maintaining high quality design and materials for the guideway, stations, and vehicles. The relatively young age of most developments and the large amounts of space between buildings also tend to lessen the visual impacts of the system. In some suburban centers, particularly with low building heights, there may be a feeling that an elevated system is incompatible in scale. Also, in centers which are very linear in their development, the system must be routed along either the front or back of buildings, both of which may be important areas visually. In more clustered developments, guideways can be a less visible element, passing between buildings and turning more frequently. In general, the visual issues at most suburban sites appear to be tractable.

Airports pose few visual problems; the primary constraint appears to be to find an available right-of-way for a system in airports that were not originally designed for AGT. Medical centers and perhaps other institutions likely will have mixed reactions to AGT's visual impacts. Narrow rights-of-way, generally older architecture, and the need to integrate the system quite extensively with existing development for security reasons will create potential problems. However, if AGT is introduced in conjunction with a broader set of changes (e.g., Duke Medical Center) such as satellite parking areas, street closings, and new, integrated development, many of these issues could be overcome.

5.7 ECONOMIC DEVELOPMENT

5.7.1 THEORETICAL PERSPECTIVE

Recognition of the dependence of economic activity on an effective transportation infrastructure has been among the chief rationales for massive transportation investments. Gasoline shortages and work stoppages in any of the principal sectors of the transportation industry provide rapid evidence of modern society's dependence on its transportation system. While the specifics of this interrelationship of transportation and economic development are not well understood, there is, nonetheless, general agreement on the elemental principle that transportation systems facilitate economic activity by providing mobility. A corollary principle is that reductions in the monetary or time costs of moving either people or goods will facilitate economic activity. In the context of urban mass transportation, this suggests that the development impact of an investment in transit service will bear a direct relationship to the extent that the investment reduces the costs of travel. The mechanisms by which the reduced costs of travel influence economic activity, however, differ by sector of the urban economy.

In the retail sector, the relative accessibility of opportunities is fundamental to economic survival. Retail establishments that are relatively more accessible to potential customers typically have a distinct competitive advantage. A cogent argument can be made that the decline in central city retail activity in many large metropolitan areas is principally attributable to changing patterns of accessibility. The simultaneous growth of the suburban ring, the expansion of metropolitan freeway systems and the increase in auto ownership created the market for large suburban shopping malls. With the development of the suburban shopping malls, central city retail concerns lost their competitive advantages in terms of relative accessibility for attracting a large population of potential shoppers. The decline in central city retail activity and the resulting reduction in the number and sometimes quality of retail opportunities further exacerbated the competitive disadvantage of central city retailers.

A public transit system will improve the relative accessibilities of retail opportunities it serves if:

- The system reduces the cost (time or monetary) of traveling to these retail opportunities from the home or work place.
- The system increases the effective density of retail opportunities (the number of retail concerns within a given access time).
- In the long term, a system affects land use patterns. The system's potential for providing ready accessibility among points it serves may stimulate development along its alignment.

In the commercial sector, issues of relative accessibilty chiefly affect employees. Firms that are relatively more accessible have a competitive advantage in recruiting employees because commuting costs are relatively less. Relative accessibility may also affect the competitive position of commercial sub-sectors that have substantial personal contact with customers (e.g., sales) or have close contact with some centralized institution (e.g., Wall Street brokerage houses).

In considering AGT's potential for facilitating economic development, it is useful to distinguish between factors unique to AGT and those common to fixed guideway technologies. In the corridor setting, AGT does not appear to have any substantial advantages over other fixed guideway technologies with regard to stimulating economic activity.[1] Predicted ridership on AGT is marginally larger than the alternate technologies studied, LRT and busway, but the predicted difference is not sufficient to stimulate substantially greater development.

A CBD-oriented fixed guideway system's impact on development either along a corridor or within a CBD cannot be predicted with great precision but one would expect some correspondence between the improvement in level of service and developmental impacts. The case studies of corridor applications suggest that a fixed guideway system would induce a moderate increase in transit's share of CBD-bound trips. For non-CBD trips within the corridor, the analyses suggest that between 5 to 10 percent of the trips would be made by transit. While the expected increases in transit use suggest appreciable increases in the accessibility of areas served by the system, the increases are not dramatic. Accordingly, predictions of substantial developmental impact <u>attributable exclusively to corridor deployment</u> may be excessively optimistic.

Within CBD's and surburban activity centers, AGT is judged to be the most feasible new fixed guideway technology. From a theoretical perspective, an AGT can contribute to economic development by increasing the effective density of retail opportunities. In the short term, effective density can be increased by improving the accessibility of existing retail opportunities. In the longer term, effective density

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[1]An exception to this observation is busway. The noise and emissions from buses are likely to substantially reduce the desirability of development surrounding a station.

can be increased if development concentrates in and around stations. The magnitude of the increase in effective density will be determined by the degree to which DPM improves existing mobility. In the CBD setting, the case studies suggest that the improvement may be only modest; DPM is predicted to attract about 5 percent of all intra-CBD trips,[1] and this percentage of trips is unlikely to be sufficient to have a substantial effect on economic development within the entire central business district. It could have a more dramatic impact, though, on the location of new development that does occur.

DPM's mode share is largely attributable to existing patterns of development. Since most development evolved in the absence of any expectation of a DPM-like system being deployed, patterns of development typically reflect the necessity of easy pedestrian access. The clustering of restaurants and shops in and around office complexes and the clustering of small shops around large department stores both reflect the role of pedestrian access. Only if a large proportion of a CBD's retail and business concerns are, or can be, located within easy access of the system will a DPM contribute significantly to accessibility and thus to economic development.

AGT's potential for facilitating economic development in suburban activity centers is particularly uncertain. One important feature distinguishing suburban activity centers from CBD's is that many of the former are only in early stages of development. If development plans are formulated to take full advantage of AGT, then accessibility among nodes in the development may conceivably be substantially better than it would have been in the absence of an AGT deployment. The relationship of intra-activity center accessibility to development potential is not well understood. Accordingly the impact of an AGT on economic development is uncertain.

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[1]This projection is based on the use of the demand models in the <u>DPM Planning Manual</u> in several sites (Chicago and Dallas in this study, and Los Angeles, Detroit and St. Paul in other studies). The DPM models have validated quite well on existing data, and offer the best projections of DPM's effects on demand short of actual experience.

Airports are the only potential market for AGT where development benefits are demonstrable. Growth in air traffic has necessitated such substantial expansions in the physical size of many airports that distances separating terminals or ramps connecting terminals to gates are prohibitively long for walk access. AGT appears to be an effective technology for providing the mechanized transportation increasingly necessitated by recent airport designs.

In summary, the economic development benefits of AGT are generally uncertain. The limited theory on the relationship between transportation and economic development suggests that in corridor and CBD settings AGT may not greatly influence economic development. Current theory is, however, sufficiently incomplete and unvalidated that a confident prediction of AGT's potential for stimulating economic development is not possible. Further, new economic development does not automatically translate into an equivalent economic benefit attributable to the AGT deployment. As discussed in Chapter 3, true economic benefits generally will be smaller than the total new economic activity and it is only these true benefits that should be directly incorporated into an economic analysis. Thus, the benefits of AGT's effects on economic development cannot be stated as being insubstantial, but neither can they be assumed to be substantial.

5.7.2 INITIAL DPM EXPERIENCE

A shared characteristic of all cities actively formulating plans for a DPM deployment is that their CBD's are currently undergoing renovation. In Bunker Hill, which is a major area served by the proposed DPM in Los Angeles, hotels, condominiums and office complexes are currently under construction or in advanced stages of planning. In downtown Miami, in addition to hotel, apartment and shopping mall construction, a new convention center and government center are under construction. Detroit's much publicized Renaissance Center is only one part of a major renewal program.

Assessing the effect of the planned DPM deployments on the renaissance of the CBD's of candidate DPM cities is difficult. DPM clearly cannot be discussed as inconsequential solely because the renovations predate the actual deployment and indeed in some instances plans for deployment. The willingness of St. Paul's business community to encumber substantial liability for the system's operating deficit is significant evidence of their perception that DPM is vital to the economic viability of downtown St. Paul. The intense debate in Miami on the alignment of the first stage deployment of the proposed system is further evidence of the importance the business community places on being near the system. Nonetheless, evidence of business support, however accurate, does not constitute evidence of DPM providing a demonstrable economic benefit from new development. The support, though, does constitute a belief that DPM will contribute significantly to expanded business activity and that this new activity will eventually translate into economic benefits.

The economic vitality of a CBD is not exclusively a function of fundamental economic issues such as taxes, zoning regulations, accessibility, proximity to markets and labor costs. Highly visible symbols of progressiveness and commitment to development also may serve as a catalyst to further economic growth. To the extent that a DPM constitutes a symbol of civic commitment to development, this may contribute indirectly to an improved economic infrastructure.

5.7.3 POLICY IMPLICATIONS

The principal observation that emerges from an examination of the potential economic development benefits of AGT is that their magnitude is highly uncertain, and federal policy toward AGT must be formulated in cognizance of this uncertainty. If the existence of significant economic development benefits is pivotal to a policy decision to deploy a specific AGT system, then it should be explicitly recognized that this decision is based on a highly uncertain premise. A second observation of importance to formulating federal policy is that AGT's potential for making a contribution to economic development is unique in CBD's, suburban activity centers and airports but not in an urban corridor setting. In corridor settings, AGT's economic benefits are unlikely to be substantially different than those of conventional rail systems.

5.8 FUNDING OF CAPITAL AND OPERATING COSTS

5.8.1 FEDERAL FUNDING

UMTA is the principal source of funds for capital investment in public mass transportation. Capital costs for substantial renovation or replacement of existing capital stock or for extension of the existing service network typically far exceed the financing capabilities of transit authorities or local governments. Without UMTA support, virtually all large investments in mass transportation would be infeasible.

The great proportion of UMTA's funding authorization originates from Sections 3 and 5 of the Surface Transportation Assistance Act. Section 5 monies are allocated among urban areas by a formula mechanism, with grants chiefly determined by population and population density. Funds distributed under Section 5 are substantial, over $1.5 billion in 1979. The authorization for 1982 is nearly $1.8 billion.

Transit authorities have considerable discretion in using Section 5 grants and these monies may be used for capital investments. However, in the past virtually all of the Section 5 grants have been used to subsidize operating expenses. In view of the precarious financial condition of most transit authorities and their substantial operating deficits, the incentives to use Section 5 grants to finance operational expenses rather than capital investment are unlikely to be reduced. The authorization for 1979-82, however, requires that a proportion of the Section 5 grants be used for capital improvements. The appropriation for 1979 and 1980 specifically designates $300 million for purchase of buses and related equipment and for construction of bus-related facilities. The bus purchase set-asides for 1981 and 1982 are $370 and $455 million respectively.

While the set-asides for bus capital costs cannot be used for capital investment in fixed guideway systems, they should reduce competition for Section 3 funds. The Section 3 grant fund is the largest discretionary grant authorization in the federal budget and is the principal source of funds for capital investments in urban mass transportation systems. Since its inception, Section 3 grants have grown from just over $50 million in 1964 to nearly $1.4 billion in 1978. Section 3 funds are used exclusively to subsidize capital investment in transit systems and underwrite 80 percent of a project's capital cost.

