Assignment Procedures

The most general assignment procedure provided by EMME/2 is a multimodal equilibrium assignment method that has variable demand. It computes the equilibrium demands, flows, and service levels for all the modes considered. Because the assignment procedures have a modular structure, the user may select equilibrium assignment with fixed or variable demand on the road network or variants of shortest path or multipath assignment on the network served by the transit and any or all of the auxiliary transit modes. For variable demand assignment, both mode choice and direct demand functions may be specified.

Results

EMME/2 permits the user to obtain a wide variety of results, both in interactive graphic form and as a printed output. The main feature of the results is interactive comparison of scenarios with accompanying graphical display. Although the main results pertaining to comparison of scenarios are related to link flows, origin-destination demands, and service levels, a wide variety of other results may be obtained by using the user-defined data (e.g., comparison of predicted versus observed flows for calibration).

Worthy of emphasis is that, unlike a batch code, where each successful execution terminates with a particular set of results, an interactive graphic code permits the user to obtain results of different types during a particular EMME/2 session. The notion of result is thus different from that of a batch code and may be considered to consist of the entire gamut of displays, results of computational procedures, data bank queries, and scenario comparisons.

Demarcation Lines and Log Book

For a given urban area the user may define demarcation lines that may be superimposed on a graphical output that covers the area spanned by the zone subdivisions. A demarcation line may identify geographical characteristics of the urban area, such as rivers or mountains or certain regions of the city, such as the central business district.

An automatic log book keeps record of the identity of the user and of the modules and elements of the data base used during all EMME/2 sessions.

EMME/2--THE COMPUTER-BASED SYSTEM

EMME/2 has been coded in standard ANSI Fortran IV and has been designed for easy transferability to various computer makes. It has been developed on the Cyber 173 of the University of Montreal; however, it may be adapted easily for other computers, including a certain class of mini or micro computers.

The EMME/2 code has a modular structure. Each of the modules is an independent program but all the modules share the EMME/2 subroutine library. All data transfers between modules occur only via the data base. Figure 3 gives a schematic representation of the program structure.

At present, EMME/2 is implemented for use on any of the Tektronix 4010 and 4110 series of terminals. Any output displayed on the screen may be copied by using the Tektronix 4631 hard copy unit. The same output may be drawn with a high technical quality by using the Tektronix 4663 digital plotter, when available. EMME/2 may be easily adapted for use with other graphic equipment of comparable resolution.

SOME OUTPUT EXAMPLES OF EMME/2

Figures 4-21 are a sample of the kind of output that is made possible by the EMME/2 system.

Jeffries Freeway Corridor Transit Design Project by Using the IGTD System

LUSIA DENDE GALLIO AND JAMES MASLANKA

This report presents the findings of an experiment in designing bus routes in a regional freeway corridor by using the Interactive Graphic Transit Design System (IGTDS). This project was conducted by the Southeastern Michigan Transportation Authority (SEMTA) in cooperation with the General Motors Transportation Systems Center. As a modeling tool, IGTDS allows the transit planner to study the alternatives and variables of a transit problem in spatial terms. The advantage of the IGTDS program is that it is easy to operate because it was designed for use by persons who have little or no computer background. Several objectives were realized by undertaking this corridor demonstration project. First, SEMTA transit planners were given an opportunity to work with and evaluate the latest computer graphics technology. Second, the IGTDS model was tested in terms of a real world transit planning situation by using existing data. Finally, the IGTDS method was compared with conventional transit planning methods in order to determine the strengths and weaknesses of each technique. This report describes and documents the IGTDS transit design process. It covers the areas of data development, operational characteristics, and alternatives analysis. Problems associated with each of the various steps are discussed. A primary part of the documentation of this experiment is a comparison of the effort involved in solving transit planning design problems by using IGTDS or conventional transit planning methods. Conclusions and recommendations are stated regarding the use of IGTDS as a feasible planning tool.

In June 1979 General Motors contacted the Southeastern Michigan Transportation Authority (SEMTA) pursuant to a proposal for a joint analysis involving Interactive Graphic Transit Design System (IGTDS) 2. IGTDS 2 is the second, advanced version of the transit design system. An agreement was reached and the responsibilities of both parties were delineated. SEMTA was to provide the experimental design, demand by census tract, network modifications, staff time, and preparation of the final report. Training on the use of IGTDS 2, computer time, the existing Detroit transportation node and link data base, and the technical support for allocating census tract demand data set to IGTDS nodes was to be provided by General Motors.

EQUIPMENT

The Department of Civil Engineering at the University of Washington, with the support of the Urban Mass Transportation Administration (UMTA), developed the Urban Transit Analysis System (UTRANS), the predecessor of IGTDS, in the early 1970s. The GM Transportation Systems Center (GM TSC) in 1977 took the UMTA users manual and developed GM TSC Release Number 1 of IGTDS. This was a conversion from the UMTA PDP-10 version to an International Business Machine (IBM) 370/168 version that operates with IBM's time sharing system (TSS). GM TSC continued to refine and improve IGTDS and later developed GM TSC Release Number 2 (1). Three versions of GM TSC Release Number 2 now exist.

In the analysis executed by SEMTA, an IBM version with TSS and the Prime computer version was used. Much of the network editing was accomplished by using the IBM time sharing version, and the data input and analysis were accomplished by using a Prime computer hard wired into the graphics display terminal.

The actual equipment required to use the software includes the following:

1. Tektronix model 4014-1 graphics display terminal,
2. Tektronix model 4631 hard copy unit, and
3. Bell Systems model 212A data communications unit.

STRUCTURE OF IGTDS

The IGTDS program is organized in a modular form. Each module can be manipulated independently but the entire system uses a common data base. A total of 17 modules or menu items form the IGTDS framework. These menu items can be classified into three functional categories: design, prediction, and performance.

