Evaluation

An opinion survey showed that residents of Singapore believe that the area license scheme has relieved congestion and improved conditions in central Singapore. Pedestrians, bus riders, taxi riders, and motorcyclists believe that they personally are better-off as a result of the scheme. Central area residents report that it is easier and safer to cross the streets, that general conditions in the restricted zone have improved, and that the amount of fumes has been reduced. Motorists report that they are worse-off, but not greatly so. All, including the motorists, believe that the effect on Singapore as a city is favorable.

In terms of the general objective of forestalling future congestion problems by forcing people to change their attitudes toward the use of automobiles for commuting, the area license scheme appears to be a success. Major modifications in travel behavior have taken place.

Whether these are simply short-term modifications or whether they represent fundamental changes in the attitudes of motorists cannot be determined at this point. It seems likely, however, that the continued use of such measures will result in a more widespread acceptance (rather than mere tolerance) of public transportation and car pooling.

Analyzing Indirect Impacts of Alternative Automated-Guideway-Transit Systems

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A computer methodology is described for analyzing at a sketch-planning level five types of indirect impact of automated guideway transit: right-of-way land consumption, community disruption, household and business displacements, aesthetics, and noise disruption. Application of the technique in a recent case study of dual-mode transit planning in Milwaukee is discussed. The methodology is also applicable to the preliminary analysis of other automated-guideway-transit systems. The procedures used in the inventory of potential link and station characteristics and in the analysis of network and corridor alternatives are reviewed. It is concluded that such analyses of neighborhood and environmental factors should be coordinated with other demand-and-supply-oriented, sketch-planning methodologies.

In the last 10 years, transportation planners have been introduced to a variety of new and proposed transportation technologies. Many of these technologies represent generic modes of travel for which there is no previous operational experience. Personal rapid transit and automated dual-mode transit are two examples of new transportation modes that, when viewed from the perspective of the traveler, offer performance characteristics that are significantly different from the more traditional, urban transportation modes. New planning methodologies and techniques are required to effectively analyze and determine the most appropriate role for a new transit technology within an existing mix of multimodal, urban transportation services. For simplicity, those new transit technologies that require some form of fixed facility or guideway are generally categorized as automated-guideway transit (AGT).

The Urban Transportation Planning System (UTPS) package of computer programs can represent the physical extent and operational characteristics of current and new transit technologies, for purposes of multimodal transportation-system, demand-and-supply analysis (13). The UTPS package can also be used for sketch-planning analysis—a procedure that can be used to rapidly iterate through alternative multimodal transportation systems and delineate feasible combinations of modes and service philosophies for more detailed, implementation-oriented studies. Sketch-planning has received increasing emphasis in urban travel-demand forecasting (1, 4, 11, 12), because it provides the following advances over the traditional urban-transportation planning process:

1. The ability to examine a much wider range and number of alternative systems to screen out concepts that can be shown to be less workable and delineate other designs for further, more detailed analysis;
2. The ability to analyze these alternatives relatively quickly and at low cost;
3. A selective focusing on major consequences and performance characteristics; and
4. The ability to perform parametric analyses that examine changes in these consequences because of variations in other system characteristics.

Sketch-planning programs are particularly useful at the system-planning level and may also be useful at more detailed levels, such as corridor planning (3, 9). They can be used in the planning and evaluation of both highway and transit systems, on a multimodal basis, and include the consideration of alternative transit technologies.