Section 3 grants are the chief source of funds for purchases of buses, modernization and extension of existing fixed guideway systems and deployment of new systems. Table 5.1 shows the distribution of Section 3 grants by purpose for the period 1964-78. Nearly

Table 5.1
Allocation of Section 3 Funds, 1964-1978

Category	Amount ($ millions)	Percentage of Total
Bus Replacement	2,942	35
Rail Modernization	2,460	29
Rail Extensions	1,270	15
New Rail Starts	1,659	20
Other	71	1
Total	8,402	100

65 percent of the Section 3 grants have been used for bus purchases or modernization of existing fixed guideway systems. Only $1.7 billion or 20 percent of the total has been used for deployments of new fixed guideway systems. Any future capital grants for deployment of an AGT would be included in the latter category.

Congress has placed only very limited restrictions on UMTA's authority to distribute Section 3 monies among categories of capital investments. Past emphasis on using Section 3 monies for maintenance of existing capital stock is, however, unlikely to change markedly in the near future.

For 1979 the Section 3 appropriation is nearly $1.4 billion. Of this about $250 million or 20 percent is earmarked for new deployment.

Requests for Section 3 grants far exceed authorization amounts. It is UMTA's policy to limit its support to projects judged to be cost-effective, measured "by the degree to which the proposed investment meets the urban area's transportation needs, promotes its social, economic, environmental and urban development goals, and supports national objectives."[1] By and large, the task of defining the dimensions of cost-effectiveness is the responsibility of the local agency requesting support.

5.8.2 LOCAL FUNDING

Section 3 funding requires local financing of 20 percent of the capital costs of the system. Moreover, UMTA grants for operational expenses subsidize only about 50 percent of the operating deficit. Thus, transit authorities contemplating deployment of an AGT system must develop the funding necessary to meet the local match and confront the increasingly difficult problem of developing funding sources to finance the local share of the annual operating deficit.

The availability of funds to finance the local obligation for capital and operating expenses is likely to be one of the major factors determining deployment rates in the principal segments of the AGT market, corridors and CBD's. Local funding is also an important limiting factor for deployments in the suburban activity center market, but currently the potential deployment opportunities in this market

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[1]Federal Register, Vol. 41, No. 185, Sept. 22, 1976.

segment appear to be relatively smaller. Only in the airport market is funding a relatively minor concern to potential operators.

Capital costs for a DPM or corridor AGT system are dependent on system length, vehicle requirements and guideway construction type. Variations in the local share of total capital costs can be quite large. The local share for a DPM will typically range from five to $15 million. For a corridor system, the analysis suggests a range of $10 to $40 million.

Even the minimum estimates of the local share may be viewed as large from a local perspective. In some instances, the burden for financing the local share can be reduced by a state or county subsidy. For example, the State of Florida has made a commitment to pay 10 percent of the capital cost (i.e., half the local share) of Miami's proposed DPM, and Dade County has made a 5 percent commitment. More typically, however, a bond issue will be used to finance a large portion of the local share, creating the necessity to develop a funding source to finance the annual debt.

A variety of sources are available for meeting the local obligation for debt retirement and the operating deficit. In St. Paul the business community pledged up to $800,000 annually to underwrite the operating deficit of the proposed DPM. (The deficit may exceed $1.7 million.) The business community commitment will be collected by an assessment dependent on proximity to the system. However, St. Paul's direct commitment from private concerns is atypical.[1] More generally, the local commitment is financed principally by general fund appropriations or special taxes.

A large number of states, but not the majority, regularly provide operating subsidies for local transit services from general revenues. A more desirable arrangement from the local perspective is development of a long term financing instrument generating a predictable amount of funds that is less subject to the uncertainties of the annual budgeting process. Such revenue sources are principally special taxes specifically designated for transit use. Table 5.2 catalogues the special taxes specifically committed to transit in major U.S. metropolitan

[1]It should also be noted that similar efforts to obtain private commitments are underway in Los Angeles and Miami.

Table 5.2
Taxes Designated for Transit in Major U.S. Metropolitan Areas

Metropolitan Area	% of Operating Expenses Covered by Fare Box and Other Transit Revenue	Tax Funds Committed Specifically to Transit
Atlanta	25	1% sales tax. Currently split 50-50 between operating and capital; maximum of 50% to operating.
Baltimore	N/A	1) $.09 per gallon gasoline tax 2) Motor Vehicle registration fees 3) Motor Vehicle excise tax of 4% on any transfer of titles 4) Corporate income tax of 0.75% (Tax revenues go into a common transportation fund)
Boston	25	1) Property tax 2) Cigarette tax $.04 a pack
Chicago	65	1) 3/32 of sales tax collected in region 2) $14 of each motor vehicle registration fee collected in Chicago 3) $5 million mandated appropriation from Cook County or Chicago 4) Up to 5% gasoline tax (collected at 5% as of Oct. 1, 1977) 5) Parking tax (not collected at this time)
Cleveland	30	1% sales tax
Detroit	43	State general transportation fund from 0.5¢/gal. gasoline tax
Houston	50	None
Kansas City	35	0.5% sales tax, of which 85% may be used for operating expenses
Los Angeles	40 (est.)	0.25% sales tax
Milwaukee	66	County property tax

Table 5.2 (continued)
Taxes Designated for Transit in Major U.S. Metropolitan Areas[1]

Metropolitan Area	% of Operating Expenses Covered by Fare Box and Other Transit Revenue	Tax Funds Committed Specifically to Transit
New York	*60 (est.)	*0.5% mortgage tax. Funding from Triborough Bridge and Tunnel Authority tolls
Philadelphia City Trans. Div.	55	None
Pittsburgh	53	None
St. Louis	31	1) 0.5% sales tax from St. Louis City and County, of which 85% may be used for operating expenses 2) 2/32 of the sales tax collected in the 3-county Illinois service area
San Francisco		
AC Transit	35	1) 45.9¢ per $100 property tax 2) Portion of 0.25% gasoline tax
BART	39	1) $.05/$100 property tax (operating) 2) 0.5% sales tax (operating) 3) 0.25% sales tax (capital) 4) Portion of 0.25% gasoline tax
Municipal Railway	*28	1) Portion of 0.25% gasoline tax 2) Operating deficits met by various city/county taxes
Seattle	32	1) 0.33% sales tax 2) 1% auto excise tax
Washington	57 (est.)	None

[1] Data from non-transit-authority source.

Source: January/February 1978/Metropolitan Magazine.

areas. Also included in the table are estimates of the percent of operating revenues covered by fare box receipts and other transit revenues. The operating deficit is typically over 50 percent of operating expenses and is never less than 30 percent of operating costs. These external revenue sources are clearly crucial to financing transit operations. The special taxes can be categorized as either taxes on auto use, sales taxes (specific or general), or property taxes.[1]

Continued availability and quite possibly expansion of such revenue sources will be crucial to the development of AGT markets. The probable necessity of instituting or expanding special tax revenue sources to make AGT deployments financially feasible from the local perspective could be an important impediment to deployment, given the increasingly grudging publc attitude on expanding governmental taxing authority. Winning legislative or municipal consent to increase property taxes also may become increasingly difficult. The sales tax financing instrument may be politically more palatable because the tax increment would be small but any increase could still arouse opposition. Corridor deployments are particularly susceptible to such opposition because typically only a minority of the regional population will directly benefit from the system.

The possibilities of approval for new taxes to support transit, however, are not uniformly bleak. The federal policy commitment to reduce gasoline consumption, the uncertainty of oil supplies, and the increasing costs of gasoline have created an environment that is, at least, tolerant to tax increases for support of expanded transit operations. Since corridor systems are likely to induce meaningful decreases in fuel consumption, the fuel reduction argument can be important in winning support for a special tax. A counterpart argument for DPM, though, is more precarious, since a DPM is unlikely to reduce auto fuel consumption substantially.

The vagaries of the political process and public attitudes on tax increases make the success of moves to institute special taxes for transit uncertain. If legislatures and municipalities prove unwilling to grant the necessary taxing authority, then the number

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[1]The corporate income tax for Baltimore does not fit into any of these categories.

of AGT deployments will be more limited than would otherwise be the case.

5.8.3 SUFFICIENCY OF FEDERAL FUNDING TO FINANCE EXPECTED AGT MARKET

Federal funds must be sufficient to subsidize the identified CBD and corridor AGT deployments if the target market is to be achieved. The 1978 Surface Transportation Assistance Act includes authorizations for Section 3 grants for 1979 through 1983 and designates specific amounts of Section 5 monies for bus replacement (Table 5.3). The total Section 3 authorization of nearly $7.5 billion is more than sufficient to finance the market of cost-effective AGT deployments but competing uses for Section 3 monies, including rail modernization, rail extension and bus capital, are certain to make substantial claims on the authorization. Table 5.4 shows the actual apportionment of Section 3 funds among competing uses through 1978 and expected apportionments for 1979 through 1981. To date, new fixed guideway starts have been allotted about 20 percent of the Section 3 monies and the allocations to new starts through 1981 are expected to remain at that level. Thus, of the total $9 billion appropriation through 1983 for capital subsidies, grants for new starts are likely to be $2 billion or less.

The national markets analysis suggests the capital requirements for the total market of cost-effective corridor and CBD AGT deployments to be in the range of $3.5 to $4.9 billion. Of the estimated $2 billion available through 1983, less than $220 million is specifically designated for AGT (the DPM program).[1] Thus, AGT will have to compete with other fixed guideway technologies for the remainder of the available funds. Moreover, a large proportion of the remainder appears to be already committed to rail deployments in advanced stages of planning (e.g., Miami, Buffalo, and Baltimore).

From a longer term perspective, the adequacy of funding may be somewhat more promising. In Table 5.5, projections of federal capital subsidies for 1980 through 1989 are given. All projections are in 1978 dollars, assuming a 6 percent inflation rate. Three projections are given. The funding for 1980 through 1983 is identical for each and is calculated from the actual appropriations in the Surface Transportation

[1]About $10 million of the $220 million appropriation has already been spent.

Table 5.3
Surface Transportation Assistance Act of 1978
Section 3 and Bus Replacement Authorizations

	Amount ($ Millions)	
Fiscal Year	Section 3	Bus Replacement (Section 5)
1979	1375	300
1980	1410	300
1981	1515	370
1982	1600	455
1983	1580	--
Total	7480	1425

Table 5.4
Distribution of Uses of Section 3 Funds, 1964-1981[1]

Use	Percentage by Category				
Fiscal Year:	1964-1977	1978	1979	1980	1981
Bus and Paratransit Systems	.35	.35	.32	.34	.37
Fixed Guideway Modernization	.30	.26	.38	.29	.29
Fixed Guideway Extensions	.14	.19	.12	.12	.09
Fixed Guideway New Starts	.20	.21	.16	.21	.20
Other[2]	.01	.00	.02	.05	.05
TOTAL	1.00	1.00	1.00	1.00	1.00

[1] From Heureny Report for the Department of Transportation and Related Agencies Appropriations for 1980, Table 2, p. 634. The Section 5 set-aside for bus capital for fiscal years 1979, 1980 and 1981 are also included.

[2] Includes appropriations specifically designated for DPM. Does not include Section 5 funds appropriated for bus capital subsidies.

Table 5.5
Federal Capital Subsidies - Forecast 1980-89[1]

	1980-83	1984-89	Total
Baseline	6.3	9.4	15.7
Optimistic	6.3	11.2	17.5
Pessimistic	6.3	7.7	14.0

Units are billions of 1978 dollars.

[1] Section 3 appropriations and Section 5 appropriations for bus capital. The bus capital appropriation for 1982 is assumed for 1983.