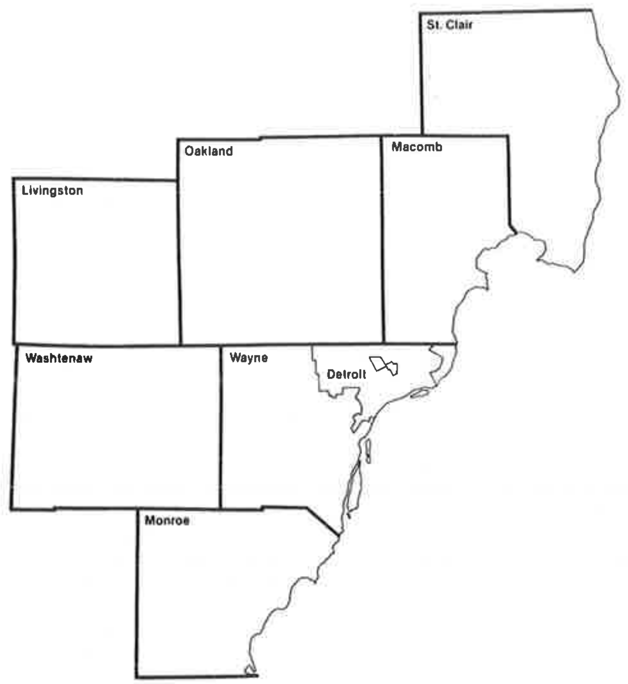
The design and prediction capabilities of IGTDS will be discussed in detail. The description of each component will follow in the order that the data are required to be input. This does not necessarily follow the numerical order of the menu items.

DESCRIPTION OF STUDY AREA

SEMTA's jurisdiction is a seven-county region that includes Wayne, Oakland, Macomb, St. Clair, Livingston, and Washtenaw (see Figure 1). SEMTA serves an estimated population of 4 697 500 in a 4603-mile^2 area. As of January 1981, SEMTA was operating a line-haul bus system of 378 coaches. In 1980, SEMTA carried approximately 11.2 million passengers and operated approximately 11.4 million revenue miles. Formed by the acquisition and merger of four privately owned suburban bus companies, SEMTA provides service between the suburbs and the Detroit central business district (CBD) and other points within the city as well as a variety of local and special services between suburban areas. The greatest volume of SEMTA patronage occurs on bus routes that connect Detroit's CBD and the suburbs. Most of SEMTA's vehicles operate in a closed door fashion on entering Detroit, meaning that SEMTA coaches cannot pick up and discharge passengers within Detroit. Thus, most of SEMTA's routes to the CBD are express in nature for the Detroit portion of the trip.

The environment of the southeastern Michigan region lends itself well to a transit analysis using IGTDS. First, there exist travel corridors that

Figure 1. Southeastern Michigan region.



have minimal current services slated for service expansion. Second, ridership habits on SEMTA services consist of a large percentage of peak-hour riders who go to one destination--the CBD. The specific orientation of the IGTDS program is directed to a many-to-one analysis. Finally, the present closed-door policy simplifies analysis by limiting the service area to be analyzed.

The SEMTA service planning staff decided that the optimum area for analysis would be the Jeffries Freeway corridor. The Jeffries corridor analysis area is principally located in Wayne County to the west of Detroit. The general boundaries of the study area are shown in Figure 2. SEMTA line-haul service in the Jeffries corridor study area is provided through the Wayne division terminal located in Inkster. Currently 18 routes operate from the Wayne division, 6 of which are park-and-ride routes.

The Jeffries corridor analysis included a total of 11 transit routes, 9 operated by SEMTA and 2 operated by the Detroit Department of Transportation (D-DOT).

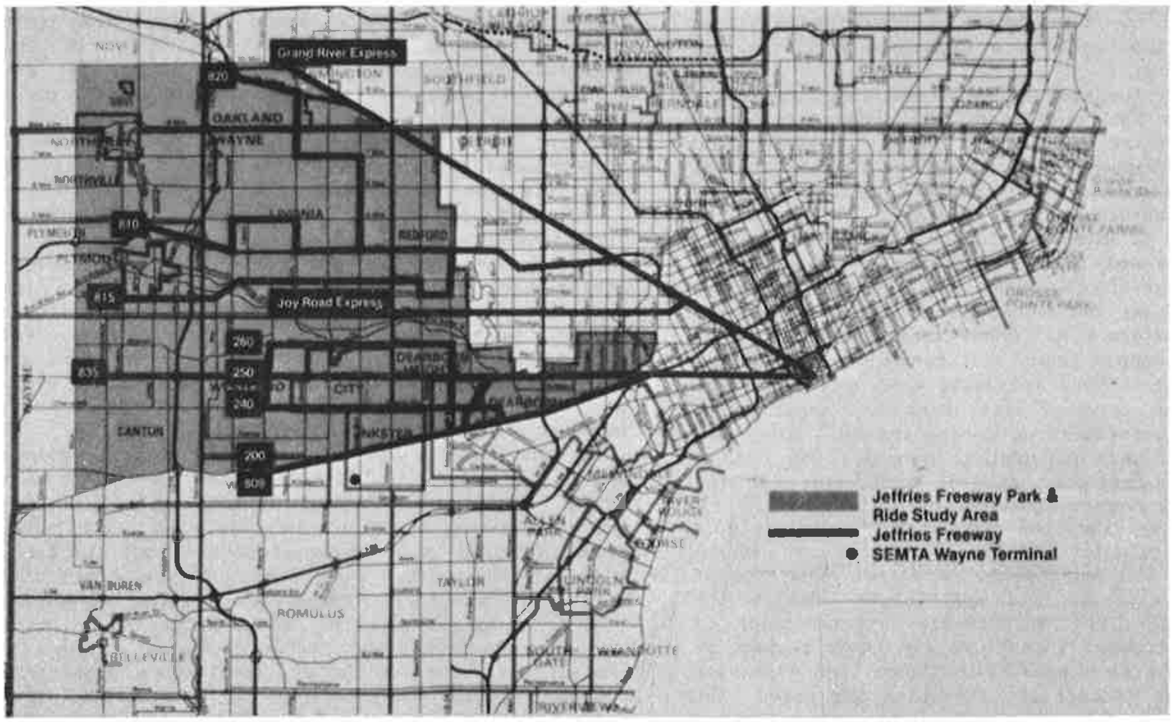
D-DOT provides transit service to the City of Detroit and some adjacent suburbs. The two D-DOT routes included in this analysis were the Grand River Express and the Joy Road Express. Inclusion of these D-DOT routes was appropriate because future plans call for the merger of the SEMTA and D-DOT systems.