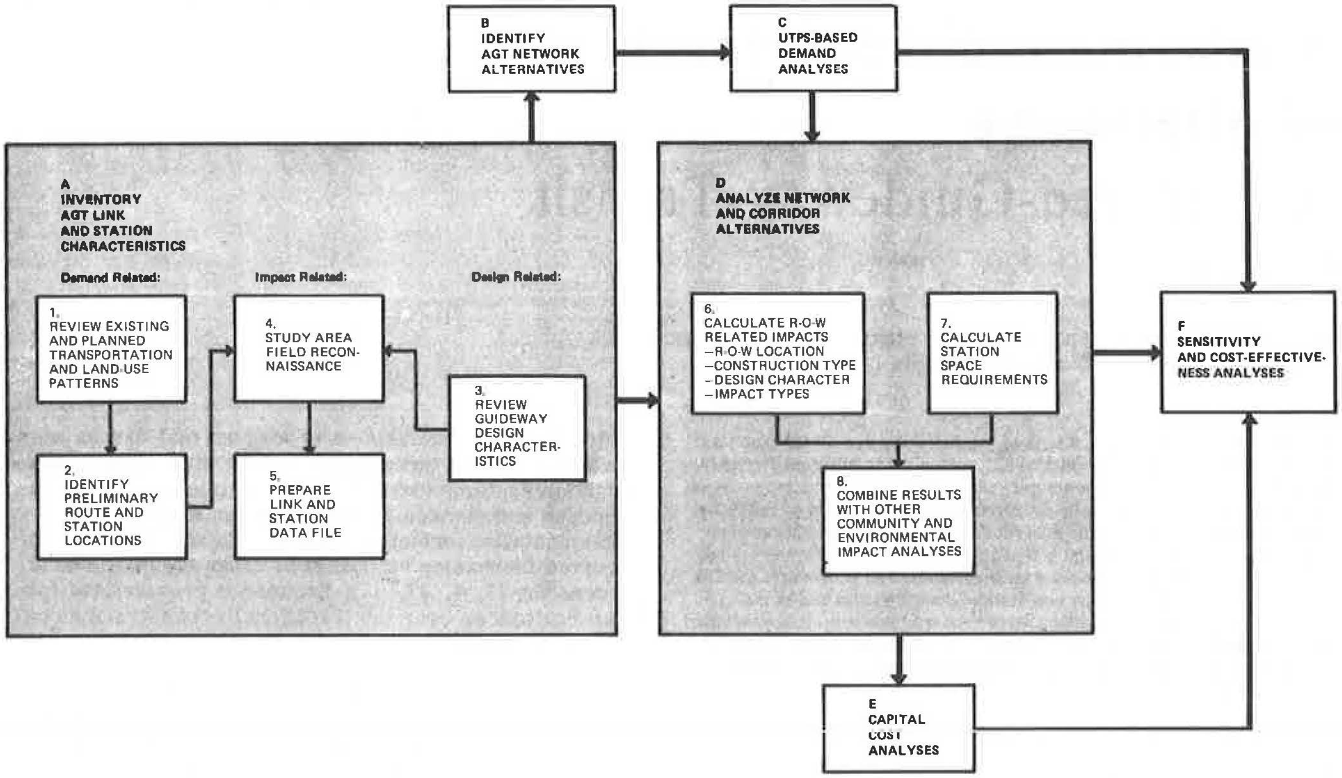
Much effort has been devoted to the development of sketch-planning procedures for analyzing travel demand and the related system-performance characteristics, but it is also important to develop methods for analyzing other, more indirect impacts of transportation-system alternatives (6, 7, 8, 10, 14). All too often, indirect impacts are not considered at the stage of alternative-

Table 1. Definitions of community and environmental-impact variables.

Category	Variable	Definition
User benefits	Consumer surplus[a]	Aggregate willingness to pay of transit users minus what they actually pay; this is an economic user-benefit measure
	Accident costs[a]	Number of accidents during peak period (highway and transit)
	Accessibility[a]	Indexes of transit accessibility to selected work, shopping, and recreation zones
	Disadvantaged[a]	Indexes of transit accessibility to selected work, shopping, and recreation zones, from primarily low-income-and-elderly zones
Environmental impacts	Air pollution[a]	Peak-period air-pollutant emissions
	Fuel[a]	Peak-period fuel consumption
	Noise	Residential neighborhoods traversed by guideway network
	Aesthetics	Types of neighborhoods traversed by elevated guideway
Neighborhood impacts	Land use for right-of-way	Land-use consumption (by type of neighborhood) for main line of guideway
	Community disruption	Community boundary orientation of guideway network
	Displacement	Number of modal-interchange stations adjacent to different types of land use
	Land values	Development potentials near several sample stations (subjective)

[a] Reductions or gains analyzed by comparison with 1990 conventional bus alternative; analyses of these impacts derived from computer-modeling outputs.

Figure 1. Indirect-impact analysis process.



systems conceptualization. Planners considering implementation of a new transit technology should be apprised of its potential for neighborhood, corridor, and regional disruption. Designs that perform well with respect to demand-and-supply considerations may ultimately succeed or fail on the basis of the indirect impacts that they generate. These indirect impacts can include, for example, potentials for community disruption or for right-of-way land-acquisition difficulties. Such impacts are rarely considered at the system-planning level and even less at the more generalized approach of sketch planning. However, the increased concern for a more comprehensive examination of social, economic, and environmental impacts at the system-planning level suggests that both demand-oriented and impact-oriented analyses are needed as the urban transportation planning process is broadened and extended.

The development of a simplified, computer-based approach for the analysis of indirect impacts, intended for application at a sketch-planning level, is the subject of this paper. The method was developed as a part of an analysis of alternative dual-mode transit systems, but can be extended to other AGT-system alternatives. Five basic impacts are considered: (a) right-of-way land consumption by type of land use; (b) community disruption; (c) household and business displacement; (d) aesthetics; (e) and noise disruption. The computerized portion of the methodology is simply an accounting procedure designed to permit the rapid analysis of many different AGT systems or networks and to facilitate parametric analyses. The method is base on a careful field reconnaissance of the study area and appears to save time and effort only if a fairly large number of alternatives (probably more than 10) are analyzed.

