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BUS ROUTE DEMAND ANALYSIS

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16. Abstract

The application of a bus route demographic analysis computer program called TRANES to several bus route planning and demand prediction problems is investigated. TRANES is an acronym for "Transportation Network Evaluation System." TRANES directly accesses U.S. Census Bureau data tapes (1980 Census, STF-1 and STF-3 tapes) to compile demographic statistics within specified distances of individual bus stops. The Central Oklahoma Transportation and Parking Authority bus system of Oklahoma City was used as a case study. The application of TRANES to the design and modification of bus routes is demonstrated. TRANES is a convenient program for compiling Federal Title VI reports and similarly provides useful demographic reports for use by transit planners. Individual bus route ridership per day is correlated to census statistics. Furthermore, a correlation, using factor and regression analysis, is established between bus stop passenger loadings and the racial, age, occupation, and income characteristics of the population residing within 1,000 ft. of the bus stops.

This report includes a listing of the entire TRANES program (written in FORTRAN IV) used in the study as well as a comparable version in BASIC for microcomputers based on the CP/M 2.2 Operating System and which uses the dBase II Database Management System. Use of the programs and transit network coding is fully documented in the report.

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METRIC CONVERSION FACTORS

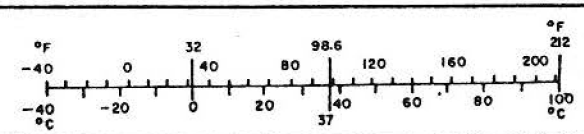
Approximate Conversions to Metric Measures

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)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
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		
kg	kilograms	2.2		
t	tonnes (1000 kg)	1.1		
		VOLUME		
ml	milliliters	0.03		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



EXECUTIVE SUMMARY

This final report is a review of the development of bus route demand models which make use of the TRANES computer programs and the 1980 Census. TRANES is an acronym for "Transportation Network Evaluation System." TRANES directly accesses U.S. Census Bureau STF-1 block level data tapes to compile demographic statistics within specified distances of individual bus stops. The Central Oklahoma Transportation and Parking Authority bus system of Oklahoma City was used as a case study to demonstrate several applications of TRANES in addition to the development of bus route demand models.

The TRANES computer programs were developed in San Diego, California, in the late 1970s and have been used in a number of jurisdictions and by consulting firms. This report includes a listing of all the TRANES programs used in the research (written in FORTRAN IV) as well as documentation on their use and transit route network coding. Early in the report the Census Bureau record system is discussed. TRANES can directly access city block level census statistics; but manual tabulation of the census statistics using census maps is necessary to capture the more extensive statistics contained at the larger census tract and block group level.

The report includes a literature review of past bus route demand models and a summary of the demographic characteristics of bus users and nonusers in Oklahoma City. Nine demographic variables were extracted from the block level census STF-1 tapes: total population, total black population, total population under 16 and over 64 years of age, and five housing variables. Block group level variables were determined manually within 1000 ft. of individual bus stops using maps and the STF-3 census tapes. Thirty-one demographic variables were thus collected: five categories each of race, total population by age, and female population by age; seven categories of occupation; and seven ranges of household income.

The best bus route demand model based on the block level statistics was determined by regression analysis applied to the nine variables and ridership data from 23 bus routes. Each census variable was normalized by subtracting the mean from each variable observation and dividing this by the standard deviation. Regression equations for both 1,000 ft. and 2,500 ft. from the bus stop yielded R^2 values of about 0.35 using the total population variable only. Forcing all nine block level variables into the equation improved the R^2 to 0.742 for variable statistics within 1,000 ft. of the bus stops, comparable in performance to bus route demand models reported in the literature.

Principal components factor analysis with equamax orthogonal rotation was used with the block group level census variables to develop correlations between bus stop passenger loadings and census statistics. Passenger loadings were counted at 372 bus stops along eight representative routes. The factor analysis yielded five factors which characterized the bus riders: high income professionals, race, youthful nonprofessionals, elderly, and middle-aged. These factors, except perhaps high income professionals, seemed to correlate with direct surveys of bus passengers conducted before this research was started. The five factors were then used in stepwise regression analysis along with bus travel time from each bus stop to the central business district. This produced a bus stop demand model with an R^2 of 0.55 and all the factors except race.

These results indicated that TRANES should prove useful in the development and modification of bus stop locations, including route extensions or deletions. In Oklahoma City, at least, the correlation between census statistics at the block level and bus route demand was somewhat weak. The bus stop analyses with factor analysis and block group data has the disadvantage of requiring the manual determination of census statistics, unlike the fully automated application of TRANES to the much more limited block level data.

This report also includes several case study applications of TRANES to practical transit planning. New bus routes were designed for the suburb of Norman, Oklahoma, with the assistance of TRANES, where the objective was to serve the college and retirement age populations. The study required the development of a census data subset of the Oklahoma City metropolitan area data file. TRANES also is a convenient and significantly time-saving tool for compiling Federal Title VI civil rights reports. One possible problem with the latter application is that census statistics are "suppressed" (deleted from the data tapes) if too few minority households are located in a census block. This is done for considerations of household privacy but could lead to underreporting of thinly distributed minority populations.

Finally, this report documents the conversion of TRANES to microcomputer applications. A new version of TRANES was written in BASIC for a CP/M 2.2 Operating System which uses the dBase II Database Management System. The BASIC listing and instructions on its use are contained in the report.

ACKNOWLEDGEMENTS

Bus Route Demand Analysis was funded as project OK-11-0003 by the Office of University Research and Training of the United States Urban Mass Transportation Administration in Washington, D.C. The support of the UMTA technical monitors, Nathaniel Jasper, Robert Trotter, and Thomas Hillegas, is gratefully acknowledged. Allen R. Cook served as principal investigator and Kenneth B. Morris was the senior research associate. Mr. Morris was responsible for implementing the TRANES computer programs and coordinating the efforts of the University of Oklahoma with local planning and transit agencies. He received a master of science degree in civil engineering in 1983, and his thesis project was derived from this research work.

The research investigators worked closely with officials of the Central Oklahoma Transportation and Parking Authority, whose transit system was used as the case study application of TRANES. The following COTPA officials are acknowledged for their support and guidance: John Terry Patillo, Executive Director; Mark Glandon, Director of Transportation; Kenneth Grantham, Coordinator of Planning and Marketing; John D. Shugart, Controller; and Michael Porter, Transportation Planner. In particular, the support of Ronnie Hull, Transportation Planner with COTPA, was vital to the success of the research. He was a former graduate student of the principal investigator and his enthusiastic support and willingness to provide all of the technical information needed were key factors which ensured the success of the research and facilitated the liaisons between COTPA and the University.

Mohsin A. Zaidi, Director of Community Development Planning and Services with the Association of Central Oklahoma Governments, provided support as needed. Mr. Morris worked part-time as a systems analyst with ACOG.

The TRANES computer programs were obtained by COTPA from the Comprehensive Planning Organization in San Diego, California, which originally developed the programs. Later versions of the programs and invaluable technical assistance were provided by Wesley R. Frysztacki and Robert Parrot of the Puget Sound Council of Governments in Seattle, Washington. Both men had previously worked on the initial development of TRANES in San Diego. At the termination of the grant in 1983 Kenneth B. Morris joined the Puget Sound Council of Governments as a Transportation Systems Analyst where one of his assignments was to be the continued application of TRANES in Seattle.

At the University of Oklahoma the assistance of a colleague, Assistant Professor Thomas H. Maze, in the factor analysis of the bus route demand data is gratefully acknowledged. Bijan Badihian and Utpal Dutta were employed as research associates. Mr. Badihian was in charge of the literature reviews, TRANES network coding, and field bus route demand data collection. He wrote the first draft of Appendix C of this report. Mr. Dutta assisted in the network coding and performed most of the statistical analysis. They were assisted in the bus route field data collection efforts by student assistants Akraiy Abu-Salah, Sad Elgharaibeh, Walid Ishrug-Laban, and S. Mostaffa.

Elie J. Malouf, a senior student in civil engineering, prepared the Norman transit system case study as a senior design project under the direction of Kenneth B. Morris. He obtained operational and financial information from Mr. Ron Sweet, director of The University of Oklahoma Campus Area Rapid Transit bus system.

Finally, this report was ably word-processed by Betty Craig and Barbara Jones, proficient technical typists at the University. Joan P. Howeth of the University's Office of Grants and Contracts was responsible for the financial record-keeping.

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* * *

INTRODUCTION

This final report is a review of the development of bus route demand models which make use of TRANES computer programs and their case study application to bus routes operated by the Central Oklahoma Transportation and Parking Authority in Oklahoma City, Oklahoma. The report includes a literature review of the state-of-the-art in bus route demand modeling and how past models compare with those developed in this research. Finally, potential applications of the TRANES computer programs are discussed.

TRANES Overview

TRANES is an acronym which stands for "Transit Network Evaluation System." The TRANES computer programs enable the bus transit planner to access U.S. Census Bureau data tapes and accumulate this information along individual bus routes and specific stops. For example, TRANES can report the total population, or any other available census statistic, living within a designated distance of a bus stop. This information can potentially be used in the design of bus stop and route locations or used merely to summarize demographic statistics by route.

In the case of the research reported in this report, the development of bus route demand models is investigated under the hypothesis that demand, at least in part, is a function of accessibility to the transit network. Alternatively, bus routes may be located where the propensity to use transit is highest, e.g., densely developed areas or areas populated with people who tend to regularly use transit.

The TRANES computer programs were developed in San Diego, California, in the late 1970s (75). TRANES has been used by the Comprehensive Planning Organization in San Diego to plan route modifications and route alternatives (81). Similar uses have been made by the Puget Sound Council of Governments in Seattle, Washington, and elsewhere, although experience in general is rather limited. McDonald Transit Associates, Inc., a consulting firm, has used TRANES to report the demographic characteristics of bus routes (11).

The TRANES programs are described in more detail in Appendix A. Program listings as used in this research are contained in Appendix B. TRANES is written in FORTRAN IV, a high level engineering and scientific computer programming language, and the programs have been run on several different main frame and mini-computers.

United States Census Records

A comprehensive census of the population is conducted every ten years in the United States by the Bureau of the Census, most recently in 1980. The research in this study made use of the 1980 census statistics, which are made available by the Bureau of the Census to interested parties on computer data tapes. The available statistics are reviewed in more detail later in this report, but the significant ones in travel demand analysis are population totals, household income, and automobile ownership.

Since TRANES essentially is a geographic data reporting system, it is important to understand the geographic reporting base structure of the Bureau of Census. This is summarized in Figure 1. In the 1980 Census metropolitan areas greater than 50,000 in total population have been designated as "Standard Metropolitan Statistical Areas", or SMSAs. The urbanized areas within the SMSA are subdivided into relatively homogeneous areas termed "census tracts." Census tracts typically contain 4,000 to 5,000 people and they are the smallest geographic unit in which all available census statistics are generally reported. In addition to being demographically homogeneous, tract boundaries follow streets and such other logical barriers as rivers and railroads. Census tracts respect political boundaries, including city and county lines, to enable aggregated statistical analysis of census data by political subdivision.

Each census tract is identified by a six digit number which is always a unique number within a county and generally within the entire SMSA. The first four digits are the basic tract number, and the remaining two digits are used if the tract is later subdivided because of population growth.

As evident in Figure 1, census tracts are too large for effective application to bus route demand analysis. Several bus routes and many stops can be contained within a tract and the boundaries, of course, do not correspond to bus routes except for the fact that arterial streets which have bus routes frequently form census tract boundaries as well.

Census tracts are subdivided into "block groups" and "blocks." The census block typically is the city block, formed entirely by streets and, occasionally, rivers or other geographic boundaries. Blocks are designated by a three digit number which is unique to the census tract. They are the smallest unit of census data aggregation, although, as detailed later, most census statistics are not available at the block level and the data that is available is subject to suppression (deleted from the data records) if it pertains to 15 or fewer individuals. The reason for this is individual privacy, since census records are anonymous. The household income characteristics of a small ethnic group, e.g., native Americans, may be unavailable for some blocks simply because there may be only one or several such households in a particular block. Thus, the investigator might be able to

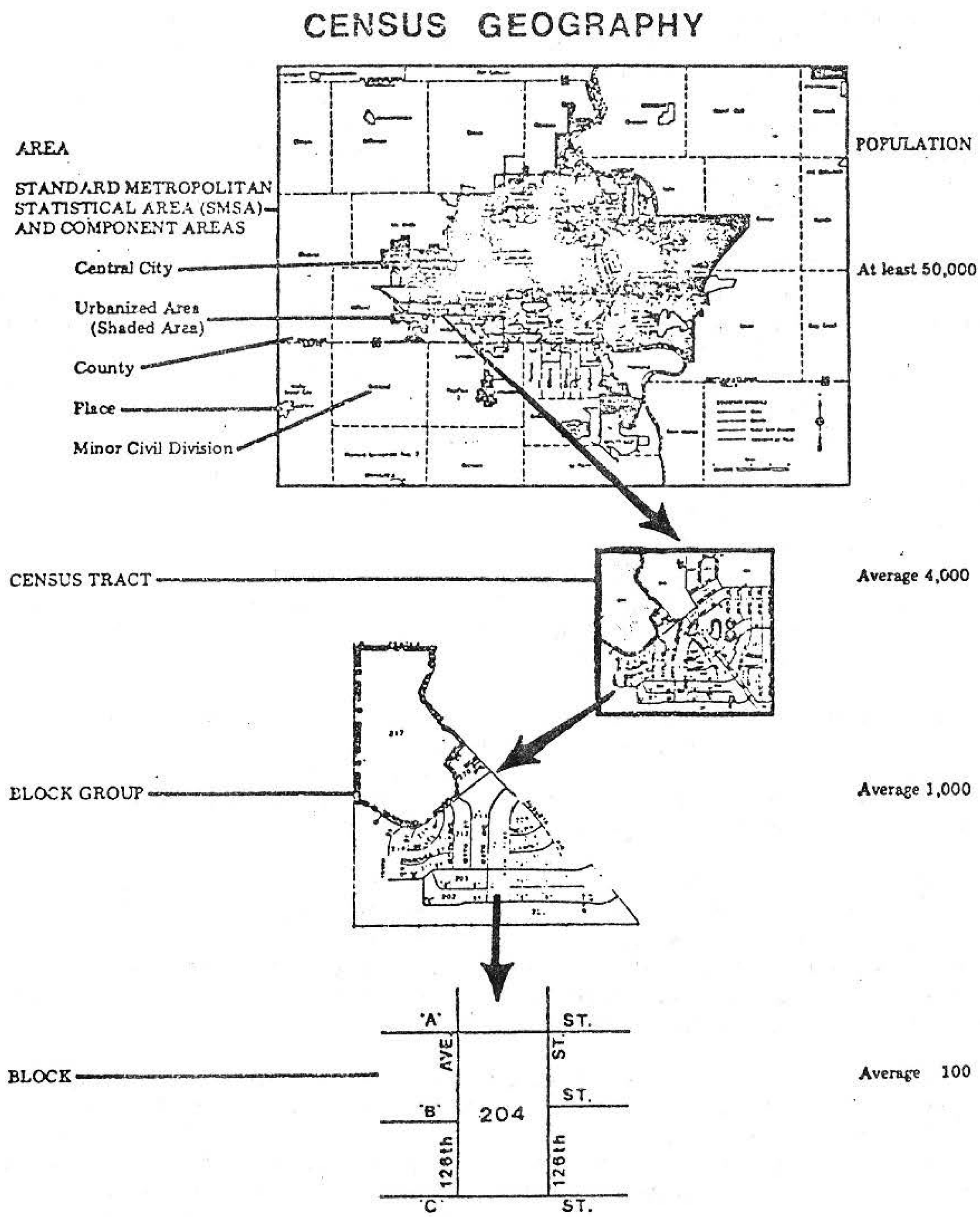


FIGURE 1

UNITED STATES BUREAU OF THE CENSUS GEOGRAPHY

Source: Reference 36, p. 21.

identify specific households. In the larger urban region, such block-level statistics would be under-reported as a result.

The TRANES computer programs are specifically designed to determine the minimum path along block faces to designated bus stops. For example, the programs can determine all of the block faces within 2,500 feet of the bus stop. The census data is reported simply by relating these blocks to the available census records, such as total population or total numbers of native Americans.

Since the census statistics at the block level are rather limited in number, this research also explored demand models which used "block group" statistics. As indicated in Figure 1, block groups are simply a group of contiguous blocks. Typically each census tract has two, three, or four block groups. The block group number is the first digit in the block number. Although block group census records are richer in available data, the group boundaries were not developed with bus routes in mind. Hence, their utility is that they are smaller tracts. Since TRANES cannot use block groups in minimum path determination, the bus route demand analyses done in this research with block groups was done with manually tabulated data. This is described in more detail later.

GBF/DIME File System

In order for the digital computer to access the above census geographies a machine-readable geographic coding system is needed. The U.S. Bureau of the Census developed the GBF/DIME file system as the geographic information system for census data analysis. GBF/DIME files are computerized representations of census geographical boundaries. GBF stands for "Geographic Base File," and DIME stands for "Dual Independent Map Encoding," the topological technique used for representing street networks and double-checking of the geocoding work. Each DIME file record includes street intersection node numbers, street name, address ranges, left and right block numbers, tract number, and usually, x and y grid coordinates to facilitate computer-based mapping.

The TRANES computer programs use the GBF/DIME file system to identify the block faces relative to the bus stops, and then to access the census records. The TRANES network development and coding is reviewed in detail in Appendix C along with a more thorough discussion of the GBF/Dime file system.

TRANES Network Development and Coding

A brief example of the coding of a TRANES network is presented here to clarify the above sections for the reader, and covered in more detail in Appendix C. Figure 2 indicates all of the census tracts in the Oklahoma City metropolitan area, the SMSA. There are 12,000 census blocks contained within these tracts.

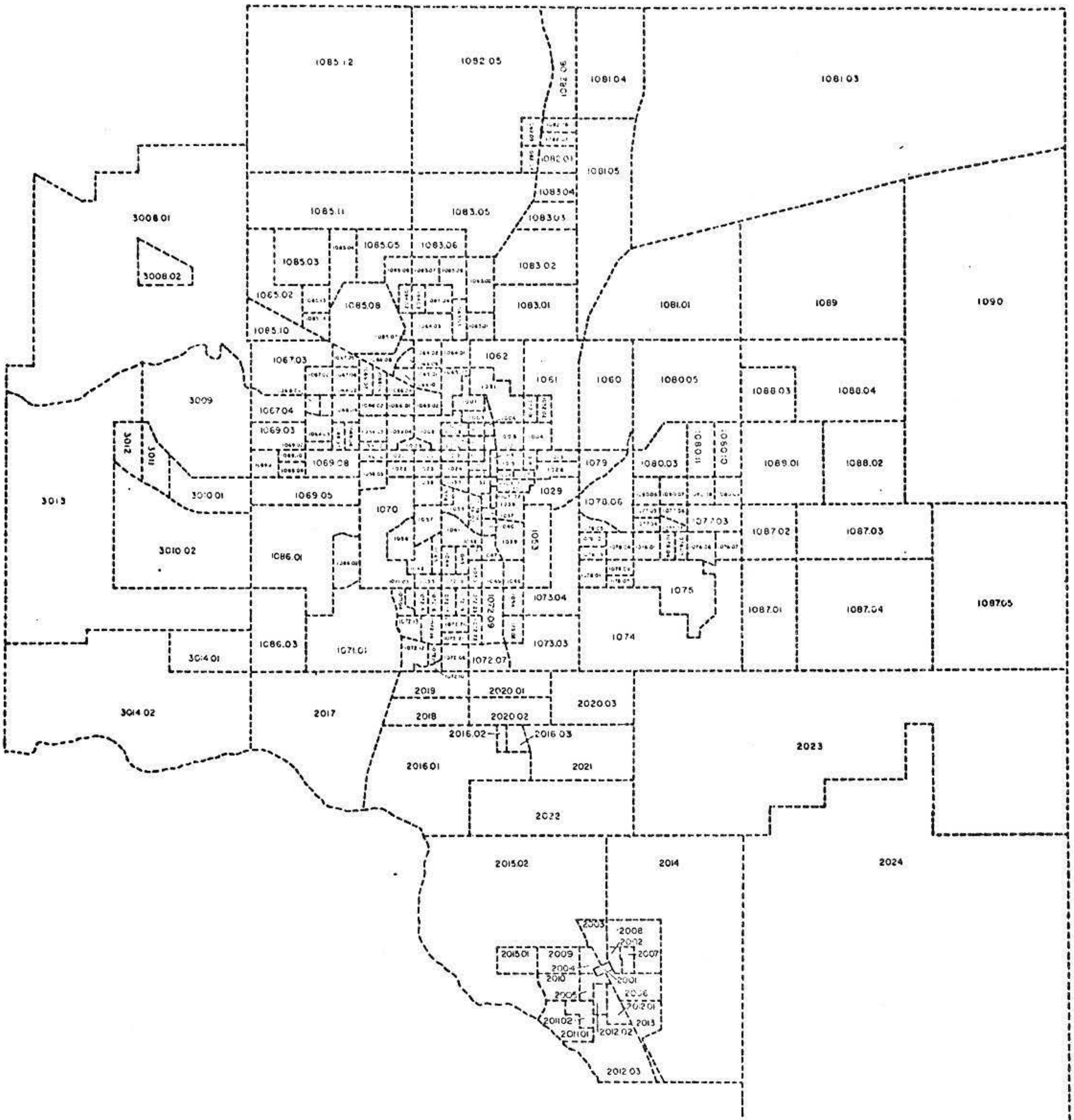


FIGURE 2

CENSUS TRACTS FOR OKLAHOMA CITY SMSA

A closer view of the tracts in the southern part of Oklahoma City is depicted in Figure 3. While the tract boundaries typically follow major streets, several boundaries along rivers and railroads can be noted in the figure. As indicated earlier, census tracts are socio-economically homogeneous, hence the Will Rogers Airport is isolated in its own tract. Finally, a six digit tract number, e.g., 1072.18, indicates that this tract is a subdivision of an earlier and larger tract once designated as 1072.

This census tract, 1072.18, is shaded in Figure 3 because it is used as an example in Appendix C. Figure 4 depicts a portion of the streets in this tract as well as that portion of COTPA's Route 2 which extends through the tract. Finally, Figure 5 depicts the census map which corresponds to the streets and bus route in Figure 4. This is an extract from the "Metropolitan Map Series" which shows the census tracts, blocks, node numbers, and other pertinent geographic features.

Figure 5 illustrates the TRANES network coding. The investigator simply designates the desired bus stops which are then related to GBF/DIME street intersection node numbers. Once processed by the computer, as illustrated in Appendix C, this information enables TRANES to access the census information in the blocks indicated in Figure 5. Finally, the designated bus stops determine the bus route, and TRANES can summarize the bus stop data by the total route or designated segments of the route.

Report Overview

The remainder of this report is organized as follows. A literature review of bus route demand modeling is presented in the next section, followed by more information on the bus routes of the case study system, the Central Oklahoma Transportation and Parking Authority. The demand model analyses are presented next. The report concludes with a review of potential applications of TRANES, some of which were demonstrated and implemented as part of the research, followed by suggestions for future research. The Appendices are reserved for detailed explanations in support of the main body of the report, notably computer programming aspects and network coding.

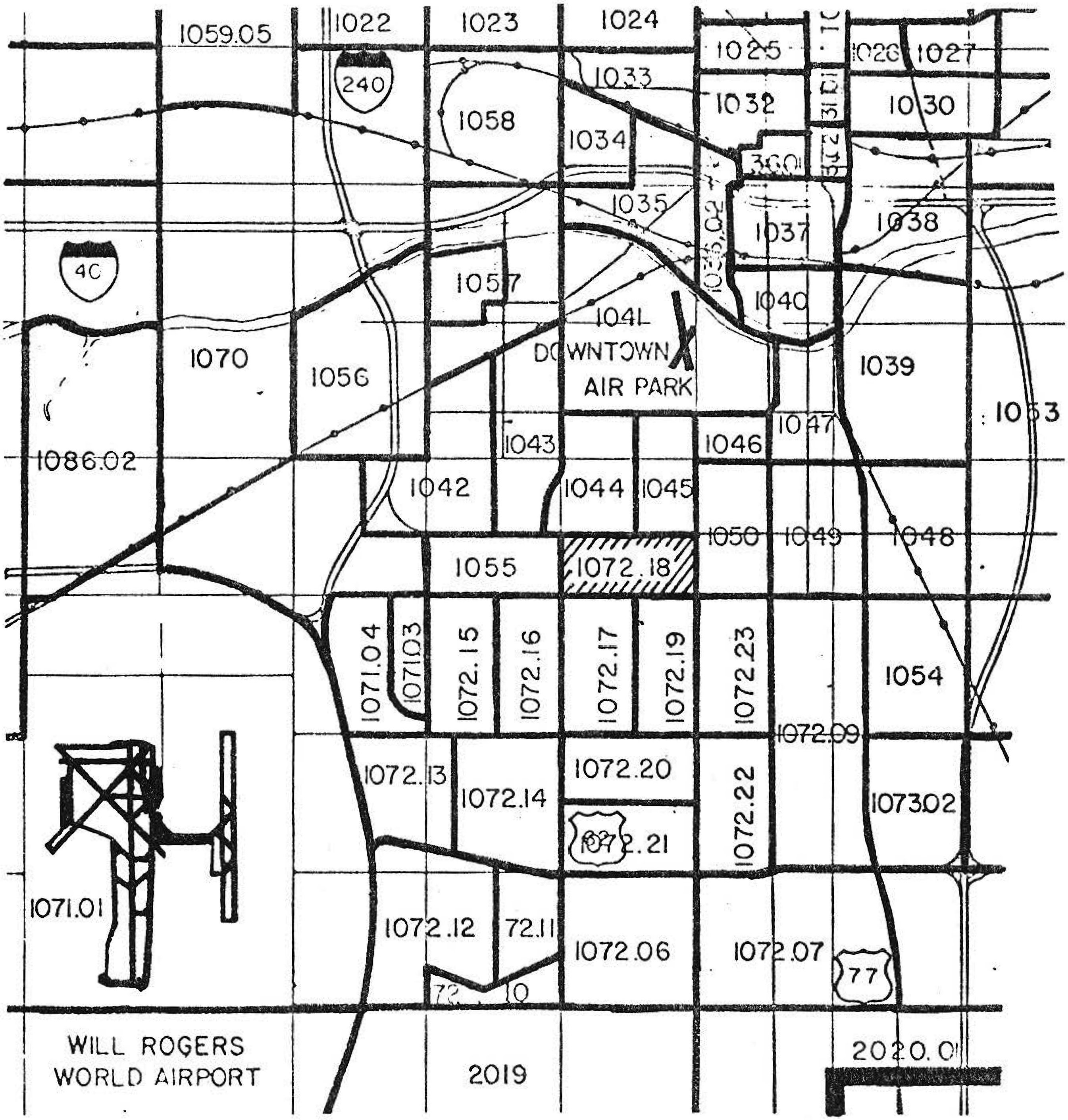
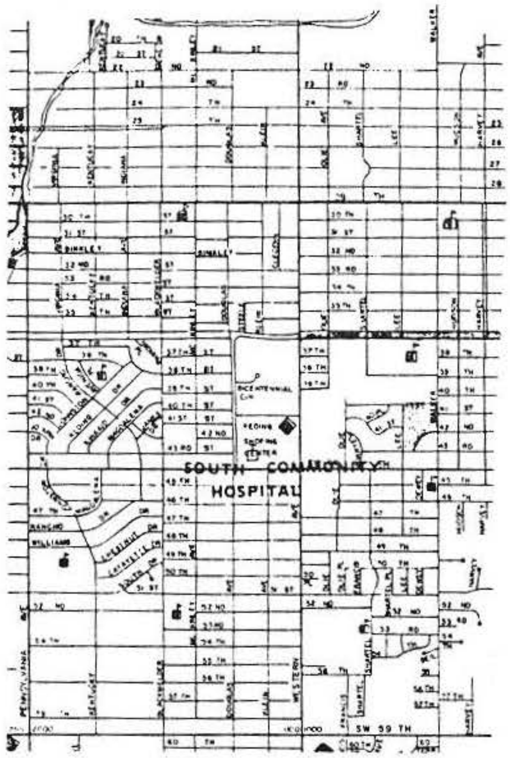


FIGURE 3

DETAIL OF CENSUS TRACTS IN SOUTHERN OKLAHOMA CITY



Oh What A Ride

cotpa

Central Oklahoma Transportation
and Parking Authority
300 E. California
Oklahoma City, OK 73104 231-2601

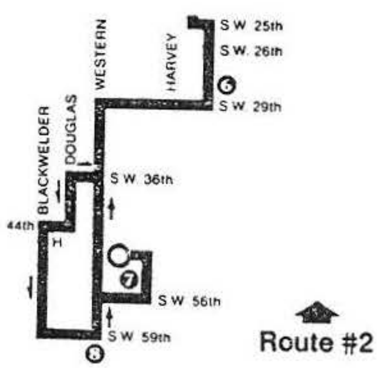


FIGURE 4

STREETS AND COTPA BUS ROUTES IN CENSUS TRACT 1072.18

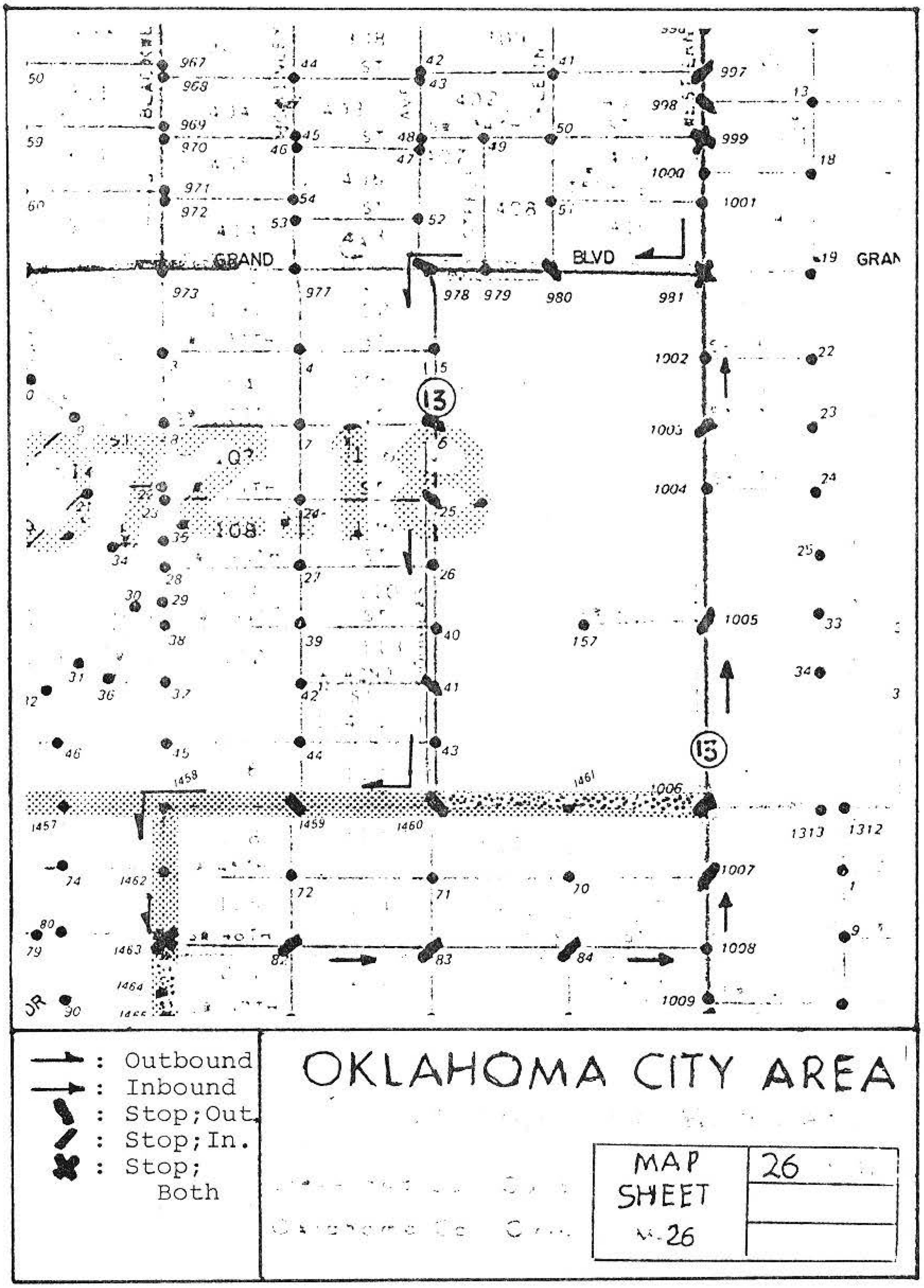


FIGURE 5

TRANES NETWORK CODING IN TRACT 1072.18

DETERMINANTS OF BUS ROUTE DEMAND

A literature review of previous work in bus route demand modeling was conducted as part of the effort to apply TRANES to the same topic. This is briefly reported in the following sections which emphasize the types of models develop, the types of data used, specific uses of U.S. Census data in these models, walking patterns to bus stops, and the accuracy of previously reported models.