Assistance Act of 1978, discounted by the assumed 6 percent inflation rate. For the assumed inflation rate, real annual expenditures would remain nearly constant during the period. The baseline estimate assumes annual real expenditures from 1984 through 1989 would equal the average of the 1980-1983 period. The optimistic projection assumes a 5 percent annual increase in real expenditures. This is one-half of the real annual growth in Section 3 appropriations between 1970 and 1978. The pessimistic projection assumes that real expenditure will decline at 6 percent annually during the post-1983 period.

If it is assumed that new starts for fixed guideway systems will continue to capture 20 percent of the Federal capital subsidies, then between $2.8 and $3.5 billion will be available to subsidize new starts during the 1980's. If the entirety of these funds were directed to AGT deployments, then the funds could be adequate. Unfortunately, this will not occur. Much of the appropriation for the 1980-83 period that will be allocated for new starts is already committed to non-AGT technologies, and there is likely to be strong competition for funds in the 1984-1990 period.

Substantial federal funds for AGT deployments in corridors and CBD's are unlikely to be available until after 1983. For the 1984-89 period, the projections suggest that between $1.5 and $2.2 billion will be available for the 80 percent federal subsidy of capital costs. In view of AGT's capital and operating cost advantages over alternative technologies, proposals for AGT deployment have the potential to compete effectively for these funds. But it is extremely unlikely that AGT deployments would be the sole recipients of this subsidy. If AGT deployments were granted half of the available monies, then the total capital investment in AGT would probably range between $1 and $1.4 billion for the period or about $160 to $230 million annually. Such expenditure levels are sufficient to permit deployments in about one-third of the cost-effective applications identified in this analysis over the next ten years.

5.9 SUMMARY

The acceptability of automated guideway transit to local governmental officials needs to be an important component of federal-level policy-making. Seven issues local government view as important in assessing a systems' cost-effectiveness are listed below. A brief summary of AGT's comparative strengths on each of these dimensions is also given, as drawn from the current analysis.

1. Capital and Operating Costs. AGT appears to have lower capital and operating costs than alternative fixed guideway technologies. However, because operational experience with AGT is so limited, considerable uncertainty remains on the magnitude of AGT's cost advantages and the certainty of their being achieved.

2. Acceptability of Elevated Structures. Visual intrusion from elevated structures is not a problem specific to AGT but is a factor mitigating the benefits of one of AGT's chief advantages. Because overhead guideways for AGT are less massive than those of alternative technologies, in many circumstances elevated construction may be feasible for AGT but not for the alternative technologies, for which subway construction may be necessary. Because elevated construction is typically less expensive than subway construction by at least a factor of two, AGT can often have very distinct capital cost advantages. However, the availability of rail and expressway rights-of-way in many corridors in which a fixed guideway system is cost-effective lessens visual issues in many cases. In cases where intrusion is an issue, it is unclear whether AGT elevated would be acceptable where other modes are not.

3. Availability of UMTA and Local Funding. The issues are not specific to AGT but due to the costs of constructing a fixed guideway system, sufficient funding is a necessary prerequisite for a substantial market for AGT. There are questions about both federal and local funding which, if not resolved, could limit the market for AGT and other guideway modes.

4. Technical Risk. The principal disadvantage of AGT is that it is perceived to be an unproven technology for urban transportation. There is considerable perceived uncertainty about its performance, reliability and operating costs. Concerns about technical risk, in effect, reduce AGT's perceived cost-effectiveness advantage.

5. Public Support. Substantial commitment to deployment of a fixed guideway system is necessary to execute the lengthy process required to plan, design, and construct a new system, and to gain the necessary UMTA approvals. This is not, however, an issue specific to AGT, but rather applies to any new fixed guideway system.

6. Crime and Vandalism. Fixed guideway systems, whether attended or unattended, are potentially conducive environments for crime. The unattended stations and vehicles of an AGT system may increase passenger vulnerability to crime but it is unlikely that the problems with crime and vandalism will differ greatly among alternative fixed guideway technologies.

7. Economic and Community Development. The effect of any fixed guideway system on development is highly uncertain. In a corridor setting, development impacts are unlikely to differ among alternative technologies. In an activity center setting (e.g., CBD, suburban center) where AGT is typically the only feasible fixed guideway technology, AGT has the potential for stimulating development, but the magnitude of the effect cannot readily be determined.

A review of these issues reveals that, in the perception of local planners, AGT will typically be competitive with alternative fixed guideway technologies. AGT's principal advantage is seen as its lower operating and capital cost. The chief disadvantage of AGT is that it is seen as an unproven technology. The parameters of the trade-off between costs and reliability are unknown but current concern about both increasing costs and AGT's reliability represent potential deterrents to deploying large-scale AGT systems. It is important that these local concerns be adequately addressed in UMTA AGT-related demonstrations.

CHAPTER 6

ACHIEVING THE AGT MARKET

6.1 THE POTENTIAL MARKET FOR AGT

The results of the case studies, consumer attitude survey, and national market estimate provide a basis for examining the effect of alternative Federal research and development (R&D) options on the potential market for AGT. The actual implementation in each potential market segment, however, will continue to be highly dependent upon site-specific characteristics, consumer attitudes, and the structure of the AGT supplier industry.

6.1.1 CONSUMER ATTITUDES

Transit mode was found to be a key factor in individual transportation decisions. On the average, transit users rated the four modes about equally. AGT, however, is preferred somewhat less than rail or express bus and valued more than local bus. Though the definition of transit mode used in the survey explicitly excludes all other factors considered, transit mode appears to be important only because of the perceived effect on other factors. The survey results indicate that consumers are influenced most by travel time, frequency of service, and price. AGT, therefore, can increase ridership with shorter travel time and more frequent service, lower price, shorter walk distances, larger vehicles, and seat guarantees, though only the first three are considered to be very important.

The consumer attitude survey was stratified to examine the demographic characteristics of potential AGT ridership. AGT is expected to attract primarily riders from other types of transit by offering improved service, although it also will appeal to some non-transit riders. The group of non-transit riders from the sample most attracted to AGT are white males in middle/upper income brackets for work-related travel.

6.1.2 POTENTIAL AGT MARKET BY TYPE OF SITE

The largest potential segment of the AGT market is in corridor applications with up to $3.9 billion for 26 systems if AGT's potential is fully realized. AGT's chief advantage over alternative modes is cost. More deployments are possible if AGT's cost advantages can be further improved.

Differentiation among AGT, LRT, and busways for corridor applications in terms of ridership, visual impacts, and construction disruption is nominal.

However, an advantage of AGT is the potential for joint development. Potential advantages, however, must be weighed against the uncertainty and risks of what decision-makers consider to be an essentially new mode. Decision-makers perceive the need for AGT to offer significant performance and cost improvements over alternative modes to offset the uncertainty of a technology that has not yet been demonstrated in an urban environment. Reduced operating and capital costs appear to be AGT's chief "lever" to show an advantage over other modes; however, projections of AGT operating costs also are viewed as being very uncertain.

The CBD segment of the AGT market in the form of downtown people movers is smaller than that for corridors and, in addition, is especially sensitive to two issues. First, AGT cost-effectiveness is strongly affected by its ability to replace a significant amount of current CBD bus operations; labor and other institutional considerations, however, may interfere with such cuts. Second, AGT cost-effectiveness is also strongly dependent on achieving economic development impacts. Specifically, between $30 million and $40 million of economic development <u>benefits</u> must occur in most cities for an AGT to be cost-effective by the definition used in this study.[1] If buses cannot be cut in the CBD, and development does not occur due to AGT, the CBD market is estimated to be about $45 million at only one site. If buses can be cut or substantial economic development benefits are attributed to AGT, the potential CBD market could rise to near $1 billion at 14 sites. Evidence that this may occur is that significant local interest in AGTs does exist. Alignment and visual issues are a concern in dense areas of the CBD, though few problems are expected in fringe areas.

Suburban centers appear to be only a limited market for AGT. Interest exists in suburban sites for AGT, but costs are a significant barrier to implementation. AGT costs are too high for developers to pay the entire amount, and Federal assistance for these sites is viewed as unlikely. Costs, though, might be mitigated through joint development or regional transit planning. Reactions to AGT

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[1]The true economic <u>benefits</u> are not the value of a development, which is its <u>cost</u>, but are usually a much smaller figure; for example, the increase in land values at and near the site.

aesthetics at suburban sites were mixed, ranging from uniformly positive at some sites to quite negative at others. On the whole, though, visual issues were generally not a problem. Sites contacted during the study expressed a preference for a simple, relatively inexpensive guideway technology; even automation was viewed as optional in some cases. An estimated market of $100 million at five sites for suburban centers is seen unless the cost dilemma can be resolved to allow for more widespread installations.

Airports are a proven AGT market, and will continue to make up an important segment of the market. Medical centers, however, do not appear to be a viable AGT market due to funding constraints, little internal circulation, and security issues.

6.1.3 POTENTIAL AREAWIDE APPLICATIONS

Many cities identified as having the potential for areawide AGT applications already have regional or corridor rail systems that would not readily interface with an AGT system; thus these larger cities should be viewed as unlikely candidates. In medium-sized cities, there are several forces working against the implementation of areawide AGT. First, the current UMTA policy of incremental funding and its associated overall funding amount work against implementation of an areawide system. Second, corridor or CBD systems that are implementated in these cities may not be compatible in all cases with an eventual areawide system. Strong steps, however, could be taken to prevent this from occurring. Also, there may be pressures in some areas to use incompatible systems. In some case study settings, there was hesitation on the part of private developers to integrate systems serving their site with a regional system, and the public agency shared this view as well. Even a few incompatible segments in an urban area can significantly reduce the high service levels possible from an integrated areawide system.

Although no estimate of areawide implementation was made specifically in this study, there are several cities with multiple corridors that have the potential for AGT deployment. If these can be constructed, perhaps with a CBD-AGT as well, over the next 10-15 years, there could be some potential to eventually expand these corridors into an areawide system in two or three cities.

6.1.4 INFLUENCE OF AGT SUPPLIER INDUSTRY

A total AGT market of $4 to $5 billion results in expected annual expenditures of $400 to $500 million on AGT over a 10-year period. Less than half this amount would go to manufacturers, and the remainder to on-site construction. Thus, under $250 million a year would be spent on hardware. This amount could be divided further into several system types of varying designs and capabilities. This compares with an annual average bus market of about $500 million and a highly variable rail transit car market of about $200 million per year. Three major US manufacturers have been in the bus market in recent years, and generally two US firms have been in the rail car market. With a potentially larger variety of vehicle types in the AGT market than in the bus or rail areas, it may be difficult to maintain a large number of suppliers in the industry.

This last observation itself may have significant effects on the AGT market. A major US rail car manufacturer is leaving the rail car market due to lack of uniformity in specifications, an unsteady flow of orders, and foreign competition. These effects may be felt even more strongly in the AGT market. The probable existence of only a small number of suppliers in the AGT market would likely result in less competition and, therefore, higher prices. Further research into the supplier industry is recommended to clarify these issues.

6.2 EFFECTS OF FEDERAL R&D OPTIONS

Federal funding of research and development (R&D) for AGT can greatly influence the realization of the potential AGT market. Possible Federal R&D options toward AGT include the following:[1]

- "do-nothing"
- a program to ensure reliability and operability of existing AGT systems
- a program to develop a high performance AGT system
- a program to reduce AGT costs

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[1]This discussion assumes that Federal funding policy allows consideration of AGT and all other modes in all settings, and that funding levels and criteria remain at the current levels. Only qualitative estimates of the effects of these research and development policies are made.