The technique was used in a recent case study of dual-mode transit-planning in the Milwaukee region (2). The 12 community and environmental-impact variables that were examined at a sketch-planning level are defined in Table 1. The analyses of the first 6 of those impacts were derived from UTPS-modeling outputs and are not to be discussed in this paper. The 5 impacts that are considered here were initially analyzed by hand. The information needed for a more systematic, computer-based analysis, which would permit consideration of a larger number of alternatives, gradually accumulated, but this kind of analysis was only partially implemented in the project. This paper consequently represents an extension of the methods actually used, and offers a recommended procedure for carrying out such analyses more efficiently.

Figure 1 summarizes the basic steps in the analysis procedure and suggests relationships with other steps in the sketch-planning process. These other steps include the design of alternative systems, travel-demand analyses, capital-cost analyses, and parametric analyses of demand, supply, cost, and impact trade-offs. The following sections of the paper will discuss each of these steps in turn, with some illustrative results from the Milwaukee study.

INVENTORY LINK AND STATION CHARACTERISTICS

The first major step shown in Figure 1 is the identification of the significant AGT-link and station characteristics to be analyzed. These characteristics fall into three categories: demand-related, impact-related, and design-related. These three types of characteristics provide inputs, in turn, to three subsequent steps in the process: (a) preliminary identification of probable AGT routes and station locations throughout the region under consideration; (b) field reconnaissance and inventory of impact-related characteristics of the most reasonable route and station locations; and (c) computer-based calculation of pertinent right-of-way-related impacts, based on the general design characteristics of the type of technology selected.

Preliminary Route and Station Locations

A preliminary examination of guideway location opportunities should be undertaken as an important site-related input to the design of the AGT-network alternatives and a subsequent input to the UTPS-based demand-and-performance analyses. In general, the identification of opportunities for multiple use of existing transportation or utility rights-of-way should be emphasized. In the Milwaukee case study, existing and planned non-transit transportation systems were examined for these location opportunities. Both route or link and station location opportunities were considered.

The following criteria were used to identify preliminary route locations. Potential AGT routes should

1. Follow existing freeway corridors to provide congestion relief;
2. Follow proposed freeway corridors to provide a modal alternative;
3. Follow major arterial streets (preferably but not necessarily those with available median rights-of-way) to provide service closer to residential trip ends;
4. Take advantage of other existing right-of-way opportunities, such as railroads, utility lines, drainage channels, and similar land uses; and
5. Cover all major urbanized and urbanizing subareas of the region with both radial and gridlike network configurations.

After preliminary, hypothetical AGT corridors were identified, the following criteria were used to identify potential AGT station locations. The stations should

1. Serve all major activity centers, including business and commercial, medical, university, governmental, recreational, and other trip-end concentrations;
2. Be interspersed according to station-spacing policies appropriate for the AGT technology under consideration [for example, 3 to 6 km (2 to 4 mi) for personal rapid transit]; and
3. Be located near major cross streets to facilitate modal transfers.

Field Reconnaissance of the Study Area

While this preliminary identification of potential AGT routes and stations can be conducted as an office activity by using the appropriate maps and plans, the development of the necessary impact-related data will require field inspections of each potential route alignment. From the analyses conducted in Milwaukee, it was concluded that the following six types of link data and four types of station-area data should be collected.

Link Data

1. Predominant right-of-way land-use: (a) freeway median or sidestrip, (b) arterial-street median or curb strip, (c) vacant (1974), (d) industrial, (e) mixed residential and commercial, (f) medium-density residential, (g) low-density residential, (h) railroad, and (i) utility;
2. Adjacent neighborhood land-use type: (a) low-density residential, (b) medium-density residential, (c) mixed residential and commercial, (d) commercial, (e) industrial, (f) vacant (1974), and (g) park and institutional;
3. Community boundary orientation: (a) follows boundary, (b) follows existing barrier (freeway), (c) follows existing spine (arterial street), (d) traverses low-density residential, and (e) traverses medium-density residential;
4. Guideway configuration (construction type): (a) at-grade, (b) open cut, (c) depressed, (d) cantilevered elevated, (e) straddling elevated, and (f) tunnel;
5. Right-of-way width; and
6. Unique features

Station Area Data

1. Right-of-way width: (a) freeway median or side-strip and (b) arterial-street median or curb strip;
2. Adjacent neighborhood land-use type: (a) low-density residential, (b) medium-density residential, (c) mixed residential and commercial, (d) commercial, (e) industrial, (f) vacant (1974), and (g) park and institutional;
3. Station configuration (construction type): (a) at-grade, (b) open cut, (c) depressed, (d) elevated, and (e) tunnel; and
4. Unique features.