Bus Route Demand Models

Menhard and Ruprecht (52) and Yuratovac (90, 95) have reviewed the state-of-the art in bus route demand modeling. Essentially, they identify four types of models:

1. Professional judgment,

2. Noncommittal potential ridership surveys,

3. Cross-sectional analysis (models which relate bus route ridership to level of service variables and socio-economic characteristics of the area served by the bus route), and

4. Time series analysis (models based on past ridership trends, largely pivot point and elasticity-based methods).

It seems evident that TRANES is applicable to both the professional judgement type of modeling and cross-sectional analysis. In the former case TRANES would be used merely to identify socio-economic statistics along the routes which, in turn, would be used by the transit planner to make judgments about the viability of a route and route segment. In this report, of course, TRANES is used to develop cross-sectional models.

Time series techniques and noncommittal surveys have no particular potential for application with TRANES, although TRANES could be used to augment a noncommittal survey. A number of investigators have developed time series models, including Benham (3), Kyte, et al. (Box-Jenkins analysis techniques, 42), and Gaudry (18). Elasticity methods are a simpler form of time series analysis in that they predict changes in existing routes based on the elasticity of consumer response to changes in level of service factors (e.g., headway) or fare. None of the time series models seem appropriate for application with TRANES, in large part because the census data set is fixed in time.

Two types of cross-sectional bus route models dominate the literature, those which are patterned after the conventional four-step travel demand forecasting process, and direct demand models. Researchers who have investigated four-step models, which typically include trip generation, distribution, and modal split, include Horowitz and Metzger (31); Koppleman (40); Stopher, et al. (72); and UMTA-funded case studies in Cleveland and Portland, Oregon (91, 92). Stopher, et al., contend that UTPS can be satisfactorily used for route demand prediction with the addition of a special program. They reported accuracies in demand prediction of ± 10 percent and said that their model configuration was particularly suitable for large bus systems.

The dominant form of cross-classification bus route demand model is direct demand, which essentially amounts to an emphasis on trip generation rather than consumer mode choice. This form of model is based on socio-economic characteristics of potential users, hence is the model category TRANES is best suited to. Among the direct demand bus route models found in the literature were models by Colangelo and Glaze (10), Golenberg and Pernaw (20), Nelson and O'Neil (56), and Shortreed (67). Regression analysis predominates, either in the form of linear relationships or product and log relationships between independent variables.

The bus route demand models in the literature typically predict demand for the entire route or along segments of routes. No models of individual bus stop demand were found, although Hobeika and Chu (28) report a supply/demand model which is sensitive to individual bus stops. Some demand models separate peak from off-peak conditions. Most models address conventional fixed-route service but several researchers have developed separate equations for different types of routes, e.g., radial, cross-town, and express. TRANES would not appear to be applicable to express services since the ridership is likely to come from a broader coverage area when express routes cater to park-and-ride situations. In such cases demographic characteristics adjacent to park-and-ride bus stops are not likely to be relevant.

Transit Trip Generation Determinants

Three basic types of input variables predominate in existing bus route demand models: socio-economic characteristics, level of service, and urban geographical statistics. Socio-economic characteristics typically include population, age, employment, and household characteristics such as income and auto ownership. Schmenner (64) devised a model which included race, schools, and shopping centers.

Level of service variables are dominated by the walking distance to bus stops (reported more fully in a following section), headway, frequency of service, fare (in modal split and elasticity formulations), seats available, presence of transfers, and alternative competing services. Urban geographical statistics include route connectivity, service to activity centers, distance to the CBD, and such urban characteristics as city size, age, and geographic location.

In terms of correlations among variables, it is common to note correlations between household income and auto ownership

(10, 70, and 92). Brown (6) hypothesizes that the presence of bus service affects adjacent socio-economic patterns, in that people with a propensity to use transit will gravitate to those corridors where the service has a high level of service (i.e., transit level of service affects land use patterns). Among the variables he investigated were age, occupation, income, and auto ownership.

Applications of U.S. Census Statistics

U.S. Census statistics are commonly used to provide socio-economic information, invariably census tract statistics. Since tracts are far too large to be useful for bus route analysis, investigators typically lay out the bus route on a tract map and identify that portion of the tract which lies within a specified distance (typically 1/4 mile) of the route. The tract socio-economic characteristics are assumed to be uniform throughout the tract and factored down to the region adjacent to the route. Past studies which have used census statistics in this manner include Fulton (17), Corradino (12, but with traffic zones instead of census tracts), Guest (23), Heathington and Brogan (27), Hobeika and Chu (28), Miller and Millar (53), and Peat, Marwick, Mitchell and Co. (85, 86, 87). Hunt, et al. (34) detailed their application of 1980 census data to Title VI compliance reporting using census tracts, a one-fourth-mile bus route service band, and interactive computer graphics. The computer determined what portion of the tracts were included within the service bands.

Walking Patterns to Bus Stops

Bus stop demand patterns have been investigated by a number of researchers. Demetsky and Lin (15) report the following bus stop impact distances as based on a survey of 67 transit agencies: 160 to 2,640 ft. in the CBD and 320 to 5,280 ft. in outlying areas. A common rule-of-thumb impact distance is 1/4 mile or 1,320 ft. A synthesis report of bus route guidelines (77) suggests that bus stops should be spaced 0.25 to 0.375 miles apart (1,320 to 2,000 ft.) in urban areas (a five minute walk on average) or up to one mile (5,280 ft.) in outlying areas.

Bus ridership demand as a function of distance to the bus stop has been investigated by Golenberg and Pernaw (20); Lam and Morrall (45); Lutin, et al. (48); and Levinson and Brown-West (46). Based on ridership surveys in Hartford, Conn., Levinson and Brown-West reported that daily ridership per 100 dwelling units decreased about 5 rides for every 100 ft. increase in distance, and even more with increased auto ownership. Their study of walking distances extended to 1,000 ft.

Lam and Morrall found that in Calgary, Alberta, Canada, 75 percent of the bus ridership lived within 1,476 ft. (450m) of a bus stop and 95 percent within 2,600 ft. (800 m). The mean walking distance was 1,073 ft. (327 m). These distances were found to vary a little depending on season of the year and location within the urban area. Finally, Lutin, et al., determined that 75 percent of bus passengers lived within 1,100 ft. and 100 percent within about 2,000 ft. of bus stops, with a median distance of 700 ft.

Hsu and Surti (33, p. 456) commented: "Transit accessibility was the most important factor, while socio-economic factors such as household income, automobile ownership, age, and ethnic factors did not have much effect on transit usage." Later in this report it was decided to focus on 1,000 ft. as an impact distance when using TRANES, although other distances extending to 2,500 ft. were also investigated.

Accuracy of Bus Route Demand Models

The accuracy of bus route demand models typically is reported either in the percent error of direct estimates of route patronage, or the coefficient of determination (R^2) of the models themselves. An approximate rule-of-thumb desired accuracy of demand predictions by route is ± 10 percent.

Route demand predictions in Portland, Oregon (91) tended to be over-estimated, with the over-estimates ranging from 4 percent to 122 percent and averaging 49 percent. In Cleveland (92) route prediction accuracy ranged from - 12.2 percent to + 58.5 percent. Also in Cleveland R^2 for various model formulations ranged from 0.355 to 0.826.

Shortreed (67) reported that the route demand predictions of his regression models were accurate to within ± 25 percent by route. He developed 16 equations whose R^2 ranged from 0.55 to 0.95. Schmenner (64) developed time series equations whose R^2 ranged from 0.60 to 0.94, with most R^2 exceeding 0.70. Models developed by Hsu and Surti (32, 33) had R^2 ranging from 0.575 to 0.656. Finally, Yuratovac (95) reported that his predictions of demand on segments of routes had percent errors ranging from - 21 percent to + 76 percent, with a total route demand error of - 5 percent. He stated that other routes in his study had errors ranging from + 2 to + 8 percent.

COTPA BUS SYSTEM CHARACTERISTICS AND ROUTE DEMAND

At the time of this research in 1982/1983 the Central Oklahoma Transportation and Parking Authority (COTPA) maintained a fleet of 101 buses which had an average fleet age of 3.66 years. The fleet included five lift-equipped mini-buses for the transport of the mobility impaired and four imitation trolley buses for downtown shuttle and charter service.

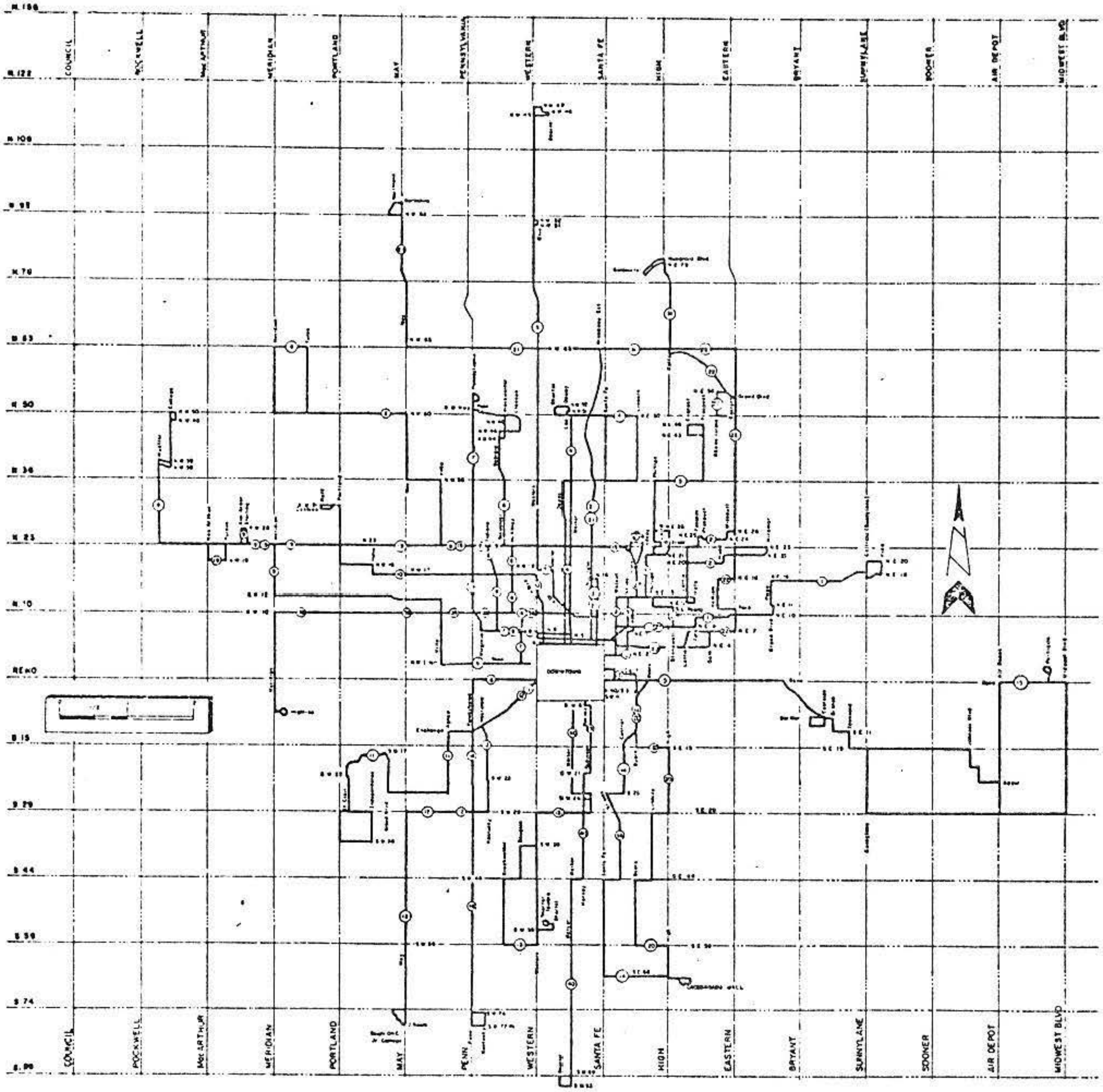
Seventy-one buses provided regular daily service along 24 local and twelve express routes. These bus routes are depicted in Figure 6 and listed in Table 1. The majority of the local transit routes served the urbanized area of Oklahoma City, itself. The routes were interlocked and radial in configuration with a common downtown transfer location operated as a timed transfer pulse service. All of the local routes provided 30 minute headways. COTPA buses logged some 9,937 bus-miles each day, Monday through Friday, and 3,550 bus-miles on Saturdays.

System patronage trends are depicted in Figure 7 for the fiscal years 1980/1981, 1981/1982, and 1982/1983. Patronage had generally increased from 1980 through 1981 and then declined throughout 1982. In late 1982 headways were decreased from one hour to 30 minutes and patronage increased to about 11,500 patrons per day in 1983 when the studies of this report were conducted. No significant seasonal trends are evident although patronage is highest in the winter months, October to March.

Average daily passenger demand by route for the first five months of 1983 is depicted in Figure 8 and route load factors are listed in Table 2. This information was collected by COTPA personnel (Figure 8 was derived from routine passenger loading statistics collected every month) or consultants. By national transit standards the local routes are relatively underutilized and some routes were barely justified in terms of demand. The most heavily patronized routes (e.g., routes 2, 3, 4, 5, and 8) tended to be radial routes serving the central portions of the metropolitan area, usually neighborhoods with concentrations of low income or minority groups.

No specific surveys of the passenger composition were conducted as part of this research, but a study had been made by ATE Management & Service Company, Inc., in early 1982 (8). For the purposes of comparison, a 1980 census profile for Oklahoma City is presented in Table 3. Oklahoma City had a population of 404,014 in 1980, which was an increase of 9.7 percent over 1970. The population was 80 percent white, 14.6 percent black, 2.6 percent American Indian, and the remainder a scattering of minorities. Oklahoma City is relatively prosperous with a low rate of unemployment and jobs dominated by the government and service sectors. The city is the state capitol and the center of a large agricultural and petroleum industry service area. The dominant housing unit is the owner-occupied single family home.

Route Map



Express Routes not shown.

FIGURE 6

COTPA BUS ROUTES, 1983

TABLE 1

COTPA BUS ROUTE DESIGNATIONS

Route Number	Designation
1	Garden Day
2	NE 23rd & Miramar
3	Park Estates
4	N Walker
5	N Western/Britton
6	48th & Classen/PenN Square
7	N Penn
8	NW 63rd & Tulsa/Shepherd Mall
9	Windsor Hills/Bethany
10	NW 31st & Portland/Crestwood
11	SW 36th & Dumas
12	S May/ OCCC
13	S Blackwelder
14	S ShieLds/Crossroads Mall
15	Midwest/Del City
16	S Penn
19	NW 23rd St. Crosstown
20	SE OKC/Crossroads Mall
21	N May
22	NE 63rd & Eastern/Zoo
23	Norman Express
26	NW Expressway Express
27	Downtown/OUHSC/State Capitol
28	First National Bank Parking Loop
29	FAA Express
30	Tinker Taxi Express
31	N Robinson/Musgrave
32	Western Electric Express
34	Midwest Miler Express
37	Edmond Express
38	I-40 & Meridian
40	S Walker
44	Downtown Shuttle

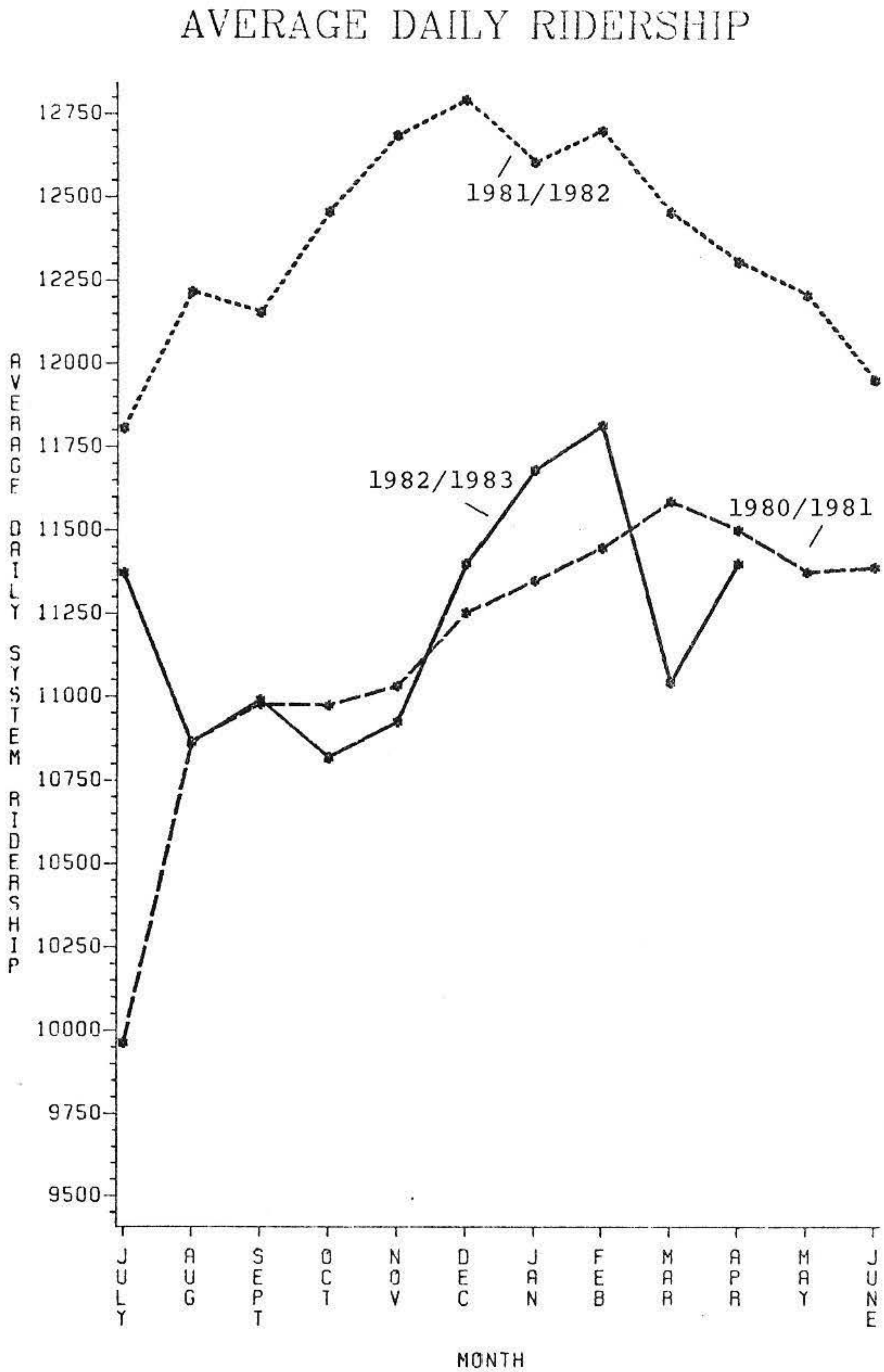


FIGURE 7

COTPA AVERAGE DAILY RIDERSHIP, 1980 to 1983

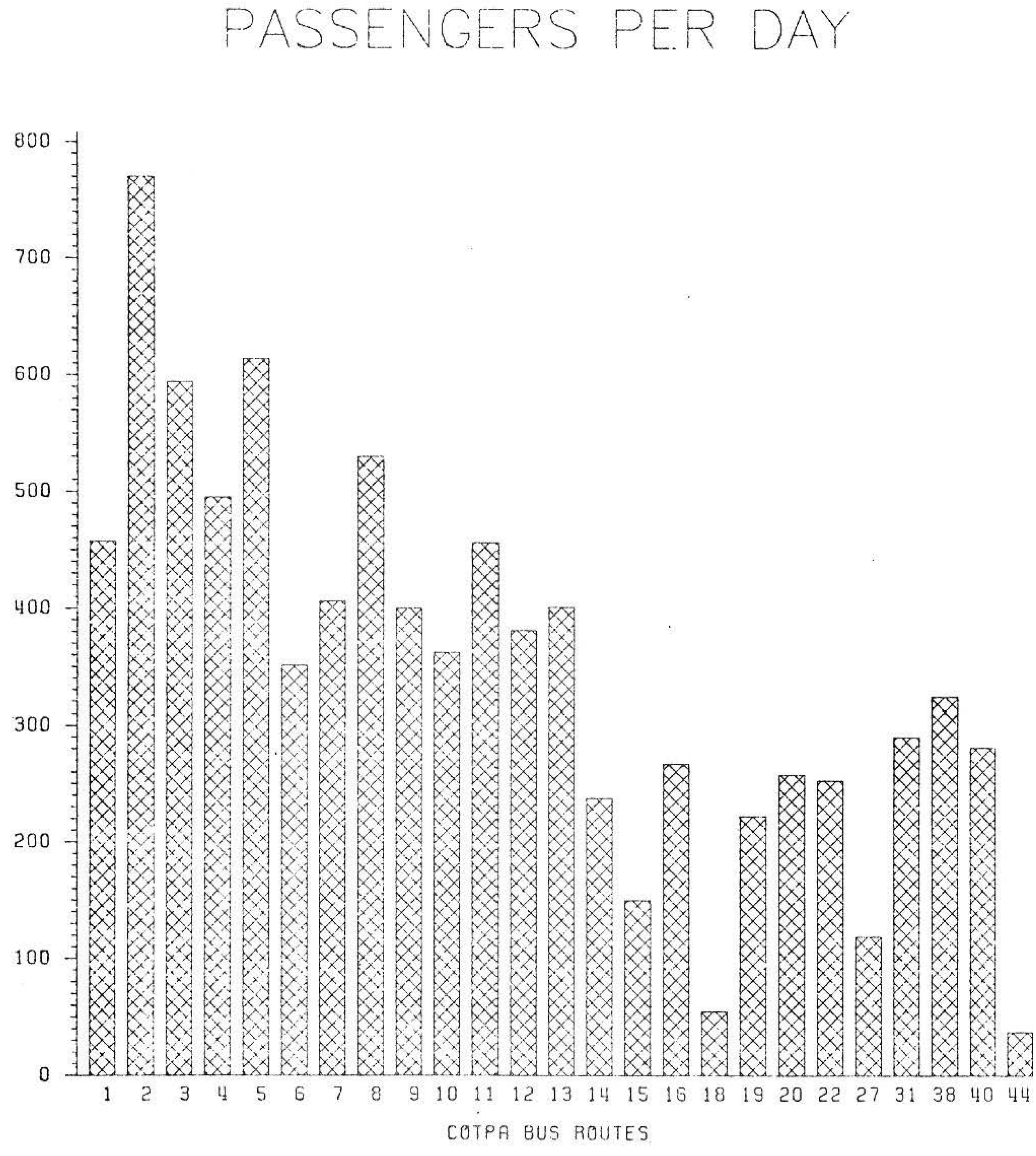


FIGURE 8

PASSENGERS PER DAY ON COTPA BUS ROUTES

TABLE 2

PEAK HOUR LOAD FACTORS ON COTPA BUS ROUTES,
MARCH 1983

Route	Number of Trip	Number of Seats	Number of Passengers	Load Factor Seats/Passengers
1*	3	133	72	.54
2*	4	179	97	.54
3*	2	87	54	.62
4	2	91	27	.30
5*	2	91	63	.69
6	2	90	21	.23
7	2	91	31	.34
8	2	90	27	.30
9*	4	181	127	.70
10	2	91	38	.42
11*	2	82	42	.51
12	2	91	39	.43
13	2	91	26	.29
14	3	133	24	.18
15*	1	46	47	1.02
16	3	137	40	.29
18	2	82	21	.26
19	2	91	19	.21
20	2	91	14	.15
21*	2	45	54	.60
22	2	90	36	.40
23	1	41	17	.41
25*	1	41	19	.46
26*	3	127	106	.83
27	2	82	3	.04
28	3	135	28	.21
29	2	86	37	.43
30	2	87	25	.29
31	2	91	35	.38
32*+	3	127	54	.43
33	1	45	17	.38
34+	1	46	11	.24
37*	2	86	68	.79
38	2	91	25	.27
40	1	45	20	.44
44	1	24	6	.25
			SYSTEM LOAD FACTOR	.41

NOTE: Load factor analysis represents data collected on Wednesday, March 16, 1983. Computations were made for all routes, within the entire system, during the A.M. Peak Period from 5:45 a.m. - 9:15 a.m. The selected peak one-hour period was 6:10 a.m. - 7:10 a.m., which represents maximum ridership and peak direction (inbound) only.

* Route Load Factor greater than System Load Factor (.41) plus ten percent (+10% = .45) due to heavy concentration of minorities.

\+ Route required a different time period due to subscription route status.

TABLE 3

1980 CENSUS PROFILE OF SELECTED DEMOGRAPHIC CHARACTERISTICS OF OKLAHOMA CITY

Characteristic	Number	Percent
Total Population:		
1980 (% of Total)	404,014	
1970 (% of Total)	368,377	
Change	35,637	9.7
Age:		
School Age (5-17)	77,112	19.1
65 and over	45,368	11.3
Median Age	29.9	
Race:		
White	322,374	80.0
Black	58,702	14.6
American Indian	10,405	2.6
Ethnicity, Spanish Origin	11,295	2.8
Household Income, 1979 (Base):	160,442	
Less Than $7,500	35,575	22.2
$10,000-$19,999	49,462	30.8
$30,000 and over	19,350	12.1
Median	$15,907	
Educ. Attainment (Persons 25+):	240,471	
High School Graduates	82,173	34.2
One or More Years College	92,005	38.3
Median Years	12.7	
Occupation (Employed Persons 16+):	191,843	
Managerial & Professional	45,694	23.8
Precision Prod., Craft & Repair	25,597	13.3
Oper., Fabricators & laborers	29,291	15.3
Industry (Employed Persons 16+):	191,843	
Construction	11,485	6.0
Manufacturing	28,899	15.1
Retail Trade	32,214	16.8
Finance, Insurance & Real Estate	14,732	7.7
Professional & Related Services	35,847	18.7
Public Administration	16,050	8.4

(continued)

TABLE 3

1980 CENSUS PROFILE OF SELECTED DEMOGRAPHIC CHARACTERISTICS OF OKLAHOMA (Continued)

Characteristic	Number	Percent
Total Housing Units (Year Round):	177,088	
Single Family	123,543	69.8
Multi-Family (3+ Units)	42,248	23.9
Mobile Home	4,377	2.5
Total Households (100% Sample):	160,002	
Owner Occupied	101,192	63.2
Median Value (Specified Units)	$40,100	
Household Size:		
1 & 2 Persons	98,050	61.3
5 or More Persons	14,837	9.3
Average	2.48	

Source: Office of Research and Economic Development, Community Development Department, City of Oklahoma City, Oklahoma.

ATE did a random telephone survey of 900 Oklahoma City metropolitan area residents in February 1982 (8). They determined that COTPA had an unusually low user incidence rate; twelve percent of the adults surveyed had used COTPA services in the preceding twelve months. They attributed this to the low population densities in the sprawling metropolitan area and a "frontier" mentality which made most residents covet the mobility advantages of their automobiles.

The results of the telephone survey are summarized in Table 4 for demographic categories similar to those of Table 3. The statistics are separately listed for "frequent users," "infrequent users," "potential users," and "staunch non-users" as defined in the table. ATE characterized the typical frequent COTPA patron as under 35 or over 55 years in age, female, white, income less than $20,000 per year, unemployed or engaged in service or clerical work, working downtown, and more likely than not to have a driver's license and access to an automobile. The dominant trip purposes among frequent users were for work (71 percent) and shopping (39 percent).

Infrequent or potential users were much more likely to be unemployed and they cited economic necessity as reasons for taking the bus. These users were much less likely to be employed downtown, the node of greatest accessibility in the COTPA network. Staunch non-users had higher incomes and more education. They cited service inferior to that of their automobile as the dominant reason why they refused to use the bus service. Some 72 percent of the staunch non-users stated that there were no service changes COTPA could make which would influence them to ride the bus.