6.2.1 THE "DO-NOTHING" OPTION

A "do-nothing" policy is likely to result in only a small fraction of the potential AGT market being realized. Corridor applications constitute the largest share of the potential market, but may be the most sensitive to Federal support in technology. The major advantage of AGT in corridors is cost; however, local decision-makers must weigh the cost advantage against the perceived risk of implementing what many believe to be an essentially "new" mode, with reliability being a particular concern. Corridor systems may have greatly increased reliability concerns relative to other sites due to their greater system size. Unless Federal support to demonstrate the reliability of AGT systems is provided, only a small part of the corridor market may be realized.[1]

Achievement of the CBD market will depend strongly on the experience of the current DPM demonstrations, with critical issues in this market being the reduction of bus services and the potential for economic development. If satisfactory results are obtained, additional strong Federal R&D support may not be required. Current AGT technology, if successful in initial cities, should be adequate for most other cities. The only exceptions would be cities wishing to use their DPM networks as CBD distribution for a regional AGT, in which case the same reservations identified for the areawide corridor market may apply. Thus, the baseline CBD market of $45 million and the maximum cost-effective market of $1 billion will probably not be strongly affected by new R&D initiatives.

Of the other types of sites, only airports generally can support the costs of AGT systems, and this market is currently being realized without Federal intervention. Other sites such as major diversified activity centers and medical centers are unlikely to be affected by R&D policy.

Thus, the size of the AGT market is significantly reduced in this "do-nothing" scenario, as the corridor market may not be realized. Activity centers and hospitals would continue to have a low probability of implementation, with only CBDs and airports likely to achieve their potential levels. The total AGT market quite likely would be less than $2 billion.

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[1]The initial DPM systems, however, will aid in demonstrating AGT's reliability in the urban transportation environment.

6.2.2 THE INCREASED RELIABILITY OPTION

A R&D strategy aimed at ensuring reliability and operability of current AGT systems in urban environments could have substantial impacts on the market. This strategy would explicitly not improve performance levels, but would focus only on ensuring that assumed levels of cost and performance are met with reasonable certainty. This effort would improve AGT's competitive position in corridor analyses to the point where it would generally be the preferred alternative due to its lower capital and operating costs, smaller structures, and higher service levels and ridership. The AGT corridor market in this scenario would be limited by the total amount of UMTA funding for new starts, but many of the cost-effective corridor projects still could be realized.

The effect of reliability and operability improvements on the CBD market is difficult to assess, again because other issues dominate. However, some increase in the market could be expected beyond the baseline projection.

The major activity center market still is unlikely to be tapped with these improvements; few implementations could be expected. Hospitals would be affected little, again because other issues dominate the decision. Finally, the airport market might increase somewhat, perhaps attaining even more than the full baseline projection, just because the system would be more adaptable to different requirements, and airports would perceive less risk.

The total market under this R&D scenario is estimated to be close to $4 billion, or even more, if corridor and CBD deployment scenarios are favorable.

6.2.3 THE HIGH PERFORMANCE OPTION

Very low headways between vehicles, complex routing and switching capabilities, and the use of small vehicles and off-line stations, of and by themselves, do not expand any of the AGT markets defined in this study. A potentially long-range benefit from this R&D strategy could occur if a high performance system also had substantially lower costs than current AGT designs, or if an extensve areawide guideway transit system could be implemented. However, the potential for areawide AGT systems is severely limited by current UMTA funding levels for new starts. Thus, this R&D option appears to have little near-term advantage over the reliability improvement option.

In corridors, there is little advantage gained by either more frequent service than 2 to 4 minute headways or by express guideway service, which often saves only 2 or 3 minutes of travel on an average trip. The results of the consumer attitude survey indicate that travel time and frequency of service are two of the most important factors of transit service; however, the wait time difference between 1 and 2 minute headways is only 30 seconds and is unlikely to significantly alter a traveler's choice of mode. Another, less important factor from the consumer attitude survey is vehicle size. Though less important than service levels, users indicate a preference for larger vehicles (30-50 passengers) over smaller vehicles (4-10 passengers). Thus, slightly increased service levels and smaller vehicle size would probably not substantially affect the corridor market. The baseline corridor market would remain near $3.4 billion.

Major diversified activity centers would not enter the AGT market under this scenario, as the performance improvements are not relevant to these needs. Similar arguments hold for medical centers and for airports. With few exceptions, all these activity centers have little need for advanced operating capabilities.

Thus, the AGT market is judged not to be sensitive, in the near future, to the development of a high performance system under current UMTA funding levels.

6.2.4 THE COST REDUCTION OPTION

If AGT capital and operating costs could be reduced substantially, or at least prevented from escalating, this would have a marked effect on the number of deployments. This R&D option also would require an increase in the amount of Federal funding available for new starts to fully implement potential AGT deployments. Federal R&D efforts to reduce costs could be directed toward new designs, better management, or new materials. While a reduction in capital costs would decrease the magnitude of individual deployments, this decrease would be more than offset by the possibility of further deployments.

The corridor market might approach a maximum level of nearly $4 billion with a 20 to 40 percent reduction in AGT costs. These reductions would increase the benefit/cost ratios of many marginal corridor deployments to a range in which they could be regarded as being cost-effective.

Likewise, CBDs could form a portion of the market considerably over the $45 million baseline if their costs were lowered, as this would also increase the benefit/cost ratios at many sites. An expenditure level of over $500 million is possible.

Major diversified activity centers might enter the market for the first time with any certainty, although some subsidy would still be required for all sites. However, a subsidy level of 10 to 40 percent might be sufficient under these reduced costs. This smaller subsidy level also might be more acceptable politically. This market might approach $100 million in this case.

Medical centers still are considered an unlikely market, although airports would become an even stronger market. Thus, the total AGT market under this R&D option could approach $5 billion.

APPENDIX A

CORRIDOR MARKET ESTIMATION METHODOLOGY

APPENDIX A
CORRIDOR MARKET ESTIMATION METHODOLOGY

A.1 OVERVIEW

The national market for AGT in corridors is analyzed with a benefit/cost methodology analyzing alternative fixed guideway and low-capital alternatives. In summary, the approach assumes that the choice of guideway technology is made in two stages. First, the most cost-effective guideway technology is chosen considering AGT, light rail transit (LRT) and busway. Then, this single fixed guideway technology is compared against the low-capital or existing bus option. Thus, if AGT is <u>not</u> the highest-ranked guideway alternative, its probability of implementation is assumed to be zero. If it is the highest ranked guideway alternative, the probability of its being considered superior to the low-capital option then is assessed.

The benefit/cost analysis makes "first order" estimates of the following benefits:

- Reduction in the inclusive cost of travel to persons using the system.

- Reductions in auto ownership. The reduction in the inclusive cost of transit travel may induce a reduction in average auto ownership levels. Viewing auto ownership as an induced demand for mobility, then a <u>non-coerced</u> reduction in auto ownership is a benefit.

- Reduction in bus operating costs. Deployment of any fixed guideway technology will generally permit a reduction in bus operating costs in the corridor where the system is deployed.

Two costs are quantified:

- Costs of the AGT system itself

- Costs of remaining bus operations.

It is assumed that construction of fixed guideway systems normally would occur in an incremental manner, with initial deployment occurring in the corridor of highest travel demand. The impact of the technology choice for this initial corridor on technology choice in any subsequent corridor applications suggests that market estimation should be done in the following two stages:

Stage 1 - Deployments in Principal Corridors

- Identify the principal corridor in each large US metropolitan area. This principal corridor is defined as the corridor with the largest daily traffic volume.

- Estimate benefit/cost ratios for the principal corridor in metropolitan area i for AGT (BC_{1i}), LRT(BC_{2i}), and Busway (BC_{3i}).

- Identify the metropolitan areas where AGT is the dominant fixed guideway technology, based primarily on the etimated benefit/cost ratios.

- In each metropolitan area where AGT is judged to be the desired fixed guideway technology, a probability of deployment, P_i^*, is estimated. The national estimate of deployments in principal corridors, D, is calculated by the sum of these probabilities. This final step is the most subjective part of the analysis. The assumed relationship between deployment probability and an AGT's benefit/cost ratio is explicitly stated so that the effect of alternative assumptions about this relationship on D can be systematically explored.

Stage 2 - Deployments in Major "Secondary" Corridors

AGT deployments in secondary corridors are considered for metropolitan areas where AGT is the dominant fixed guideway system in the principal corridor. In these areas, all major secondary corridors are identified, using the same minimum daily volume for a corridor as used for primary corridors. It is recognized that some cities may develop a mix of guideway modes in different corridors to suit varying needs, but this possible degree of local variation is beyond the scope of the analysis. Thus, the assumption is made that a single guideway technology is used in each area considered. Corridors in which a fixed guideway technology is not warranted are assumed to use a low-capital bus option.

For each major secondary corridor, a benefit/cost ratio is estimated. The probability of deployment is then assessed using the same relationship between deployment probability and benefit/cost ratio as used for principal corridors. Total deployments in major secondary corridors is estimated as follows.

Let k_i = number of major secondary corridors in a metropolitan area where AGT is the dominant fixed guideway system in the primary corridor.

P_{ik} = probability of AGT deployment in secondary corridor k in metropolitan area i.

d = total deployments in all secondary corridors.

i^* = set of metropolitan areas i where AGT is the dominant fixed guideway alternative in the principal corridor.

$$d = \sum_{i^*} (P_i^* \sum_{k_i} P_{ik}) \tag{1}$$

A.2 BENEFITS OF TRAVEL COST SAVINGS

Headways on fixed guideway systems are typically shorter than on regional bus service and their average operating speeds are nearly always greater. The former reduces transit out-of-vehicle travel time (OVTT) and the later, transit in-vehicle time (IVTT). To estimate the value of the reduction in transit OVTT, IVTT, ΔOVTT and ΔIVTT for patrons of a fixed guideway system, a distinction must be made between former patrons of the regional bus system and new transit patrons.

For the former group, the value of this level-of-service improvement is estimated by $TC^B - TC^F$, where TC^B is the average time cost of travel on the regional bus system and TC^F is the time cost of travel on the fixed guideway system.[1]

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[1]The functional forms defining each benefit and cost are the same for each fixed guideway technology; only parameter values (e.g., cost per guideway mile) and variable levels (e.g., system ridership) vary across systems. Thus, to avoid cumbersome notation, the discussion does not distinguish system technologies.

Estimating the value of the level-of-service improvement for the latter group (new ridership) is more difficult. The ridership on a transit system is a function of the inclusive cost of travel on the system. For any given origin and destination, the inclusive cost of transit travel includes the time cost of transit travel between the origin and destination and the out-of-pocket cost of the trip. An analogous price also exists for other potential modes of travel between these two points.

Transit ridership is determined by its relative inclusive cost. If transit ridership is a linear function of the inclusive price of transit use (holding the price of other modes constant),[1] then it can be shown that the average benefit to a <u>new</u> transit user is one-half the benefit to a previous patron of the regional transit system; Figure A.1 is a graphic representation of this result. Thus, an estimate of the annual benefits accruing to system riders as a result of the level of service improvement is:

$$TCB_{ik} = \Delta TC_{ik}(R^B_{ik} + 1/2[R^F_{ik} - R^B_{ik}]) \qquad (2)$$

$$\Delta TC_{ik} = TC^B_{ik} - TC^F_{ik} \qquad (3)$$

where:

TCB_{ik} = Total annual travel cost benefit in corridor k in metropolitan area i

R^F_{ik}, R^B_{ik} = Annual ridership on a fixed guideway system and an all-bus system respectively in i, k

TC^F_{ik}, TC^B_{ik} = Time cost of travel on a fixed guideway system and an all-bus system, respectively.