(Links are defined as intervals between potential stations and may be further subdivided if significant land use changes occur. Link-data items 1, 2, 4, and 5 and station-area-data items 2 and 3 can be determined from field reconnaissance. Link-data items 1, 3, and 4 and station-area-data items 1 and 3 can be determined by analysis of appropriate maps and plans. Link-data item 4 and station-area-data item 3 should indicate minimum cost or disruption configurations. Link-data item 5 applies only to constricted route locations. Link-data item 6 and station-area-data item 6 are not coded.)

In the case study of dual-mode transit planning the existing urban development, land use, and transportation characteristics of the Milwaukee region were surveyed. Much of the data listed above were collected. The purpose of the field surveys was to become directly familiar with the potential locations for guideway alignment and right-of-way and for stations. Basic right-of-way characteristics for 20 different potential AGT-service corridors (including alternative alignments within some corridors) were inventoried, and more than 100 potential station areas were located along these hypothetical guideway alignments. The Milwaukee central business district and seven outlying commercial centers were visited to become familiar with activity-center characteristics. Detailed field notes and sketch maps were prepared. Each of the 20 potential guideway corridors was driven on.

ANALYZING ALTERNATIVE NETWORKS AND CORRIDORS

The next major step in the analysis process shown in Figure 1, the identification of alternative AGT networks and the associated station-spacing and service policies is largely external to the indirect-impact analysis. In the Milwaukee case study, only five basic networks were initially identified, and it was therefore possible to carry out much of the indirect-impact analysis by hand. However, after a series of additional networks was identified as a part of the parametric analyses and the number of networks increased, it began to appear that a more streamlined procedure for performing routine calculations would be useful. The more tedious portion of the impact analyses described below, the derivation of station-space requirements, was carried out by a simple computer program from the beginning.

Impacts Related to Right-of-Way

After the alternative networks have been identified in the overall sketch-planning process, it is possible to calculate and analyze the right-of-way-related impacts. As indicated in Figure 1, this requires four types of input data. The first involves the designation of an assumed right-of-way alignment within those corridors where alignment options—in terms of land-use requirements—have been defined, for each alternative AGT system to be analyzed. The second involves the designation of an assumed type of guideway construction for those links where more than one construction type appears applicable. In both cases, the purpose is to identify a single set of AGT links and their associated impact characteristics, from among all of the links that were inventoried, to unambiguously represent a single AGT system.

The third type of input data involves design-related location characteristics. These vary by type of AGT technology (for example, bus rapid transit, light rail transit, small-group rapid transit, and personal rapid transit) and, again, an unambiguous designation of guideway design features that may affect indirect impacts should be made. The pertinent design-related characteristics include

1. Guideway, right-of-way width requirements by technology and construction types (these width requirements need be verified only for those links where a constricted right-of-way has been indicated, to flag those locations where additional displacements might be created) and
2. Station-space requirements (preferably both width and total area), as related to passenger-flow volumes, by technology and construction types (these data should be in the form of a table or graph indicating changes in station-space requirements as a function of passenger flow and covering three station components: the mainline guideway-ramp connections, the station site itself, and the park-and-ride facilities).

The fourth type of input data involves the impact-related inventory characteristics collected in the field reconnaissance and office research activities. The impact-analysis process then involves no more than the summation of the indirect impacts for each particular set of links and station areas contained within each alternative system. A report can then be generated, either by hand or preferably by computer, that describes the length of the route or the number of stations in each right-of-way land-use category, neighborhood land-use type, and community boundary-orientation category and each station-location land-use category and neighborhood land-use category traversed by the guideway. Further interpretations and comparisons, particularly among the different systems, can then be made.

Analysis of Requirements for Station Space

In addition to developing generalized sketch-planning impact data by summing the link and station characteristics that fall in the different categories, analyses of the station-space requirements should also be made. Particularly for dual-mode transit stations where modal-interchange operations must take place, the relatively large station-space requirements can lead to significant dislocation impacts, so that even at a sketch-planning level of detail, some preliminary indication of the number and size of such stations is desirable. These analyses must be based on the station-design concepts and site plans that have been developed as a part of the hardware-oriented, AGT-system planning (5). A simplified computer subroutine was developed to process the demand-modeling outputs (as indicated in Figure 1) and the design-related data together to determine the average station-space requirements for each alternative system.