All of the transit routes selected for this analysis serve the Detroit CBD. The five SEMTA park-and-ride routes operate during the peak period only and serve the Detroit CBD exclusively. A total of three SEMTA routes travel on the Jeffries expressway for the majority of the trip to the CBD. The remaining six SEMTA routes enter the CBD by traveling on Michigan Avenue (refer to Figure 2 for transit route configurations).

DATA DEVELOPMENT

Three components were required to form the IGTDS

Figure 2. Jeffries Freeway park-and-ride study area.



data base: (a) the base network on which the transit system was designed, (b) the node-oriented trip demand set from the analysis area to a candidate destination, and (c) the various parameters and model coefficients involved.

Base Network

The base network is an abstract version of the regional street system. In IGTDS, the street system is represented in the form of links and nodes. The base network is input and modified in menu item 2, the network editor.

The network editor will input the desired nodes and links by using numeric (keyboard) or graphic input. A network link is a one-way connection between two nodes and is indicated by selecting the beginning and ending nodes. Unless a one-way street is desired, links must be entered for both directions. The length of the link and the travel times for each of the three travel modes are input after the link is entered into the network. The same is true for the node attributes. After the node is entered and assigned x and y coordinates by the computer, the demand value and space cost for park-and-ride facilities are input. The network editor has the capability to delete or modify links and nodes on command.

The TRIMS network was used for the Jeffries corridor analysis project. The TRIMS network was developed by the Southeastern Michigan Council of Governments (SEMCOG) for use as a highway sketch planning network. Several modifications had to be made to this network to adapt it for the Jeffries corridor analysis. Initially, the TRIMS network could only be used as a geographic reference because it lacked sufficient detail.

For example, transit vehicles are capable of traveling on almost every roadway in the Jeffries corridor study area. However, the TRIMS Network consisted of a 2- to 3-mile grid system. To replicate the existing transit environment more accurately, a 1-mile grid system was developed. Also, the coding of the TRIMS network prohibited buses on freeway links. A transit travel time was given to all transit-suppressed links.

Because of the inadequacies of the TRIMS network, the inputting of the Jeffries corridor analysis base network was a slow process. Most of the network editing was done on the IBM computer with the TSS. This also hampered the process because, when the communication lines were interrupted, the editing process would be halted. The network editing process went much smoother with the Prime computer.

Travel time must be assigned to all links in the base network. Three time attributes are required: driving travel time, transit travel time, and walking time. SEMTA staff planners conducted a field survey of Wayne County roads to determine the speeds for the network. It was assumed that transit vehicles would travel at a constant 20 mph on most arterials and 45 mph on expressways. The automobile travel time was assumed to be 5 mph less than the posted speed on all roads. The walk travel time value of 20 min for a 1-mile link remained constant.

Demand Set

Three demand sets were developed initially for the Jeffries corridor analysis. The first demand set consisted of the total number of persons in the Jeffries corridor analysis that are employed in the Detroit CBD. Demand set 2 combined the total number of persons in the analysis area employed in the New Center area, which is approximately 3 miles north of the Detroit CBD. The third demand set included the number of persons in the analysis area employed at one Detroit CBD employer. Although three demand sets are available for use with IGTDS, only demand set 1 was actually tested, mainly because of its large size and Detroit CBD orientations. The following is a description of the methodology used for developing the demand set data. This explanation will focus on the development of demand set 1, but all three demand sets were developed by using the same methodology.

Residential location data for the tricounty SEMTA service area was collected from major employers through the joint efforts of SEMTA's planning and business development departments. The residential location data collected from major employers varied slightly in nature. Some employers have released the addresses of their employees, but other employers have released only the summaries at zip code levels (number of employees who live in each zip code). By using the Regional DIME geographic base file (GBF) and the U.S. Census Bureau's ADMATCH program (2) the census tract that contains each address was identified. Those addresses that were not identified by the program were processed manually to identify the corresponding census tracts. Note that the manual process of address matching was one of the most time-consuming project activities; it required several months of effort by SEMTA staff.

The employee location data, which was only a sample of total demand, were expanded to reflect total Detroit CBD employment. A direct expansion of the sample data was not appropriate because the sample data were not an accurate representation of the total employment in the CBD and their respective proportions for each type of industry. An expansion within similar industrial categories was used. The actual expansion from the sample data to the control totals within each category was performed at zip code level. These data were transferred to the small geographic level of census tracts by using a zip code-census tract equivalency table.

The next step consisted of extracting from the total tricounty employment data set the employment data by census tract for the Jeffries corridor analysis area. It was then necessary to convert these data to SEMCOG's traffic analysis zones (TAZs). This was done to facilitate the conversion of these data to the node-based form required by IGTDS. Since the TAZ's zonal centroids were available and the census tract centroids were not, the conversion was necessary. In order to apply the IGTDS system, the travel demand data in TAZ form were transferred to the nodes of the Jeffries corridor transportation network. The link-to-node data conversion system (ZONOCO) (3) was employed to effect the conversion.