TABLE 4

DEMOGRAPHIC PROFILE COMPARISONS*

	Frequent Users (N = 56)	Infrequent Users (N = 61)	Potential Users (N = 75)	Staunch Non-Users (N = 708)
Sex:				
Male	30%	43%	51%	50%
Female	70	57	49	50
Age:				
Under 25	29%	24%	21%	21%
25 to 34	29	24	10	25
35 to 44	8	10	14	13
45 to 54	8	12	11	14
55 to 64	8	6	12	12
65 or over	16	22	31	13
No Response	1	2	1	4
Race:				
White	66%	67%	75%	86%
Black	29	26	19	6
Hispanic	–	–	–	1
Oriental	2	–	3	–
Other	4	5	1	2
Refused	2	2	3	4
Household Income:				
Under $10,000	25%	6%	32%	10%
$10,000 to $14,000	20	23	11	12
$15,000 to $19,999	8	14	17	11
$20,000 to $24,999	13	14	9	14
$25,000 or over	18	18	17	36
No Response	17	26	15	17
Education:				
Some High School/Less	32%	21%	21%	14%
High School Graduate	30	41	29	35
Some College	20	15	27	26
College Grad./Plus	16	18	17	22
No Response	2	5	5	3

(continued)

TABLE 4

DEMOGRAPHIC PROFILE COMPARISONS* (continued)

	Frequent Users (N = 56)	Infrequent Users (N = 61)	Potential Users (N = 75)	Staunch Non-Users (N = 708)
Employment:				
Full-Time	59%	49%	33%	57%
Part-Time	13	10	12	9
Unemployed	29	38	53	31
No Response	–	5	1	3
Occupation:				
Professional/Technical	7%	10%	12%	13%
Managerial	11	7	7	10
Clerical	29	13	5	14
Sales	2	2	–	7
Craftsmen/Foremen	2	7	4	8
Operatives	2	7	7	4
Laborers	4	3	–	2
Service/Household Workers	16	12	5	4
Not Employed	29	38	53	31
No Response	–	5	1	3
Employment Location:				
Downtown	41%	30%	16%	15%
Outlying Area	30	30	27	51
Not Employed	29	38	53	31
No Response	–	5	4	3
Length of Area Residence:				
Less Than 6 Months	–	4%	5%	2%
6 Months to 1 Year	9%	3	1	4
1 to 3 Years	5	10	7	8
3 to 5 Years	8	3	9	4
5 to 10 Years	15	2	9	10
10 Years or More	63	76	68	69
Driver's License Possession:				
Yes	66%	90%	80%	94%
No	34	8	17	5
No Response	–	2	1	2

(continued)

TABLE 4

DEMOGRAPHIC PROFILE COMPARISONS* (continued)

	Frequent Users (N = 56)	Infrequent Users (N = 61)	Potential Users (N = 75)	Staunch Non-Users (N = 708)
Car Availability:				
Yes	61%	80%	72%	93%
No	4	10	8	1
No Answer/No Drivers License	34	10	19	6
Household Composition:				
Married Couple	34%	46%	47%	60%
Single Male	9	10	17	10
Single Female	34	20	23	15
Roommates	11	13	5	4
Other	13	10	7	7
Refused	–	2	3	4
Presence of Children Age 15 or Younger:				
Yes	39%	43%	21%	28%
No	59	56	75	70
Refused	2	2	3	2

* Telephone survey of 900 Oklahoma City metropolitan area residents conducted in February 1982.

Frequent User: Has used the bus 24 or more days in the 12 months preceding the survey.

Infrequent User: Has used the bus between 1 and 23 days in the past 12 months.

Potential User: Has not used the bus in the past 12 months but expresses a definite or probable intention to use the bus during the next 12 months.

Staunch Non-User: Has not used the bus during the past 12 months and expresses a definite or probable intention not to use the bus during the next 12 months.

Source: Reference 8, pp. 95-97.

BUS ROUTE DEMAND ANALYSIS WITH TRANES

Network and Demand Data Development

Two data sets were created as part of the effort to develop bus route demand models based on census data and TRANES. The first data set was derived from census block data. The nine variables of Table 5 were taken from the STF1 summary tape. Although they do not include all of the demographic statistics which can likely be correlated with bus route demand, they represent what is available at the census block level and, hence, what could be directly accessed by TRANES.

In order to broaden the list of variables available for analysis, manual compilation was undertaken of additional census variables on the STF3 summary tape. The selected variables are listed in Table 6 . These variables are tabulated only to the census tract and census block group level. For eight representative COTPA routes this data was manually determined by first identifying what fractions of each block group were within 1000 ft. of each bus stop along the eight routes using census tract maps. Then, assuming that the block groups were homogeneous in demographic character, the variables in Table 6 were determined for each bus stop using the data from the STF3 tape.

Two types of models were considered, models based on total route statistics and models based on bus stop demand patterns. The census variables in Tables 5 and 6 were correlated with route and bus stop ridership. For the total route models the average daily ridership on 23 local COTPA routes was derived from 12 months of operating statistics collected in 1982 and 1983 (Figure 8).

Eight representative local routes were selected for the analysis of transit demand at individual bus stops. These routes, numbers 2, 5, 8, 9, 11, 13, 18, and 40, are depicted in Figure 9. The routes were selected as being representative of all the local routes, particularly in terms of the urban corridors they served, and for being spaced far enough apart so that these routes did not compete for passengers along substantial portions of their routes. Four of the routes were "interlocked," which means that the same bus traverses two routes, changing route numbers in the CBD. This proved to be a convenience for the student assistants who were observing passenger boardings and could compile data on two routes while riding the same bus.

Bus stop boardings and departures were determined manually by having observers ride the eight selected bus routes for three days in April and May 1983. Statistics for 372 bus stops were collected and at least one-fourth of all the riders using the eight selected routes on the three analysis days were observed. On four of the routes half of the daily patronage was observed.

TABLE 5

CENSUS BLOCK STATISTICS EXTRACTED FROM

THE STF1 CENSUS TAPE

1.	Total Population
2.	Total black population
3.	Total population under 16 years
4.	Total population over 64 years
5.	Total housing--owner occupied
6.	Total housing--renter occupied
7.	Total housing--value less than $15,000
8.	Total housing--value $15,000 to $34,999
9.	Total housing--value over $35,000

TABLE 6

CENSUS BLOCK GROUP STATISTICS EXTRACTED FROM

THE STF3 CENSUS TAPE

RACE:	R1:	Total white population
	R2:	Total black population
	R3:	American Indian, Eskimo, Aleut Population
	R4:	Asian and Pacific Islanders
	R5:	Others (including Spanish surnames)
AGE:	A1:	0 to 15 years
	A2:	16 to 24 years
	A3:	25 to 34 years
	A4:	35 to 64 years
	A5:	Over 65 years
	FA1:	Females only, 0 to 15 years
	FA2:	Females only, 16 to 24 years
	FA3:	Females only, 25 to 34 years
	FA4:	Females only, 35 to 64 years
	FA5:	Females only, Over 65 years
OCCUPATION:	01:	Executive, administrative and managerial
	02:	Professional, specialty
	03:	Technicians and related support
	04:	Sales
	05:	Clerical, administrative support
	06:	Private household service
	07:	Protective survice
	08:	Machine operators, assemblers, inspectors
	09:	Transportation and material moving
HOUSEHOLD INCOME:	I1:	$0 to $10,000
	I2:	$10,000 to $15,000
	I3:	$15,000 to $20,000
	I4:	$20,000 to $25,000
	I5:	$25,000 to $35,000
	I6:	$35,000 to $50,000
	I7:	Over $50,000

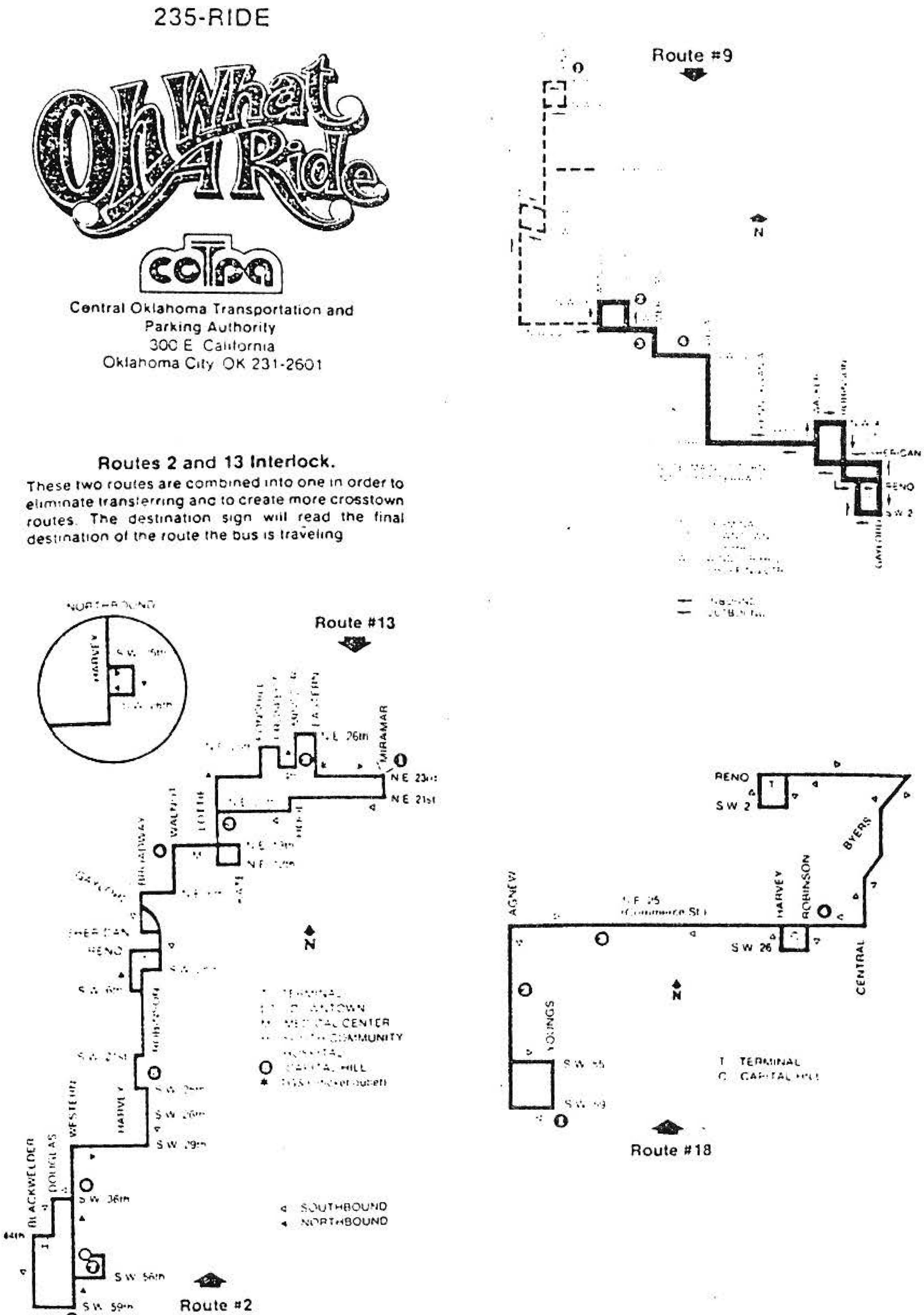
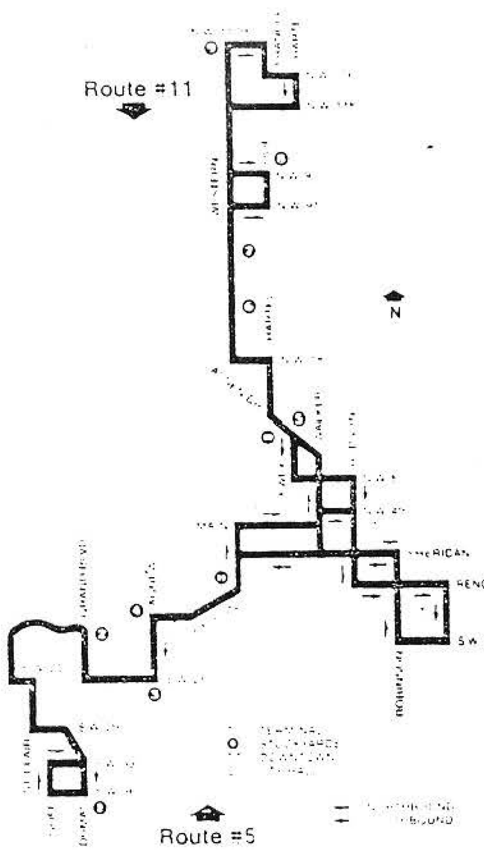


FIGURE 9

COTPA BUS ROUTES SELECTED FOR PASSENGER BOARDING SURVEY

Routes 5 and 11 Interlock

These two routes are combined into one in order to eliminate transferring and to create more crosstown routes. The destination sign will read the final destination of the route the bus is traveling.



Routes 8 and 40 Interlock.

These two routes are combined into one in order to eliminate transferring and to create more crosstown routes. The destination sign will read the final destination of the route the bus is traveling.

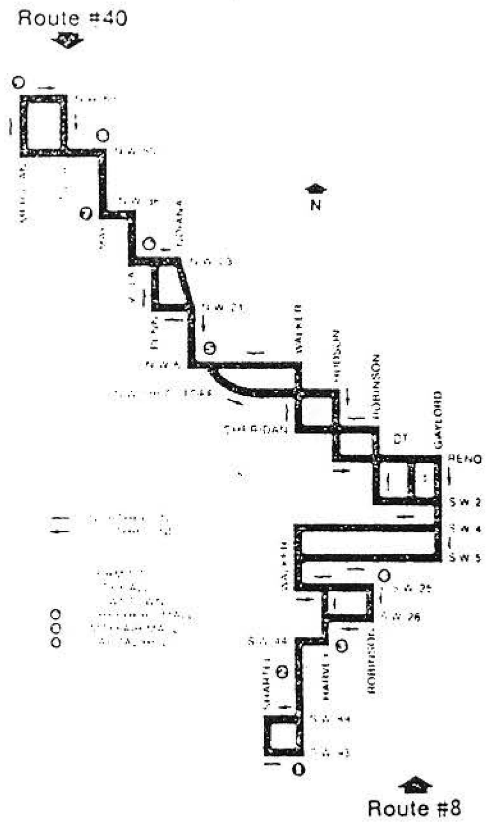


FIGURE 9 (continued)

The survey form depicted in Figure 10 was used to collect the passenger boarding information. The bus stop boardings were linked to the TRANES node numbers by using the form depicted in Figure 11. The information from the Figure 11 forms constituted the boarding data for the bus stop demand analysis work.

Finally, two types of statistical analyses were employed. One was step-wise regression analysis. The other was principal components factor analysis with equamax orthogonal rotation. Factor analysis was used to reduce the census variables to a set of factors which would indicate the fundamental structure of the relationships among the census variables. A demand model would then be based on these factors which, in turn, should identify the key determinants of demand.

Factor analysis is fairly commonly used in transportation analysis, particularly in the analysis of census statistics or other data sets with large numbers of variables, such as UMTA Section 15 performance measures (references 13, 14, 24, 57, 58, 93). For example, Guseman, et al. (24) applied factor analysis to transit level of service attributes in Beaumont and Waco, Texas. Constantino (13) related census tract statistics to transit attributes, yielding regression equations whose coefficients of determination (R^2) ranged from 0.47 to 0.74. Perle, et al. (57, 58) used factor analysis to identify trip generation determinants based on census statistics adjacent to proposed rail rapid transit stations in Detroit. A factor analysis text by Guertin (22) was used as reference for the following analysis and the factor analysis programs of the SAS Institute, Inc. ("Statistical Analysis System") were used for the computational analysis.

Analysis with U.S. Census Block Data (STF1)

As a first step in the analysis of COTPA route demand, the average daily ridership on 23 COTPA routes was directly correlated with the nine STF1 census variables of Tables 7 and 8 for distances of 1,000 ft. and 2,500 ft., respectively, from the bus stops.

A plot of total population within 1,000 ft. of the bus stop versus average daily passenger route demand is depicted in Figure 12. Similarly, total population within 2,500 ft. of the bus stops versus route demand is depicted in Figure 13. The correlation was very weak, with an R^2 of only 0.15. It was even weaker for total population within 2,500 ft.; $R^2 = 0.05$.

Normalizing the census variables before doing the regression analysis improved the correlations to some extent. The normalization consisted of subtracting the mean of each variable from each variable observation, and dividing this by the standard deviation of the variable set. With this done, the following regression equations were determined for total population within 1,000 and 2,500 ft. of the bus stops along the 23 routes:

SURVEY TRIP SHEET

(1) Trip Serial No. ________ (2) Date ________ (3) Day of Week ________ (4) Time Period ________

(5) Route No. ________ (6) Vehicle Inventory Number ________ (7) Total Capacity ________ (8) Seated Capacity ________

(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Stop No.	Stop Description	Arrival Time	Odometer Reading	Passengers Boarded	Passengers De-boarded	Passengers on Board	Distance Between Stops	Passenger Miles (15)x(16)	Minutes Between Stops	Passenger Minutes (15)x(18)
			TOTALS	(20)		(21)	(22)	(23)	(24)	(25)

(26) Capacity Miles (7)x(22)

(27) Seat Miles (8)x(22)

Form UMTA F2710.4 (12-77)

FIGURE 10

SURVEY TRIP SHEET

Route No. -----   Direction -----

Date -----   Day of Week -----   Time Period -----

Number	Intersection	TRANES Node No.	Boarded	De-boarded				Remarks
		TOTALS						

FIGURE 11

TRANES NODE NUMBER MATCHING FORM

TABLE 7

1980 CENSUS TABULATION TOTALS BY ROUTE
WITHIN 1,000 FEET OF BUS STOPS

COTPA Route	Riders per Month	Census Variable*								
		1	2	3	4	5	6	7	8	9
1	436	4100	2354	403	84	38	267	34	2647	411
2	716	4835	2482	693	135	319	427	64	3049	735
3	547	2303	1069	397	65	74	274	59	1356	435
4	478	4024	1787	799	76	162	455	39	2311	754
5	676	4316	2978	868	63	41	150	107	3883	1017
6	351	5237	2615	978	127	98	557	68	3351	853
7	409	2536	1496	472	45	27	191	25	1950	424
8	664	5309	3450	803	48	65	357	37	4037	782
9	439	6702	4305	1228	140	176	317	126	5503	1410
10	384	3731	1306	959	72	69	519	45	1920	868
11	505	4537	3627	383	95	61	161	96	4114	545
12	447	4548	3047	578	121	125	255	62	3594	654
13	447	3269	2231	547	69	31	143	51	2804	646
14	314	1553	1318	127	24	3	39	45	1460	189
16	236	2820	1819	291	84	84	211	32	2040	303
18	109	4914	3723	818	88	43	92	95	4677	1042
19	237	2913	1620	794	74	28	158	63	2414	821
20	261	3953	2931	524	69	31	160	47	3434	594
22	445	6043	2267	1117	125	241	876	48	2799	861
27	80	2083	875	460	46	36	261	21	1241	318
31	290	2543	1106	641	45	99	268	49	1626	665
38	329	2794	1943	278	64	91	172	74	2232	405
40	320	3192	2109	28	61	92	164	43	2499	434

* 1. Total Population
2. Population - Negro
3. Population- Under 16 years old
4. Population - Over 64 years old
5. Housing - Total owner occupied
6. Housing - Total renter occupied
7. Housing Values - Less than $15,000
8. Housing Values - $15,000-$34,999
9. Housing Values - Over $35,000

TABLE 8

1980 CENSUS TABULATION TOTALS BY ROUTE
WITHIN 2,500 FEET OF BUS STOPS

COTPA Route	Riders per Month	Census Variable*								
		1	2	3	4	5	6	7	8	9
1	436	11023	7274	1121	223	287	628	203	8300	1320
2	716	9482	5284	1295	256	504	766	112	6449	1312
3	547	5936	2485	1071	146	242	754	98	3221	922
4	478	6495	3315	1150	132	202	627	83	4125	1185
5	676	14050	10755	2024	266	141	358	346	13022	2642
6	351	7859	4442	1489	175	111	642	113	5705	1452
7	409	5447	3044	1013	98	130	434	55	4018	877
8	664	8981	6172	1278	101	112	478	80	7238	1292
9	439	17142	10458	2824	351	684	1029	278	12959	3058
10	384	6351	3173	1369	149	86	610	89	4253	1370
11	505	12288	7918	1705	230	316	811	196	9432	1853
12	447	12327	8158	1873	259	239	647	190	9932	2115
13	447	11145	8091	1534	230	217	411	228	9738	1936
14	314	4303	3385	493	76	44	127	98	3946	662
16	236	8650	5498	1112	187	163	630	113	6434	1068
18	109	12048	8182	2032	259	169	525	215	10284	2445
19	237	10898	7188	2030	219	179	460	189	9258	2169
20	261	10480	6794	1625	231	141	637	104	8161	1761
22	445	16133	8188	2348	348	586	1532	152	9766	2002
27	80	5010	1971	935	94	165	498	49	2639	759
31	290	6383	3668	1228	102	159	473	82	4703	1258
38	329	12055	7283	1857	248	302	1029	228	8777	1787
40	320	6712	4391	1040	136	153	339	99	5421	1096

* 1. Total Population
2. Population - Negro
3. Population- Under 16 years old
4. Population - Over 64 years old
5. Housing - Total owner occupied
6. Housing - Total renter occupied
7. Housing Values - Less than $15,000
8. Housing Values - $15,000-$34,999
9. Housing Values - Over $35,000

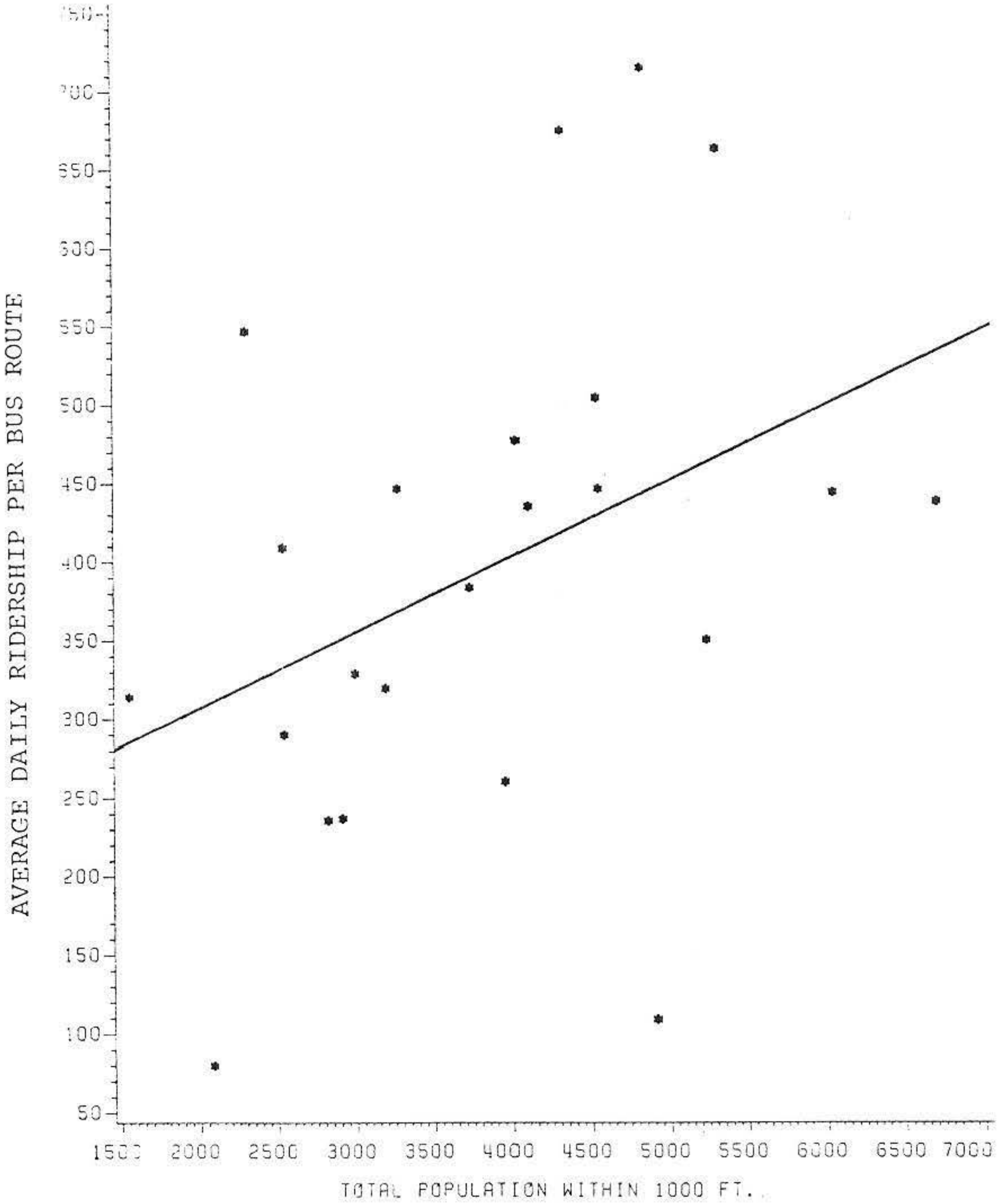


FIGURE 12

BUS ROUTE RIDERSHIP VS. TRANES TOTAL

POPULATION WITHIN 1,000 FEET

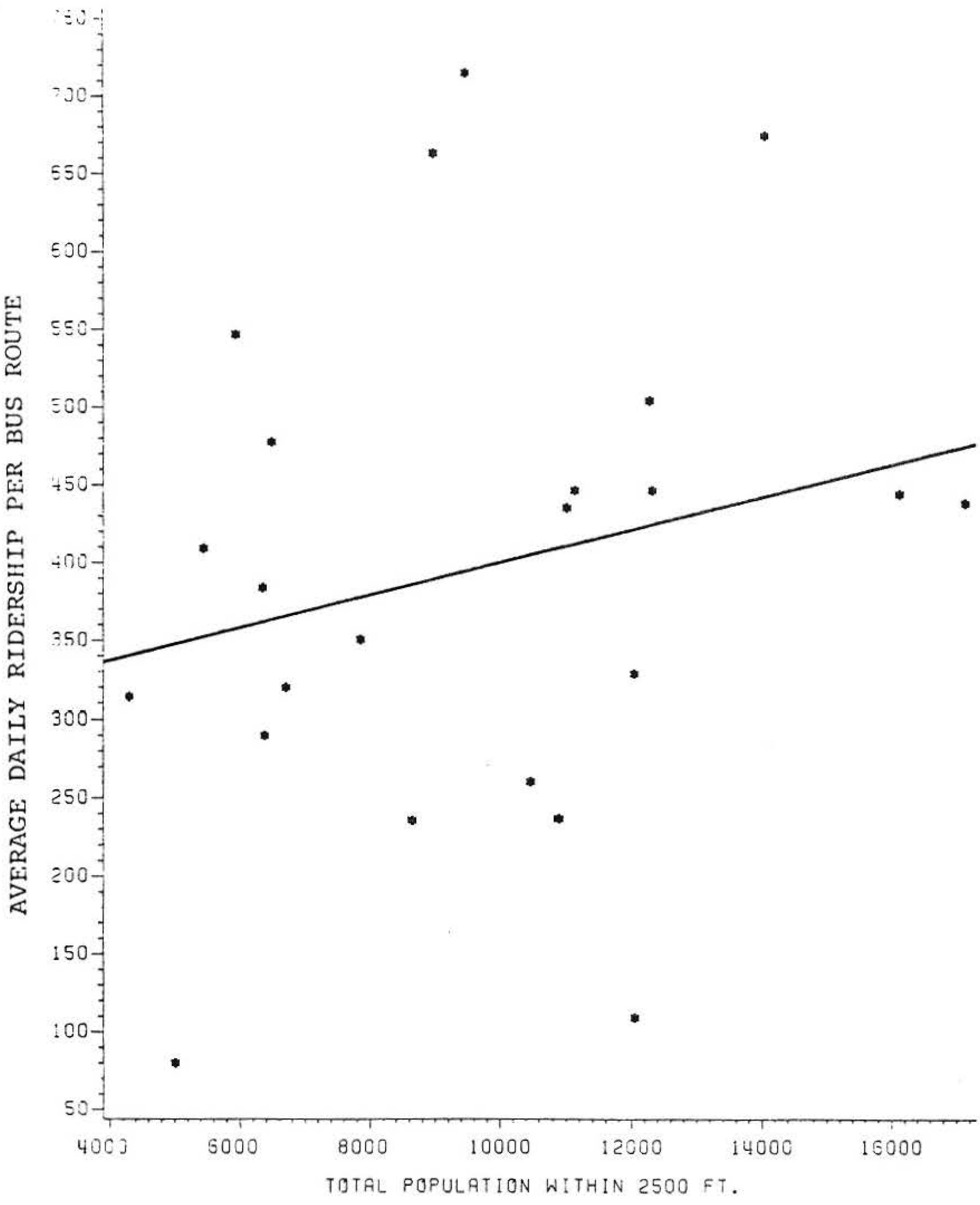


FIGURE 13

BUS ROUTE RIDERSHIP VS. TRANES TOTAL

POPULATION WITHIN 2,500 FEET

$$1{,}000 \text{ ft.:} \quad y = 30.20 - 0.04\,x, \quad R^2 = 0.346$$
$$2{,}500 \text{ ft.:} \quad y = 30.50 - 0.04\,x, \quad R^2 = 0.354$$

where: y = normalized average daily ridership by route,
x = normalized total population.

The negative signs on the total population variable indicate that these are not logical models. Forcing all nine of the Table 5 variables into the regression equation of 1,000 ft. improves the R^2 to 0.742. This is a respectable correlation but the resulting equation is large, cumbersome because the variables are normalized, and the coefficients tend to be negative. However, this equation is comparable in performance, in terms of R^2, to many of the bus route models found in the literature survey.

Total population is a significant contributor to this regression equation (95 percent degree of confidence), as is total population over 64 years of age, and total owner-occupied and rental housing. Total population and population over 64 years enter the equations first in step-wise linear regression.

The corresponding regression equations for 2,500 ft. distance from the bus stops yielded an R^2 of only 0.476 when all 9 variables were forced into the equation. Total population was the only significant contributor to this equation.