Two types of demand-analysis data are required for the determination of station-space requirements: (a) peak-hour person trips, inbound and outbound, by zone [covering walk-in, park and ride, on-board (no transfer), and transfer trips] and (b) number of stations per zone by station type (modal-interchange, walk-in only, transfer only, and possibly others).

The following analysis steps are then taken:

1. Allocate passengers per zone among stations per zone;
2. Use the total number of walk-in, park-and-ride, and transfer passengers per zone (peak direction) to calculate, by using station design and size requirements, the space requirements for each station; and
3. Calculate average station size and space requirements by station type (this step is important to emphasize that the space requirements calculated for any particular station or zone should not be taken too literally, since they are preliminary and generalized and that only average or total station-space requirements are pertinent at a sketch-planning level of detail).

Results of Milwaukee Case Study Illustrative

Tables 2 to 8 summarize the results derived in the Milwaukee case study of dual-mode transit planning. The results for the five initial dual-mode networks and the four networks defined as a part of the parametric analysis are given. The five basic networks were of two small-scale, two medium-scale, and one full-scale systems. The four parametrically-derived networks

Table 2. Dual-mode systems summary: guideway configurations.

	Length of Type of Construction (km)						
System	At Grade	Open Cut	Depressed	Elevated (cantilevered)	Elevated (straddling)	Tunnel	Total
A4	17.2	3.4	—	3.5	4.8	—	29.0
A1	7.4	5.6	2.7	10.8	2.6	—	29.1
A1 max	18.7	11.7	2.7	14.2	2.6	—	49.9
A1 min	1.8	3.4	1.6	6.9	2.6	—	16.3
B4	11.7	5.5	6.9	34.0	14.5	1.1	73.5
B1	9.7	5.5	6.9	25.3	12.9	—	60.2
B1 max	73.1	15.0	6.9	52.1	15.1	—	162.2
B1 min	5.1	5.5	6.0	21.6	7.6	—	45.7
C4	110.4	18.7	6.9	90.6	32.3	1.1	260.1

Note: 1 km = 0.62 mile.

Table 3. Dual-mode systems summary: land-use consumption (main line of guideway).

	Length of Guideway in Type of Land Use (km)								
System	Railroad	Low-Density Residential	Medium-Density Residential	Mixed Residential and Commercial	Industrial	Vacant (1974)	Median or Curb Strip of Arterial Street	Median or Side Strip of Freeway	**Total**
A4	7.4	—	—	—	—	—	5.8	15.8	29.0
A1	5.6	—	—	3.2	0.6	—	3.9	15.8	29.1
A1 max	5.6	—	—	3.2	0.6	—	3.9	36.5	49.9
A1 min	1.6	—	—	3.2	0.6	—	—	10.8	16.1
B4	7.4	—	—	—	1.8	—	35.1	29.3	73.5
B1	5.3	—	—	—	1.8	—	25.4	27.5	60.0
B1 max	18.8	—	—	—	1.8	—	45.4	96.1	162.1
B1 min	2.3	—	—	—	1.8	—	23.2	18.3	45.5
C4	32.7	—	—	—	2.6	20.0	93.3	111.4	260.1

Notes: 1 km = 0.62 mile.
Stations and intersections not included.

Table 4. Dual-mode systems summary: community-boundary orientation.

	Length of Guideway (km)					
System	Following Boundary	Following Existing Barrier (freeway)	Following Existing Spine (arterial street)	Traversing Low-Density Residential Area	Traversing Medium-Density Residential Area	Total
A4	—	23.2[a]	5.8	—	—	29.0
A1	—	20.6	8.5	—	—	29.1
A1 max	—	41.5	8.5	—	—	50.1
A1 min	—	11.6	4.7	—	—	16.3
B4	6.4	35.7	17.1	—	14.3	73.5
B1	6.4	31.9	7.4	—	14.3	60.0
B1 max	6.4	111.7	29.1	—	14.3	161.6
B1 min	6.4	19.6	5.1	—	14.3	45.5
C4	53.9	124.1	47.5	10.5	24.1	260.1

Note: 1 km = 0.62 mile.

[a] Includes portions where guideway follows railroad.

Table 5. Dual-mode systems summary: land use in station-area environs.