The ZONOCO program operated by creating a three-dimensional surface over the Jeffries corridor study area by using a data-gridding procedure. Demand density at the TAZ centroids was used to approximate density values at the grid intersection. Grid intersections were then assigned to the nearest node. Demand data values were then assigned to the nodes based on the density of each grid intersection in the node service area and the number of the intersections. By this process, the IGTDS demand file was created.

Parameters and Coefficients

The third component of the IGTDS data base consists of the model coefficients and parameters. Calibration values are required for the logit mode choice model and for the cost model. Parameters must be initialized to describe vehicle characteristics, analysis time period, origin and destination walk time, destination parking fee, and transit waiting time. All default values and parameters will require modifications that correspond to the transit environment being analyzed. Any one of these values can be changed interactively. The calibration of the Jeffries corridor model is documented in the explanation of menu item 10, the mode split.

Initially, this IGTDS study obtained the logit model parameters and coefficients used in the Bellevue, Washington, IGTDS demonstration (4) and checked them with previous SEMTA surveys and transit experience. Values were assigned to approximate existing conditions that affect the SEMTA system as of September 1980. These values are initialized in menu item 1 of the IGTDS program.

The variables for the cost model and for the vehicle characteristics are entered in menu item 17, cost model parameters. First the vehicle characteristics table is displayed. Data related to the operation of the transit vehicle are entered in this module. Up to four vehicle types can be used. For each vehicle type the following characteristics are input: number of seats, number of standing spaces, comfort level, operating cost per mile and hour, fixed cost, and the driver cost per hour.

In the Jeffries corridor analysis vehicle types 3 and 4 were used. All local routes in the transit design were assigned type 3 vehicles because a passenger standing situation is likely to occur. Ten standing spaces were assigned to this vehicle type. Park-and-ride routes were assigned type 4 vehicles with zero standing. These routes are considered long-haul, express service, and a situation in which a passenger must stand for as long as an hour is undesirable. The vehicle classifications are input, for each route, in menu item 8 of the IGTDS program. Some problems were encountered in determining the operating and fixed cost data.

Next, the computer displays the table of cost model coefficients and parameters. As mentioned earlier, some problems were encountered in the data and use of the cost model. In most cases the IGTDS concept of specific costs was not compatible with SEMTA's accounting procedures so that some data were unavailable in the form required. This was not considered to be a deficiency of IGTDS, but it did prevent the cost model component of IGTDS from being fully tested in the Jeffries corridor analysis.

OPERATIONAL DATA INPUT

Once the street network is in place, the transit route design may be input. Menu item 4, transit route design, provides for the initial definition of a transit system that serves the destination node, which in this design is the Detroit CBD. The defined transit design can be modified by using menu item 16, the route editor.

First, in designing the transit system a window is selected and the street network is displayed. A route is designed by inputting the first transit stop or lot closest to the destination node and, moving outward, plotting the transit stops or lots until the starting point of the route is reached. Each route in the transit design is input in this fashion. The only constraint that affects the route design is that it must not violate the graph theory definition of a tree, that is, there can be only one possible transit path from a node to the destination.

A good deal of time was spent on the transit design. Problems existing with the original TRIMS network, as transit was suppressed on a number of links and in some cases, additional links were added. To input these modifications required further sessions with the network editor. Additional transit stops were added to the design on the number 810, number 815 and number 820 park-and-ride routes in order for the actual configurations to be represented.

Another problem encountered involved menu item 16, the route editor, which has the capability to correct a wrong input made in the initial design in menu item 4. For example, if a stop was designated instead of a lot, the route editor has the ability to delete the stop and replace it with a lot. When this module was used by SEMTA staff, the instructions in the IGTDS manual were not clear enough to allow the delete line function to be executed successfully. This necessitated the use of menu item 4 for the entry of all route design data, without the assistance that the delete line function of menu item 16 could have provided. Subsequent testing of the route editor by GM staff members, however, reported that the delete line function was operational. Also, because the street network was not labeled, inputting of the transit design was hindered until the operator became familiar with the grid. This situation was somewhat alleviated by referring to a copy of the street network grid that had been correctly labeled. In the Jeffries corridor demonstration project, nine existing SEMTA lines and two D-DOT routes were input (see Figure 3). The transit design included a total of 22 park-and-ride lots, 21 of these were on SEMTA routes. One informal lot serves the D-DOT Grand River express. Also included are 78 transit stops. To simulate the actual service pattern of local routes, which stop frequently, stops are input at each node intersection on the transit line. A total of nine stops were designated on park-and-ride routes, most of which were inserted to correct a route configuration problem.

The function of menu items 5 and 6, parking lot sizes and parking fees, is to input the size of each lot, by number of parking spaces, and the parking fee that is to be charged, if any. All 22 lots were listed in the numerical order that they appear on the transit design network and lot sizes were designated (see Figure 4).

As of September 1980, SEMTA did not own any of the park-and-ride lots. Various agreements are made between the lessor and SEMTA. Payments to the lessor may range from $0 to $2000. These payments are either for the actual lease or they cover fees for maintenance activities executed by the lessor. The daily cost for each lot was listed as $1.00. This reflects the value given the variable operating cost parameter, which was $1.40/day for each lot. The $1.40 figure represents an average cost per day by using the total annual cost for all lots. The computer has rounded off this figure to the nearest one.

Menu item 6 was not particularly significant to this design problem. SEMTA does not charge its patrons for parking at designated park-and-ride lots. A zero fee was entered under the appropriate heading for each park-and-ride lot. No significant problems were encountered in menu items 5 or 6.