<u>Estimating Transit Ridership, R^B_{ik}, R_{ik}</u>

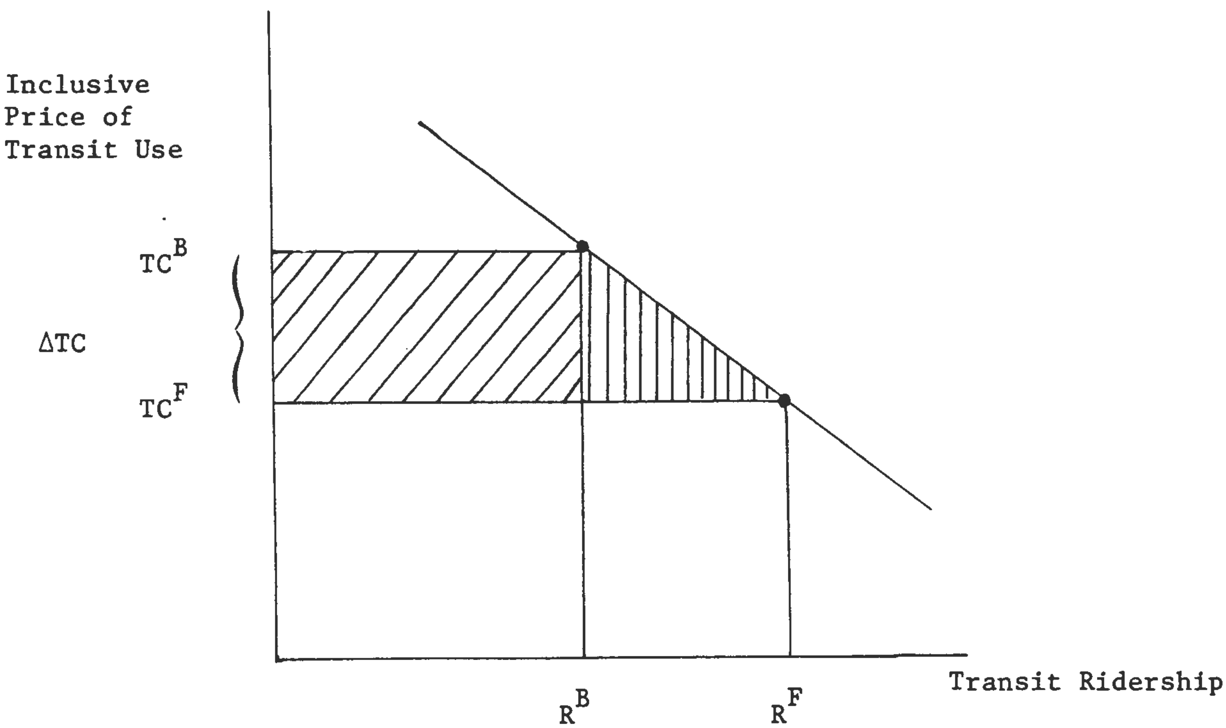
Figure A.2 shows a generalized radial configuration of corridors converging on a CBD that is representative of most metropolitan areas. The two ridership variables are estimated by:

[1]A fixed guideway system will not, in general, affect the inclusive price of other modes.

FIGURE A.1

The Travel Cost Benefits

of a Fixed Guideway System



Area of $=$ $\Delta TC \cdot R^B$

Area of $=$ $\frac{1}{2}\Delta TC(R^F - R^B)$

R^B = ridership on the current bus system

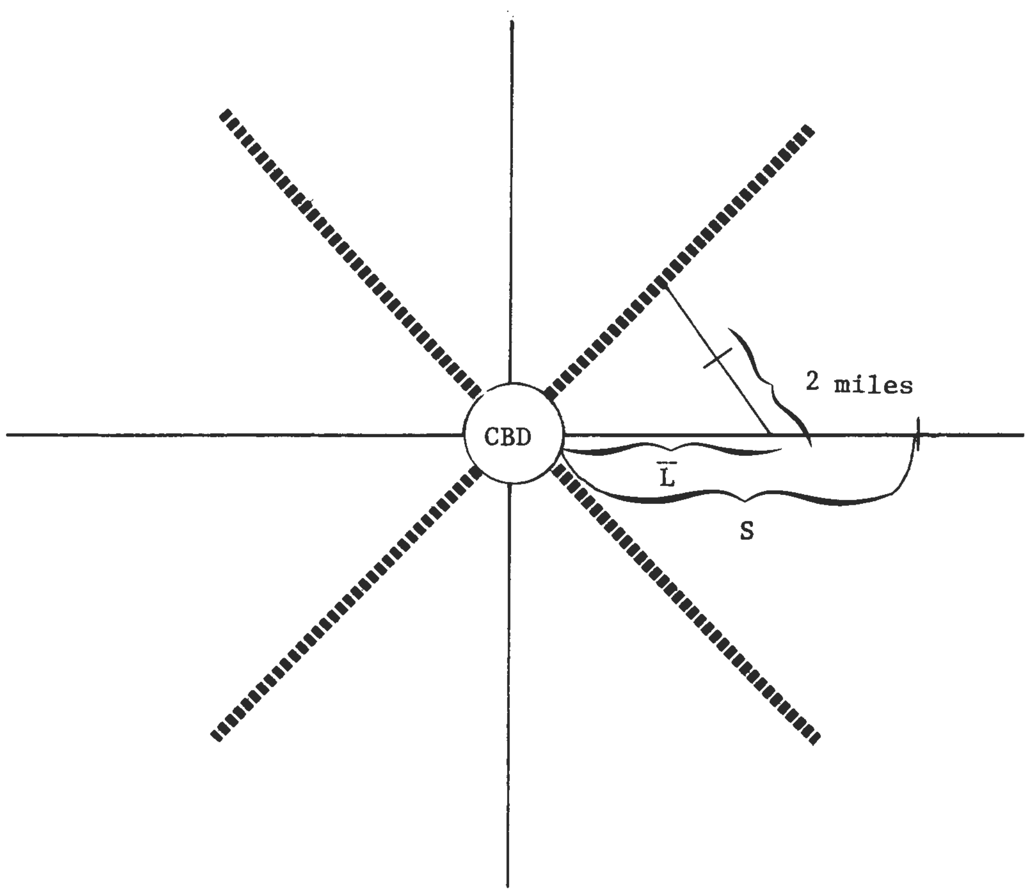
R^F = ridership on a fixed guideway system

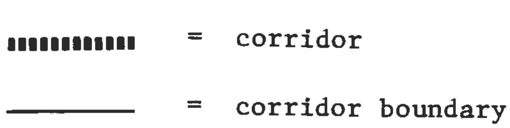
TC^B = average inclusive price of travel on the bus system

TC^F = average inclusive price of travel on the fixed guideway system

FIGURE A.2

Typical Bus System





$$R^{B}_{ik} = 1.2\ (K_{i}\ .\ F_{ik}\ .\ H(S + 2))\ .\ E_{i} - 2w_{i})\ P^{B}_{i} \quad (4)$$

$$R^{F}_{ik} = 1.2\ (K_{i}\ .\ F_{ik}\ .\ H(S + 2))\ .\ (E_{i} - 2w_{i})\ P^{F}_{i} \quad (5)$$

where:

P^{B}_{i}, P^{F}_{i} = transit mode share for CBD-bound work trips for an all-bus system and a fixed guideway system respectively in metropolitan area i.

K_{i} = an estimate of the total trip ends entering the CBD originating from corridor k in i

F_{ik} = For the average trip length in i, $\overline{L}_{i}$ is the proportion of the distance between the corridor spine and the corridor boundary that is within two miles of the spine.

H(S + 2) = proportion of trips less than the system length, S, plus two miles

E_{i} = CBD trip ends in i

w_{i} = CBD employment in i

Since the two equations differ only in the final term, only the structure of R^{F}_{ki} is defined. The term $(E_{i} - 2w_{i})P^{F}_{i}$ estimates CBD-bound ridership if an area-wide fixed guideway system were deployed. The term $(K_{i}\ .\ F_{ik}\ .\ H(S + 2))$ estimates the proportion of the areawide ridership that would be attributable to the guideway system in corridor k. The term K_{i} estimates the proportion of <u>all</u> trips entering the CBD that originate in corridor k. The F_{ik} term derives from an assumption that corridor transit trips greater than two miles from the guideway will be made on remaining bus transit service in the corridor. The final term in the parentheses, H(S + 2), is included on the assumption that trips on the system originating further than two miles from the end of the guideway will be rare. The final scale factor, 1.2, is included because the remaining terms estimate CBD-bound ridership. It is assumed, based on work performed by Zupan, that intra-corridor ridership and ridership with destinations beyond the CBD are in total about 20 percent of CBD-bound ridership.

Estimating Fixed Guideway Transit Mode Share, P_i^F and ΔTC_{ik}

The approach to estimating P_i^F bears directly upon the approach to estimating the average travel cost savings, ΔTC_{ik}. P_i^F is estimated by:

$$P_i^F = \frac{P_i^B \; e^{u_i}}{(1 - P_i^B) + P_i^B \; e^{u_i}} \tag{6}$$

$$\Delta u_i = \gamma_0 + \gamma_1 \, \Delta IVTT_i + \gamma_2 \, \Delta OVTT_i \tag{7}$$

where

γ_0 = fixed guideway mode constant

γ_1 = value of in-vehicle travel time (1/min.)

γ_2 = value of out-of-vehicle travel time (1/min.)

$\Delta IVTT_i$ = reduction in transit in-vehicle time for typical trip length in i

$\Delta OVTT_i$ = reduction in out-of-vehicle time for typical transit trips in i

The pre-test results of the consumer attitudes survey were used to estimate the parameters, γ_0, γ_1, and γ_2. P_i^B is estimated with Census data. The variables $\Delta IVTT_i$ and $\Delta OVTT_i$ were estimated based on assumptions of typical trip lengths, headways on the existing bus system, headways on the guideway system and its feeder service, average bus and guideway vehicle speeds and the proportion of guideway system users who use feeder service.

To estimate ΔTC_{ik}, a monetary value is placed on the unitless utility quantity, Δu_i. The consumer attitudinal survey described in Volume III generated a parameter, γ_3, the value of out-of-pocket costs; its units are 1/cents. Thus,

$$\Delta TC_{ik} = \Delta u / \gamma_3 \tag{8}$$

APPENDIX B

CBD MARKET ESTIMATION METHODOLOGY

APPENDIX B
CBD MARKET ESTIMATION METHODOLOGY

B.1 INTRODUCTION

The estimate of the national market for AGT in central business districts (CBD's) is based on a benefit/cost analysis for each candidate city comparing a downtown people mover (DPM) form of AGT to an existing base case bus system. Three potential benefits are quantified:

- reduction in the time cost of travel in the CBD
- reduction in parking costs
- reduction in bus operating cost

Two costs are quantified:

- costs of remaining bus operations
- costs of the DPM

B.2 REDUCTION IN TIME COST OF CBD TRAVEL

To estimate the change in the time costs of CBD travel in each candidate city, the average time cost of travel in that city's CBD if a DPM were deployed, C_{Di}, is estimated. Next, the average cost of CBD travel in city i with its existing bus system, C_{Bi}, is estimated. The difference, $C_{Bi} - C_{Di}$, estimates the change in the average time cost of CBD travel resulting from deployment of a DPM. The annual benefits (or costs) from the change in the time costs of travel in city i, BT_i, is:

$$BT_i = R_i \, (C_{Bi} - C_{Di}) \qquad (1)$$

where: R_i = CBD transit ridership in city i, including both DPM riders and persons riding on the remaining bus routes.