	Number of Stations Adjacent to Type of Land Use																											
	Low-Density Residential				Medium-Density Residential				Mixed Residential and Commercial				Commercial				Industrial				Vacant (1974)				Park or Institutional			
	Freeway		Arterial		Freeway		Arterial		Freeway		Arterial		Freeway		Arterial		Freeway		Arterial		Freeway		Arterial		Freeway		Arterial	
System	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W	M	W
A4[a]	–	–	–	–	1	–	–	–	–	–	1	–	1	–	–	–	5	–	–	–	2	–	1	–	2	–	–	–
A1	–	–	–	–	3	2	–	1	–	–	–	–	–	3	3	1	2	4	1	–	–	–	–	–	2	1	–	–
B4[a]	2	–	–	–	8	–	10	–	–	–	14	–	4	–	10	–	6	–	6	–	–	–	–	–	4	–	–	–
B1	–	–	–	–	5[b]	2[b]	3	5	–	–	–	–	2	6	3	3	4	7	1	–	–	–	–	–	2	1	1	1
B1 with shorter station spacing	–	–	–	–	5[b]	11[b]	3	15	–	–	–	–	2	12	3	8	4	14	1	2	–	–	–	–	2	3	1	1
B1 with longer station spacing	–	–	–	–	5[b]	–	3	1	–	–	–	–	2	3	3	1	4	1	1	–	–	–	–	–	–	2	1	1
B1 with minimum guideway	–	–	–	–	4[b]	–[b]	2	3	–	–	–	–	1	4	3	3	4	6	1	–	–	–	–	–	2	1	1	1
B1 with maximum guideway	1	5	–	–	6[b]	6[b]	7	14	–	–	–	1	3	6	5	6	6	7	1	–	15	8	1	–	3	4	1	1
C4[a]	3	–	–	–	11	–	15[c]	–	1	–	13	–	3	–	9[b]	–	6	–	4	–	13	–	14[d]	–	2	–	–	–

Note: M = modal-interchange station; W = walk-in-only station.

[a] Walk-in station locations were not investigated for the initial baseline systems. For these systems, modal interchange (or transfer) stations for both automated guideway and manual on-street operations were analyzed.

[b] One additional station located on railroad right-of-way.

[c] Includes 3 stations within railroad right-of-way.

[d] Includes 4 stations within railroad right-of-way.

Table 6. Dual-mode systems summary: neighborhoods traversed by elevated guideway.

	Length of Guideway in Type of Neighborhood Traversed (km)							
System	Low-Density Residential	Medium-Density Residential	Mixed Residential and Commercial	Commercial	Industrial	Vacant	Park or Institutional	Total
A4	0.6	–	2.3	0.6	1.3	2.1	1.3	8.2
A1	–	4.0	–	4.3	3.7	–	1.3	13.4
A1 max	–	5.8	–	4.3	4.7	–	1.9	16.7
A1 min	–	2.1	–	2.4	3.7	–	1.3	9.5
B4	–	28.0	2.9	9.5	7.7	–	0.3	48.4
B1	–	19.2	2.9	8.0	7.7	–	0.3	38.1
B1 max	–	30.6	6.8	14.6	8.7	2.1	1.4	66.9
B1 min	–	16.4	0.2	7.2	5.1	–	0.3	29.3
C4	9.3	56.0	13.4	21.4	15.4	3.4	4.0	123.0

Note: 1 km = 0.62 mile.

Table 7. Dual-mode systems summary: neighborhood environs traversed.

	Length of Guideway in Type of Neighborhood Land Use (km)							
System	Low-Density Residential	Medium-Density Residential	Mixed Residential and Commercial	Commercial	Industrial	Vacant (1974)	Park or Institutional	Total
A4	0.6	1.9	2.3	0.6	8.5	11.3	3.7	29.0
A1	–	8.4	1.4	4.3	11.1	0.2	3.9	29.3
A1 max	4.3	16.7	1.4	5.0	12.4	4.2	6.1	50.2
A1 min	–	2.7	1.4	2.4	5.6	0.2	3.9	16.3
B4	–	39.1	2.9	11.3	16.3	–	4.0	73.5
B1	–	29.1	2.9	8.7	16.3	–	2.9	59.9
B1 max	10.6	51.0	6.8	17.5	20.0	47.6	8.0	161.6
B1 min	–	23.2	0.2	7.7	13.7	–	0.8	45.5
C4	20.8	80.1	13.7	25.4	29.0	76.0	15.0	260.1

Note: 1 km = 0.62 mile.

Table 8. Dual-mode systems summary: station-space requirements.

	Avg Station Size (m^2)			
	Modal-Interchange Station			
System	Basic Station Facility	Park-and-Ride Area	Total	Walk-in-Only Station
A4[a]				
A1	11 812	5209	17 021	5266
B4	11 812	3427	15 239	6885
B1	11 812	3785	15 597	5194
B1 with shorter station spacing	11 812	3980	15 792	5176
B1 with longer station spacing	11 812	3022	14 834	5454
B1 with minimum guideway	11 812	3785	15 597	5184
B1 with maximum guideway	11 812	3785	15 597	5197
C4	11 812	2210	14 022	6900

Note: 1 m^2 = 10.7 ft^2.