Access and egress characteristics for each route are input in menu item 7, transit route deadhead characteristics. The term deadhead is used to describe the time or the distance required for a transit vehicle to travel from the storage facility to the point where revenue service begins and from the point where revenue service ends back to the storage facility.

Both time and distance deadhead access characteristics were entered for each route in the network. Egress deadhead characteristics were given a zero value because SEMTA vehicles do not necessarily return to the bus garage after each run to the CBD. Some vehicles that serve park-and-ride routes will return to the original point of revenue service and make a second trip. Other vehicles may work split runs, or in terms of local service, travel back and forth on that route for the entire time period.

The values for the default return trip and the return trip were calculated by the computer based on the default values in menu item 17 under the heading of transit line deadhead characteristics. No problems were encountered in using this menu item.

Transit operating characteristics are entered into the program in menu item 8. The transit design is displayed. For every transit line, the vehicle type and headway is entered. The IGTDS computer program determines the maximum number of vehicles, by using the assumption that there will be one vehicle for each revenue trip made on the route during the analysis period. The minimum number of vehicles is determined by allowing the vehicles to return to the origin point of revenue service for additional trips. The computer also lists a cost for both the minimum and maximum alternatives. The number of actual vehicles was input in the last column (see Figure 5).

Vehicle type for each route was listed as either a type 3 or a type 4, based on information from menu item 17 under vehicle characteristics. Park-and-ride routes were classified as vehicle type 4 and local routes received a vehicle type 3 designation.

The transit system fare structure is designed in menu item 9. In this module a base fare is input. If zone charges are required, then the transit design appears and fares are input at zone boundaries located with the graphic crosshairs. Unfortunately, the transit design appears on the screen without the aid of the street network grid. Once again a labeled network map must be used as a reference. Also, zone fare designations must be input for each route. When the data input are complete, the fare at all stops is automatically displayed. SEMTA's base fare in September 1980 was $0.60. The $0.60 fare covers zones one and two. The SEMTA service area is divided into eight zones. Each zone thereafter is an additional $0.20. Park-and-ride routes had a base fare of $0.80. That fare applies to travel through zones one and two. Each subsequent zone is an additional $0.20. D-DOT charges a base fare of $0.60. No zone charges applied to D-DOT routes in the study area.

DATA ANALYSIS

After all the required data have been entered into the program, the modal split may be computed. Menu item 10 performs the modal split and public transportation system capacity-restrained assignment computations. This process involves an estimation of the number of tripmakers likely to use either the walk-and-ride, park-and-ride, or drive mode. The computer model will, at the same time, assign potential transit patrons to the transit lines in the design by means of the shortest impedence paths. The probability that a tripmaker will travel to the specified destination is determined by comparing the impedences associated with each mode of travel. By using a series of estimation equations, the IGTDS computer program calculates a mode split value for each node in the network. It then assigns the park-and-ride and walk-and-ride demand to transit routes and parking lots based on the shortest impedence path between the node and destination node. If route and lot capacity is exceeded, the excess demand will be assigned to a route or lot on the second shortest path or to a different mode in the next iteration of the modal split process. The computer will perform as many iterations as the analyst desires, unless 100 percent of the demand has been allocated.

When all demand has been allocated, the computer will display the results in menu item 11, perfor-

Figure 3. Jeffries corridor transit network, 1980.

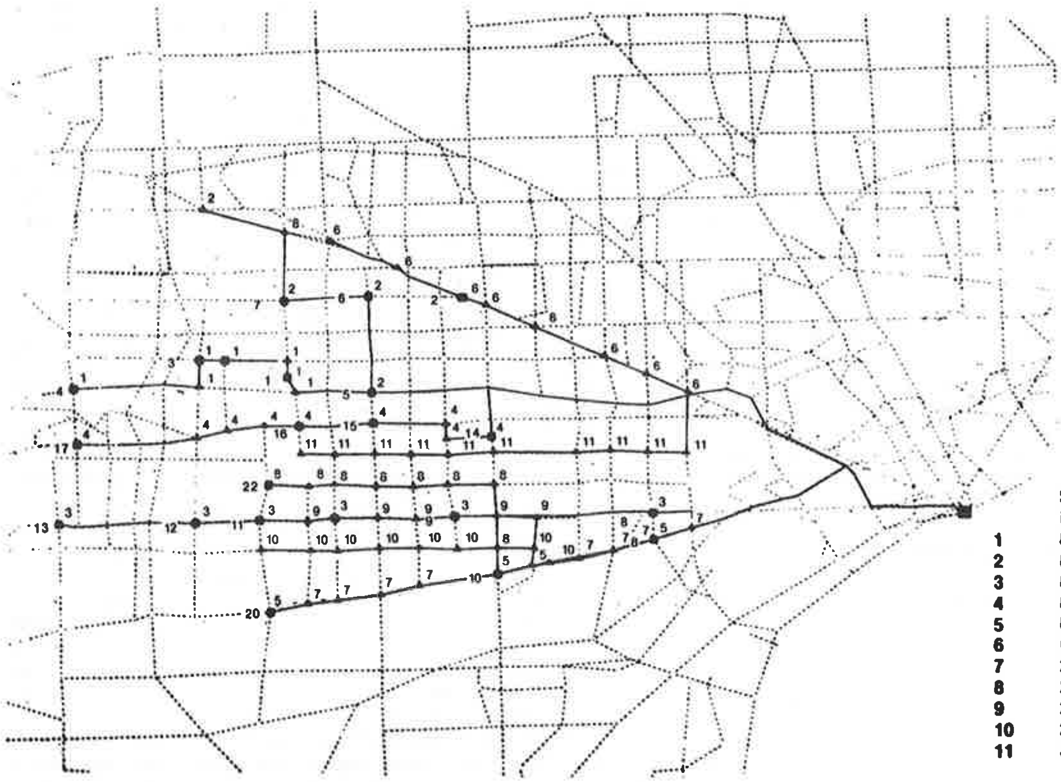


Figure 4. Jeffries corridor park-and-ride lot sizes, 1980.