The particular form of DPM analyzed is a shuttle system. The following discussion develops the methodology utilized to estimate the average time cost of travel with the proposed DPM/bus system and an existing all bus system.

B.2.1 SHUTTLE DPM CONFIGURATION

Consider the shuttle DPM system shown in Figure B.1. Next consider a transit passenger on a bus route entering from the south with a destination at D (Figure B.2).

To travel to the final destination, D, this individual can:

1. alight from the bus at B and walk a distance L to his destination;

2. ride to point A, transfer to the DPM, ride to point C and walk the remainder of the distance to D.[1]

The marginal costs of these two options are:

$$C_W = B_2L \tag{2}$$

$$C_{DPM} = (B_1 + B_2)W + B_3L + k \tag{3}$$

where:

C_W, C_{DPM} = costs of options (1) and (2), respectively

L = distance along DPM axis measured from A

W = distance along Bus axis measured from A

B_1 = cost of riding the bus (¢/mi)

B_2 = cost of walking (¢/mi)

B_3 = cost of riding the DPM (¢/mi)

k = transfer and waiting cost for using DPM

Equations (2) and (3) define the costs of each option for a southern approach with a southern destination (S,S). These equations are also appropriate for a north/north (N/N) approach and destination. For (N,S) and (S,N) combinations, the appropriate equations are (see Figure B.3):

$$C_W = B_1W + B_2L \tag{4}$$

$$C_{DPM} = B_2W + B_3L + k \tag{5}$$

The following unit costs are assumed, based on work performed by Zupan.[2]

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[1]To simplify the analysis, it is assumed that a passenger can alight anywhere on the DPM.

[2]Zupan, Jeffrey, Aggregate DPM Demand Forecasting, Regional Planning Association, New York, NY, 1978.

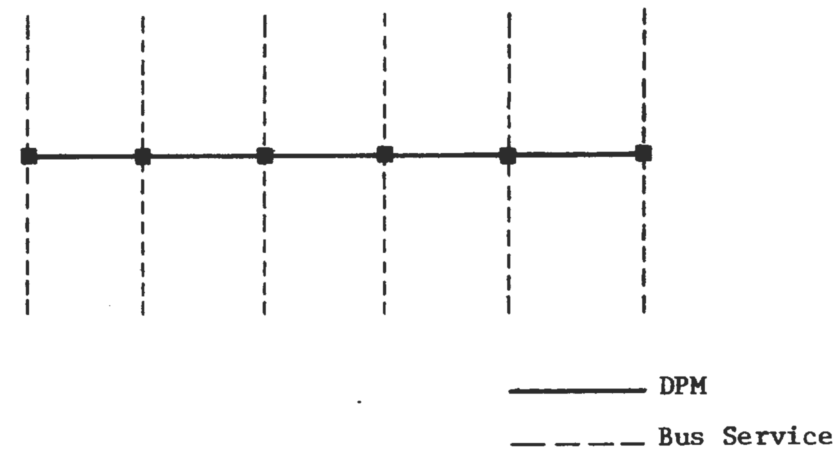


FIGURE B.1

Downtown People Mover Shuttle Configuration

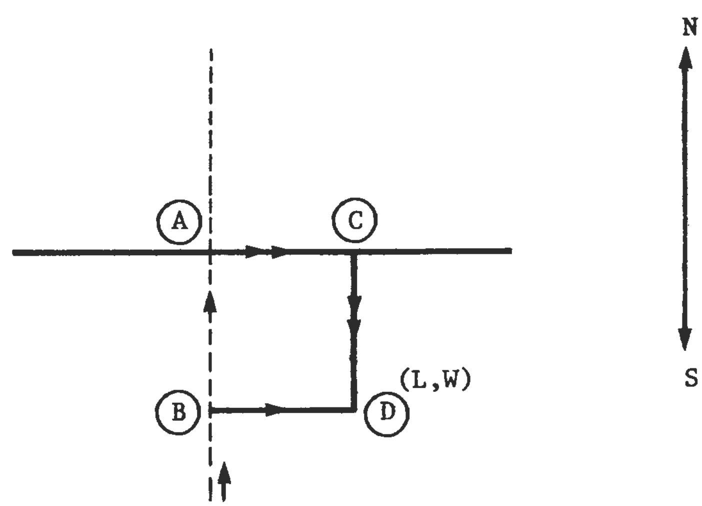


FIGURE B.2

Bus Access to DPM Shuttle System, Approach Direction 1

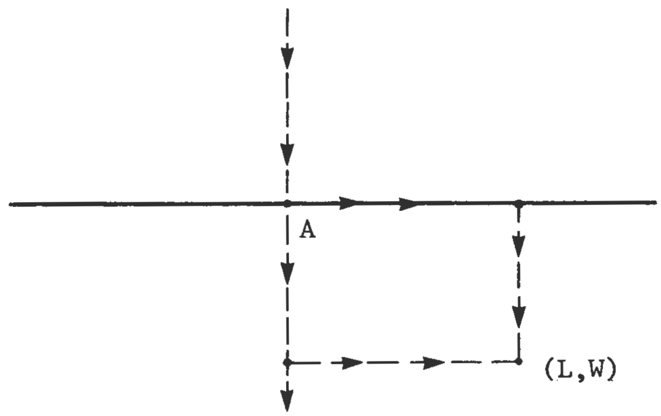


FIGURE B.3

Bus Access to DPM Shuttle System,
Approach Direction 2

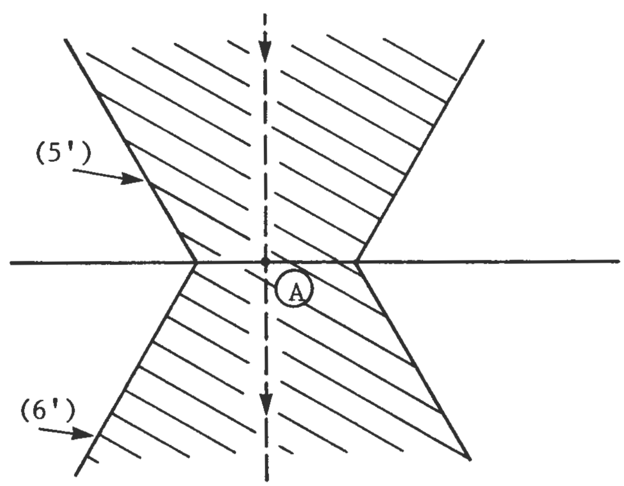


FIGURE B.4

Bus Transfer Envelope

B_1 = 20¢/mi.

B_2 = 120¢/mi.

B_3 = 15¢/mi.

k = 5¢/mi.

To estimate the proportion of bus riders who will transfer to the DPM, the loci of points defined by $C_W = C_{DPM}$ are examined. For all destinations along this line, a person would be indifferent between options 1 and 2.

For (N,N) and (S,S) combinations:

$$C_W = C_{DPM}$$

$$B_2L = (B_1 + B_2)W + B_3L + k$$

$$L = h_1(w) = \frac{k}{B_2 - B_3} + \frac{B_2 + B_1}{B_2 - B_3} w \qquad (6)$$

Substituting assumed parameter values:

$$L = .05 + 1.33w \qquad (6')$$

For (S,N) and (N,S) combinations, $C_W = C_{DPM}$ implies:

$$L = \frac{k}{B_2 - B_3} + \frac{(B_2 - B_1)}{B_2 - B_3} w \qquad (7)$$

$$L = h_2(w) = .05 + .95w \qquad (7')$$

Equations (6') and (7') are shown in Figure B.4 for an individual making a northern approach.[1] The shaded area in Figure B.4 defines the destinations surrounding the bus route where the cost of option 1 (i.e., the non-transfer option 1 is less than the DPM option). Assuming that all persons arriving on this bus route with destinations outside the shaded area will transfer to DPM, the proportion of destinations in the non-shaded area can be computed.

[1]Distances along the DPM and bus axes are measured from point A; coordinates in each quadrant are all positive.

To compute the transfer proportion, an assumption about the distribution of destinations must be made. Assuming the density of destinations declines linearly from the spine of the CBD (Figure B.5):

$$f(w) = \frac{2}{\bar{L}\,\bar{w}} \left(1 - \frac{2}{\bar{w}} w\right) \tag{8}$$

where $f(w)$ = density of destinations as a function of w

$\bar{w}$ = total width of CBD

$\bar{L}$ = total length of CBD

The density function, Eq. (8), is normalized so that if it is integrated between $(0, \bar{w}/2)$, the cumulative will equal .5. This is done to reflect the fact that half the destinations are to the north of the spine and half to the south.

To compute the proprotion who will transfer, P_T, the proportion who will not transfer, P_w, is first computed and $P_T = 1 - P_2$ is then used to estimate P_T.

<u>Estimating Bus to DPM Transfers, P_w, P_T</u>

P_w is dependent on the point where the entry bus route intersects the CBD spine. Figure B.6 shows two possibilities. The route in Panel A is close to the CBD boundary and the non-transfer area to its left is less than that for the route shown in Panel B. For a route running along the CBD fringe, the proportion not transferring will be exactly half the proportion for the route in Panel B. To approximate P_w for all routes, the average of P_w is taken for:

1. routes intersecting the midpoint of the spine.
2. routes at the end points of the spine.

This average equals 75 percent of P_w for routes intersecting the halfway point on the spine.