Factor analysis was conducted on the nine Table 5 variables for the 372 bus stop demand data set. This was relatively unsuccessful, too. The analysis yielded three factors, but all nine variables loaded heavily onto the first factor which explained 56.4 percent of the total variance in the data. This is indicative of a poorly defined variable set. Applying the three factors to a regression model where the dependent variable was bus stop demand yielded an R^2 of 0.177.

In summary, it was not possible to develop an entirely satisfactory bus route demand model for Oklahoma City with just the variables in Table 5, the STF1 census block data. The best indicator variable was total population, which suggests that simply using TRANES to count population along the routes can be useful for evaluating new or existing routes.

Analysis with U.S. Census Block Group Data (STF3)

Factor analysis was performed on the variables of Table 6 and the 372 bus stops for eight routes. Deleted from the analysis were bus stops with no boardings at all and bus stops with no population within 1,000 ft. (typically, downtown bus stops). Only inbound passenger loadings were considered. This was done because unsatisfactory factors were obtained when using all the data.

The factor analysis yielded five factors as indicated in Table 9. Different variables loaded onto each factor, suggesting a

TABLE 9

ROTATED ORTHOGONAL FACTOR LOADINGS

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Race:					
R1	0.11188	0.91356	0.05785	0.11918	0.17960
R2	0.00431	-0.93572	0.07611	-0.14735	-0.11267
R3	-0.29347	0.11513	-0.45758	0.13369	-0.29421
R4	0.10171	0.02364	0.03298	0.41803	0.09399
R5	-0.35228	0.17524	-0.23331	-0.18225	-0.03744
Age:					
A1	-0.40555	-0.07121	0.19667	-0.57998	0.36306
A2	-0.38278	0.05657	0.60626	-0.32786	-0.10765
A3	0.25594	0.46708	0.54983	0.06758	0.02086
A4	0.06592	0.26111	-0.00967	0.01863	0.88117
A5	-0.16690	0.08355	-0.05627	0.84256	0.00402
Female Age:					
FA1	-0.40174	-0.00194	0.11166	-0.59406	0.40165
FA2	-0.35842	0.01924	0.70638	-0.29231	0.03716
FA3	0.25950	0.47346	0.48831	-0.10915	0.10368
FA4	0.11927	0.24078	0.11349	0.00890	0.85746
FA5	-0.12423	0.04395	0.00027	0.86286	-0.02939
Occupation:					
01	0.66890	0.43200	0.28961	0.12087	0.19835
02	0.69123	0.22232	0.37459	0.18317	0.15088
03	0.24835	-0.11062	0.47492	-0.02266	0.34251
04	0.54160	0.48507	0.41300	0.21694	0.18489
05	0.32781	0.26390	0.66289	0.16210	0.07537
06	-0.12353	-0.26405	0.28345	0.19852	-0.23503
07	-0.32111	-0.40611	-0.11752	0.00887	0.61026
08	-0.41974	0.56094	0.12112	-0.27550	0.16517
09	-0.62370	0.12902	0.02015	0.12321	-0.01654
Household Income:					
I1	-0.46811	-0.21814	-0.43513	0.52969	-0.03155
I2	0.02212	0.45817	0.35297	0.39007	0.23884
I3	0.14773	0.28967	0.49440	0.36076	0.28681
I4	0.33878	0.37099	0.49072	-0.09580	0.25757
I5	0.56587	0.31081	0.35345	-0.08926	0.33465
I6	0.58589	0.29756	0.23612	0.05710	0.10867
I7	0.60885	0.27892	-0.02063	0.06565	0.05380

more satisfactory data set. Furthermore, the factors could be characterized in a plausible manner, based on a telephone survey of COTPA patrons conducted in 1982 and presented previously in Table 4. The characterizations, indicated below and in Table 10, tend to reflect COTPA patronage:

Factor 1:	High income professionals,
Factor 2:	Race,
Factor 3:	Youthful non-professionals,
Factor 4:	Elderly,
Factor 5:	Middle-aged.

These five factors explained 60.9 percent of the total variance in the data set. No one factor dominated. Interestingly, the first factor could be characterized as high income professional and managerial persons. In fact, a comparison of the statistics in Table 6 (1980 census profile for Oklahoma City) and Table 4 (ATE survey of frequent riders of COTPA) indicates that the bus service does attract nearly its share of professionals and managers.

The other factors seem to reflect the ridership composition noted by ATE: the "typical" patron tends to be female, white, under 35 or over 55 years of age, clerical, and works downtown. Factor 2 is strongly loaded by the total white population (R1), and negatively loaded by the black population (R2). The clerical occupation (05) loads onto Factor 3, and females load heavily onto Factors 3 (FA2--females aged 16 to 24), 4 (FA5--females aged 65 and over), and 5 (FA4--females aged 35 to 64).

The five factors identified in Table 10 were then used in a step-wise regression analysis where inbound passenger loadings per bus stop was the dependent variable. The travel time from each bus stop to the downtown transfer station was included as an additional independent variable. All of the factors and travel time were normalized in the manner indicated previously. The results of the step-wise regression analysis (using the SAS programs) are presented in Table 11.

All of the factors, except factor 2 ("race"), proved to be highly significant contributors to the regression equation. The final equation with all of the factors except factor 2 and travel time had an $R^2 = 0.55$. The order in which the independent variables entered the regression equation is as follows: factor 5 ("middle-aged"), factor 1 ("high income professionals"), factor 3 ("youthful non-professionals"), factor 4 ("elderly"), and travel time. Travel time was a marginally significant contributor to the final equation, as indicated in Table 11.

This was the best bus route demand model produced by the study. It was interesting that demand could be correlated to individual bus stops, although the correlation was mediocre. Actually, since past bus route demand models cited in the literature had R^2 ranging from as low as 0.355, this bus stop model

TABLE 10

INTERPRETATION OF ROTATED ORTHOGONAL FACTOR LOADINGS

FACTOR 1

High Income Professionals

Var.	Loading
02	0.69
01	0.67
09	-0.62
I7	0.61
I6	0.59
I5	0.57
04	0.54

% of variance explained: 14.7

FACTOR 2

Race

Var.	Loading
R2	-0.94
R1	0.91
03	0.56

% of variance explained: 13.3

FACTOR 3

Youthful Non-Professional

Var.	Loading
FA2	0.71
05	0.66
A2	0.61
A3	0.55
I3	0.49
I4	0.49

% of variance explained: 12.3

FACTOR 4

Elderly

Var.	Loading
FA5	0.86
A5	0.84
FA1	-0.59
A1	-0.58
I1	0.53

% of variance explained: 10.9

FACTOR 5

Middle-Aged

Var.	Loading
A4	0.88
FA4	0.86
07	0.61

% of variance explained: 9.7

Total amount of variance explained: 60.9

Only those variables with loadings greater than ± 0.5 are listed above for each factor.

TABLE 11

REGRESSION EQUATION FOR BUS STOP DEMAND USING

FACTORS AND TRAVEL TIME TO CBD

Independent Variable*	Coefficient	t-statistic	Significance Level
Intercept	0.0231		
F1	0.0268	7.04	0.0001
F3	-0.0327	-8.04	0.0001
F4	-0.0132	-4.46	0.0001
F5	-0.0237	-6.20	0.0001
T	0.0014	1.72	0.0880

* All of the dependent variables are normalized by subtracting from each the mean value of the variable, and dividing by the standard deviation of the variable.

F1, F3, F4, and F5 are the factors, normalized, of Table 10, while T is the normalized total travel time from each bus stop to the CBD.

The dependent variable is inbound passenger loadings per bus stop.

$R^2 = 0.55$

performance is encouraging. Models of entire routes or route segments should do better statistically than a model of bus stop demand.

It seems doubtful if better statistics could be obtained from the Oklahoma City patronage, but the study indicated that similar model approaches are worth investigating in other metropolitan areas, particularly areas with substantially greater transit demand. However, the need to manually collect some of the census statistics to some extent defeats the purpose of an automated program such as TRANES.

Conclusions

An entirely satisfactory or convenient bus route demand model based on TRANES census statistics was not obtained with the Oklahoma City data. Inherent to the application of TRANES is the assumption that demographic statistics can be related to patronage if the statistics include those patrons living very near to the bus stops and for whom the transit level of service is particularly good. However, the straight-forward application of TRANES to census data directly accessible by the program (STF1 tape) uncovered at best a weak positive correlation, largely with total population residing within 1,000 ft. of the bus stops to average daily route patronage.

Augmenting the census data with manually collected block group statistics from the STF3 tape significantly improved the correlation of census statistics with demand, although the statistical techniques are complex. However, two significant positive results were obtained. First, it was possible to correlate individual bus stop passenger loadings with census data. This implies that one useful application of TRANES is the development and modification of bus stop locations, including route extensions or deletions. Bus stop location is determined by a number of factors, but consideration of the demographic profile of the adjacent neighborhood appears to be a worthwhile exercise.

Second, the factor loadings had some correspondence with a previous direct survey of passengers. This reinforces the utility of demographic surveys of passengers and suggests that TRANES can be one aspect of a marketing program to promote transit. TRANES can be used to identify the locations of those patrons most likely to use transit, or confirm the validity of route plans intended to address specific markets. As an example based on the findings noted above, consider factor 1, high income professionals. Although these patrons typically are not attracted to bus transit, the fact that they appeared as a factor suggests that when the level of service is high enough, they will ride the bus. In this case, these patrons lived very close (1,000 ft. or less) to a bus stop where a bus would take them directly to the CBD. This could be addressed in design efforts to develop bus services attractive to these people. An option would be an express bus service which tours neighborhoods with these demographic characteristics and then proceeds directly to the CBD. This is hardly a new idea, but TRANES may be a useful design tool in this regard.

Other applications for TRANES are suggested in the following section, with case study applications. Based on the Oklahoma City experience, it was not possible to devise a simple model to forecast patronage, but that does not mean that total population counts along routes or compilations of other demographic statistics are not worthwhile. Furthermore, demand models derived from TRANES may prove more feasible in larger cities and/or cities with higher levels of per capita ridership. In this regard, the findings in this study which correlated bus stop patronage to census statistics are particularly encouraging.

CASE STUDY APPLICATIONS OF TRANES

In addition to the demand analysis studies reported in the previous section, TRANES was applied to several different types of practical studies in the Oklahoma City metropolitan area. Three case studies are reported below: the use of TRANES to document population and socio-economic characteristics along existing COTPA bus routes, the analysis of new bus routes in suburban Norman, and the use of TRANES to satisfy Title VI reporting requirements.

Demographic Reports by Bus Route

TRANES was used to develop demographic tables for each of the 23 conventional bus routes operated by the Central Oklahoma Transportation and Parking Authority (COTPA). The metropolitan area served by the fixed-route bus system had a population of about 650,000 people in 1980. Within this area there were about 8,000 census blocks, 24,000 street links and 835 transit stops.

The TRANES programs used in the project have a theoretical capacity of 32,000 links, but it turned out that the network of 24,000 links could not be handled by the programs. Outlying counties in the metropolitan area, which had little or no bus service anyway, were discarded from the network, which reduced the TRANES network to 14,000 links. This network worked fine in the computer compilations.

Of primary interest to COTPA were demographic reports for each of these lines. Nine population and housing variables, listed in Table 5, were extracted from the STF1 census tapes, and consisted of block-level statistics which could be directly extracted by the TRANES program. Bus stop and line summary reports were produced for each bus route at distances of 900 feet and 1,500 feet from each bus stop.

Potentially, this information can be used in the analysis of the market area covered by each route and applied to the design of new routes or modifications to existing routes. Such modifications could include changed bus stop locations, route extensions, and route deletions.

Two specific case studies of bus route design and analysis were carried out with the TRANES programs, the preliminary design of new bus routes in Norman, Oklahoma, and the development of Title VI reports for COTPA. These are reviewed in the following sections.

Norman Bus Route Analysis

Norman, Oklahoma, is a city of 74,000 people located within the metropolitan area of Oklahoma City. About 27 percent of the population consists of university students and 10 percent are 65 years of age or greater. Norman was separated from the Oklahoma

City metropolitan network noted above and separately coded.

The city of Norman has 193 square miles, but only the central 20 census tracts encompassing 12 square miles, were included in the network coding. These tracts are indicated in Figure D-1 of Appendix D. This appendix also provides the TRANES node equivalency tables for all 20 census tracts. There were some 2,800 street links in the network used to develop bus routes for Norman.

TRANES was used to investigate the feasibility of expanded bus service in Norman, the expansion consisting of an augmentation of the campus bus service of the University of Oklahoma in Norman. The campus service applied for UMTA funding for the first time in 1983, and one of the requirements of Federal funding is that the transit system services the general population, not just a portion such as university students and staff.

The demographic characteristics of eight potential routes were explored using TRANES. The same variables listed in Table 5 were used, with emphasis on total population, population under 16 years of age, population greater than 64 years of age, and renter-occupied housing. These statistics were compiled for distances of 1,000 and 1,800 feet from proposed bus stops. Student assistants familiar with coding TRANES for Oklahoma City found no trouble in developing the Norman network.

The advantages of TRANES were evident: it enabled the easy preparation and analysis of many bus route alternatives and provided useful summary statistics. Per capita ridership levels borrowed from Oklahoma City were used to estimate demand levels for each route. This information, in turn, was used to estimate revenues for the service based on alternative fare structures which included discounts for the young and elderly.

TRANES is not a complete substitute for manual inspection of census maps and land use maps, but it proved to be a significant time-saver in evaluating route options. A manual survey of campus routes done a year previous to this work took an estimated 80 person-hours to plot a 10 percent sample of all student addresses on street maps (40 hours) and identify major apartment locations (another 40 hours).

In a university environment it is important to identify apartment concentrations with large numbers of student residents. Developing new bus routes with TRANES amounted to a preliminary inspection of land use maps and other sources of student and elderly resident location information, and the sketching out of routes for processing by TRANES.

<u>Title VI Reporting Requirements</u>

Title VI of the U.S. Civil Rights Act of 1964 states:

"No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

In terms of transit service this is interpreted by UMTA to mean that the services available to minority groups are comparable to those of the general population. UMTA also requires that transit route load factors identify those routes with concentrations of minorities. Finally, UMTA requires an enumeration of accessibility via transit to employment, shopping, medical, social services, and educational opportunities in terms of travel times for minority and non-minority populations. This information is to be obtained from representative sample census tracts.

Title VI reports need to be submitted once and then updated annually if significant changes in transit routing or other aspects of transit service planning and provision have changes. In 1983 COTPA staff members compiled a thorough Title VI report. Although no records were kept of the staff efforts involved, the effort involved several staff persons devoting most of their time to the task over a period of several weeks. All of the tabulations were done manually using print-outs of census statistics and census tract maps.

The TRANES programs were run with the COTPA bus routes as a case study. Twenty-three local transit lines were coded for TRANES with a transit stop at every other census block. The program was run with the first twelve transit lines and then the remaining eleven transit lines to conserve on computer execution times.

Interesting enough, the minority populations served within the transit service area were higher than anticipated, and higher than the manual tabulations done a year previously. According to the 1980 census, approximately 370,000 persons live within the COTPA transit service area of which 167,460 persons or 44 percent live within 1,500 feet of a transit stop based on the TRANES reports. The results of TRANES showed that the Black population served was 26,478 persons or 37 percent of the Black population living within the transit service area, the American Indian population served was 3,435 persons or 24 percent of the American Indians living withing the transit service area, the Asian and Pacific Islanders served was 3,888 persons or a surprising 89 percent of the Asian and Pacific Islanders living within the transit service area, and finally, the Spanish Origin portion of the population served was 2,303 persons or 16 percent of the persons of Spanish Origin.

The TRANES output should be more precise than a manual determination since TRANES counts census block statistics within a specified distance of the bus stops while manual techniques assume that the tracts are homogeneous such that census statistics are directly proportional to the fraction of the tract area within a specific distance of the bus stop. Manual work also is prone to errors in tabulation given the magnitude and tedium of the task. Another advantage is that revised reports are easy to produce when route changes are made.

The disadvantage of using TRANES, apart from the effort involved in getting the information system data base developed, lies principally in the suppression of census data at the block level. Minority group statistics will be suppressed if fewer than 15 individuals reside within the record category--the block-- hence, thinly scattered minorities will be under-reported by TRANES. It is likely, for example, that TRANES under-reported the American Indian population (26 percent of the population in Oklahoma City), residing near bus lines.

OTHER POSSIBLE APPLICATIONS OF TRANES

The case study applications of TRANES presented in the preceding section should be sufficient to justify the addition of TRANES to the computer-based capabilities of most transit agencies, particularly those at least as large as COTPA, the transit operator in Oklahoma City. A number of other possible applications are reviewed below.

Successive Overlays

The analysis and interpretation of graphical depictions of urban area statistics was promoted for planning purposes by McHarg (50), among others. Corradino, et al. (12) advocated the successive overlays technique for small city transit planning, as do Miller and Millar (53). TRANES, in fact, has been used to generate graphical depictions of potential transit ridership in Colorado Springs, Colorado (11). The project consultant developed a computer program which converted TRANES-generated demographic information within 1/4 mile of bus stops to 1,000 ft. by 1,000 ft. subareas of the metropolitan area. The demographic information included total population, minority population, population over 65 years of age, low income households, households without cars, and handicapped population. The maps of these subareas depicted the extent to which the transit service was meeting the needs of potential users. The consultant concluded that "this represents the most detailed market segmentation evaluation presently available, given current computer software capabilities."

Route Modifications

As indicated previously, TRANES should be useful in planning bus route modifications, particularly those that entail the addition or deletion of bus stops. Larger transit agencies such as the Chicago Transit Authority may make 10 to 20 such route changes a year, and such modifications may involve several weeks of staff analysis and preparation (77). In this report TRANES was shown to be sensitive to individual bus stop demands, and the literature indicates that a number of route segment demand prediction models have been developed. In fact, TRANES is probably as useful a tool as the transit planner is likely to find for supporting bus stop change considerations.

Support for Other Bus Route Demand Models

A number of previous bus route demand modeling efforts would seem to be able to make profitable use of TRANES. For example, Hobeika and Chu's (28) supply/demand model for bus routes could make use of the bus stop demographic data generated by TRANES. TRANES-generated data could also be used in model formulations devised by Boyle (5); Golenberg and Pernaw (20); Hsu and Surti (32); Ross and Wilosn (63); Turnquist, et al., (79, 80); and Yuratovac (95).

CONCLUSIONS AND SUGGESTED RESEARCH

TRANES has been shown to be a useful addition to the computer-based analytical tools available to the transit planner. The collection of socio-economic information near bus stops is useful in planning new bus routes, making changes in existing routes, supplementing marketing surveys, and collecting bus route service impact statistics (e.g., satisfying Title VI reporting requirements). TRANES has significant potential in the development of bus route demand models since route demand can be correlated with demographic statistics of potential patrons living within 1,000 ft. of bus stops. In this report TRANES-generated demographic data was found to have some correlation with total bus route patronage and bus stop demands. The correlations, while not strong, were comparable in performance to other bus route demand models found in the literature.

Suggestions for future research include the application of TRANES to demand models developed by other researchers. The application of TRANES to demand model development, following the lines of approach developed in this report, would be useful for larger metropolitan areas with greater levels of per capita transit ridership. It would appear that Oklahoma City's patronage was exploited to its limit in this report.

Finally, the TRANES programs, themselves, would be enhanced with improved user interaction at the computer terminal. Graphical enhancements appear feasible since all of the input data is in machine-readable form. Among the capabilities that should be useful to a TRANES user with a computer terminal and CRT screen include the graphical display of street and transit networks with bus stop locations, and the ability to activate and deactivate transit stops and lines at the terminal.

APPENDIX A

TRANSIT NETWORK EVALUATION PROGRAM (TRANES)

The Transit Network Evaluation (TRANES) Program was developed on a Burroughs mainframe computer by the Comprehensive Planning Organization (CPO) in San Diego, California under an Urban Mass Transit Administration (UMTA) research grant in 1977-1978 (75). The research team was composed of Wesley R. Frysztacki and Lee Johnson of the CPO and Robert Parrot and Peter Loubal serving as consultants. The objective of the project was to develop a program, TRANES, which would allow the transit planner to retrieve census and survey data at the census block level of geography.

The transit network consists of census tract nodes taken from the GBF/DIME file and renumbered to form a unique TRANES network of nodes and interconnecting links. Each node in the network represents an existing or potential transit stop in the transit network. Census data files are linked to TRANES by using the GBF/DIME file record number as a random access key and associating it with the appropriate census block.

The various TRANES programs and their associated data files are diagrammed in Figure A-1 and briefly described below. The reader should consult reference 75 for more information and guidance on implementing the TRANES programs. A listing of the TRANES programs and subroutines is contained in Appendix B. They are written in FORTRAN IV, the predecessor to the current standard FORTRAN 77 language. The programs were compiled and run on an IBM 3081 mainframe computer at The University of Oklahoma using the FORTRAN IV G1 compiler, version 2.

INPUT REQUIREMENTS

Preprocessor Programs

The preprocessor programs are used to prepare the regional pointer files used in the EXTRACTOR program. The pointer files are necessary to renumber the GBF/DIME file node numbers into a sequential order for efficient searching by TRANES. Additionally, the preprocessor programs create a file necessary for allocating the census block socio-economic information to the GBF/DIME street segments. The preprocessor programs are run only after major changes have been made to the regional GBF/DIME file. Therefore, the user will only have to run these programs occasionally. There are four steps in preprocessing, including a system sort utility used to create regional pointer files. In Figure A-1, the process of file creation can be traced from the preprocessor programs through to the TRANES program.

<u>Preprocessor Step 1</u>. In the first step, two files are created, one a condensed version of the GBF/DIME file (150 characters per record), the other containing two records for each

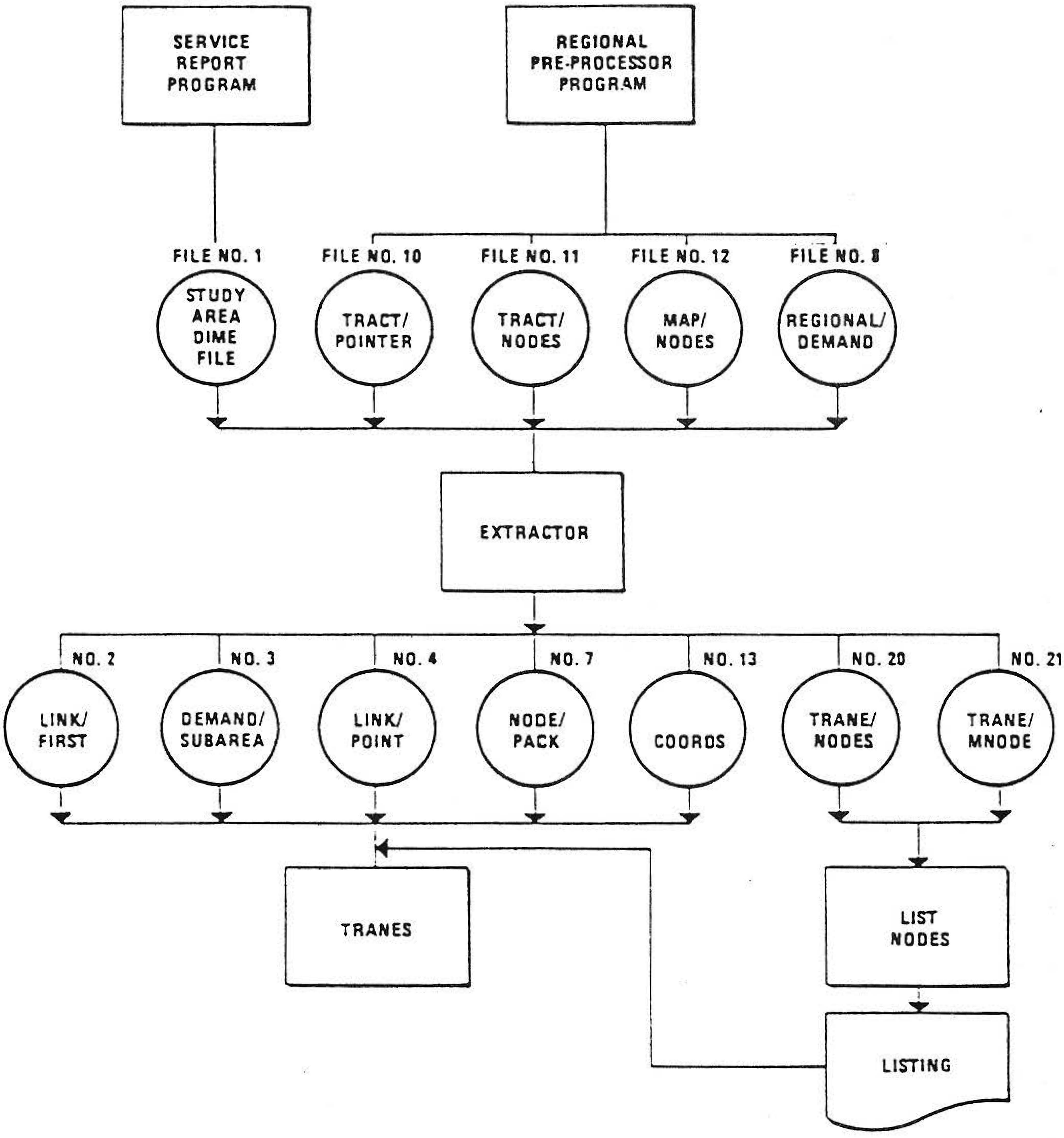


FIGURE A-1

TRANES PROGRAMS AND THEIR ASSOCIATED DATA FILES street segment ("nickel" file). The first file is called DIMECON and it is used by the EXTRACTOR program. The second file is used in Step 2 of the preprocessor program.

Preprocessor Step 2. In the second step, the nickel file is sorted in numerical order based on the GBF/DIME file record number and the census tract node number (numbers 1 to 699 and numbers greater than 5000) or metropolitan map series node numbers (numbers 700 to 4999, which are the nodes along the census tract boundaries). After sorting, the program assigns new and unique node numbers for each census tract or census map node (if the node is on a tract boundary). The resultant file contains the unique GBF/DIME file record numbers, census tract interior node numbers , and census tract boundary node numbers.

Preprocessor Step 3. The unique node file is used as input into a fourth program which creates a TRACT/NODES file, a MAP/-NODE File, and a TRACT/POINTER file which all are used as input to the EXTRACTOR program. The TRACT/NODES file contains the lowest and highest node numbers for each census tract listed in numerical order. The MAP/NODES file contains the map number and the lowest and highest census tract boundary numbers in sequential order by map number. The TRACT/POINTER file points to the first record for each census tract prefix in the TRACT/NODES file.

Preprocessor Step 4. The fourth step in the preprocessor program sequence is to create a binary census information or "demand" file. The binary demand file provides the census-derived information associated with each TRANES link segment. The TRANES program used in this research project is limited to creating nine different categories of census items. This could include total population, housing units, ethnic composition, age composition, household income, or other census information found on the STF1 (census block) data tape. The 1980 U.S. Census statistics available at the census block level are listed in Table 5 of this report. Other data files which contain street addresses, such as employment or labor statistics, could also be geoprocessed by using the U.S. Census Bureau ADMATCH program along with the GBF/DIME file to obtain block level data matches associated with the GBF/DIME file record number.

EXTRACTOR Program

The purpose of the EXTRACTOR program is to create files for the TRANES Program and to give the user the ability to extract portions of the metropolitan region GBF/DIME file for the desired analysis (e.g., a transit corridor). The inputs for the EXTRACTOR program come from the preprocessor programs as indicated in the previous section. These files are shown in Figure A-1. The outputs from the EXTRACTOR program are a demand file, a link/pointer file, a node/pointer file, a coordinate file, and TRANES node number files.

Extracted Demand File. The demand file is a subset of the regional demand file which corresponds to the specific geographic area or corridor under study. This file has the desired census information listed by GBF/DIME file record number and it retains the sequential order of the original GBF/DIME file. Census-derived or locally geocoded data can be used.

Extracted Link/Pointer File. The link/pointer file serves as both a unique link file for the specific subarea and a pointer to connected links. This is the main file used by TRANES to find transit paths.

Extracted Node/Pointer File. The node/pointer file is used as a pointer file for all the unique nodes created in preprocessing. The node/pointer file also works in conjunction with the link/pointer file in the TRANES pathfinder algorithm.

Extracted Tract/Node File and Map/Node File. The tract/node and map/node files provide an equivalency listing for the census tract, census map, census node, and the unique TRANES node numbers. With these equivalency tables, the transit planner can convert GBF/DIME file nodes to TRANES nodes representing active transit stops. The actual coding of the transit lines is discussed in detail in Appendix C.

TRANES INPUT FILES

The basic input files for TRANES consist of the link/pointer file, the node/pointer file, the subarea demand file, the command file, and the TRANES node number files. The first three files were created by the EXTRACTOR program while the command file must be created by the user with a text editor or word processor. The command file contains input parameter values, node classifications, and transit line information as input for TRANES. The technical details of coding the command file are given in the TRANES Technical Report (75).

A primary function of the EXTRACTOR program is to convert the GBF/DIME node numbers into unique sequential numbers for use by TRANES in pathfinding. The converted numbers are contained in two files, TRANE/NODES and TRANE/MNODES. The first file contains the original internal census tract numbers, and new TRANES numbers, x and y coordinates, and grid cell data for interactive applications. TRANE/MNODE contains the same information for those nodes located on the census tract boundaries.

TRANES PROGRAM

TRANES has two principal components, an ability to access census information at the block level within a specified distance along an existing or projected transit route, and an ability to summarize this information for all of the bus stops along a designated route. The user of TRANES specifies the transit lines and stops to be evaluated, selects the census information to be tabulated, specifies the access limits for the bus stops (e.g., walking distances), and formats the desired summary report.

Within TRANES a pathfinder algorithm determines all of the network links (census block faces) which can be accessed by a each designated bus stop within the pre-specified "impedance" or walking distance. The pathfinder algorithm determines the optimal path to the far end of the link. It is noted that the pathfinder algorithm connects links rather than nodes. Hence, the reported census statistics are those for the block faces which comprise the links along the optimal paths emanating in all directions from the bus stop.

The TRANES program output consists of two reports, the transit stop report and the transit line report. The transit stop report gives a detailed list of census or transit data items by transit stop for two accessibility limits (e.g., walking distance to bus stops). A grand total is printed at the end of the transit stop report for all stops on all lines. The transit line report gives a summary of census or transit data items by transit line. This is done by adding up all of the transit stop data for each stop along each line. Common stops will be counted twice for each line using that particular stop. Also, if lines run parallel along two adjacent streets, some census data will be counted twice if the selected accessibility limits are greater than the distances between the lines. When analyzing the output from TRANES, this needs to be taken into account.