ENTER NUMBER OF PARKING SPACES AVAILABLE
DURING THE ANALYSIS PERIOD FOR
EACH P-R LOT

LOT	SPACES	DAILY COST (DOLLARS)
1	105	1
2	50	1
3	75	1
4	80	1
5	100	1
6	65	1
7	60	1
8	40	1
9	25	1
10	30	1
11	50	1
12	30	1
13	30	1
14	100	1
15	150	1
16	75	1
17	50	1
18	25	1
19	50	1
20	50	1
21	25	1
22	30	1
0		

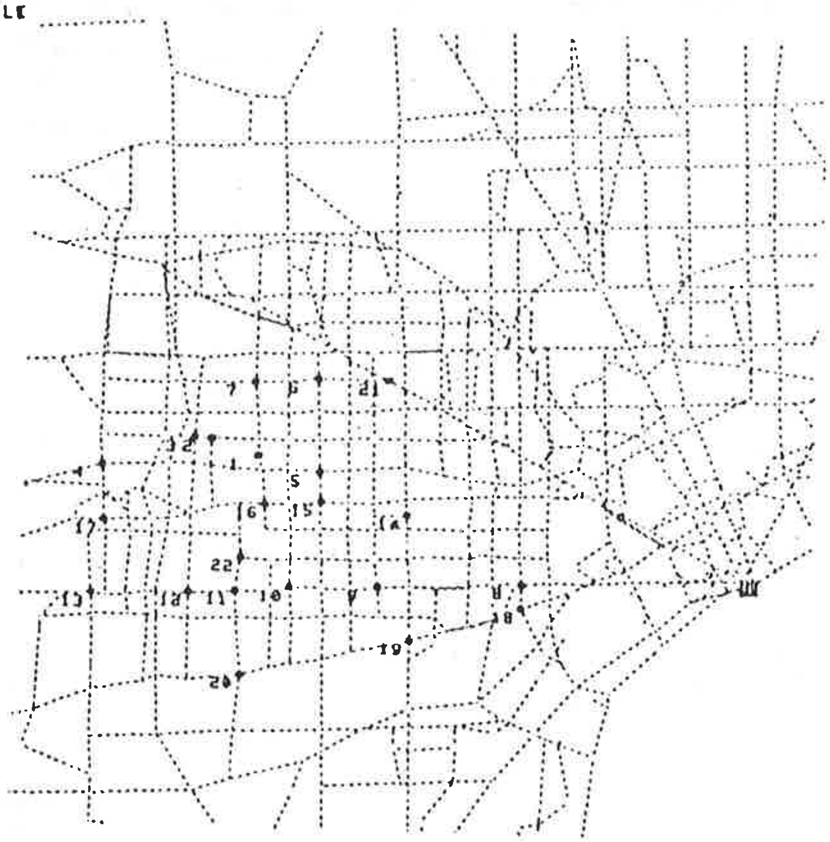


Figure 5. Jeffries corridor transit route operating characteristics, 1980.

HEADWAYS WHICH MINIMIZE LAYOVERS

LINE	R.T. TIME	1	2	3	4	5	6	7	8	9	10
1	106.91	120	60	40	30	24	20	18	15	14	12
2	137.31	120	60	40	30	24	20	18	15	14	12
3	176.41	120	60	40	30	24	20	18	15	14	12
4	164.31	120	60	40	30	24	20	18	15	14	12
5	103.01	103	52	35	26	21	18	15	13	12	11
6	135.61	120	60	40	30	24	20	18	15	14	12
7	106.51	107	54	36	27	22	18	16	14	12	11
8	123.61	120	60	40	30	24	20	18	15	14	12
9	103.01	104	52	35	26	21	18	15	13	12	11
10	111.31	112	56	38	28	23	19	16	14	13	12
11	147.01	120	60	40	30	24	20	18	15	14	12

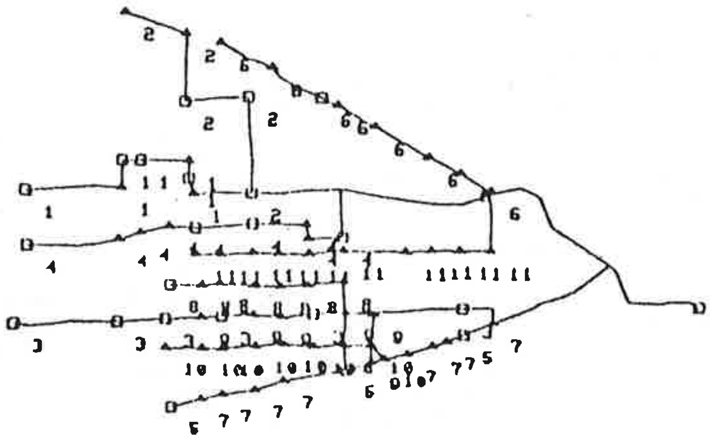
ANALYSIS PERIOD IS 120 MINUTES

ENTER OPERATING CHARACTERISTICS

LINE	VEH TYPE	HDWY	LAY-OVER	MIN VEHS	COST	MAX VEHS	COST	ACTUAL VEHS
1	4	12	0	10	191	10	191	10
2	4	10	0	12	229	12	229	12
3	4	14	0	9	172	9	172	9
4	4	24	0	5	96	5	96	5
5	4	14	18	8	162*	9	171	8
6	3	8	0	15	286	15	286	15
7	3	5	13	22	439*	24	457	22
8	3	23	0	6	114	6	114	6
9	3	24	0	5	95	6	96	5
10	3	16	11	7	144*	8	152	7
11	3	15	0	8	153	8	153	8

0

TOTALS 107 VEHICLES
5217 CAPACITY
2081 DOLLARS



mance summary. First the modal split summary will appear on the screen. The trips allocated to each mode are shown in terms of the number and percentage of the total demand for the analysis area. The summary also contains data regarding cost-revenue design parameters and trip characteristics. Detailed information for each route and parking lot in the design was obtained by selecting either the line summaries or lot summaries.