To estimate the average transfer proportion:

$$P_w(\bar{w}) = .75 \times 2 \left(\int_0^{\bar{w}/2} 2h_1(w)\, f(w)\, dw = \int_0^{\bar{w}/2} 2h_2(w)\, f(w)\, dw \right. \tag{9}$$

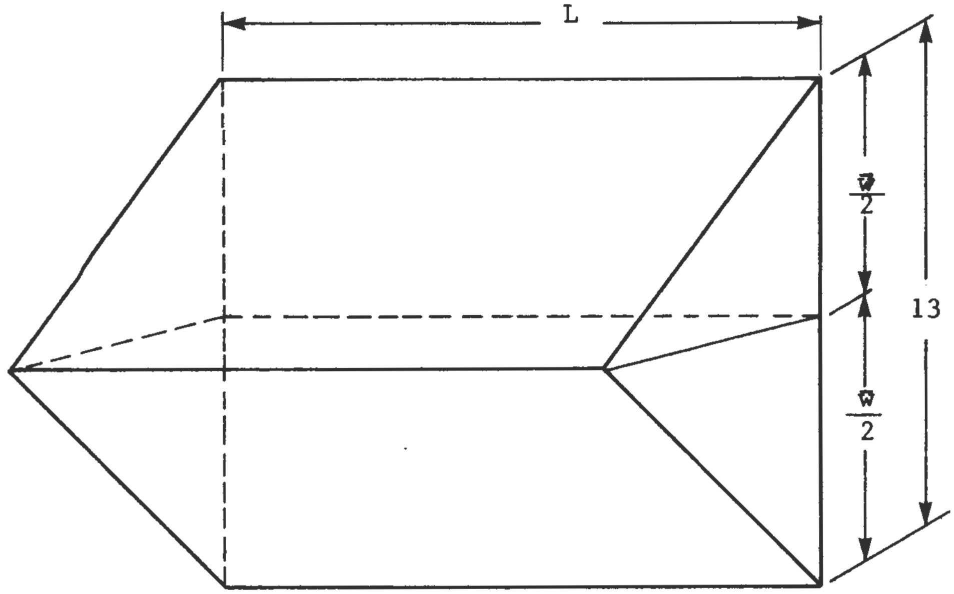
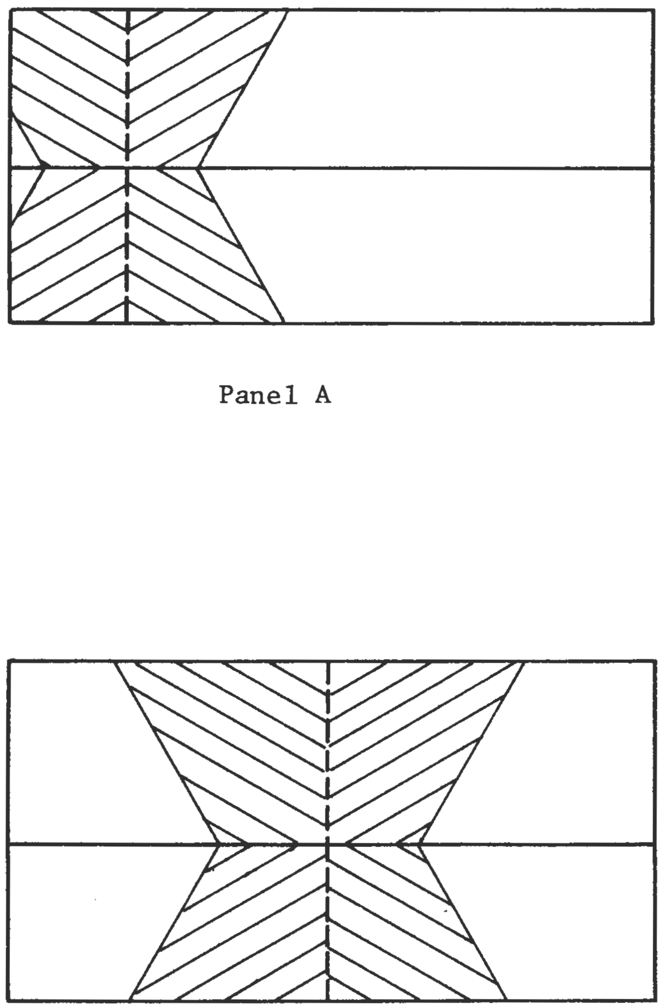


FIGURE B.5

Assumed Distribution of Passenger Destinations



Panel A

Panel B

FIGURE B.6

Estimating Bus to DPM Transfers

where:

$h_1(w)$ = equi-cost line for (N,N) and (S,S) entry/destination combinations

$h_2(w)$ = equi-cost line for (S,N) and (N,S) combinations

Note also that the formulation of this analysis imposes implicit constraints on $\bar{L}$ and $\bar{w}$. In particular, for a route intersecting the midpoint of the spine:

$$h_1(w) \leq \bar{L}/2 \tag{10}$$

and

$$h_2(w) \leq \bar{L}/2 \tag{11}$$

Since $h_1(w) > h_2(w)$, the binding constraint is (10). For the assumed parameter values, (10) implies:

$$\bar{w} \leq .75\ \bar{L} - .075 \tag{12}$$

The constraint defined by (12) implies a rectangular CBD which is not an unreasonable abstraction.

If (9) is computed for the assumed parameter values, the result is:

$$P_w(\bar{w}) = \frac{.75}{\bar{L}}\ (.1 + 1.33\ \bar{w} - .92\ \bar{w}^2) \tag{9'}$$

where $\bar{w} \leq .75\ \bar{L} - .075$

For a CBD with $\bar{L}$ = 1 mi. and $\bar{w}$ = .67 mi., P_w = .43 and consequently, P_T = .57.

Estimating Average Time Cost of CBD Travel by DPM, C_D

The estimate of C_D must include the average cost of travel for all regional bus users whether they transfer to the DPM or not. The re-routing of regional buses entering the CBD to accommodate the DPM will affect all bus patrons. Thus, C_D must reflect any change in time costs to non-transfers as well as transfers.

<u>Time Costs for Non-Transfers</u> (C_D^N)

A typical non-transfer trip is defined by the average walk distance along the L axis, D_L, and the average length of the bus trip along the w axis, D_w, for non-transfers. In terms of the cost parameter used previously:

$$C_D^N = 120\, D_L + 20 D_w \tag{13}$$

Point B in Figure B.7 shows the location of the average non-transfer trip. First, observe that D_L is equal to half the distance from A to the equi-cost line defining the locus of coordinates where a rider is indifferent about transferring. The distance, V, from the DPM axis to A is the mean distance from the DPM that non-transfers will alight. Because the non-transfer probability is dependent upon a rider's entry/destination combination, V for (N,N) and (S,S) combinations will be different than for (S,N) and (N,S) combinations.

To simplify the analysis:

$$\bar{h}\,(V) = \frac{1}{2}h_1(V) + \frac{1}{2}h_2(V) \tag{14}$$

$$= .05 + 1.12V \tag{14'}$$

where:

$h_1(V)$, $h_2(V)$ = equi-cost lines for (1) (N,N) and (S,S) and (2) (S,N) and (N,S) trips, respectively.

Also from the result in Figure B.7:

$$D_L = \frac{1}{2}\,\bar{h}(V)$$

The distance V can be estimated by computing the integral:[1]

[1]The term $2/P_w$ is a normalization. The non-transfer proportion in the "northern CBD" is $P_w/2$. Since V is computed conditional upon not transferring, the normalization of $2/P_w$ is necessary.

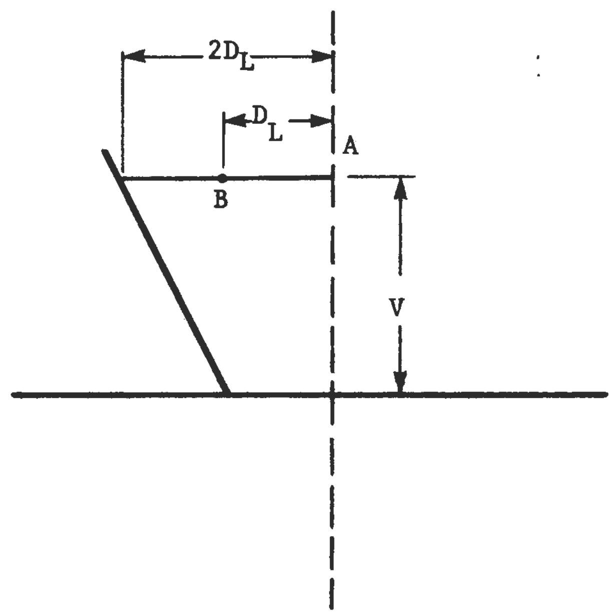


FIGURE B.7

Time Costs for Non-Transfers

$$V = \frac{2}{P_w} \int_0^{\bar{w}/2} 2\bar{h}(v) f(v) dv$$

$$= \frac{2}{P_w \bar{L}} (.0043\bar{w} + .024\bar{w}^2) \qquad (15)$$

Since destinations are symetrically distributed about the spine and entry direction is independent of the destination, $D_w = \bar{w}/2$. Thus, Eq. (13) can be rewritten as:

$$C_D^N = 60\bar{h}(v) + 10\bar{w} \qquad (16)$$

Time Cost for Transfers (C_D^T)

The average time cost for transfer includes:

1. the cost of riding the bus to the CBD spine which is a distance $\bar{w}/2$.
2. the costs of transferring.
3. the cost of the average trip length on the DPM, B_L.
4. the cost of the average walk distance from the DPM station to the destination, B_w.

$$C_D^T = 5 + 20\bar{w}/2 + 15B_L + 120B_w \qquad (17)$$

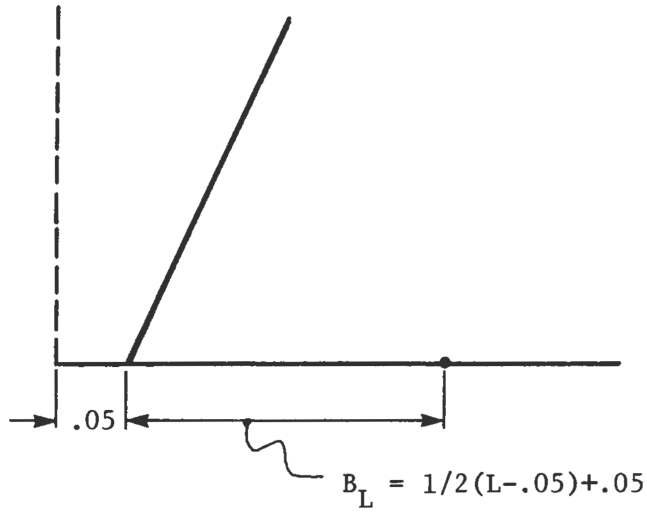
The average walk distance, B_w, can be estimated easily by drawing upon the result that the average distance from the CBD spine for all trips is $\bar{w}/6$. Thus,

$$\bar{w}/6 = P_w V + (1 - P_w) D_w$$

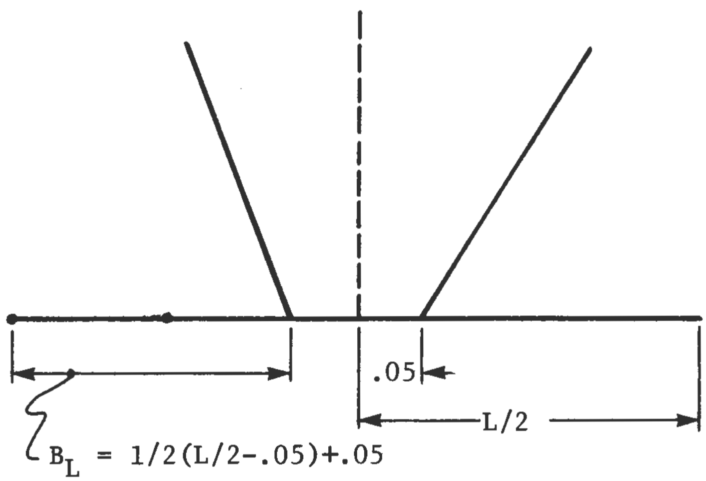
or

$$D_w = \frac{1}{(1-P_w)} (\bar{w}/6 - P_w V) \qquad (18)$$

The average trip on the DPM depends upon the point at which the bus route intersects the DPM axis; two possibilities are shown in Figure B·8.