[a] This initial baseline system was not analyzed.

were minimum and maximum alternatives of the small-scale and medium-scale systems. The following conclusions are derived from the results reported in Tables 2 through 8.

1. Because of relatively narrow guideway-width requirements, it appears possible to locate most of the main line of the guideway within existing transportation rights-of-way (freeways, arterial streets, and railroads). The system B4 network would require acquisition of about 2 or 3 percent of its land from land in current development, and the system C4 network would require acquisition of about 1 percent of its land from land in current development and about 8 or 9 percent from land that is currently vacant.

2. Community-disruption potentials would exist, but not in any major degree. Furthermore, the disruption caused by the relatively narrow, often-elevated guideway would probably be much less than that commonly associated with urban freeways. About 20 percent of the system B4 network and 12 percent of the system C4 network would traverse residential neighborhoods, not following existing boundaries, barriers, or (typically strip commercial) spines.

3. There are fairly significant residential and business displacement potentials associated with guideway-station-space requirements, especially for modal-interchange stations on arterial streets. For the system A4 network, 9 percent of the guideway stations would be in residential areas and none on arterial streets. For both systems B4 and C4, 30 percent of the stations would be in residential areas, and 15 percent would be on arterial streets. In each system, a smaller percentage of stations would be in commercial or industrial areas. While this would achieve close integration with surrounding urban land uses, which would maximize the potential

for walk-in patronage, the typical modal-interchange, station-space requirement of 3010 to 10 950 m^2 (32 500 to 99 000 ft^2) would create significant displacement problems. Further work in hardware design aimed at minimizing the space requirements of stations appears necessary.

4. Aesthetic-intrusion potentials were assessed primarily in relation to the land uses traversed by the elevated guideway. Even though there are fairly pleasing guideway and vehicle designs, the mere presence of an elevated guideway in a residential area, for example, could be aesthetically distracting. About 36 percent of the system B4 and 24 percent of the system C4 networks would be located in residential neighborhoods, where the disruption potential might be highest.

5. Noise intrusion potentials were related primarily to the extent to which guideways would pass through residential neighborhoods of varying density. Because the anticipated noise characteristics of dual-mode transit vehicles do not greatly exceed the ambient noise characteristics typically found in residential neighborhoods, the potential for serious noise intrusion does not appear very great. About half of the system B4 and 44 percent of the system C4 networks would be located in residential neighborhoods.

6. The minimum or maximum guideway networks (for systems A1 and B1) do not affect (reduce or increase) the right-of-way land requirements (for the main-line guideway only) for areas currently in urban development. For either variation of the system, guideways added or deleted would be located within existing transportation rights-of-way.

7. The minimum or maximum guideway networks would not affect (reduce or increase) the length of guideway traversing residential neighborhoods. For either variation of the system, guideways added or deleted would primarily follow existing boundaries or barriers (freeways or railroads).

8. The minimum and maximum guideway networks have some potential for reducing or increasing aesthetic intrusion in residential neighborhoods. For the system A1 network, the potential for such intrusion would be decreased from 4.0 to 2.1 km (2.5 to 1.3 miles) for the minimum guideway and increased from 4.0 to 5.8 km (2.5 to 3.6 miles) for the maximum guideway. For the system B1 network, the variations would be from 19.2 to 16.4 km (11.9 to 10.2 miles) for the minimum guideway and from 19.2 to 33.3 km (11.9 to 20.7 miles) for the maximum guideway. There are similar variations for commercial and industrial areas.

9. The minimum and maximum guideway networks have similar potentials for reducing or increasing the extent to which residential neighborhoods are exposed to some additional degree of noise intrusion. For the system A1 network, the length of guideway through residential neighborhoods would decrease from 9.8 to 4.2 km (6.1 to 2.6 miles) for the minimum guideway and increase from 9.8 to 11.5 km (6.1 to 14.0 miles) for the maximum guideway. The comparable figures for the system B1 network are 32.0 to 23.3 km (19.9 to 14.5 miles) and 32.0 to 64.7 km (19.9 to 40.2 miles).

SENSITIVITY ANALYSES

A major part of the Milwaukee case study dealt with the parametric analysis of significant variables—supply, demand, cost, and community and environmental characteristics—associated with dual-mode systems. The emphasis was on the use of the UTPS sketch-planning, demand-analysis methodology, with its relatively low costs and quick turn-around time, to examine the consequences of designated changes in selected variables. The results of such analyses can, of course, be extremely useful in the more careful design of subsequent system alternatives, as more detailed levels of system planning are undertaken. After the most significant variables in each cluster—supply, demand, cost, environmental—were identified, a three-stage approach to the parametric analysis was followed. The three stages included single-variable analysis, within-cluster analysis (relations between variables within the same cluster), and between-cluster analysis (which is more demanding, and necessarily more selective, because the between-cluster combinations of variables that might affect one another can be large) (2).