The first run of the Jeffries corridor analysis data produced a mode split summary that was inconsistent with existing ridership data. Existing demand was derived by dividing the August 1980 ridership totals for the routes in the design by the CBD demand figure in demand set 1. The total transit ridership estimated in the IGTDS model was off by 18 percent. The IGTDS model allocated 10.4 percent of the demand to transit; the actual demand was 8.5 percent. That figure could have been acceptable; however, the majority (10.1 percent) was allocated to walk-and-ride. According to the August 1980 ridership figures, the walk-and-ride mode received 5.6 percent of transit riders and park-and-ride received 2.9 percent of transit riders.

The inconsistency in the IGTDS mode split summary could be related back to the initialization values. There is a sensitive relation between the walk-and-ride and park-and-ride constants. The default value associated with drive time affects park-and-ride also. By comparing empirical data that describe ridership with the initial IGTDS ridership output, adjustments were made in the walk-and-ride and park-and-ride default values to achieve a more realistic balance between the two modes.

For this analysis, the basic network consisted of a 1-mile grid of highways and all demand allocated to the nodes that comprise the intersections of the highways. Such a demand allocation impedes accurate walk-and-ride predictions because it does not account for the long walks necessary for individuals who live in the interior of the cells to access transit vehicles as walk-and-ride patrons. This problem could be alleviated by inputting additional demand nodes and pedestrian links in the network, but such an effort could dramatically increase the time and effort necessary for network coding, and was thus not considered for this study.

The final results regarding the mode split analysis proved to be sound. The IGTDS modal split performance summary estimated transit ridership at 7.9 percent, which is approximately 0.6 percent less than the actual ridership figure. The walk-and-ride mode was 0.1 percent less than the actual ridership but the park-and-ride demand estimate was still low at 0.5 percent less than existing ridership. The IGTDS modal split estimations were considered to be adequate and acceptable for the Jeffries corridor analysis.

Sensitivity Analysis

Once an acceptable mode split was achieved for the 1980 Jeffries corridor study, a series of tests was conducted to determine the sensitivity of the IGTDS process to changes in certain variables. The following is a list of alternatives tested:

1. Fare increase,
2. Parking lot sizes,
3. Headway modifications,
4. Route configuration changes, and
5. 1978 data base.

Fare Increase

The first experiment involved the testing of the ridership model in terms of fare elasticity. SEMTA was planning a fare increase on July 1, 1981. A test was planned to determine what effect it might have on ridership. The base fare was to be increased to $0.75, which was a $0.15 increase from the current base fare of $0.60. The park-and-ride base fare also was increased by $0.15, from $0.80 to $0.95. Zone charges remained constant at a $0.20 increase per zone.

The new transit fares were input by using menu item 9, transit fares. All other Jeffries corridor transit design data remained the same. The IGTDS modal split summary estimated that a shift of 0.2 percent would occur between walk-and-ride and the drive mode. This meant that a total of 95 transit riders would transfer from the walk-and-ride mode to the drive mode. There was no percentage change in the park-and-ride mode. According to these results the fare increase was not substantial enough to have a significant effect on ridership.

Parking Lot Sizes

Park-and-ride lot sizes were increased as a test to determine their effect on ridership. The first test involved increasing the size of lot 4 at the Jeffries Freeway and Middlebelt from 100 spaces to 350. SEMTA anticipated that a larger lot would become available near this existing lot. We wanted to determine whether an increased lot size at this location would affect ridership for the park-and-ride mode. The IGTDS mode split summary estimated that park-and-ride would increase by 0.6 percent, meaning an increase of 260 patrons. The majority of this increase was due to a shift from the drive mode to park-and-ride. The walk-and-ride mode also lost some patrons to the park-and-ride mode.

The mode split was also run with park-and-ride lot sizes increased at some lots. All lots that were listed in the SEMTA park-and-ride lot inventory as having no limit were raised to 100 spaces from the original number designated. Also, lots that listed the estimated use as higher than the capacity per agreement were increased to the number of spaces actually required.

The results were generally the same as when the spaces in the single lot were increased. The park-and-ride total increased by an additional 0.8 percent to a total of 3.8 percent for that mode. Both the walk-and-ride and the drive modes lost patrons; the greater shift came from the drive mode. We assumed that the potential exists for increased park-and-ride ridership in the Jeffries corridor analysis area if expanded parking facilities are available.

Headway Modifications

Another experiment involved reducing the headways on the park-and-ride routes in the Jeffries corridor analysis area to determine what effect this would have on ridership. Headways were reduced to 5 min on four of the five park-and-ride routes. The headway for the number 815 Western Wayne was reduced to 15 min because its original headway was 24 min. Headways on the other park-and-ride routes were originally less than 15 min.

Headway reduction also has a positive effect on park-and-ride ridership estimates. The IGTDS modal split summary calculated a 0.4 increase in ridership for the park-and-ride mode. The shift in riders from the drive mode accounted for approximately 90 percent of the increase in the park-and-ride mode.

Another modal split was run by using an alternative that combined the effects of the reduced headways and the expanded park-and-ride adjustments. This produced an increase of 881 patrons or 2.0 percent in the ridership estimates for park-and-rides. Once again, the shift in riders from the drive mode accounted for 91 percent of this increase. According to IGTDS calculations, enough potential transit ridership demand existed to justify a service expansion program that would include headway reductions on existing routes and increased capacity at existing park-and-ride lots.