APPENDIX B

TRANES COMPUTER PROGRAM LISTING

```
C PROGRAM NAME : NP1-1
C ***********************************************************
C *   PROGRAM TO EXTRACT MAP/NODE AND TRACT/NODE RECORDS     *
C *   FOR INPUT INTO THE SORT ROUTINE (NP1-2)                *
C *     WRITTEN BY KEN MORRIS                                *
C *                AUGUST 11, 1982                           *
C ***********************************************************
C ---VARIABLE NAMES---
C    NSF - NON-STREET FEATURE CODE
C     FM - FROM MAP NUMBER
C     TM - TO MAP NUMBER
C     RN - DIME FILE RECORD NUMBER
C    CTL - CENSUS TRACT LEFT
C    CTR - CENSUS TRACT RIGHT
C     FN - FROM NODE NUMBER
C     TN - TO NODE NUMBER
C     FX - FROM STATE PLANE (X COORDINATE)
C     FY - FROM STATE PLANE (Y COORDINATE)
C     TX - TO STATE PLANE (X COORDINATE)
C     TY - TO STATE PLANE (Y COORDINATE)
C
C ----INITIALIZE VARIABLES
C
      IMPLICIT INTEGER(A-Z)
      NR = 0
C
C ----READ IN MAPS,TRACTS,NODES, AND COORDINATES FROM DIME FILE
C
    5 READ(2,10,END=99)NSF,FM,TM,RN,CTL,CTR,FN,TN,FY,FX,TY,TX
   10 FORMAT(T29,I1,T46,I3,2X,I3,T85,I6,1X,2I6,T123,2I4,T231,4I7)
C
C ----CHECK FOR NONE STREET FEATURES AND ZERO COORDINATES---
C ------FOR NODES < 700 CREATE TRACT/NODE FILE---
C ------FOR NODES > 700 CREATE MAP/NODE FILE---
      IF(NSF.GT.1)GO TO 5
      IF(FX.EQ.0.AND.FY.EQ.0)GO TO 15
      IF(FN.LT.700)WRITE(3,20)CTL,FN,RN,FX,FY
      IF(FN.GT.700)WRITE(3,25)FM,FN,RN,FX,FY
   15 IF(TX.EQ.0.AND.TY.EQ.0)GO TO 5
      IF(TN.LT.700)WRITE(3,20)CTR,TN,RN,TX,TY
      IF(TN.GT.700)WRITE(3,25)TM,TN,RN,TX,TY
   20 FORMAT(3X,I6,I4,I5,2I7)
   25 FORMAT(I3,6X,I4,I5,2I7)
C
C ----INCREMENT RECORD COUNTER---
      NR = NR + 2
      GO TO 5
C
C ----WRITE NUMBER OF OUTPUT RECORDS IN NODE FILE---
   99 WRITE(4,101)NR
  101 FORMAT(/1X,'OUTPUT RECORDS : ',I6)
      STOP
      END
```

```
C PROGRAM NAME : NP1-3
C ***********************************************************
C *   PROGRAM TO SELECT UNIQUE NODES FOR MAPS AND TRACTS     *
C *   FOR INPUT INTO THE FILE CREATION PROGRAM.              *
C *     WRITTEN BY KEN MORRIS                                *
C *                AUGUST 11, 1982                           *
C ***********************************************************
C ---VARIABLE NAMES---
C        MAP OR MAP1 - DIME FILE MAP NUMBER
C    TRACT OR TRACT1 - DIME FILE CENSUS TRACT NUMBER
C      NODE OR NODE1 - DIME FILE NODE NUMBER
C     RECNUM OR REC1 - DIME FILE RECORD NUMBER
C    XCOOR OR XCOOR1 - DIME FILE STATE PLANE (X COORDINATE)
C    YCOOR OR YCOOR1 - DIME FILE STATE PLANE (Y COORDINATE)
C                 NR - RECORD COUNTER FOR UNIQUE NODES
C
C ---INITIALIZE VARIABLES---
      IMPLICIT INTEGER(A-Z)
      NR = 0
C
C ----READ RECORDS FROM NODE DATA FILE---
    5 READ(2,10,END=99)MAP,TRACT,NODE,RECNUM,XCOOR,YCOOR
   10 FORMAT(I3,I6,I4,I5,2I7)
   15 READ(2,10,END=99)MAP1,TRACT1,NODE1,REC1,XCOOR1,YCOOR1
C
C ---IF CENSUS TRACT IS BLANK, COMPARE CENSUS MAP AND NODES
C ---FOR NODES < 700 WRITE UNIQUE TRACT/NODE RECORDS---
C ---FOR NODES > 700 WRITE UNITQUE MAP/NODE RECORDS---
      IF(TRACT.EQ.0)GO TO 20
      IF(TRACT.EQ.TRACT1.AND.NODE.EQ.NODE1)GO TO 15
      GO TO 25
   20 IF(MAP.EQ.MAP1.AND.NODE.EQ.NODE1)GO TO 15
   25 IF(NODE.LT.700)WRITE(3,110)TRACT,NODE,RECNUM,XCOOR,YCOOR
      IF(NODE.GT.700)WRITE(3,120)MAP,NODE,RECNUM,XCOOR,YCOOR
C
C ----INCREMENT NODE RECORD COUNTER---
C ----REASSIGN COMPARISON REGISTER VARIABLES---
      NR = NR + 1
      MAP = MAP1
      TRACT = TRACT1
      NODE = NODE1
      RECNUM = REC1
      XCOOR = XCOOR1
      YCOOR = YCOOR1
      GO TO 15
C
C ----WRITE OUT NUMBER OF UNIQUE NODE RECORDS---
   99 WRITE(4,101)NR
  101 FORMAT(/1X,'OUTPUT RECORDS : ',I6)
  110 FORMAT(3X,I6,I4,I5,2I7)
  120 FORMAT(I3,6X,I4,I5,2I7)
      STOP
      END
```

```
C PROGRAM NAME : NP1-4
C ************************************************************
C *   PROGRAM TO CREATE MAP/NODE & TRACT/NODE FILES          *
C *      AND A TRACT/POINTER FILE                            *
C *   FOR INPUT INTO THE TRANES EXTRACTOR PROGRAM.           *
C *     WRITTEN BY KEN MORRIS                                *
C *                  AUGUST 11, 1982                         *
C ************************************************************
C
C ---VARIABLE NAMES---
C              LRN - LOW RECORD NUMBER
C              HRN - HIGH RECORD NUMBER
C              TRP - CENSUS TRACT POINTER RECORDS
C              NTP - NUMBER OF TRACT POINTER RECORDS
C              NTN - NUMBER OF TRACT/NODE RECORDS
C              NMN - NUMBER OF MAP/NODE RECORDS
C      MAP OR MAP1 - DIME FILE MAP NUMBERS
C TRACT OR TRACT1 - DIME FILE CENSUS TRACT NUMBER
C   NODE OR NODE1 - DIME FILE NODE NUMBERS
C  RECNUM OR REC1 - DIME FILE RECORD NUMBERS
C XCOOR OR XCOOR1 - DIME FILE STATE PLANE (X COORDINATES)
C YCOOR OR YCOOR1 - DIME FILE STATE PLANE (Y COORDINATES)
C TCOMP OR TCOMP1 - TRACT PREFIX COMPARISON VARIABLES
C
C ----INITIALIZE VARIABLES---
C
      IMPLICIT INTEGER(A-Z)
      LRN = 0
      HRN = 0
      TRP = 0
      NTP = 0
      NTN = 0
      NMN = 0
C
C ---READ IN FIRST TRACT/NODE OR MAP/NODE RECORD---
C
    5 READ(2,10,END=99)MAP,TRACT,NODE,RECNUM,XCOOR,YCOOR
   10 FORMAT(I3,I6,I4,I5,2I7)
C
C ---DEFINE TRACT PREFIX BY TCOMP
C
   15 TCOMP = TRACT / 100
      NR = 0
C
C ---INCREMENT RECORD COUNTER---
C
      NR = NR + 1
C
C ----CHECK TRACT, IF ZERO, EXECUTE MAP ROUTINE---
C
      IF(TRACT.EQ.0)GO TO 40
```

```
C
C ---READ IN SECOND NODE RECORD TO BE COMPARED--
C
   20 READ(2,10,END=99)MAP1,TRACT1,NODE1,REC1,XCOOR1,YCOOR1
C
C ----DEFINE SECOND TRACT PREFIX BY TCOMP1
C
      TCOMP1 = TRACT1 / 100
C
C ---COMPARE TRACT PREFIX'S, IF SAME, INCREMENT COUNTER, GO READ RECORD
C
      IF(TCOMP.EQ.TCOMP1)NR = NR + 1
      IF(TCOMP.EQ.TCOMP1)GO TO 20
C
C ----INCRMENT TRACT POINTER COUNTER---
C ----INCREMENT LOW RECORD COUNTER AND HIGH RECORD COUNTER
C
      TRP = TRP + 1
      LRN = HRN + 1
      HRN = HRN + NR
C
C ---WRITE TRACT/POINTER RECORD---
C ---WRITE TRACT/NODE RECORD---
C
      WRITE(3,25)TRP
   25 FORMAT(I6)
      WRITE(4,35)TRACT,LRN,HRN
   35 FORMAT(3I6)
C
C ---REASSIGN TRACT AND MAP VALUES FOR COMPARISON---
C ----INCREMENT TRACT/NODE COUNTER AND TRACT/POINTER COUNTER---
C
      TRACT = TRACT1
      MAP = MAP1
      NTP = NTP + 1
      NTN = NTN + 1
      GO TO 15
C ********************************
C ---MAP/NODE CREATION ROUTINE---
C ********************************
C ----INITIALIZE VARIABLES---
C
   40 LRN = 0
      HRN = 0
   45 NR = 0
C
C ---INCREMENT RECORD COUNTER---
C
      NR = NR + 1
C
C ---READ NODE RECORD FOR MAP/NODE COMPARISON---
C
   50 READ(2,10,END=99)MAP1,TRACT1,NODE1,REC1,XCOOR1,YCOOR1
```

```
C
C ----IF MAP AND MAP1 SAME, INCREMENT COUNTER, READ ANOTHER RECORD--
C
      IF(MAP.EQ.MAP1)NR = NR + 1
      IF(MAP.EQ.MAP1)GO TO 50
C
C ----INCREMENT LOW RECORD NUMBER AND HIGH RECORD NUMBER---
C
      LRN = HRN + 1
      HRN = HRN + NR
C
C ----WRITE MAP/NODE RECORD----
C
      WRITE(8,35)MAP,LRN,HRN
C
C ----REASSIGN MAP VALUE FOR COMPARISON---
C
      MAP = MAP1
C
C ---INCREMENT MAP/NODE RECORD COUNTER---
C
      NMN = NMN + 1
      GO TO 45
C
C ---WRITE NUMBER OF POINTER , TRACT/NODE , MAP/NODE RECORDS---
C
   99 WRITE(9,101)NTP,NTN,NMN
  101 FORMAT(/1X,'POINTER RECORDS : ',I6/1X,'TRACT/NODE RECORDS : ',
     *I6/1X,'MAP/NODE RECORDS : ',I6)
      STOP
      END
```

```
C PROGRAM NAME : DIMECON
C ************************************************************
C *   PROGRAM TO CREATE DIMECON FILE FROM GBF/DIME FILE.     *
C *   FOR INPUT INTO THE EXTRACTOR PROGRAM                   *
C *     WRITTEN BY KEN MORRIS                                *
C *                AUGUST 18, 1982                           *
C ************************************************************
C
C ---VARIABLE NAMES---
C  ST(I) - ARRAY CONTAINING DIME FILE STREET INFORMATION
C    NSF - NON-STREET FEATURE CODE
C     FM - FROM MAP NUMBER
C     TM - TO MAP NUMBER
C    CLF - CODING LIMIT FLAG
C    LLA - LEFT LOW ADDRESS
C    LHA - LEFT HIGH ADDRESS
C    RLA - RIGHT LOW ADDRESS
C    RHA - RIGHT HIGH ADDRESS
C     RN - DIME FILE RECORD NUMBER
C     CD - CHECK DIGIT
C    CTL - CENSUS TRACT LEFT
C    CTR - CENSUS TRACT RIGHT
C     ZL - ZIP CODE LEFT
C     ZR - ZIP CODE RIGHT
C     FN - FROM NODE NUMBER
C     TN - TO NODE NUMBER
C    PCL - PLACE CODE LEFT
C    PCR - PLACE CODE RIGHT
C    CDL - COUNTY CIVIL DIVISION LEFT
C    CDR - COUNTY CIVIL DIVISION RIGHT
C     BL - CENSUS BLOCK LEFT
C     BR - CENSUS BLOCK RIGHT
C     FX - FROM STATE PLANE (X COORDINATE)
C     FY - FROM STATE PLANE (Y COORDINATE)
C     TX - TO STATE PLANE (X COORDINATE)
C     TY - TO STATE PLANE (Y COORDINATE)
C    NRI - NUMBER OF INPUT RECORDS
C    NRO - NUMBER OF OUTPUT RECORDS
C
C ----INITIALIZE VARIABLES
C
      IMPLICIT INTEGER(A-Z)
      DIMENSION ST(10)
```

```
      NRI = 0
      NRO = 0
C
C ----READ IN MAPS,TRACTS,NODES, AND COORDINATES FROM DIME FILE
C
    5 READ(2,10,END=99) (ST(I) ,I=1,7) ,NSF,FM,TM,CLF,LLA,LHA,RLA,RHA,RN,
     *CD,CTL,CTR,ZL,ZR,FN,TN,PCL,PCR,CDL,BL,CDR,BR,FY,FX,TY,TX
   10 FORMAT(6A4,A2,2X,I1,T46,2(I3,2X),I1,4I6,4X,I6,I1,2I6,2I5,T123,
     *4I4,T144,I3,T152,I3,T163,I3,T171,I3,T231,4I7)
C
C ----INCREMENT INPUT RECORD COUNTER
C
      NRI = NRI + 1
C
C ----CHECK FOR NONE STREET FEATURES AND ZERO COORDINATES---
C
      IF(NSF.GT.1)GO TO 5
      IF(CTL.GE.2000.AND.CTR.GE.2000) GO TO 5
      IF(FX.NE.0.AND.FY.NE.0) GO TO 15
      IF(TX.EQ.0.AND.TY.EQ.0) GO TO 5
C
C ----WRITE DIME FILE INFORMATION TO DIMECON FILE---
C
   15 WRITE(3,20) FM,CTL,FN,TM,CTR,TN,NSF,(ST(I),I=1,7),LLA,LHA,BL,ZL,
     *PCL,CDL,RLA,RHA,BR,ZR,PCR,CDR,CLF,RN,CD,FY,FX,TY,TX
   20 FORMAT(2(I3,I6,I4),I1,6A4,A2,2(2I6,I3,2X,I5,I4,I3),I1,I6,I1,3X,
     *4I7)
C
C ----INCREMENT OUTPUT RECORD COUNTER
C
      NRO = NRO + 1
C
C ----WRITE TO RECORD NUMBER/TRACT/BLOCK FILE---
C ------USED TO MATCH DIME RECORDS NUMBER WITH DEMAND FILE---
C
      IF(CTL.GT.1000.AND.BL.GT.0) WRITE(4,40)RN,CTL,BL
      IF(CTL.EQ.CTR.AND.BL.EQ.BR) GO TO 5
      IF(CTR.GT.1000.AND.BR.GT.0) WRITE(4,40)RN,CTR,BR
   40 FORMAT(2I6,I3)
      GO TO 5
C
C ----WRITE OUT INPUT AND OUTPUT RECORD COUNTS---
C
   99 WRITE(8,101)NRI,NRO
  101 FORMAT(/1X,'GBF RECORDS : ',I6/1X,'DIMECON RECORDS : ',I6)
      STOP
      END
```

```
C PROGRAM NAME : EXTRACTOR
C ***************************************************************
      COMMON LDD(70000,3)
      DIMENSION IBMAP(2),ITRC(2),NODES(2),IY(2),IX(2)
      DIMENSION ITPTR(212),ITRACT(370),LOW(370),IHIGH(370)
      DIMENSION MAPP(50),MLOW(50),MHIGH(50)
      INTEGER*2 NEWMAP(20000),LDD,LP(70000),LD(70000),
     * NEWPT2(70000),NEWPTR(70000)
      DIMENSION LINKER(2)
      DIMENSION IDMD9(9),IDMD9T(9)
      DIMENSION IEMP9(9),IEMP9T(9)
      EQUIVALENCE(LP(1),LDD(1,1))
     *  ,(LD(1),LDD(1,2))   ,(NEWPTR(1),LDD(1,1)),
     *  (NEWPT2(1),LDD(1,3))
      DATA NUM,NEXT,IB,NONST,INODEM,IDMD9T/14*0/,LINKS/0/
      DATA NEWMAP/20000*0/
      DEFINE FILE 3(20000,45,E,JD)
      DEFINE FILE 8(75000,45,E,JD)
C     DEFINE FILE 22(75000,45,E,JD)
C ***** INPUT FILES ***********
C  8- CENSUS LINKS
C 10- TRACT/POINTER
C 11- TRACT/NODES
C 12- MAP/NODES
C 16- DIMECON
C 22- EMPL LINKS (OPTIONAL)
C ***** OUTPUT FILES **********
C  2- LINKTEST (USED AS INPUT TO PREP)
C  3- SUB DEMAND
C  4- LINKPT
C  9- NODPAC
C 13- COORDS
C 20- TRANES/NODES
C 21- TRANES/MNODE
C 23- SUB EMPL (OPTIONAL)
C***********************************************************************C
C                           S T E P  # 1                                C
C                  READ CONTROL CARDS AND TABLES                        C
C                       IOPT =0 FOR FULL RUN                            C
C                       IOPT =1 FOR MAIN PROGRAM ONLY                   C
C                       IOPT =2 FOR SUBROUTINE PREP ONLY                C
C***********************************************************************C
      READ(1,3000)IOPT
```

```
      IF(IOPT.NE.2)GO TO 1
C                        READ THE NUMBER OF LINKS AND NODES(NEXT) FOR PREP C
      READ(1,5000)LINKS,NEXT
      GO TO 910
    1 NEXT=1
      DO 4 I=1,500
    4 READ(10,1100,END=5) ITPTR(I)
    5 DO 6 I=1,370
    6 READ(11,5000,END=7) ITRACT(I),LOW(I),IHIGH(I)
    7 DO 8 I=1,38
    8 READ(12,5000,END=9) MAPP(I),MLOW(I),MHIGH(I)
C*********************************************************************C
C                                 S T E P  # 2                        C
CC                       READ LINKS AND RENUMBER NODES                C
C*********************************************************************C
    9 DO 200 JJ=1,100000
      READ(16,1000,END=900) (IBMAP(K),ITRC(K),NODES(K),K=1,2),ITYPE,JD,
     & (IY(LM),IX(LM),LM=1,2)
      NUM=NUM+1
C                         STEP 2.1    SKIP NON STREET LINKS,
C                                     SKIP TRACTS AND NODE = 0
C                                     CREATE COORDINATE FILE FOR PLOTTING
      IF(ITYPE.GT.0.AND.ITYPE.LT.8) GO TO 175
      IF(ITRC(1).EQ.0.OR.ITRC(2).EQ.0) GO TO 150
      IF(NODES(1).EQ.0.OR.NODES(2).EQ.0) GO TO 150
      IF(IX(1).GT.0.AND.IX(2).GT.0.AND.IY(1).GT.0.AND.IY(2).GT.0) GOTO 3
      IB=IB+1
      WRITE(6,6003) NUM
    3 WRITE(13,7001) JD,(IX(LM),IY(LM),LM=1,2)
C                         STEP 2.2  RENUMBER ALL NODES
   33 DO 100 I=1,2
      IROW=0
      ICOL=0
      IF(NODES(I).GE.700.AND.NODES(I).LT.5000)GO TO 75
C                         STEP 2.2.1 RENUMBER TRACT NODES
      KPTR = 1
C     SEARCH ITRACT TABLE FOR THIS CENSUS TRACT
   10 IF(KPTR.EQ.0.OR.KPTR.GT.370) GO TO 200
      IF(ITRACT(KPTR).EQ.ITRC(I)) GO TO 20
      KPTR=KPTR+1
      GO TO 10
   20 ND=NODES(I)
C        REDUCE NODES ABOVE 4999
      IF(NODES(I).GE.5000) ND=700+(NODES(I)-4999)
C      NODPTR IS THE NODE NUMBER PLUS THE LOWEST NUMBER
C         IN THAT TRACT IN SEQUENTIAL ORDER FOR ALL TRACTS.
C         THEN SUBTRACT 1.
      NODPTR=ND+LOW(KPTR)-1
      IF(NODPTR.GT.IHIGH(KPTR)) GO TO 195
C         IF NEW NUMBER ABOVE 70000 MUST GO TO NEW ARRAY FOR SPACE
      IF(NODPTR.GT.70000) GO TO 25
C         ELEMENT OF NEWPTR ARRAY IS ASSUGNED NEXT AVAILABLE
C         NUMBER IF NOT ALREADY ASSIGNED
      IF(NEWPTR(NODPTR).NE.0) GO TO 30
      NEWPTR(NODPTR)=NEXT
```

```
C         CONVERT X AND Y TO GRIDS FOR LATER INTERACTIVE TRANES
      IF(IX(I).EQ.0.OR.IY(I).EQ.0)GO TO 21
      IROW=(IY(I)-50000)/2000+1
      ICOL=(IX(I)-1500000)/2000+1
   21 WRITE(20,8000)ITRC(I),NODES(I),NEXT,IX(I),IY(I),IROW,ICOL
C          INCREMENT NEXT AND ASSIGN NEW NUMBER TO LINKER
      NEXT=NEXT+1
   30 LINKER(I)=NEWPTR(NODPTR)
      GO TO 100
C         THE FOLLOWING STEP ARE SIMILAR TO THOSE ABOVE
C          EXCEPT THE ARRAY NEWPT2 IS USED FOR SPACE
   25 NODPTR=NODPTR-70000
      IF(NEWPT2(NODPTR).NE.0) GO TO 35
      NEWPT2(NODPTR)=NEXT
      IF(IX(I).EQ.0.OR.IY(I).EQ.0)GO TO 31
      IROW=(IY(I)-50000)/2000+1
      ICOL=(IX(I)-1500000)/2000+1
   31 WRITE(20,8000)ITRC(I),NODES(I),NEXT,IX(I),IY(I),IROW,ICOL
      NEXT=NEXT+1
   35 LINKER(I)=NEWPT2(NODPTR)
      GO TO 100
C                    STEP 2.2.2 RENUMBERMAP NODES
C               CONVERT ALPHA MAPS TO NUMBERS
   75 IMAP=0
   80 IMAP = IMAP + 1
      IF(IBMAP(I).EQ.0) GO TO 200
      IF(MAPP(IMAP).EQ.0) GO TO 200
      IF(IBMAP(I).GT.MAPP(IMAP)) GO TO 80
      IF(IBMAP(I).LT.MAPP(IMAP)) GO TO 200
C         THIS PROCESS IS THE SAME AS ABOVE EXCEPT FOR MAPS
      NODPTR=(NODES(I)-700)+MLOW(IMAP)-1
      IF(NODPTR.GT.MHIGH(IMAP)) GO TO 195
      IF(NEWMAP(NODPTR).NE.0) GO TO 40
      NEWMAP(NODPTR)=NEXT
      IF(IX(I).EQ.0.OR.IY(I).EQ.0)GO TO 41
      IROW=(IY(I)-50000)/2000+1
      ICOL=(IX(I)-1500000)/2000+1
   41 WRITE(21,8000)IBMAP(I),NODES(I),NEXT,IX(I),IY(I),IROW,ICOL
      NEXT=NEXT+1
   40 LINKER(I)=NEWMAP(NODPTR)
  100 CONTINUE
C                   CALCULATE LINK DISTANCE,PACK DATA                   C
C                   WRITE LINK FILE(2) AND DEMAND FILE(3)               C
      IDIST=0
      IF(IX(1).EQ.0.OR.IX(2).EQ.0.OR.IY(1).EQ.0.OR.IY(2).EQ.0)GO TO 140
      IXDIST=IX(2)-IX(1)
      IYDIST=IY(2)-IY(1)
      IDIST=((IXDIST*IXDIST)+(IYDIST*IYDIST))**.5+.5
  140 IF(IDIST.LE.0.OR.IDIST.GT.5280)GO TO 45
      GO TO 48
   45 WRITE(6,6006)JD,IDIST
      IDIST=300
   48 WRITE(2,2400)IDIST,LINKER(1),LINKER(2)
      LINKS=LINKS+1
      IF(JD.GT.95000) GO TO 142
```

```
      READ(8'JD,8100) IDMD9
C     READ(22'JD,8100) IEMP9
      GO TO 144
  142 INODEM=INODEM+1
      WRITE(6,6005) NUM,JD
      DO 143 I=1,9
  143 IDMD9(I)=0
  144 DO 145 KK=1,9
C     IEMP9T(KK)=IEMP9T(KK)+IEMP9(KK)
      IDMD9T(KK)=IDMD9T(KK)+IDMD9(KK)
  145 CONTINUE
C     WRITE(3,8200)JD,IDMD9
C     WRITE(23,8100) IEMP9
      GO TO 200
  150 WRITE(6,4000)NUM,ITRC(I),NODES(I)
      GO TO 200
  175 NONST=NONST+1
      GO TO 200
  195 WRITE(6,2300)NUM,NODPTR,IBMAP(I),ITRC(I),NODES(I)
  200 CONTINUE
  900  NEXT1=NEXT-1
C*****************************************************************************C
C                          S T E P  # 3                                       C
C                     WRITE INFO AND GO TO PREP IF IOPT NE 1
C*****************************************************************************C
      WRITE(6,2100)LINKS,NEXT1
      WRITE(6,2001)NUM
      WRITE(6,2002)IB,INODEM,NONST
      WRITE (6,6001) (IDMD9T(I),I=1,9)
C     WRITE(6,6002)(IEMP9T(I),I=1,9)
 6001 FORMAT(1X,'CENSUS'/1X,9(I7,5X))
 6002 FORMAT(1X,'EMPLOYMENT'/1X,9(I7,5X))
      IF(IOPT.EQ.1)GO TO 980
  910 CALL PREP(LINKS,NEXT-1)
  980 CONTINUE
C*****************************************************************************C
C                                  F O R M A T S                              C
C*****************************************************************************C
 1000 FORMAT(2(I3,I6,I4),I1,85X,I6,4X,4I7)
 1100 FORMAT(I6)
 2001 FORMAT(1X,'NUM= ',I5)
 2002 FORMAT(1X,'NO COORD REC= ',I5,2X,'NO DEMAND RECS=',I5,
     * 1X,'NON STREETS=',I5)
 2100 FORMAT(1X,'NUMBER OF LINKS=',I7/1X,'HIGHEST NODE NUMBER=',I7)
 2300 FORMAT(1X,'HIGH POINTER----REC # =',I6,1X,'HPOINTER=',I6,
     *  1X,'MAP=',I4,1X,' CT=',I6,' NODE=',I5)
 2400 FORMAT(3I5)
 3000 FORMAT(I1)
 4000 FORMAT(1X,'NO POINTER FOR REC#=',I6,' CT=',I6,' NODE=',I5)
 5000 FORMAT(3I6)
 6003 FORMAT(1X,'NO COORDS REC#= ' ,I6)
 6005 FORMAT(1X,'NO DEMAND REC# ',I6,' LINK#=',1X,I6)
 6006 FORMAT(1X,'RECORD ',I6,' DISTANCE IN FEET=', I8)
 7001 FORMAT(I6,4I7)
 8000 FORMAT(I6,I4,I5,2I7,2I3)
```

```
 8100 FORMAT(9I5)
 8200 FORMAT(10I5)
      STOP
      END
      SUBROUTINE PREP(LINKS,NUMNOD)
      COMMON LDD(70000,3)
      INTEGER*2 NP(60000),LDD,LP(70000),LD(70000)
      EQUIVALENCE (LP(1),LDD(1,1)),(LD(1),LDD(1,2))
      DATA NP/60000*0/
      REWIND 2
C*********************************************************************C
C                            S T E P  # 1                             C
C                  READ LINKS AND UNPACK THEM
C                  INITIALIZE NP WITH NEGATIVES                       C
C*********************************************************************C
      DO 1 JJ=1,LINKS
      J=JJ*2
      I=J-1
      READ(2,2500)LD(JJ),LP(I),LP(J)
    1 CONTINUE
      DO 5 MM=1,NUMNOD
    5 NP(MM)=-MM
      LN=2*LINKS
C*********************************************************************C
C                            S T E P  # 2                             C
C                  THIS LOOP DOES THE ACTUAL POINTER CREATIONS        C
C*********************************************************************C
      DO 10 I=1,LN
      II=LP(I)
      LP(I)=NP(II)
      NP(II)=I
   10 CONTINUE
C
C     CLOSE THE POINTER LOOP
C
      DO 12 I=1,LN
      IF(LP(I).GT.0) GO TO 12
      II=-LP(I)
      LP(I)=NP(II)
   12 CONTINUE
C*********************************************************************C
C                            S T E P  # 3                             C
C                  DIVIDE DISTANCE BY 10,MAKE B NODE NEGATIVE         C
C                  FOR TRANES ,WRITE LINK INFO TO FILE 4 AND NODE     C
C                  POINTER INFO TO 9. THEN RETURN.
C*********************************************************************C
      DO 11 JJ=1,LINKS
      J=JJ*2
      I=J-1
      IC=LD(JJ)/10
      LDK=-LP(J)
      WRITE(4,2400)IC,LP(I),LDK
   11 CONTINUE
   14 CONTINUE
      DO 20 I=1,NUMNOD
```

```
   20 WRITE(9,7000)NP(I)
 2400 FORMAT(3I6)
 2500 FORMAT(3I5)
 7000 FORMAT(I6)
      RETURN
      END
```

```
C PROGRAM NAME : LIST
      DIMENSION NODE(1000),NEW(1000)
      DATA NODE/1000*0/,NEW/1000*0/,IEND/0/
C ****************************************************************
C *                                                              *
C * THIS PROGRAM READS IN THE SORTED TRANES NODES FILES          *
C * FILE 1=TRACT NODES, FILE 2=MAP NODES FROM TRANES             *
C * AND PRODUCES A LISTING BY CT AND MAP SHEET OF                *
C * THE RENUMBERED NODES.                                        *
C *                                                              *
C ****************************************************************
      IFILE=1
    1 NUM=0
      READ(IFILE,1000,END=100) ITRC,MODE,MEW
      GO TO 20
    5 READ(IFILE,1000,END=100) JTRC,MODE,MEW
      IF(JTRC.EQ.ITRC) GO TO 20
    7 K=NUM/8+1
      L=1
      WRITE(6,1500)
      WRITE(6,4000)
      IF(IFILE.EQ. 1) WRITE(6,3000) ITRC
      IF(IFILE.EQ.2) WRITE(6,3200) ITRC
      WRITE(6,4000)
      WRITE(6,3500)
      WRITE(6,4200)
      DO 10 I=1,K
      L7=L+7
      WRITE(6,2000) (NODE(J),NEW(J),J=L,L7)
      IOUT=IOUT+1
      L=L+8
   10 CONTINUE
      DO 15 I=1,NUM
      NODE(I)=0
      NEW (I)=0
   15 CONTINUE
      WRITE(6,4000)
      IF(IEND.EQ.1) GO TO 200
      NUM=0
      ITRC=JTRC
   20 NUM=NUM+1
      NODE(NUM)=MODE
      NEW (NUM)=MEW
      GO TO 5
  100 IEND=1
      GO TO 7
  200 IF(IFILE.EQ.2) GO TO 900
      IFILE =2
      IEND=0
      GO TO 1
  900 STOP
 1000 FORMAT(I6,I4,I5)
 1500 FORMAT('1'/10X,'T R A N E S   E Q U I V A L E N C Y   T A B L E'/)
 2000 FORMAT(8(1X,I4,2X,I5,3X))
 3000 FORMAT(1H0,20X,'C E N S U S   T R A C T  ',I6)
 3200 FORMAT(1H0,20X,'C E N S U S    M A P  ',I6)
 3500 FORMAT(//8(1X,'DIME',2X,'TRANES',2X)/8(1X,'NODE',3X,'NODE',3X))
 4000 FORMAT(1X,120('*'))
 4200 FORMAT(1X,120('-'))
      END
```

```
C PROGRAM NAME : TRANES
C ***************************************************************