The first two stages of the parametric analysis, for the five community and environmental factors considered here, were conducted by using a series of eight sample guideway stations, of which seven involved dual-mode modal-interchange stations, one involved a walk-in-only station, and four involved an adjacent guideway intersection. There was a balanced geographic distribution among these prototype stations: Three were located on arterial streets, at medium-density residential (with commercial frontage), low-density residential, and low-density commercial locations. The field reconnaissance indicated that, for most arterial-street guideways, there are commercial land uses of some kind at most of the major intersections identified as candidates for station areas. The sample also included four guideway-on-freeway stations, at medium-density residential and low-density residential locations, and one CBD station.

For each of the eight station locations, generalized site plans were sketched by using the results of the station-space analyses. A minimum land-consumption design was used and, as a part of the single-variable and within-cluster parametric analyses, a few design variations were explored. The only impact variable of the five considered here that varied significantly was that of household and business displacements.

Between-cluster parametric analyses were then conducted at the level of the overall system. Of all the between-cluster variations that were examined parametrically for system-wide sketch-planning analyses, only the minimum guideway and maximum guideway variations resulted in significant changes in all five of the neighborhood environmental-impact variables.

Station-area impacts, particularly household and business displacements, can also vary with other supply-and-demand variations of the system. These impacts can vary both with changes in the number of stations and in their average size. Station-area land requirements and household and business-displacement potentials can change in association with eight basic variations of system supply and demand; shorter station spacing, longer station spacing, lower station sizing (decrease in demand), higher station sizing (increase in demand), minimum guideway, maximum guideway, increased land-use density (in the vicinity of station areas), and decreased urban sprawl (increased concentrations of demand closer to the central city).

CONCLUSIONS

The parametric analysis of neighborhood and environmental impacts, set within a broader sketch-planning methodology, can help to enrich the amount of information on the consequences of AGT systems. For example, potential route alignments and station locations with significant negative impacts can be quickly identified, and a general picture of the extent of these impacts can be gained. Subsequent alternatives can be refined to reduce or mitigate such impacts. Other combinations of potential guideway links and stations—additional system alternatives—can be quickly tested by specifying those individual links and stations to be included in the new alternative. It may also be necessary to add more potential links and stations to the initial field inventory; this can be an important contribution to the thoroughness with which later system planning is conducted. Finally, the related between-cluster impacts on community and environmental factors that can be attributed to the many supply-and-demand variations of the system can be quickly examined.

The limitations of the indirect impact-analysis methodology suggested here should also be clearly understood; these are essentially the limitations attached to sketch-planning in general.

1. Sketch-planning results are generalized in nature. Specific impact estimates for individual links or station areas, such as areas of land to be acquired and numbers of dwelling units to be displaced, should not be expected, and procedures for their calculation are not included.
2. Care must consequently be exercised in using these generalized results in community and public-agency interactions. Because specific alignments, centerlines, and station locations are not investigated, it is possible that subsequent system and corridor planning will, for any individual link or station, significantly alter the initial assessment of consequences.
3. In the area of community and environmental factors, particularly at the corridor-planning level, considerable and major additional efforts are necessary to adequately specify the indirect effects that will actually be generated.

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Comparison of the Usefulness of Two Multiregional Economic Models in Evaluating Transportation Policies

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This report describes and compares two large-scale economic-forecasting models—the multiregional input-output model developed by Polenske and the multrieginal, multi-industry forecasting model developed by Harris—to examine their usefulness for transportation planning at national, state, and local levels. The models use fundamentally different methods of economic forecasting, and thus have different appropriate applications. Both the Polenske and the Harris models are currently used in analyzing regional economic activity by industrial sectors. A basic difference is that the Polenske model is used mainly for analyzing the effects of changes in interindustry trade flows between regions, whereas the Harris model is used mainly in forecasting regional growth and evaluating effects of alternative highway and other transportation systems. The Polenske model provides a framework for describing and analyzing the sales and purchases of all industries in every region of the economy and has been used to analyze the role of trade in the economic growth of particular regions, such as the California-Oregon-Washington region, as compared to the rest of the United States. The Harris model is designed to make both short-run and long-run forecasts of economic growth. Because it provides a framework for analyzing interindustry purchases, it has been used to evaluate the regional economic and environmental effects of alternative highway systems.