Route Configuration Changes

An experiment was conducted to determine what effect changing the configuration of a route would have on the modal split. One route, number 815 Western Wayne park-and-ride, was selected for the test because SEMTA staff planners were considering a change in the route at the time. Four different alternatives were input. All four route alignment alternatives for the 815 affected the modal split summary. Unfortunately, the effect was negative in terms of transit ridership. In this instance the cost-allocation model would have been useful. But, as stated earlier, certain problems with the data prevented its use here.

1978 Data Base

A new transit design was created to simulate the service in the Jeffries corridor analysis area that existed in September 1978. Only eight transit lines were operating in the Jeffries analysis corridor at that time, three routes fewer than in 1980. The data were input in the same fashion as for the 1980 transit design network. The initialization values and parameters used in the 1980 transit design remained constant. The results of the first-run modal split calculations were consistent with the actual ridership for the September 1978 time period. Actual ridership divided by the total demand in the IGTDS demand set resulted in a walk-and-ride demand of 5.5 percent and a park-and-ride demand of 0.7 percent. The IGTDS modal split summary estimated walk-and-ride at 5.4 percent and park-and-ride at 0.9 percent. These results were considered to be acceptable and appropriate for the 1978 Jeffries corridor analysis network.

COMPARISON OF IGTDS TO CONVENTIONAL ANALYSIS

One of the objectives of the Jeffries corridor demonstration project was to compare the conventional transit route planning method with IGTDS. This will be accomplished by first describing the conventional transit demand determination methodology used by SEMTA. This will be followed by a general comparison of IGTDS and the conventional system in terms of method, time, and application. For purposes of this discussion, the comparison between IGTDS and conventional transit planning techniques will be limited to the modal split portion of the analysis. Because available SEMTA financial information could not be reconciled with the data needs of the cost-analysis component of IGTDS during this project, no comparison will be made between conventional SEMTA cost-allocation techniques and those employed by IGTDS.

Conventional Analysis-Demand Determination

The service planning staff of SEMTA has developed a simple methodology for estimating ultimate ridership levels on CBD-oriented routes in metropolitan Detroit. This methodology uses the major employer data base to produce travel demand from each census tract in the region to the Detroit CBD. The major employer data base is also used for the IGTDS demand set. An ultimate ridership estimate can be made by allocating transit demand to the service areas of the proposed bus routes and then applying a transit mode split.

The methodology for predicting ridership on the manual analysis of the Jeffries corridor began by superimposing the transit routes on a census tract map of the analysis area. The second step was to determine the width of the assumed service area. From previous experience with park-and-rides, it appears that on assumption of a 2-mile wide service area, 1 mile on each side of the route, is appropriate for a park-and-ride that has no local routes within 2 miles of it. In those cases in which a new route is only 1 mile between parallel routes, a 1-mile service area was assumed. Generally, a 0.5-mile service area, 0.25 mile on either side of a route, is assumed for local routes.

On obtaining this information, the employment demands for each census tract within the service area of a transit route are located in the computer printout of residential location data by census tract. The applicable demand for each route is determined by taking a percentage of the total demand allocated to each census tract. This percentage is based on the portion of the census tract that is in the service area of the transit route. A mode split of 20 percent was applied to the demand totals for each route to obtain the total number of people that would possibly use bus service in that route's service area. The 20 percent mode split figures is a conservative estimate based on empirical evidence of mode split behavior for those corridors in the southeastern Michigan region well served by transit.

In comparing the potential demand to actual ridership, this demand estimation process produced acceptable results for the transit routes in the Jeffries corridor analysis. It predicted that existing SEMTA bus routes would carry 2289 people into the Detroit CBD. This compares favorably with actual ridership of 2193 in May 1981 from this corridor to the Detroit CBD.

IGTDS Versus Conventional Analysis

The IGTDS process and the conventional transit planning process were compared in terms of the nature of the method employed and the time and personnel needed to accomplish the analysis.

Obviously, with the conventional analysis all graphic displays and calculations must be done manually. This is naturally a time-consuming and, at times, a tedious process. Depending on the form in which the base network and demand data are available, the initial data input for IGTDS may also require additional time expenditures. However, once that data base is input, the rest of the process becomes relatively easy. Also, IGTDS is capable of calculating a mode split in a matter of seconds or minutes, depending on the number and type of jobs being processed simultaneously with IGTDS by a time-sharing computer installation. In the Jeffries corridor analysis, both the conventional methods and IGTDS produced acceptable results in terms of the mode split calculations related to existing service.

The most significant difference between the two transit route planning methods is the ability of IGTDS to predict traveler response to changes in service level. The sensitivity analysis performed on the Jeffries corridor area by using IGTDS would have taken months to accomplish if conventional analysis techniques were applied. Much of the analysis would have been based on past experience or educated estimations. The nature of the conventional transit planning methodology is not fully interactive. Each component is dealt with separately; however, IGTDS is capable of analyzing the effect of all the components and alternatives for the analysis problems as a whole. This seems to be the greatest asset of the IGTDS program.

In terms of personnel, development of the base network for both analysis types requires the efforts of several people. Also, with the IGTDS program, initial setup may require some training period. However, when both systems are set up, only one person is required to perform the analysis. The productivity of IGTDS is greater, however, because of its increased capacity for data manipulation.

CONCLUSIONS AND RECOMMENDATIONS

The major objectives of the Jeffries corridor demonstration project were accomplished successfully. The transportation planners at SEMTA greatly increased their knowledge of computer graphics technology and transit route planning in general. IGTDS was found to be a useful transit planning tool, especially in terms of analysis capabilities. Finally, IGTDS compares favorably with the conventional planning method and is capable of performing certain analyses that are beyond the realm of conventional techniques.

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