Panel A



Panel B

FIGURE B.8

Time Costs for Transfers

Assuming that the bus intersects the CBD spine uniformly, then:

$$B_L = \frac{1}{3}(\bar{L} - .05) + .05 \tag{19}$$

With the above results (17) can be re-written as:

$$C_D^T = 5 + 20\bar{w}/2 + 15(\frac{1}{3}(L - .05) + .05)$$
$$+ 120\left(\frac{1}{1 - P_w}(\bar{w}/6 - P_w V)\right) \tag{20}$$

The final form of C_D, the average cost of CBD travel with DPM is then:

$$C_D = P_w C_D^N + (1 - P_w) C_D^T \tag{21}$$

B.2.2 ESTIMATING AVERAGE TIME COST OF CBD TRAVEL FOR A BUS SYSTEM

The average time costs, C_B, for the CBD leg of a transit trip in a city relying exclusively on buses for transit service is significantly affected by the alignment of bus routes. To compute C_B, it is assumed that bus routes are configured as shown in Figure B.9. Routes entering from the east or west run along the CBD spine and routes entering from the north or south intersect the spine at its mid-point. The average time cost of CBD travel for this configuration is:

$$C_B = PC_B^E + (1 - P)C_B^N \tag{22}$$

where P = proportion of bus riders entering on the spine axis (E-W axis)

C_B^E, C_B^N = average cost of travel on the E-W and N-S axes respectively

To simplify the analysis, no transferring between routes on the different axes is allowed. This assumption is consistent with the observation that transfers within a CBD for distribution purposes are infrequent.

C_B^E is defined as:

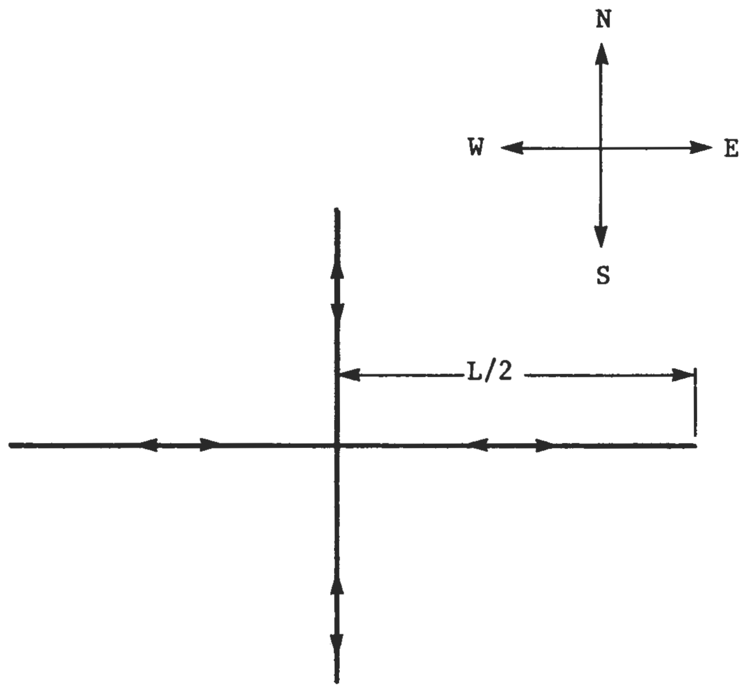


FIGURE B.9

CBD Bus Route Configuration

$$C_B^E = 20\ D_L^E + 120\ D_W^E$$

where

D_L^E , D_W^E = average distance travelled on E-W axis and N-S axis respectively for E-W entries

Since destinations are uniformly distributed on the L axis and entry direction is assumed independent of destination, $D_L^E = \bar{L}/2$. Also, as previously stated, the average distance on the w axis to a destination is w/6. Thus,

$$C_B^E = 10\ \bar{L} + 20\bar{w} \qquad (23)$$

Because of the assumptions of independence between entry direction and the symmetry of the CBD about the N-S routes:

$$C_B^N = 20\ (\bar{w}/2) + 120\ (\bar{L}/4) \qquad (24)$$

$$= 10\ \bar{w} + 30\ \bar{L}$$

Substituting Equations (22) and (23) into (21), the final form of C_B becomes:

$$C_B = 10\bar{w}(P + 1) + \bar{L}(30 - 20P) \qquad (25)$$

The final ingredient necessary to estimate the savings in the time costs of CBD travel is R_i. Because time savings for park 'n ride patrons are assumed to be negligible, R_i includes regional bus riders entering the CBD plus circulation patrons.

B.3 REDUCTION IN PARKING COSTS

The analysis of the potential ridership of park n' ride patrons on DPM is based on work performed by Zupan, and assumes that the primary attraction of DPM to potential park 'n ride patrons is reduced parking costs. The Zupan analysis suggests tht this attraction is sufficiently large that park 'n ride demand would exceed parking supply at stations on the CBD periphery. The benefits of reduced parking costs will thus most likely be determined by the fringe lot parking supply in each candidate city, S_i. The annual benefits to park 'n ride patrons are estimated by:[1]

$$PB_i = 325S_i\ (\Delta DPR_i) \quad (26)$$

where:

PB_i = annual benefits from reduced parking costs in city i

ΔDPR_i = average reduction in daily parking rate in city i

(Assume 325 weekday equivalents per year.)

To estimate ΔDPR_i, two relationships developed by Zupan are utilized. One is the average daily parking rate as a function of CBD floorspace. The other is a spatial relationship defining the percent decline in parking rates as a function of percent of maximum CBD density. The Zupan relationship indicates that the cost of parking at peripheral CBD lots would be about 25 percent of the average daily parking rate, DPR_i. Thus (26) can be re-formulated as:

$$PB_i = 243\ S_i DPR_i \quad (26')$$

Equation (26') estimates the annual parking cost reduction benefits. Long-term benefits, LPB_i, are estimated by:

$$LPB_i = \frac{243S_i DPR_i}{r} \quad (27)$$

where r is the discount rate.

B.4 REDUCTION IN BUS OPERATING COSTS

Deployment of a DPM may permit the transit authority to reduce bus operations within the CBD, and thus provide an immediate benefit in the form of reduced bus operating costs. Further, the magnitude of this benefit may increase over time if the bus operating

[1]The out-of-pocket cost savings to park 'n ride patrons also includes a reduction in auto operting costs. This saving, however, is not included in the analysis because park 'n ride patrons will generally be required to pay a fare and it is assumed that the operating costs savings are cancelled by the fare.

costs increase faster than DPM operating costs. The analysis approach allows this possibility.

The cost of operating buses in the CBD, OC_i, is estimated as follows:

Let:

V_i = number of buses entering the CBD daily

R_i = number of transit trips entering the CBD daily

CD_i = average CBD trip length (both in and out leg)

O = operating cost per vehicle mile (1979 dollars)

C = total bus operating cost (annual, 1979 dollars)

Then,

$$V_i = R_i/25 \quad \text{(assuming an average load of 25 passengers per bus)} \tag{28}$$

$$OC_i = O \cdot V_i \cdot CD_i \cdot 325 \tag{29}$$

The term $V_i \cdot CD_i$ estimates weekday bus VMT in the CBD; operating costs are assumed proportional to VMT. For the abstract CBD defined previously,

$$CD_i = P_i C_i + (1 - P_i) W_i$$

where P_i is the proportion of buses entering on the spine.

Substituting this relationship and (28) into (29):

$$OC_i = 13 \cdot O \cdot R_i \cdot (P_i L_i + (1 - P_i) W_i) \tag{29'}$$

The change in annual capital costs of providing bus service in the CBD requires an estimate of the reduction in the vehicle fleet that could be accomplished if buses did not enter the CBD. This reduction is estimated as follows:

ΔV_i = reduction in vehicle fleet that would be accomplished by terminating all routes at the periphery of CBD_i

S = average CBD bus speed (min/mi)

V_{Ei} = number of buses entering CBD_i <u>in the peak period</u>

E = length of the peak period (minutes)

Then:

$$\Delta V_i = \frac{CD_i \cdot S \cdot V_{Ei}}{E} \qquad (30)$$

The numerator represents the number of vehicle minutes saved in each peak period, while the denominator is simply its length. For every E minutes saved, a vehicle can be eliminated. For a peak period of 120 minutes, 25 percent of all transit passengers typically enter the CBD, but average vehicle occupancies are also higher than during non-peak periods. V_{Ei} is then assumed to be 20 percent of V_i. Assuming that S = 10 min/mi.:

$$\Delta V_i = \frac{R_i}{2225} \left(P_i L_i + (1-P_i) W_i\right) \qquad (30')$$

The annual capital cost savings for these V_i vehicles is estimated with assumptions on vehicle costs ($100,000) and vehicle life (10 years). The combined annual capital and operating savings, ΔBS_i, assuming a θ proportion reduction in CBD bus operations is:

$$\Delta BS_i = \theta \left[\underbrace{100000\ V_i}_{\text{Capital Costs}} + \underbrace{13\ \ 0\ \ R_i \left(P_i L_i + (1-P_i) W_i\right)}_{\text{Operating Costs}}\right] \qquad (31)$$

To estimate the long term benefits, ΔLBS_i, an additional parameter, α, the long term rate of increase in <u>real</u> operating and capital costs is introduced. For a discount rate, r:

$$\Delta LBS_i = \frac{1 + \alpha}{r - \alpha} \Delta BS_i \qquad (32)$$

$$(r > \alpha)$$

B.5 DPM CAPITAL AND OPERATING COSTS

The operating and capital costs of a DPM/Bus system are comprised of the costs for the DPM itself and the costs for the remaining bus operations. The annual capital and operating costs for the residual bus service can be estimated by substituting $(1-\theta)$ for in Eq. (31). Similarly, the long term costs can be estimated by substituting the resulting estimate of bus operating and capital costs into Eq. (32).

B.5.1 DPM CAPITAL COSTS

Capital costs incurred in deploying a DPM include vehicle purchase costs, guideway construction costs and costs of constructing a maintenance and vehicle storage facility. The life of the latter two capital investments (30 years) is sufficiently long that they can be treated as one-time costs. Vehicle life (12 years) is not sufficiently long to treat this capital expense as a one-time cost. The approach to estimation of capital costs reflects this difference.

The number of vehicles required depends on the system length, average vehicle speeds and headways. Assuming an average speed of 7.5 minutes/mile (including layover time) and headways of 2 minutes, the number of vehicles required is 3.75 times twice the length of the guideway. If it is further assumed that a backup fleet of 20 percent is necessary, then the number of vehicles required is about four times twice the system length.

Let:

A_0 = construction costs for maintenance and storage facility

A_1 = construction costs per mile of guideway

A_2 = cost per vehicle

Then, for a shuttle DPM system, capital costs, CC_{Di}, are:

$$CC_{Di} = A_0 + A_1L_1 = 8A_2L_i \tag{33}$$

Since vehicle costs are a recurring capital cost, assuming a vehicle life of 12 years and an annual rate of increase in the real cost of vehicles, α, the following costs are added to Eq. (33):

$$8L_i\left(\frac{1+\alpha}{1+r}A_2\right)^{12} \tag{33'}$$

B.5.2 DPM OPERATING COST

Annual DPM operating costs, OC_i, are assumed to be proportional to DPM VMT. In a peak period of 180 minutes, each vehicle travels 24 miles. Assuming 1300 peak period equivalents per year, each vehicle will travel 31,200 miles per year. In computing annual operating cost, the number of vehicles is estimated as 3.75 times twice the system length.

$$OC_i^P = 234000 \; BL_i \tag{34}$$

where

B = cost per vehicle mile travelled

To estimate the long term operating costs, LOC_i^D, real operating costs are assumed to increase at the same rate as DPM vehicle costs, α. Thus,

$$LOC_i^D = \frac{1 + \alpha}{r - \alpha} \; OC_i \tag{35}$$

$$(r > \alpha)$$

* U.S.G.P.O. 727-723/1302-1686