      COMMON LINKS,MNODE,NODES,MAXD,LIMF,LIMS
      COMMON /B1/NET(3,30000),NP(23000),ISQ(3000)/B2/NK(23000),
     *  LSN(1000)
      DIMENSION LIPC(150),LIST(1000),LP(16),LX(9),ICC(3),
     *LLN(500),LLY(6,500),LSY(6,500),NR(6),JA(4),LIN(20)
      INTEGER*2 NET,NP,ISQ,NK,LSN,J,LCD,LCH,IA(4),IB(4),IC(4),
     * IARRAY(50)
      DATA LIPO/150*0/,LIST/1000*0/,LR/16*0/,LX/9*0/,ICC/3*0/,
     *  LLN/500*0/,LLY/3000*0/,LSY/3000*0/,NR/6*0/,IARRAY/50*0/,
     *  JA/4*0/,LIN/20*0/,IA,IB,IC/12*0/,KNT,KNL,KLS/3*0/
      DEFINE FILE 3(45000,45,E,1)
C ***************************************************************
C FILE 1=LINKPT
C FILE 2=NODPAC
C FILE 3=DEMAND
C FILE 4=PATHS
C FILE 5=CARD INPUT
      JI=0
C
C    DEFLAULT THE CENSUS INFORMATION TO 1-TOTAL POPULATION
C                                       2-POPULATION UNDER 16
C                                       3-POPULATION OVER  64
      ICC(1)=1
      ICC(2)=3
      ICC(3)=4
C     I N P U T
C
      READ(5,215)LINKS,MNODE,NODES,MAXD,LIMF,LIMS
      WRITE(6,122)LINKS,MNODE,NODES,MAXD,LIMF,LIMS
      IF(MAXD.GT 0) GO TO 2
      MAXD=3000
    2 DO 10 I=1,NODES
   10 READ (5,115)N,NK(N)
      KHT=0
C
C    T R A N S I T  L I N E  I N P U T
C    READ DATA, FIRST NEG. DATA IS TRANSIT LINE FOLLOWED BY NODES
C
      K=0
      WRITE(6,126)
   11 READ(5,115) (LR(I),I=1,16)
      IF(LR(1).EQ.0) GO TO 17
      WRITE(6,555) (LR(I),I=1,16)
      II=1
      IF(LR(1).LT.0) GO TO 16
   12 DO 13 I=II,16
      IF(LR(I).EQ.0) GO TO 14
   13 CONTINUE
   14 KK=I-II
C     TRANSIT LINE CODING EXPANSION
      KY=0
      DO 56 I=1,KK
      KY=KY+1
      J=I+II-1
      IF(LR(J).GT.0)GO TO 15
      KI=-LR(J)
```

```
      KA=LR(J-1)
      KB=LR(J+1)
      LA=LIPO(KI)
      DO 20 JK=1,JI
      IF (LIN(JK).EQ.KI)GO TO 24
   20 CONTINUE
      WRITE (6,125)
      GO TO 99
   24 LB=LIPO(LIN(JK+1))-1
      DO 51 L=LA,LB
      IF(LIST(L).EQ.KA)GO TO 54
      IF(LIST(L).EQ KB)GO TO 53
   51 CONTINUE
      WRITE(6,125)
      GO TO 99
   53 KB=KA
   54 LLCK=L+1
      DO 55 M=LLCK,LB
      LIST(K+KY)=LIST(M)
      IF (LIST(M).EQ.KB) I=I+1
      IF (LIST(M).EQ.KB) GO TO 56
      KY=KY+1
   55 CONTINUE
   15 LIST(K+KY)=LR(J)
   56 CONTINUE
      K=K+KY
      GO TO 11
C
C     DETERMINE POINTERS, THEN RETURN TO PLACE NODE SEQUENCE IN LIST
C
   16 LL=-LR(1)
      LIPO(LL)=K+1
      II=2
      JI=JI+1
      LIN(JI)=LL
      GO TO 12
C
C     FILL IN EMPTY POINTER SPACES
C
   17 IF(LL EQ.0) GO TO 19
      LL=LL+1
      KK=K
      LIPO(LL)=K+1
      LLCK=LL-1
      DO 18 I=1,LLCK
      J=LL-I
      IF(LIPO(J) .GT.0) GO TO 18
      LIPO(J)=LIPO(J+1)
   18 CONTINUE
      WRITE(6,127)LIPO(LL)
      LIPOLL=LIPO(LL)
      WRITE (6,555) (LIST(I),I=1,LIPOLL)
C
C     C O M M A N D  L I N E  I N P U T
C     SCANS LINES TO INTERPRET NUMERIC COMMAND, ALSO OBTAINS NEXT VALUE
C     (MF) OR VALUE RANGE (MF,MS)
C     IN FUTURE, THIS ROUTINE TO BE EXPANDED TO PERMIT USE OF MNEMONIC
C     ALPHA CODE AND MENU ON SCREEN FOR INTERACTIVE PROCESS
```

```
C
C     READ COMMAND DATA
C
   19 MF=0
      MS=0
   21 CALL INPUT (ICODE,IARRAY)
      IF (ICODE.EQ.-1)  GO TO 99
      IF (ICODE.EQ. 2)  IKS=0
      IF (ICODE.EQ. 9)  IKL=0
      IF (ICODE.LT.12)  GO TO 23
      ICODCK=ICODE-11
      GO TO (40,50,60,60,80,90),ICODCK
      GO TO 99
C
C     CHECK WHETHER COMMAND EXPECTS VALUES
C
   23 IF (IARRAY(1) .EQ. 0) GO TO 98
      JJ=0
   25 JJ=JJ+1
      IF (IARRAY(JJ) .EQ. 0)GO TO 21
      MF=IARRAY(JJ)
      IF (IARRAY(JJ+1) .GE. 0) GO TO 28
      MS=-IARRAY(JJ+1)
      JJ=JJ+1
   28 ICODCK=ICODE-1
      GO TO (45,48,30,32,34,36,38,155),ICODCK
C
C     REINITIALIZE VALUES
C
   29 MF=0
      MS=0
      GO TO 25
C
C     A C T I V A T E   L I N E S
C     ACTIVATE LINE(S) IDENTIFIED BY VALUE OR VALUE RANGE
C
   30 IF(MS.EQ.0)MS=MF
      DO 31 I=MF,MS
C
C     ACTIVATE LINE UNLESS ALREADY ACTIVATED
C
      IF(LIPO(I).LT.0) GO TO 31
      K=LIPO(I)
      KE=LIPO(I+1)-1
      IF(KE.LT.0)KE=-KE-2
      LIPO(I)=-LIPO(I)
      IF(KE.LT.K) GO TO 31
      DO 43 IJ=K,KE
C
C     AND ALSO ACTIVATE STOPS ON LINE
C
      NS=LIST(IJ)
      IF(NK(NS).GT.1000) GO TO 43
      NK(NS)=NK(NS)+1000
   43 CONTINUE
   31 CONTINUE
      GO TO 29
C
```

```
C      A C T I V A T E   N O D E S   B Y   N A M E
C
   32 IF(MS.EQ.0)  MS=MF
      DO 33 I=MF,MS
      IF(NK(I).GT.1000)  GO TO 33
      NK(I)=NK(I)+1000
   33 CONTINUE
      GO TO 29
C
C      A C T I V A T E   N O D E S   B Y   C L A S S
C
   34 IF(MS.EQ.0)  MS=MF
      DO 35 I=1,MNODE
      IF(NK(I).LT.MF.OR.NK(I).GT.MS)GO TO 35
      NK(I)=NK(I)+1000
   35 CONTINUE
      GO TO 29
C
C      D E S A C T I V A T E   N O D E S   B Y   C L A S S
C
   36 IF(MS.EQ.0)MS=MF
      DO 37 I=1,MNODE
      IF(NK(I).LT.1000)  GO TO 37
      NK(I)=NK(I)-1000
      IF(NK(I).GE.MF.AND.NK(I).LE.MS)  GO TO 37
      NK(I)=NK(I)+1000
   37 CONTINUE
      GO TO 29
C
C      D E S A C T I V A T E   L I N E S
C
   38 IF(MS.EQ.0)  MS=MF
      DO 39 I=MF,MS
      IF(LIPO(I).GT.0)  GO TO 39
      KE=LIPO(I+1)-1
      IF(KE.LT.0)  KE=-KE-2
      LIPO(I)=-LIPO(I)
      K=LIPO(I)
      IF(KE.LT.K)  GO TO 29
      DO 39 IJ=K,KE
      NS=LIST(IJ)
      IF(NK(NS).LT.1000)  GO TO 39
      NK(NS)=NK(NS)-1000
   39 CONTINUE
      GO TO 29
C
C      D E S A C T I V A T E   A L L   S T O P S   A N D   L I N E S
C
   40 DO 41 I=1,MNODE
      IF(NK(I).GE.1000) NK(I)=NK(I)-1000
   41 CONTINUE
      DO 42 I=1,LL
      IF(LIPO(I).LT.0)  LIPO(I)=-LIPO(I)
   42 CONTINUE
      GO TO 21
C
C      D I S A C T I V A T E   N O D E S   B Y   N A M E
   48 IF(MS.EQ.0)MS=MF
```

```
      DO 49 I=MF,MS
      IF(NK(I).LT.1000)GO TO 49
      NK(I)=NK(I)-1000
   49 CONTINUE
      GO TO 29
C     S E T   N E W   N O D E   C L A S S
   45 IF(IKS.NE.0) GO TO 46
      IKS=MF
      GO TO 29
   46 IF(MS.EQ.0) MS=MF
      DO 47 I=MF,MS
      ISS=0
      IF(NK(I).GT.1000) ISS=1000
      NK(I)=IKS+ISS
   47 CONTINUE
      GO TO 29
   50 CONTINUE
C     ************
      CALL LINKER(KHT,KNT,KNL,KLS)
C     ************
      KX=0
      GO TO 21
  155 IF  (MS.EQ.0)  MS=MF
      DO 58 I=MS,MF
      IKL=IKL+1
   58 ICC(IKL)=I
      IF  (IKL .EQ.  3)GO TO 19
      GO TO 29
C
C    O U T P U T   A L L O C A T I O N   T O   S T O P S
C    CLEAR ACCUMULATORS, IF NECCESSARY
C
   60 DO 61 J=1,KNT
      DO 61 I=1,6
      LSY(I,J)=0
   61 CONTINUE
      DO 65 I=1,LINKS
      IF(NET(3,I))65,62,62
   62 READ(3'I,3000) LX
      J=NET(1,I)
      LCD=NET(2,I)
      LCH=NET(3,I)
      IF(LCD.GT.LIMF)  GO TO 63
      IU=0
      GO TO 64
   63 IF(LCD.GT.LIMS)  GO TO 65
      IU=3
C
C    ADD TO APPROPRIATE ACCUMULATOR, BASED ON FIRST OR SECOND LIMIT
C
   64 DO 66 K=1,3
      LSY(K+IU,J)=LSY(K+IU,J)+LX(ICC(K))  / 4
   66 CONTINUE
   65 CONTINUE
C    OUTPUT ALLOCATION RESULTS
C
      WRITE(6,114)
      WRITE (6,139)
```

```
      WRITE (6,118) (LIMF,LIMS,(ICC(I),I=1,3),(ICC(I),I=1,3))
      DO 69 J=1,6
   69 NR(J)=0
      DO 68 I=1,KNT
      WRITE(6,110) I,LSN(I),(LSY(J,I),J=1,6)
C     SUM TOTALS
      DO 68 J=1,6
      NR(J)=NR(J)+LSY(J,I)
   68 CONTINUE
      WRITE(6,120) (NR(J),J=1,6)
      MP=0
      IF (ICODE .EQ. 14) GO TO 21
C
C    O U T P U T   A L L O C A T I O N   T O   L I N E S
C    IDENTIFY ACTIVE LINES AND CLEAR ACCUMULATORS
      J=0
      DO 71 I=1,100
      IF(LIPO(I).GE.0)GO TO 71
      J=J+1
      LLN(J)=I
   71 CONTINUE
C
C    REMEMBER NO. OF ACTIVE LINES
C
      KNL=J
      DO 70 I=1,KNT
      IU=LSN(I)
      NP(IU)=I
   70 CONTINUE
      DO 75 J=1,KNL
      DO 72 I=1,6
      LLY(I,J)=0
   72 CONTINUE
      LI=LLN(J)
      K=LIPO(LI)
      KE=LIPO(LI+1)-1
      IF(K.LT.0) K=-K
      IF(KE.LT.0)KE=-KE-2
C
C    IDENTIFY STOPS ON LINE BY SEQUENCE NO  OF STOP
C
      IF(KE LT K) GO TO 75
      DO 74 M=K,KE
      MM=LIST(M)
      IU=NP(MM)
C
C    CHECK IF STOP IS ACTIVE
C
      IF(NK(MM).LT.1000) GO TO 74
      DO 73 I=1,6
C
C    ACCUMULATE ALLOCATIONS TO ALL STOPS ON LINE
C
   73 LLY(I,J)=LLY(I,J)+LSY(I,IU)
   74 CONTINUE
   75 CONTINUE
C
C     OUTPUT ALLOCATION RESULTS
```

```
      WRITE(6,113)
      WRITE  (6,139)
      WRITE  (6,119)  (LIMF,LIMS,(ICC(I),I=1,3),(ICC(I),I=1,3))
      DO 78 I=1,KNL
      WRITE(6,110) I,LLN(I),(LLY(J,I),J=1,6)
   78 CONTINUE
      MF=0
      GO TO 21
C
C     O U T P U T   P A T H F I N D E R
C
   80 WRITE(6,111)
      IF(KNT.EQ.0) GO TO 83
      WRITE(6,112)
      KK=1
      DO 81 I=1,LINKS
      IF(NET(3,I).LT.0) GO TO 81
      IB(KK)=NET(1,I)
      IA(KK)=NET(2,I)
      IC(KK)=NET(3,I)
      KJ=IB(KK)
      IF(KJ.LE.KNT) GO TO 180
      IB(KK)=999999
      GO TO 181
  180 IB(KK)=LSN(KJ)
C
C
  181 JA(KK)=I
      KK=KK+1
      IF(KK.LE.4)GO TO 81
      WRITE(6,109) (JA(KI),IA(KI),IB(KI),IC(KI),KI=1,4)
      WRITE(4,109)  (JA(KI),IA(KI),IB(KI),IC(KI),KI=1,4)
      KK=1
   81 CONTINUE
      WRITE(4,109) (JA(KI),IA(KI),IB(KI),IC(KI),KI=1,KK)
      WRITE(6,109) (JA(KI),IA(KI),IB(KI),IC(KI),KI=1,KK)
  109 FORMAT(4(3I6,I2))
   83 MF=0
      GO TO 21
C     R E A D   N E W   P A R A M E T E R S
   90 READ(5,220) MDIST,LIMF,LIMS
      WRITE(6,124) MDIST,LIMF,LIMS
      GO TO 21
  110 FORMAT(10I8)
  111 FORMAT  (//1X,' P A T H F I N D E R   R E P O R T ')
  112 FORMAT('   LINK   DIST   STOP N   LINK   DIST   STOP N   LINK   DIST   STOP
     * N   LINK   DIST   STOP N')
  113 FORMAT  (1H1,' T R A N S I T   L I N E   R E P O R T ')
  114 FORMAT  (1H1,' T R A N S I T   S T O P   R E P O R T ')
  115 FORMAT(16I5)
  116 FORMAT(2I5,I4)
  117 FORMAT(16X,I5,2I4)
  118 FORMAT  (22X,'FIRST LIMIT=',I4,'0 FT     SECOND LIMIT=',I4,
     *'0 FT'/21X,'CENSUS  CENSUS  CENSUS  CENSUS  CENSUS  CENSUS'
     */5X,'SEQ.',4X,'STOP',6(6X,I2))
  119 FORMAT  (1X,21X,'FIRST LIMIT=',I4,'0 FT     SECOND LIMIT=',I4,
     1'0 FT'/1X,20X,'CENSUS  CENSUS  CENSUS  CENSUS  CENSUS  CENSUS'
     2/5X,'SEQ.',4X,'LINE',6(6X,I2))
```

```
 120  FORMAT(' GRAND TOTAL IS ',6I8)
 121  FORMAT(' RUN COMMANDS ARE',16I6)
 122  FORMAT(' RUN PARAMETERS ARE',6I8)
 124  FORMAT(' NEW PARAMETERS ARE',3I8)
 125  FORMAT(' ERROR IN REFERENCING COMMON TRANSIT LINE ')
 126  FORMAT(' TRANSIT LINES')
 127  FORMAT(' THE NUMBER OF NODES IN LIST IS',I5)
 138  FORMAT(' VALUE EXPECTED AFTER COMMAND')
 139  FORMAT(1X,'****************************************'/)
 215  FORMAT(6I5)
 220  FORMAT(3I5)
 555  FORMAT(1X,16(I6))
3000  FORMAT(9I5)
  98  WRITE(6,138)
  99  STOP
      END
```

```
      SUBROUTINE INPUT(ICODE,IDIGIT)
      INTEGER*2 IDATA(80),IERROR(80),IDIGIT(50),II,JJ
      INTEGER*2 A,C,D,L,N,O,P,R,S
      INTEGER*2 ZERO,ONE,TWO,THREE,FOUR,FIVE,SIX,SEVEN,EIGHT,NINE
      INTEGER*2 BLK,MNS,IDIG
      DATA INDX/90/,NMAX/50/,IEOF/0/,IDATA/80*'  '/
      DATA A,B,C,D,E,F,G/'A','B','C','D','E','F','G'/
      DATA H,I,J,K,L,M,N/'H','I','J','K','L','M','N'/
      DATA O,P,Q,R,S,T,U/'O','P','Q','R','S','T','U'/
      DATA V,W,X,Y,Z,BLK,MNS/'V','W','X','Y','Z',' ','-'/
      DATA ZERO,ONE,TWO,THREE,FOUR/'0','1','2','3','4'/
      DATA FIVE,SIX,SEVEN,EIGHT,NINE/'5','6','7','8','9'/
      II=0
      JJ=0
      DO 5 I=1,50
    5 IDIGIT(I)=0
      IF(IEOF.GT.0)GO TO 8000
   10 IF(INDX.LE.80)GO TO 100
      CALL DATAIN(IDATA,IEOF)
      INDX=1
      IF(IEOF.GT.0)GO TO 8000
C
C          LOOK FOR FIRST NON-BLANK CHARACTER
C
  100 IF(IDATA(INDX).NE.BLK)GO TO 110
      INDX=INDX+1
      GO TO 10
C
C          IF FIRST CHARACTER NOT ALPHA IT'S AN ERROR.
C
  110 IF(IDATA(INDX).EQ.A)GO TO 200
      IF(IDATA(INDX).EQ.C)GO TO 200
      IF(IDATA(INDX).EQ.D)GO TO 200
      IF(IDATA(INDX).EQ.O)GO TO 200
      IF(IDATA(INDX).EQ.R)GO TO 200
C
C          IT'S AN ERROR.  SCAN FOR NEXT OP CODE THEN PRINT EVERYTHING
C          PREVIOUS AS BAD DATA.
C
  120 IPTR=0
      ISAVE=INDX
      INDX=INDX+2
  140 IF(IDATA(INDX).EQ.A)GO TO 160
      IF(IDATA(INDX).EQ.C)GO TO 160
      IF(IDATA(INDX).EQ.D)GO TO 160
      IF(IDATA(INDX).EQ.O)GO TO 160
      IF(IDATA(INDX).EQ.R)GO TO 160
      INDX=INDX+1
      IF(INDX.LE.80)GO TO 140
      INDX2=INDX-1
      DO 150 I=ISAVE,INDX2
      IPTR=IPTR+1
      IERROR(IPTR)=IDATA(I)
  150 CONTINUE
      CALL DATAIN(IDATA,IEOF)
      INDX=1
      ISAVE=1
      IF(IEOF.LE.0)GO TO 140
```

```
  160 IF(ISAVE.EQ.INDX)GO TO 170
      INDX2=INDX-1
      DO 165 I=ISAVE,INDX2
      IPTR=IPTR+1
      IERROR(IPTR)=IDATA(I)
  165 CONTINUE
  170 IF(IPTR.LE.0)GO TO 180
      WRITE(6,20000) (IERROR(I),I=1,IPTR)
      IF(IEOF.GT.0)GO TO 8000
  180 IPTR=0
  200 II=IDATA(INDX)
      IF(INDX.LT.80)GO TO 205
      IPTR=0
      NFLD=0
      IERROR(1)=0
      CALL DATAIN(IDATA,IEOF)
      IF(IEOF.GT.0)GO TO 1400
      INDX=0
  205 CONTINUE
      JJ=IDATA(INDX+1)
      IF(II.EQ.A)GO TO 300
      IF(II.EQ.C)GO TO 400
      IF(II.EQ.D)GO TO 500
      IF(II.EQ.O)GO TO 600
      IF(II.EQ.R)GO TO 700
C
C          IT'S AN ERROR.
C
  210 GO TO 120
C
C          THE FIRST CHARACTER IS AN A.  NEXT MUST BE C, L, N OR S.
C
  300 IF(JJ.EQ.C)GO TO 310
      IF(JJ.EQ.L)GO TO 320
      IF(JJ.EQ.N)GO TO 330
      IF(JJ.EQ.S)GO TO 340
      GO TO 210
C
C          THE SECOND CHARACTER IS A C.
C
  310 ICODE=6
      GO TO 1000
C
C          THE SECOND CHARACTER IS AN L.
C
  320 ICODE=4
      GO TO 1000
C
C          THE SECOND CHARACTER IS AN N.
C
  330 ICODE=5
      GO TO 1000
C
C          THE SECOND CHARACTER IS AN S.  ** NOT YET IMPLEMENTED **.
C
  340 GO TO 210
C
C          THE FIRST CHARACTER IS A C.  NEXT MUST BE A, C,D OR P
```

```
C
  400 IF(JJ.EQ.A)GO TO 410
      IF(JJ.EQ.C)GO TO 420
      IF(JJ.EQ.D)GO TO 425
      IF(JJ.EQ.P)GO TO 430
      GO TO 210
C
C          THE SECOND CHARACTER IS AN A    ** NOT YET IMPLEMENTED **.
C
  410 GO TO 210
C
C          THE SECOND CHARACTER IS A C.
C
  420 ICODE=2
      GO TO 1000
C
C         THE SECOND CHARACTER IS A D
C
  425 ICODE=9
      GO TO 1000
C
C          THE SECOND CHARACTER IS A P.
C
  430 ICODE=17
      GO TO 800
C
C          THE FIRST CHARACTER IS A D.  NEXT MUST BE A, C, L, N OR S.
C
  500 IF(JJ.EQ.A)GO TO 510
      IF(JJ.EQ.C)GO TO 520
      IF(JJ.EQ.L)GO TO 530
      IF(JJ.EQ.N)GO TO 540
      IF(JJ.EQ.S)GO TO 550
      GO TO 210
C
C          THE SECOND CHARACTER IS AN A.
C
  510 ICODE=12
      GO TO 800
C
C          THE SECOND CHARACTER IS A C.
C
  520 ICODE=7
      GO TO 1000
C
C          THE SECOND CHARACTER IS AN L.
C
  530 ICODE=8
      GO TO 1000
C
C          THE SECOND CHARACTER IS AN N.
C
  540 ICODE=3
      GO TO 1000
C
C          THE SECOND CHARACTER IS AN S.  ** NOT YET IMPLEMENTED **.
C
  550 GO TO 210
```

```
C
C         THE FIRST CHARACTER IS AN O.  NEXT MUST BE A, L, P OR S.
C
  600 IF(JJ.EQ.A)GO TO 610
      IF(JJ.EQ.L)GO TO 620
      IF(JJ.EQ.P)GO TO 630
      IF(JJ.EQ.S)GO TO 640
      GO TO 210
C
C         THE SECOND CHARACTER IS AN A.  ** NOT YET IMPLEMENTED **.
C
  610 GO TO 210
C
C         THE SECOND CHARACTER IS AN L.
C
  620 ICODE=15
      GO TO 800
C
C         THE SECOND CHARACTER IS A P.
C
  630 ICODE=16
      GO TO 800
C
C         THE SECOND CHARACTER IS AN S.
C
  640 ICODE=14
      GO TO 800
C
C         THE FIRST CHARACTER IS AN R.  NEXT MUST BE P OR S
C
  700 IF(JJ.EQ.P)GO TO 710
      IF(JJ.EQ.S)GO TO 720
      GO TO 210
C
C         THE SECOND CHARACTER IS A P.
C
  710 ICODE=13
      GO TO 800
C
C         THE SECOND CHARACTER IS AN S.  RUN STOP - GO TO EOF ROUTINE.
C
  720 IEOF=1
      GO TO 8000
C
C         INCREMENT POINTER BEYOND CURRENT COMMAND
C
  800 INDX=INDX+2
      GO TO 9000
C
C         NOW LOOK FOR FOLLOWING NUMBERS.
C
 1000 INDX=INDX+2
      ISAVE=INDX
      GO TO 1050
 1020 INDX=INDX+1
 1050 IF(INDX.LE.80)GO TO 1200
 1100 CALL DATAIN(IDATA,IEOF)
      INDX=-1
```

```
      IF(IEOF.GT.0)GO TO 1400
      GO TO 1000
C
C         LOOK FOR A DIGIT
C
 1200 IF(IDATA(INDX).EQ.BLK)GO TO 1020
      IF(IDATA(INDX).EQ.ZERO)  GO TO 1205
      IF(IDATA(INDX).EQ.ONE)   GO TO 1205
      IF(IDATA(INDX).EQ.TWO)   GO TO 1205
      IF(IDATA(INDX).EQ.THREE) GO TO 1205
      IF(IDATA(INDX).EQ.FOUR)  GO TO 1205
      IF(IDATA(INDX).EQ.FIVE)  GO TO 1205
      IF(IDATA(INDX).EQ.SIX)   GO TO 1205
      IF(IDATA(INDX).EQ.SEVEN) GO TO 1205
      IF(IDATA(INDX).EQ.EIGHT) GO TO 1205
      IF(IDATA(INDX).EQ.NINE)  GO TO 1205
      GO TO 1400
 1205 CONTINUE
C
C         DIGIT FOUND - CONTINUE SEARCHING
C
      NFLD=0
      NDIG=0
      MINUS=0
      IDIGIT(1)=0
 1210 NDIG=NDIG+1
      IF(NDIG.GT.1)GO TO 1215
      NFLD=NFLD+1
      IDIGIT(NFLD+1)=0
 1215 CONTINUE
      IF(IDATA(INDX).EQ.ZERO)  IDIG=0
      IF(IDATA(INDX).EQ.ONE)   IDIG=1
      IF(IDATA(INDX).EQ.TWO)   IDIG=2
      IF(IDATA(INDX).EQ.THREE) IDIG=3
      IF(IDATA(INDX).EQ.FOUR)  IDIG=4
      IF(IDATA(INDX).EQ.FIVE)  IDIG=5
      IF(IDATA(INDX).EQ.SIX)   IDIG=6
      IF(IDATA(INDX).EQ.SEVEN) IDIG=7
      IF(IDATA(INDX).EQ.EIGHT) IDIG=8
      IF(IDATA(INDX).EQ.NINE)  IDIG=9
      IDIGIT(NFLD)=(IDIGIT(NFLD)*10)+IDIG
 1220 INDX=INDX+1
      IF(INDX.LE.80)GO TO 1230
      CALL DATAIN(IDATA,IEOF)
      INDX=1
      IF(IEOF.GT.0)GO TO 1290
 1230 IF(IDATA(INDX).EQ.ZERO)  GO TO 1210
      IF(IDATA(INDX).EQ.ONE)   GO TO 1210
      IF(IDATA(INDX).EQ.TWO)   GO TO 1210
      IF(IDATA(INDX).EQ.THREE) GO TO 1210
      IF(IDATA(INDX).EQ.FOUR)  GO TO 1210
      IF(IDATA(INDX).EQ.FIVE)  GO TO 1210
      IF(IDATA(INDX).EQ.SIX)   GO TO 1210
      IF(IDATA(INDX).EQ.SEVEN) GO TO 1210
      IF(IDATA(INDX).EQ.EIGHT) GO TO 1210
      IF(IDATA(INDX).EQ.NINE)  GO TO 1210
      NDIG=0
      IF(MINUS.EQ.0)GO TO 1240
```

```
      IF(MINUS.GT.NFLD)GO TO 1240
      IDIGIT(NFLD)=-IDIGIT(NFLD)
      MINUS=0
 1240 IF(IDATA(INDX).EQ.BLK)GO TO 1220
      IF(IDATA(INDX).NE.MNS)GO TO 1290
      MINUS=NFLD+1
      GO TO 1220
 1290 IF(MINUS.EQ.NFLD)IDIGIT(NFLD)=-IDIGIT(NFLD)
 1300 IF(NFLD.GT.0)GO TO 9000
      GO TO 8000
 1400 IPTR=2
      IF(NFLD.LE.0)GO TO 1450
      IF(INDX.EQ.ISAVE)GO TO 1450
      INDX2=INDX-1
      DO 1410 I=ISAVE,INDX2
      IPTR=IPTR+1
      IERROR(IPTR)=IDATA(I)
 1410 CONTINUE
 1450 WRITE(6,20000) (IERROR(I),I=1,IPTR)
      IPTR=0
      IF(IEOF.GT.0)GO TO 8000
      GO TO 10
 8000 ICODE=-1
 9000 RETURN
20000 FORMAT(1X,'ERROR ',66A1)
      END
```

```
      SUBROUTINE DATAIN(IDATA,IEOF)
      INTEGER*2 IDATA(80)
      READ(5,1000,END=800) IDATA
      WRITE (6,1100)IDATA
      IEOF=0
      GO TO 900
  800 IEOF=1
  900 RETURN
 1000 FORMAT(80A1)
 1100 FORMAT (1X,' COMMAND CARD ',2X,80A1)
      END
```

```
      SUBROUTINE LINKER(KHTBOB,KNTBOB,KNLBOB,KLSBOB)
      COMMON LINKS,MNODE,NODES,MAXD,LIMF,LIMS
      COMMON /B1/NET(3,30000),NP(23000),ISQ(3000)/B2/NK(23000),
     *LSN(1000)
      INTEGER*2 NET,LD,LPA,LPB,LST,I,LCH,IP,JJ,LPP,NP,ISQ,NK,LSN
      IP=0
C
      KLSBOB=0
      DO 5 I=1,LINKS
      READ(1,1000,END=7) (NET(J,I),J=1,3)
    5 CONTINUE
    7 REWIND 1
      DO 3 I=1,MNODE
      READ(2,2000,END=4) NP(I)
    3 CONTINUE
    4 REWIND 2
C
C     INITIALIZE SEQUENCE TABLE, COUNTERS,POINTERS
C
      DO 20 I=1,MAXD
   20 ISQ(I)=0
      KHF=0
      KHTBOB=0
      LIS=0
C
C     CHECK FOR INCORRECT POINTERS- TO BE ADDED LATER
C
C
C     ALLOCATE LINKS AT STOPS
C     FIND ACTIVE TRANSIT STOPS AND ALLOCATE ADJACENT LINKS
C
      KNTBOB=0
      DO 40 J=1,MNODE
      IF(NK(J).LT.1000) GO TO 40
      I=NP(J)
      KNTBOB=KNTBOB+1
      LSN(KNTBOB)=J
C
C     ACTIVE STOP FOUND DETERMINE ADJACENT LINK
C
   25 L=(I+1)/2
      LAB=1
      LD=NET(1,L)
      LPA=NET(2,L)
      LPB=NET(3,L)
      IF(I-I/2*2.EQ.0) LAB=0
C
C     BY-PASS IF ALREADY ALLOCATED
C
      IF(NET(3,L).LT.0)GO TO 31
   32 LD=LD+2000
      NET(1,L)=LD
      NET(2,L)=LPA
      IF(LPA.GE.I) GO TO 40
      I=LPA
      GO TO 25
   31 LPB=-LPB
      LST=KNTBOB
```

```
      NET(3,L)=ISQ(LD)
      ISQ(LD)=L
      LIS=LIS+1
      IF(LAB.EQ.0) GO TO 30
      LPP=LPA
      LPA=LPB
      LPB=LPP
   30 NET(1,L)=LST
      NET(2,L)=LPA
C
C     FIND OTHER ADJACENT LINKS
C
      IF(LPB.GE.I) GO TO 40
      I=LPB
      GO TO 25
   40 CONTINUE
C     DO 45 I=1,LINKS
C  45 WRITE(6,6000) I, (NET(J,I),J=1,3)
C6000 FORMAT(1X,4I6)
C     WRITE(6,6001) LIS,KNTBOB
C6001 FORMAT(1X,'LIS',I5,' KNTBOB',I5)
C     DO 48 I=1,KNTBOB
C  48 WRITE(6,6002)I,LSN(I)
C6002 FORMAT(1X,'LSN',I5,' = ',I5)
C     DO 49 I=1,3000
C     IF(ISQ(I).EQ.0)GO TO 49
C     WRITE(6,6003)I,ISQ(I)
C6003 FORMAT(1X,'ISQ',I5, '=',I5)
C  49 CONTINUE
      IF(KNTBOB.EQ.0) GO TO 98
C
C     CHECK WHETHER IT COMPLETES LOOP AROUND NEW
C     P R O C E S S   R E M A I N I N G   L I N K S
C     INCREMENT POINTER AND CHECK FOR EXIT CONDITIONS
   50 IP=IP+1
      IF(IP.GT.MAXD) GO TO 99
      IF(LIS.EQ.0) GO TO 99
      IF(ISQ(IP).EQ.0) GO TO 50
C
C     EXTRACT LINK AT NEW DISTANCE, SET HOOK, DETERMINE ADJACENT LINK
C
      KHTBOB=ISQ(IP)
      NEW=KHTBOB
   60 LIS=LIS-1
      LST=NET(1,NEW)
      I=NET(2,NEW)
      LCH=NET(3,NEW)
      KLSBOB=KLSBOB+1
C
C     ********** PROGRAM CHANGE ***************
C      THE FOLLOWING STATEMENTS SHOULD BE ACTIVATED IF THE LINK CHAIN
C     IS TO BE SAVED FOR SKIMMING OR FLOW ASSIGNMENT
C     NP(KLSBOB)=NEW
C     IF (KLSBOB.EQ.IDIM)GO TO 97
C     LIST OF LINKS IN SEQUENCE REACHED IS SAVED IN VECTOR NP
C     IDIM MUST BE SET TO MAX DIMENSION OF NP
C
      IF(LST.LT.2000)GO TO 75
```

```
      LST=LST-2000
      NET(3,NEW)=0
      NET(1,NEW)=LST
      NET(2,NEW)=IP
      GO TO 81
   75 L=(I+1)/2
   80 IF(L.EQ.NEW)GO TO 82
      LD=NET(1,L)
      LPA=NET(2,L)
      LPB=NET(3,L)
      IF(NET(3,L).LT.0)  GO TO 78
      LD=LD+2000
      NET(1,L)=LD
      NET(2,L)=LPA
      I=LPA
      GO TO 75
   78 LPB=-LPB
      LID=IP+LD
      IF(I/2*2.EQ.I)  GO TO 77
      LPP=LPA
      LPA=LPB
      LPB=LPP
C
C     MAKE SURE LINK IS NOT OUTSIDE SEQUENCE TABLE BOUND
C
   77 I=LPB
      IF(LID.GT.MAXD)GO TO 75
C
C     PLACE LINK IN SEQUENCE TABLE, SWITCH CHAIN, INCREMENT COUNTER
C
      JJ=ISQ(LID)
      NET(3,L)=JJ
      ISQ(LID)=L
      LIS=LIS+1
   79 NET(1,L)=LST
      NET(2,L)=LPA
C
C     FIND ANOTHER ADJACENT LINK
C
      GO TO 75
C
C     CHECK WHETHER LAST LINK AT THAT CUMULATIVE IMPEDANCE
C
   82 NET(3,NEW)=2
      IF(I/2*2.EQ.I)NET(3,NEW)=1
      NET(1,NEW)=LST
      NET(2,NEW)=IP
   81 IF(LCH.EQ.0)GO TO 50
      NEW=LCH
      GO TO 60
   97 WRITE(6,102)
      GO TO 99
   98 WRITE(6,100)
   99 WRITE(6,123) KLSBOB,MAXD
  100 FORMAT(' NO ACTIVE NODE')
  101 FORMAT(10I8)
  102 FORMAT(' INSUFFICIENT SPACE FOR CHAIN STORAGE-MODIFY PROGRAM')
  123 FORMAT(I6,' LINKS WERE REACHED, MAXIMAL IMPEDANCE WAS',I6)
 1000 FORMAT(3I6)
 2000 FORMAT(I6)
      RETURN
      END
```

APPENDIX C

TRANES NETWORK DEVELOPMENT AND CODING

This section describes the steps required to identify and code TRANES node numbers for transit stops along the desired transit routes for input to TRANES. This procedure includes map preparation, network DIME file node tabulation, and TRANES node number extraction. This section will begin by briefly introducing GBF/DIME files and elaborating on the quality of census data before describing the above procedure.

GBF/DIME FILES

GBF/DIME files are computerized representations of census maps. GBF stands for "Geographic Base File." DIME stands for "Dual Independent Map Encoding" the topological technique used for representing street networks and double checking the accuracy of the geocoding work. As a major geocoding innovation in 1970's, each DIME file record includes street intersection node numbers, street name, addresses, census block and tract numbers, and, usually x and y grid coordinates. The U. S. Census Bureau used GBF/DIME files as a primary geographic resource in metropolitan areas for the 1980 census. For each street segment a GBF/DIME file record (Figure C-1) contains the following information (81):

1) Street name (or other feature description such as river, railroad track, political boundary, etc.), type, (avenue, boulevard, drive, etc.), and direction;

2) address ranges for both sides of the street segment,

3) geographic area codes, census block and tract numbers and local political jurisdictions for both sides of the segment, and

4) the identification number of the node (intersection) at each end of the segment.

5) Geographic x and y coordinates for each node, typically based on state survey plane coordinates, to enable computer-generated mapping and sorting of GBF/DIME file information into grid or other geographic subareas.

TRANES uses the GBF/DIME file in two ways. First, it is the basis for coding the transit routes and stops on the urban street network for input to the TRANES programs. Second, the file is used to link census or other street address-based socioeconomic data with specific street segments along the transit network.

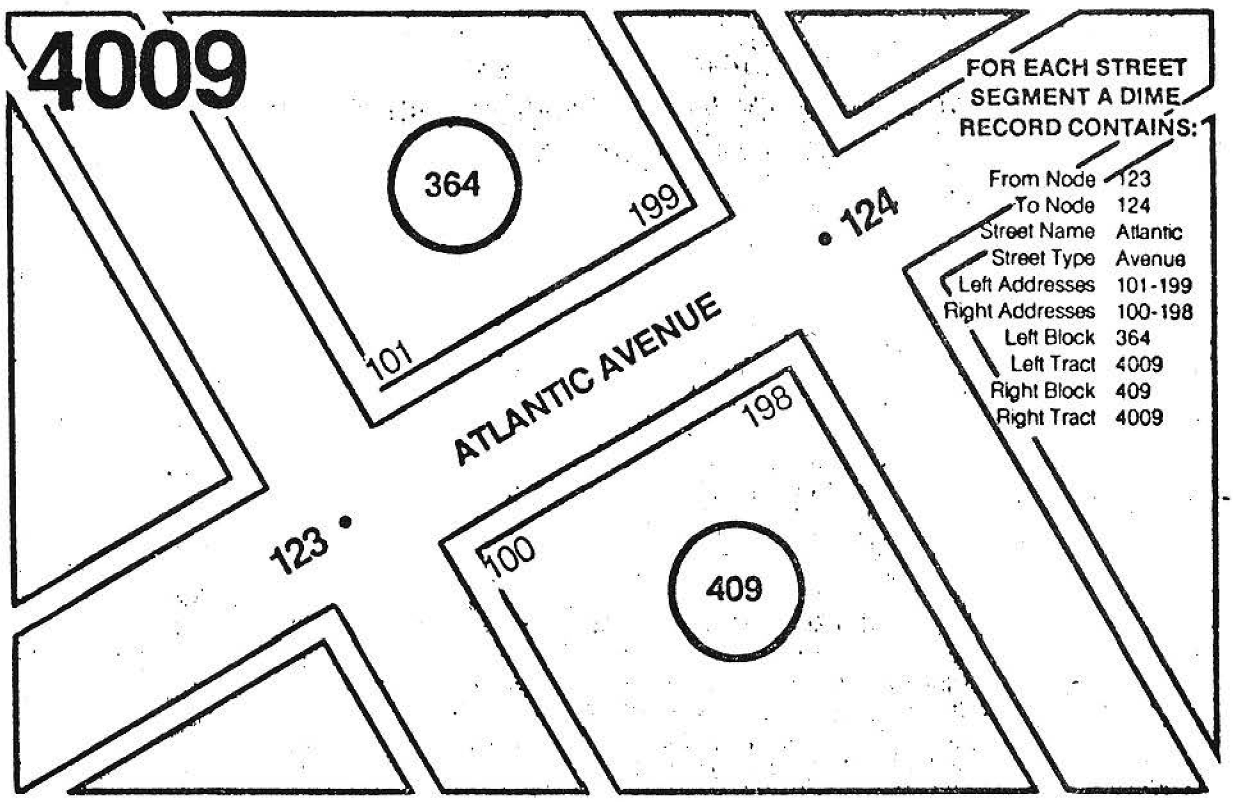


FIGURE C-1

GBF/DIME STREET SEGMENT FILE RECORD

TRANES NETWORK CODING

The material required for TRANES network coding consists of the appropriate census maps with DIME records and transit route street alignments and stop locations. The coding consists of defining the study area using the DIME file maps and drawing the transit routes which pass through the study area on these maps.

Metropolitan Map Series

The 1980 Metropolitan Map Series census maps developed by the U. S. Census Bureau were used in this research. The Metropolitan Map Series typically covers the urbanized area and often the remainder of the Standard Metropolitan Statistical Area (SMSA). The predominant scale for these maps is one inch equals 1,600 feet. In high density urbanized areas the scale may be one inch equals 800 feet. Other less common scales include one inch equals 1,667 feet and one inch equals 3,200 feet. The maps can be obtained from the Data User Services Division of the U. S. Bureau of the Census.

Copies of map sheets used by local agencies to prepare GBF/DIME files (referred to as DIME file maps) are available with a scale of one inch equals 800 feet. This is the map size and type that the TRANES coding is based on (Figure C-2). These maps include the GBF/ DIME file node numbers and the scale is adequate for accurately reading the node and tract numbers and providing sufficient space to draw the transit network. This is particularly important in central business districts or other areas where several transit routes intersect or closely parallel each other.

Transit Network Route Information

Having current transit route information plays a crucial role in TRANES coding. It is very important that analysis begin with the latest updated version of network routes. Any attempt to incorporate subsequent changes to the routes after they have been drawn on the DIME file maps or in later stages of the analysis will prove tedious and time consuming. It will also result in maps that contain deleted or re-routed lines which may cause miscoding of the nodes.

Prior to drawing the transit routes on the maps, their terminals and paths should be clearly defined. This is especially important if the network contains "interlocking" (or "interline") routes. Interlocking means that a bus serving a particular route changes its route number and destination sign to serve another route. In such instances, combining both route numbers into one route is not recommended. Instead, it is preferable to consider the interlocked route as two separate routes designated by their route numbers. This is to prevent future confusion over the route numbers by the users of the system.

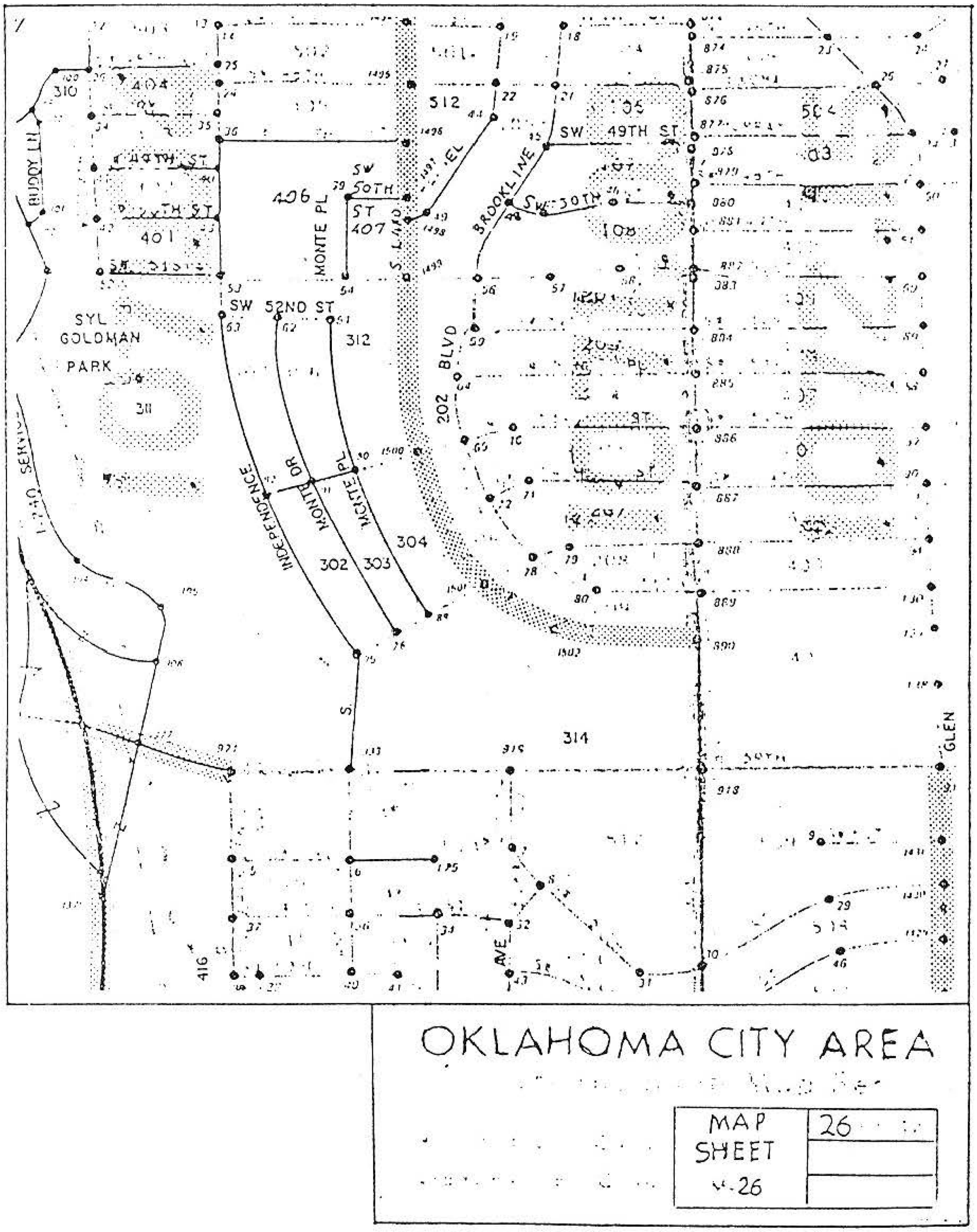


FIGURE C-2

TRANES CODING MAP

Map Preparation Procedure

The map preparation procedure begins by selecting the study area and obtaining the appropriate set of DIME file maps. At this stage and using the final description of the routes under consideration, each route can be plotted on the appropriate map(s) (Figure C-3). It is advised to differentiate each route by color. However, each route needs to be distinctly numbered at several points. As each route is drawn, the intersections that are to be coded as planned bus stops can be marked using a separate marker color, in order to distinguish them from other nodes along the route.

The scheme employed in this study consisted of marking the "outbound" bus stops first (Figure C-3). This was done using a color marker (e.g., red) and marking the outbound bus stops with a slash (/) mark. Next, inbound bus stops were identified and marked with a slash of opposite incline (\) and using a different color (e.g., green). This procedure results in the identification of the nodes that were outbound only (/), the inbound only nodes (\), and those nodes which contained both inbound and outbound bus stops (x).

Network DIME File Node Tabulation

Following the first stage of the coding procedure, where bus stop nodes and transit routes were determined and plotted on the DIME file maps, a table is created (referred to as the coding sheet) to tabulate the extracted network containing the GBF/DIME file node numbers (Figure C-4). The obtained numbers will be used in the final step, the designation of unique TRANES node numbers.

In tabulating the GBF/DIME file node numbers the following considerations are to be taken into account. Each route is coded starting from the established route terminal. For those nodes not on the tract boundary the tract and node number is recorded. For nodes on the tract boundaries, the map sheet number and node number are recorded as well. Special care needs to be taken to avoid confusing of the tract numbers or map numbers. However, such errors are often apparent when the TRANES program output is inspected. The quality control procedure for checking the tabulated numbers will vary according to the size of the network being coded. A simple means for checking node numbers along each route is to retrace the route pattern, checking for duplications and missing numbers.

Common transit route segments (routes that have common paths in some segments) can be established at this stage if common route coding is to be used. (This will be explained later under Input Data Preparations). This can be accomplished by making appropriate notes on the remarks column of the coding sheet (Figure C-4). For this purpose, the first common node, the last common node, and the common route number are identified. It is recommended that for each route the outbound route is tabulated

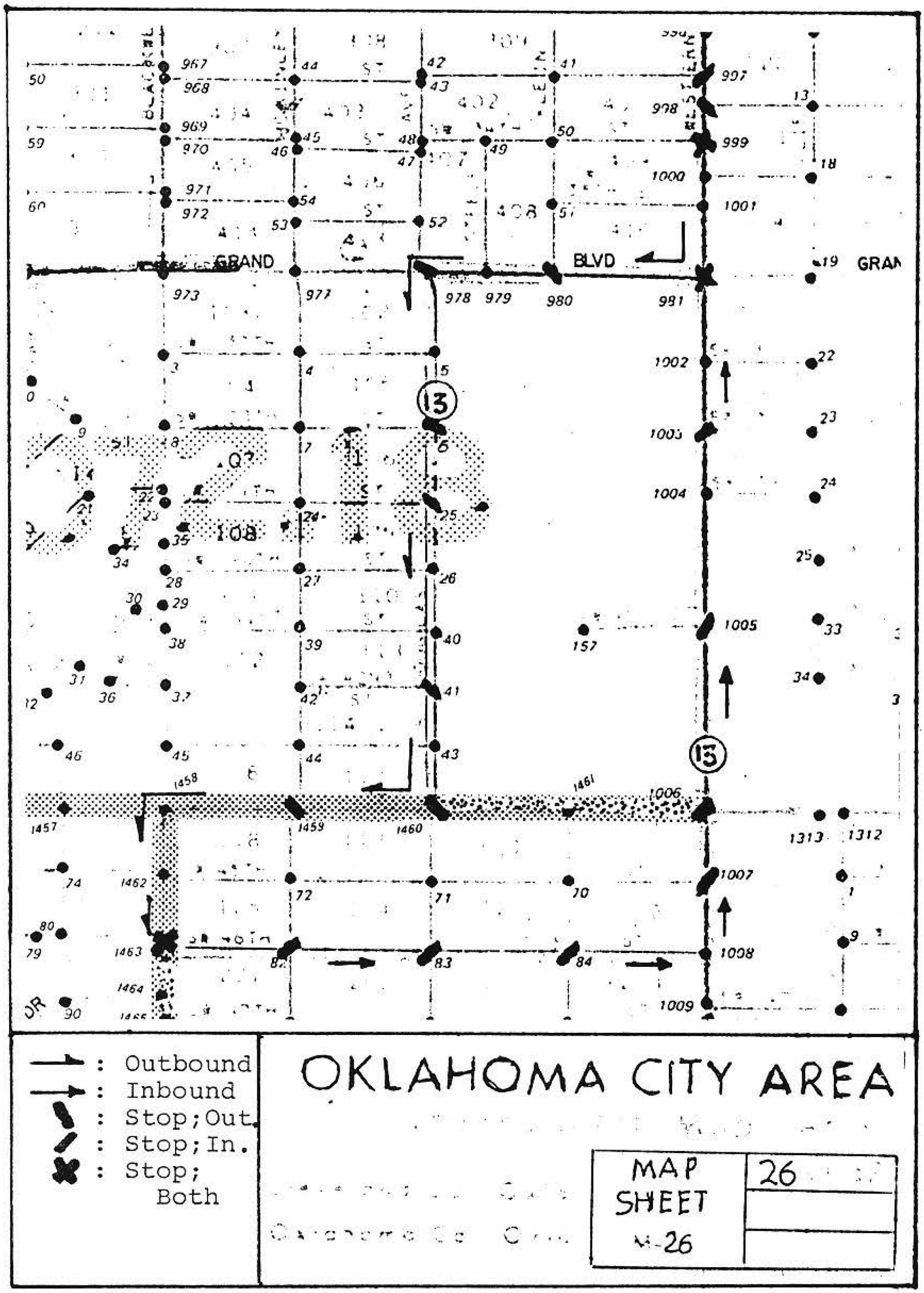


FIGURE C-3

TRANES NETWORK CODING IN TRACT 1072.18

Oklahoma City Area Transit Study

MASSTRANS Coding 1982

Route Number	Census Tract Number	MAP #	Census DIME Node Number	TRANES Node Number	Remarks

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FIGURE C-4

TRANES NETWORK CODING FORM

first, specifying those nodes common with the inbound direction (designated as "B" in Figure C-5). In such a case, the inbound tabulations will consist of those nodes that are inbound only. Such a procedure will assist the user in activating or deactivating the outbound and/or inbound routes as desired. For example, activating route 13 (Figure C-6) but deactivating nodes designated as "O" would result in an inbound route (this will include nodes designated as "B" and "I").

Node Number Preprocessor

The node number preprocessor converts the GBF/DIME node numbers to unique sequential numbers for use in the EXTRACTOR and TRANES programs. The records produced by this program contain the tract and node number if the node is not a tract boundary. For census tract boundary nodes the record contains the map sheet number and node number. For each node in the file one separate record is produced. The TRANES equivalency tables produced by this preprocessor program are referred to as "look up" tables. Example extracts from the equivalency tables used in the coding example are presented in Table C-1.

TRANES Node Number Extraction

Using the extracted network DIME file node numbers and the "look-up" tables produced by the preprocessor program, the final stage of coding can begin.

The procedure for TRANES node number extraction is straight forward. It consists of matching each GBF/DIME file node number recorded on the coding sheet (Figure C-5) with the appropriate record number in the node number equivalency tables (Table C-1) that contains the relevant tract and node number (or map sheet number and node). The newly obtained record numbers can be entered into the coding sheet in the space provided in the fifth column, "TRANES Node Numbers," as indicated in Figure C-6. The TRANES node numbers are the ones used by TRANES.

INPUT DATA PREPARATION FOR THE TRANES PROGRAM

The TRANES node numbers for each bus route are entered in a five-digit integer (I5) format in the computer data files, as indicated in Table C-2. Each route number is distinguished from node numbers by a negative sign and entered in the first of 16 I5 fields on the first input card. The line number is followed by a list of bus stop nodes (as TRANES node numbers) that make up that line. The successive node numbers fill the remaining 15 fields of the first card and then all 16 fields of the additional cards are needed. The TRANES program recognizes the next transit line when it encounters a negative number in the first I5 field of a card, which is the route number of the next transit route.

Common route coding (for routes that have common paths in some segments) may be used to reference any portion of a transit

MASSTRANS Coding 1982

Route Number	Census Tract Number	MAP #	Census DIME Node Number	TRANES Node Number	Outbound/In-bound/Both*
					Begin Outbound
13		26	997		B
"		"	998		O
"		"	999		B
"		"	981		B
"		"	980		O
"		"	978		O
"	1072.18		6		O
"	1072.18		25		O
"	1072.18		41		O
"		26	1460		O
"		"	1459		O
"		"	1463		B
					Begin Inbound
13	1072.19		82		I
"	1072.19		83		I
"	1072.19		84		I
"		26	1007		I
"		"	1005		I
"		"	1003		I

* O: Outbound Only
I: Inbound Only
B: Both (Outbound and Inbound)

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FIGURE C-5

TRANES NETWORK CODING FORM FILLED IN

TABLE C-1

EXAMPLE TRANES EQUIVALENCY TABLES

CENSUS TRACT 107218

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	4367	21	9531	41	4933
2	4366	22	7785	42	4934
3	4365	23	4610	43	5031
4	4364	24	4609	44	5032
5	4363	25	4608	45	5033
6	4463	26	4707	46	5034
7	4464	27	4708	47	5035
8	4465	28	4709	48	9739
9	4466	29	7787	49	9533
10	4467	30	9454	50	5036
11	4468	31	4937	51	10314
12	4469	32	9455	52	5037
13	4470	33	9738	53	5038
14	4471	34	9737	54	9458
15	4611	35	7788	55	9459
16	7646	36	4936	56	4938
17	7647	37	4935	57	4959
18	9463	38	4809	58	4811
19	10309	39	4808	59	4810
20	9532	40	4807	60	4710
				61	4711

CENSUS MAP 26

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
727	2212	986	2630	1000	4061
728	2527	987	2774	1001	4062
...	....	988	2906	1002	4362
975	4263	989	3026	1003	4462
976	4264	990	3205	1004	4607
977	4260	991	3358	1005	4806
978	4259	992	3496	1006	5157
979	4258	993	3495	1007	5272
980	4257	994	3639	1008	5381
981	4256	995	3640	1009	5472
982	2187	996	3777	1010	5473
983	2186	997	3778	....	....
984	2397	998	3926	1458	5159
985	2504	999	3927	1459	5158

Route Number	Census Tract Number	MAP #	Census DIME Node Number	TRANES Node Number	Outbound/In-bound/Both*
					Begin Outbound
13		26	997	3778	B
"		"	998	3926	O
"		"	999	3927	B
"		"	981	4256	B Begin 1 (out)
"		"	980	4257	O
"		"	978	4259	O
"	1072.18		6	4463	O
"	1072.18		25	4608	O
"	1072.18		41	4933	O
"		26	1460	5386	O End 1 (out)
"		"	1459	5158	O
"		"	1463	5278	B
					Begin Inbound
13	1072.19		82	--	I
"	1072.19		83	--	I
"	1072.19		84	--	I
"		26	1007	5272	I
"		"	1005	4806	I
"		"	1003	4462	I

* O: Outbound Only
I: Inbound Only
B: Both (Outbound and Inbound)

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FIGURE C-6

TRANES NETWORK CODING FORM FOR BUS ROUTE 13

TABLE C-2

TRANES NODE NUMBERS FOR COTPA BUS ROUTES

Route Number	TRANES Node Numbers
1	-1 40 41 42 99 399 477 478 480 484 485 626 628 630 634 635
	639 896 1439 1442 1444 1448 1665 1857 1869 1539 1452 1440 1437 1434 806 636
	482 481 479 230
2	-2 311 979 981 982 983 986 988 990 839 1215 1532 1736 1376 2235 8714
	2536 2433 2435 2436 2542 2675 2676 2543 2244 2247 2243 2250 1991 1990 1989 1997
	1986 1935 1955 1953 1951 1415 1105 887 991 984
3	-3 227 979 980 982 1546 1730 1967 1969 2225 2226 3539 3966 4073 4081 4082
	4083 4084 5194 5493 5494 5299 3392 1407 1297 398
4	-4 256 426 1016 1241 1576 1761 200310659 2320 3087 3559 3700 3998 4383 4654
	4854 5957 5312 5426 5582 5677 5670 5630 5939 4339 4643 4637 4076 4075 4074 4851
	5294 5673 5680 5773 5842 5682 5681 5511 5393 4742 4555 2286 1242 1017 501 341
	257 181 179
5	-5 9242 256 426 575 1244 1469 1762 2001 2293 2553 2821 3279 370110690 4559
	4858 5062 5316 5515 5586 6036 9328 7649 8330 6955 6991 912010694 7138 7199 7559
	7296 7396 7401 7402 7415 7459 7482 9108 7502 750610476 9016 7523 7529 7533 7532
	7509 7430 7371 7154 9037 777110585 6561 6053 5777 4744 4388 4132 3088 2683 2444
	2095 1471 1248 1138 1021 505 345 181 179
6	-6 9242 256 426 700 702 9367 908 1141 1477 2301 2638 2958 3294 3565 3846
	4137 4393 4563 4964 5067 5321 5519 5518 5433 5320 5322 4750 4308 3991 3706 2449
	697 501 341 181 179
7	-7 9749 9751 9537 8456 105 7777 9507 442 59110190 915 1149 14371022210224
	2100 2307 2691 2963 3292 3522 3353 4142 4393 4567 3993 3713 3570 8129 2452 2101
	1879 1676 1261 823 9679 265 9753 9750 9618 8242
8	-8 9242 256 340 341 343 345 346 9677 7777 440 589 706 820 1027 1256
	10225 2100 2307 2310 2311 2314 2563 2967 3422 3717 4002 4151 4153 4321 9320 9821
	5068 9822 5699 5694 5696 5697 5699 5701 5704 5706 5707 5710 5713 5703 5700 5698
	5693 4937 4147 3296 2334 2304 9440 8459 265 263 259 257
9	-9 9749 9751 9537 9438 9506 9759 24 35 37 25 11410640 713 827 920
	922 924 927 929 932 935 936 938 939 1174 1512 1401 1596 2130 1786 2339
	2340 2343 2345 2346 2347 2349 2355 2477 2734 2995 3315 3457 3603 4198 4436 4531
	4529 4900 3317 2863 2986 5542 4434 4344 3391 3535 3383 3247 2352 2350 2348 2344
	2341 931 92510192 199 9762 7775 9756 8456 9753 9750 9618 8242
10	-10 8242 261 431 580 1249 1578 1580 1581 1583 1585 1586 1587 1589 1590 1689
	1776 1777 1780 2019 2464 2706 2778 3432 3434 2331 2120 1591 1592 1138 1021 505
	345 196
11	-1110461 841110443 8657 7675 9659 7544 1194 2199 2541 2643 2644 2646 1632 2073
	2211 2654 2931 3239 3903 4295 3304 1629 1825 2069 2521 2642 1953 8658 9147 9149
	2155 8242
12	-12 841110443 555 865510711 1375 1527 1715 2102 2500 2730 3032 3215 3218 3220
	3222 3224 3225 3377 3798 4277 4624 4950 5175 5391 5473 5622 5919 5921 6041 6122
	6273 6416 9143 7046 9859 7106 7049 6359 5977 9856 5404 4722 4625 3518 1187 8652
	10351 8242
13	-13 130 775 962 136510399 2055 2182 2391 2498 2523 3198 3200 3202 3205 3496
	3926 4256 4257 4259 4463 4933 5158 6255 6254 6252 6251 6158 6120 6083 6081 5974
	6081 6083 5975 5879 5816 5629 5559 5473 5272 5157 4806 3927 3358 3204 3201 131
	10351 8242
14	-14 128 2375 2981 3111 3467 3751 3904 4343 4593 4773 5014 5098 5246 5356 7600
	5783 5916 6015 6106 6216 6476 6756 6761 6763 6755 6765 6760 5097 4032
16	-16 86521035410235 795 8657 1190 1528 1717 2062 2405 2633 3218 3503 3788 4472
	4712 4940 5164 5382 5620 581710247 603910249 6261 6412 6491 6665 6770 6361 6945
	7017 7034 7095 7093 7094 70641025010243 574310244 5273 9460 4812 4612 4265 3939
	7760 7784 962110351
18	-1810324 285 8043 1288 1916 2145 2433 2607 2604 2623 2625 2627 2629 2631 2633
	2634 2636 2638 2640 2641 3512 3792 4071 4491 4716 4944 5168 5385 5565 6263 6266
	4617 4270 3371 2918 1695 8045 207 3034
19	-19 1729 1966 2220 2292 2301 2305 2307 2309 2310 2311 2317 2318 2322 2326 2331
	2332 2333 2334 2336 1786 2339 234 2343 2345 2347 2344 2335 2327 2323 2306 2299
	2294
20	-2010137 8057 285 1290 1292 1294 1295 1305 2154 2613 3052 3149 3148 3472 3755
	4036 4226 4587 4782 5017 5103 5101 5359 5550 5730 5911 6018 6155 6220 6222 6475
	6755 6019 5912 4588 4037 3619 3472 2155 1291 207
22	-22 8253 8057 40 146 149 155 156 160 9711 407 570 8549 9499 800 997
	1429 1654 1858 1997 2244 2676 2946 3034 3549 4088 5834 8555 6132 6528 6525 6524
	6523 8844 6131 5937 5501 8554 2543 1557 1427 1424 996 799 634 495 418 412
	241 157 87 39
27	-27 8057 40 478 480 482 983 992 981 1206 1545 2223 1728 1205 481 479
	476 229 87 39
31	-31 1572 1670 1757 2232 3555 3982 6515 6365 6523 6951 9499 4076 4124 3335 3697
	3265 1462 1239 1129 1013 903 911 696 572 337 253
38	-38 1319 697 700 702 705 707 711 715 717 719 726 115 9911 130 8602
	722 699 696 572 337 9747 252
40	-40 75 779 864 2393 2626 2625 2623 3352 3633 4055 4701 5267 5458 5555 5733
	5876 6035 6078 6364 6493 6658 7015 7206 7340 7339 7120 7136 6943 6900 6630 6250
	6970 5143 4027 4799 4250 3199

route that has previously been coded. The methodology consists of listing the beginning bus stop node in common with a transit route, the negative of the transit route being referred back to, and the last bus stop node in common.

SUMMARY

This section has described the steps involved in preparing the "line values" for input to TRANES, namely, map preparation, transit network GBF/DIME file nodes extraction, and TRANES node number extraction. The map type used, the procedure to plot the network and required considerations in tabulating the DIME file node numbers were discussed. Finally, the method of extracting TRANES node numbers and preparing the input data for the TRANES program were explained.

It is estimated that a transit route with 50 bus stop nodes will take an average of 90 to 120 minutes to be coded. This includes drawing the route on the DIME file map, identifying the bus stop nodes, tabulating the transit network DIME file nodes, and TRANES "line value" extraction.

APPENDIX D

TRANES TRANSIT EQUIVALENCY TABLES FOR NORMAN, OKLAHOMA

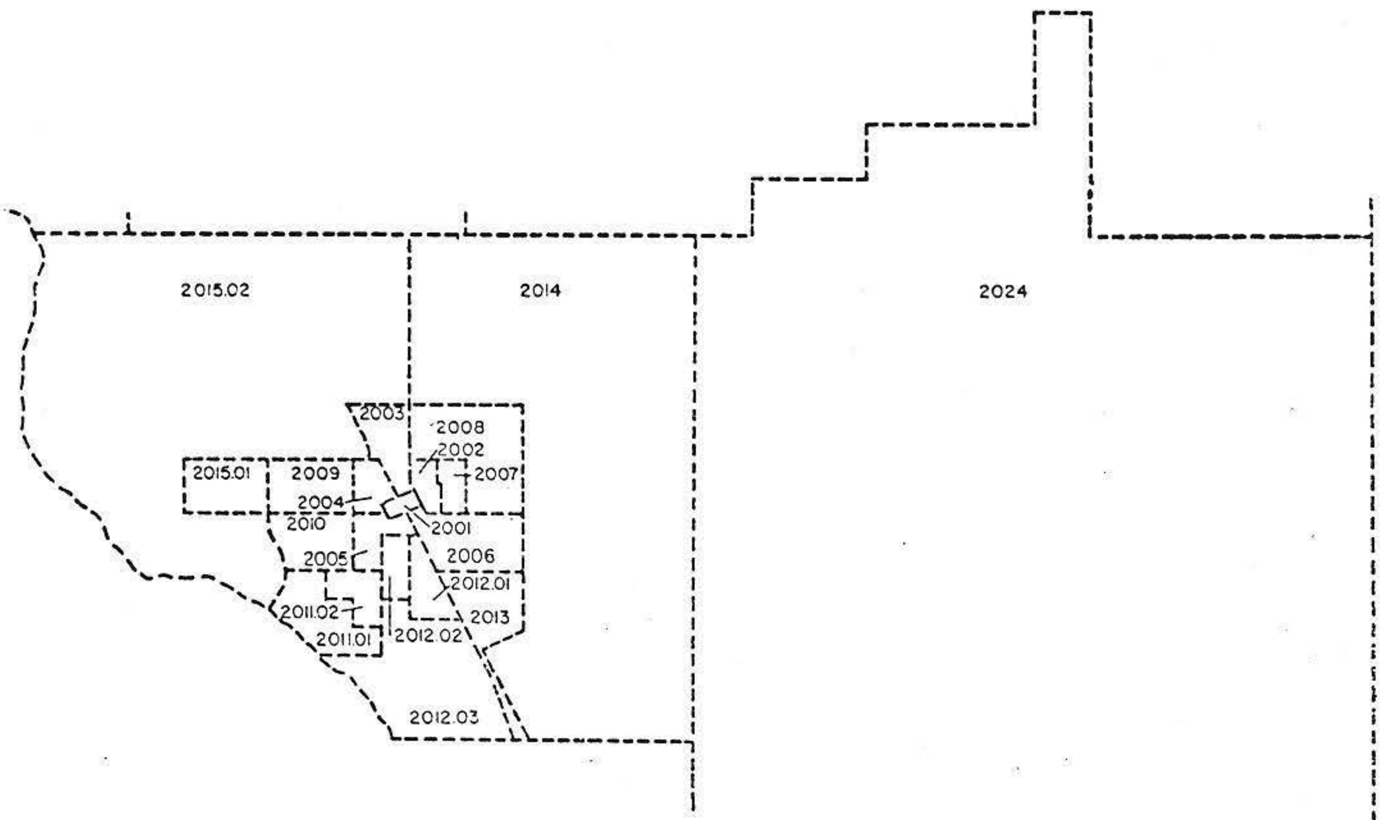

FIGURE D-1

CENSUS TRACTS FOR NORMAN, OKLAHOMA

T R A N E S   E Q U I V A L E N C Y   T A B L E

****

C E N S U S   T R A C T   200100

****

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	2090	2	1973	3	1246	4	2089	5	1544
6	1833	7	918	8	917	9	1292	10	1291
11	1296	12	1245	13	1297	14	1298	15	1667
16	1666	18	1251	19	1665	20	1543	21	1659
22	916	23	854	24	853	25	852	26	860
27	861	28	862	29	1129	30	1128	31	1127
32	1126	33	1119	34	1120				

****

****

C E N S U S   T R A C T   200200

****

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1871	2	1320	3	1172	4	1808	5	830
6	829	7	828	8	827	9	1809	10	1537
11	826	12	1536	13	1171	14	1319	15	1535
16	1870	17	1170	18	1924	19	825	20	1926
21	824	22	1225	23	1169	24	1224	25	1223
26	1412	27	1168	28	1413	29	823	30	239
31	238	32	237	33	236	34	235	35	234
36	1869	37	1294	38	1167	39	1295	40	822
41	279	42	859	43	280	44	688	45	832
46	858	47	1662	48	1166	49	1661	50	856
51	857	52	1122	53	1123	54	1124	55	689
56	903	57	904	58	281	59	690	60	2041
61	1174	62	1873	63	291	64	292	65	293
66	282	67	294	71	691	72	1175	73	1626
74	1925	75	1923						

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T R A N E S   E Q U I V A L E N C Y   T A B L E

****

C E N S U S   T R A C T   200300

****

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1486	2	1485	3	1484	5	2073	6	2044
23	990	24	935	25	939	26	934	27	2071
28	1840	29	2070	30	2045	31	1839	32	1838
33	2072	34	933	35	276	36	277	37	1732
38	1731	39	932	40	1730	41	931	42	1837
43	1928	44	1159	45	1929	46	1326	47	1158
48	1323	49	1324	50	930	51	929	52	928
53	927	54	1836	55	2126	56	1157	57	2043
58	1015	59	1014	60	1011	61	1012	62	926
63	1835	64	1547	65	1156	66	1946	67	1947
68	1091	69	1353	70	1351	71	1155	72	1349
73	1350	74	925	75	924	76	1753	77	1546
78	1154	79	1755	80	1389	81	1153	82	1386
83	1387	84	923	85	922	86	1533	87	1532
88	1531	89	1152	90	1538	91	1160	92	1545
93	1552	94	1834	95	921	96	920	97	1221
98	1220								

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TRANES EQUIVALENCY TABLE

CENSUS TRACT 200400

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1073	2	1072	3	1190	4	1249	5	1248
6	1189	7	1188	8	1247	9	1539	10	1187
11	1186	12	1049	13	1071	14	1377	15	1378
16	1921	17	1052	18	1051	19	1050	20	1417
21	1416	22	1184	23	1415	24	1343	25	1344
26	249	27	248	28	247	29	246	30	245
31	244	32	243	33	242	34	1002	35	1003
36	1004	37	1005	38	1006	39	307	40	306
41	1510	42	1509	43	1183	44	1508	45	1507
46	1064	47	1065	48	1760	49	1573	50	1182
51	1761	52	1762	53	305	54	304	55	1557
56	1556	57	386	58	1181	59	1555	60	1554
61	1037	62	1038	63	1039	64	385	65	384
66	1180	67	1572	68	2092	69	1300	70	1301
71	1179	72	383	73	1302	74	1185	75	1376
76	1414								

CENSUS TRACT 200500

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1266	2	867	3	866	4	865	5	724
6	864	7	1131	8	833	9	725	10	1134
11	868	12	1135	13	1845	14	1192	15	1574
16	726	17	834	18	1092	19	1822	20	296
21	297	22	298	23	299	24	1823	25	1093
26	300	27	1704	28	1330	29	1322	30	1321
31	1728	32	1193	33	1553	34	727	35	1094
36	1824	37	621	38	320	39	1627	40	1253
41	1522	42	1080	43	1079	44	1078	45	1085
46	1040	47	321	48	1088	49	1087	50	1254
51	1692	52	322	53	622	54	2101	55	512
56	513	57	514	58	515	59	516	60	1590
61	553	62	984	63	983	64	982	65	600
66	601	67	602	68	644	69	603	70	1694
71	1693	72	1575	73	1194	74	1827	75	1828
77	673	78	1655	79	1654	80	1132	81	1133
82	819								

T R A N E S   E Q U I V A L E N C Y   T A B L E

* **

C E N S U S   T R A C T   200600

****

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1549	2	1679	3	257	4	258	5	692
6	693	7	694	8	695	9	696	10	1999
11	1918	12	1919	13	2087	14	960	15	959
16	958	17	957	18	956	19	955	20	954
21	1559	22	797	23	937	24	1558	25	1550
26	1082	27	938	28	1083	29	798	30	1084
31	1163	32	799	33	1162	34	1161	35	1111
36	1112	37	1113	38	800	39	1114	41	1752
42	1751	43	1750	44	411	45	1920	46	1975
47	1739	48	878	49	879	50	1740	51	367
52	412	53	1640	54	1742	55	1641	56	1741
57	1653	58	1652	59	801	60	802	61	2093
62	1551	63	498	64	499	65	500	66	501
68	502	69	503	70	504	71	505	72	374
73	369	74	368	75	402	76	371	77	372
78	373	79	370	80	1804	81	1874	82	803
83	804	84	1807	85	1805	86	805	87	1806
8	375	89	1333	90	597	91	596	92	376
93	595	94	594	95	593	96	592	97	773
98	774	99	748	100	308	101	309	102	1472
103	1471	104	1971	105	749	106	1115	107	806
108	807	109	750	110	1044	111	1646	112	1647
113	1733	114	1734	115	42	116	43	117	44
118	45	119	46	120	47	121	48	122	49
123	50	125	1993	126	1991	127	1992	128	526
129	527	130	528	131	1820	132	1819	133	703
134	702	135	701	136	2095	137	2008	138	2055
139	2003	140	2056	141	2050	142	2004	143	2009
144	227	145	226	146	225	147	2048	148	2049
149	2127	150	2005	151	2128	152	2123	153	2124
154	2006	155	508	156	507	157	506	158	224
159	1927	160	271	161	716	162	717	163	2007
164	251	165	1994	166	2125	167	2199	168	1996
169	1995	170	252	176	392	177	391	178	390
179	389	180	388	181	272	182	387	183	844
184	845	185	843	186	470	187	333	188	332
189	712	190	711	191	598	192	471	193	472
194	1650	195	1738	196	1906	197	1747	198	1648
199	1649	200	1803	201	2088	202	2060	206	2000
207	2001	208	2002						

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T R A N E S   E Q U I V A L E N C Y   T A B L E

C E N S U S   T R A C T   200700

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1280	2	1316	3	1317	4	1281	5	1318
6	705	7	704	8	1405	9	1282	10	315
11	314	12	316	13	1381	14	1380	15	1383
16	2121	17	2120	18	1382	19	2022	20	2023
21	1664	23	2011	24	2122	25	1278	26	1279

C E N S U S   T R A C T   200800

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
18	1144	19	537	20	1145	21	1771	22	1770
23	1772	36	229	37	228	38	1366	39	536
40	1365	41	1364	42	1363	43	26	44	25
45	2157	46	2201	47	535	48	1367	49	1368
66	1972								

T R A N E S   E Q U I V A L E N C Y   T A B L E

****
C E N S U S   T R A C T   200900
****

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	70	2	69	3	68	4	67	5	2046
6	1825	7	19	8	66	9	65	10	18
11	1749	12	1748	13	1008	14	1009	15	1010
16	64	17	1516	18	1515	19	1514	20	1513
21	619	22	620	23	618	24	1719	25	1718
26	617	27	2074	28	1212	29	1213	30	1210
31	1211	32	1214	33	63	34	1356	35	62
36	953	37	952	38	951	39	950	41	949
42	947	43	948	44	1636	45	1637	46	1721
47	1720	48	1491	49	1490	50	1489	51	1487
52	1488	53	1354	54	666	55	365	56	676
57	1116	58	678	59	312	60	313	61	1117
62	662	63	663	64	723	65	722	66	661
67	651	68	650	69	674	70	665	71	708
72	652	73	653	74	710	75	709	76	668
77	667	78	664	79	363	80	1054	81	362
82	1056	83	1007	84	361	85	360	86	1511
37	1512	88	2156	89	1207	90	1206	91	359
92	358	93	357	94	356	95	1205	96	1208
97	1390	98	1391	99	946	100	945	101	1997
102	943	103	944	104	1209	105	1203	106	355
107	354	108	353	109	1202	110	1445	111	1444
112	1055	113	2155	114	1204	115	2214	116	677
117	675	118	364	119	1053	120	1047	121	1048

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T R A N E S E Q U I V A L E N C Y T A B L E

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C E N S U S T R A C T 201000

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1446	2	1447	3	641	4	640	5	100
6	101	7	82	8	83	9	1274	10	1328
11	1756	12	1519	13	1262	14	1998	15	2053
16	2052	17	2051	18	1268	19	284	20	285
21	286	22	287	23	1710	24	1426	25	1427
26	1712	27	1714	28	1715	29	1264	30	1263
31	1716	32	842	33	1329	34	1709	35	1273
36	84	37	102	38	1769	39	792	40	534
41	103	42	533	43	532	44	85	45	1272
46	633	47	632	48	1218	49	629	50	1217
51	2172	52	1520	53	660	54	659	55	658
56	657	57	656	58	655	59	654	60	2160
61	2206	62	1969	63	1588	64	1589	65	1705
66	1043	67	1680	68	1265	69	1359	70	1922
71	631	72	630	73	491	74	87	75	86
76	718	77	719	78	720	79	2094	80	721
81	793	82	394	83	393	84	334	85	335
:6	1976	87	794	88	795	89	796	90	609
91	1074	92	608	93	1443	94	649	95	89
96	524	97	523	98	2161	99	1569	100	607
101	1542	102	606	103	1541	104	289	105	1757
106	1568	107	288	108	1540	109	522	110	521
111	520	112	519	113	518	114	517	115	1591
116	985	117	1592	118	986	119	988	120	648
121	647	122	1683	123	1695	124	1682	125	1681
126	1970	127	646	128	645	129	604	130	340
131	605	132	341	133	1696	134	1802	135	339
136	338	137	337	138	1606	139	1800	140	1801
141	1604	142	1607	143	1605	144	1582	145	1583
146	1711	147	1713	148	987	149	88	150	492
151	90	152	1075						

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T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   T R A C T   201101

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1441	2	548	3	547	4	91	5	779
6	778	7	1355	8	92	9	546	10	93
11	469	12	468	13	1342	14	1151	15	94
16	1244	17	2024	18	1442	19	95	20	96
21	2116	22	2117	23	1164	24	1521	25	1165
26	97	27	98	28	99	29	1440	30	545
31	1399	32	1400	33	763	34	466	35	978
36	1401	37	467	38	1832	39	1341	40	1402
41	256	42	979	43	980	44	1701	45	1964
46	1965	47	1936	48	2030	49	1702	50	1700
51	1312	52	1311	53	1310	54	991	55	1309
56	1307	57	1308	58	756	59	757	60	758
61	1347	62	1348	63	2013	64	2012	65	992
66	489	67	1608	68	230	69	231	70	1609
71	490	72	994	73	993	74	771	75	2014
76	2015	77	772	78	2016	79	1398	80	1392
81	1393	82	1657	83	331	84	995	85	1656
86	232	87	330	88	328	89	329	90	1474
91	1473	93	1941	94	1940	95	1939	96	1560
97	1561	98	1724	99	1725	100	1603	101	1602
102	1601	103	1776	104	1727	105	1726	106	1942
107	2032	108	2135	109	2136	110	2017	111	1518
114	1777								

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T R A N E S E Q U I V A L E N C Y T A B L E

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C E N S U S T R A C T 201102

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	761	2	760	3	1913	4	447	5	448
6	463	7	759	8	464	9	1395	10	1394
11	789	12	2129	13	462	14	461	15	449
16	450	17	253	18	254	19	1396	20	790
21	415	22	416	23	2153	25	614	26	615
27	1846	28	1196	29	1577	30	1403	31	1197
32	1404	33	1110	34	1109	35	1108	36	1768
37	1336	38	1226	39	1337	40	612	41	613
42	2212	43	1847	44	1338	45	2213	47	881
48	880	49	1848	50	1849	51	1852	52	2163
53	2166	54	2165	55	2164	56	1853	57	1850
58	1141	59	1142	60	1778	61	1851	62	1707
63	2134	64	1708	65	477	66	476	67	1143
68	1691	69	1581	70	1580	71	1579		

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C E N S U S T R A C T 201201

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1745	2	2096	3	1814	4	1818	5	1815
6	1813	7	1817	8	1746	9	588	10	589
11	590	13	1140	14	1598	15	1260	16	1610
17	1269	18	1611	19	1150	20	1149	21	1148
22	1147	23	1599	24	1261	25	1703	26	1270
27	1517	29	1177	30	395	31	1176	32	1271
33	1600	34	2081	35	396	36	1678	37	1506
38	397	39	398	40	818	41	1826	42	399
43	1821								

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T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   T R A C T   201202

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	835	2	981	7	324	8	2119	9	2118
10	599	11	585	12	836	13	1095	14	1617
15	325	16	1618	17	1619	18	1096	19	837
20	838	21	1097	22	2	23	1	24	2200
25	4	26	5	27	6	28	1098	29	839
30	840	31	1099	32	10	33	9	34	966
35	8	36	967	37	1100				

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C E N S U S   T R A C T   201203

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	327	2	2132	3	2130	4	2131	5	901
6	900	7	764	8	765	9	766	10	767
11	768	12	769	13	770	15	1685	17	877
18	876	19	875	20	874	21	873	22	872
23	871	24	846	25	847	26	848	27	849
28	850	29	851	31	1686	32	672	33	671
34	670	36	887	37	886	38	885	39	884
40	883	41	882	42	1584	43	1042	44	1722
45	1723	46	1063	47	669	48	1688	49	1687
50	1689	51	2031	52	1530	53	529	54	530
55	746	56	747	59	697	60	52	61	53
62	2144	63	2143	64	2145	65	2146	66	1989
67	1990	68	2021						

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T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   T R A C T   201300

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	809	2	1067	3	1057	4	1076	5	1077
6	1058	7	1068	8	1962	9	1643	10	1069
11	1409	12	1070	13	1644	14	1963	15	810
16	1645	17	1642	18	1410	20	1787	21	1788
22	1789	23	273	24	274	25	275	26	278
27	1107	28	1106	29	1105	30	1104	31	1790
32	1795	33	2162	34	1103	35	636	36	637
37	1786	38	1781	39	1782	40	1791	41	1966
42	1799	43	1783	44	1784	45	1785	46	1792
47	1578	48	1968	49	1967	50	1793	51	2100
52	1794	53	2099	55	811	56	345	57	642
58	996	59	997	60	317	61	318	62	319
63	1219	64	1139	65	1086	66	998	67	643
68	347	69	221	70	346	71	222	72	223
73	813	74	812	75	814	76	815	77	2034
78	2035	79	2033	80	816	81	1408		

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T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   T R A C T   201400

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
8	1227	9	33	10	60	11	1228	14	116
15	117	28	138	34	137	45	963	46	962
47	961	48	1200	49	1199	50	1066	51	1198
53	2065	54	2064	55	2063	56	2062	57	136
58	132	59	131	60	1810	61	130	62	115
63	58	64	2061	65	30	78	59	86	32
97	1631	98	12	99	1632	100	1633	101	1938
102	1937	103	1634	104	11	105	13	107	1635
108	31	113	2210	114	1101	115	1102	116	1335
117	1334	118	2218	119	2182	120	2181	121	1585
122	1586	123	1587	124	965	125	964	126	2180
127	2217	128	2179	129	2202	130	1216	131	1981
132	1980	133	1215	134	1979	135	1978	136	2178
137	2177	138	2176	140	775	141	776	142	2215
144	777	145	1986	146	2149	147	2170	148	2108
149	15	150	16	151	17	152	2211	153	1982
158	29	159	28	160	1902	161	1901	162	1900
3	1565	164	2171	165	2169	166	2148	167	1985
168	1984	169	2209	170	2208	171	1983	172	2147
173	1423	174	1424	175	1425	176	1562	177	1905
178	1563	179	1564	186	2098	187	2109	188	1961
189	1346	190	1345	191	1888	192	1357	193	1889
194	1358	195	541	196	540	197	539	198	1904
199	1855	200	1903	201	538	202	2110	203	2097
204	2111	205	2112	206	1954	207	114	208	135
209	1955	221	134	222	133	236	2054	237	113
238	112	239	111						

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T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   T R A C T   201501

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	488	2	487	3	486	4	485	5	1428
6	1429	7	1676	8	1677	9	551	10	1706
11	2133	12	1418	13	1419	14	550	15	1420
16	1421	17	1422	18	1499	19	1454	20	1455
21	1462	22	1498	23	1497	24	1907	25	2059
26	1908	27	413	28	1909	29	414	30	1910
31	1911	32	1912	33	120	34	121	35	1894
36	1916	37	1858	38	1896	39	1857	40	1895
41	1138	42	1137	43	1136	44	2207	45	1856
46	942	47	1651	48	941	49	403	50	404
51	1899	52	940	53	119	54	1496	55	1495
56	1460	57	1456	58	1494	59	1493	60	1893

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T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   T R A C T   201502
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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
1	1505	2	1468	3	1457	4	1465	5	1466
6	1432	7	1435	8	128	9	1046	10	2040
11	127	12	126	13	1864	14	1863	15	1859
16	1860	17	1862	18	1861	19	2036	20	1438
21	1434	22	1437	23	1436	24	1461	25	1492
26	2174	27	2019	28	40	29	2010	30	2173
31	2018	32	483	33	1988	34	1987	35	482
36	481	42	480	43	39	44	1892	45	1891
46	1890	66	77	67	1236	68	38	69	1237
70	1062	71	788	72	76	73	75	74	1238
75	1239	76	1240	77	1241	78	1242	79	1243
80	125	81	142	82	159	83	158	84	141
85	2069	86	2085	87	1930	88	2084	89	2083
90	1934	91	1935	92	2086	93	2104	94	1931
95	584	96	583	97	124	98	1504	100	73
101	74	102	2068	103	2067	104	783	105	784
106	1255	107	785	108	1796	109	1797	110	1798
111	786	112	1061	113	787	114	1060	115	1059
119	37	120	36	125	715	126	714	127	713
128	1960	129	1766	130	2076	131	2075	132	1831
133	1765	134	999	135	1000	136	1001	137	1090
138	1089	139	1595	140	1596	141	1332	143	1717
144	1016	145	1017	146	1286	147	1025	148	1597
149	1259	150	1024	151	2159	152	1023	153	1887
154	1865	155	1866	156	1886	157	1331	158	2158
159	1764	160	1256	161	1257	162	1258	163	2113
164	1594	165	1767	166	72	167	562	168	560
169	561	170	563	171	1503	172	123	173	1290
174	140	175	157	176	1949	177	156	178	1385
179	1384	180	1289	181	1288	182	581	183	582
184	580	185	1361	186	1362	187	782	188	781
189	2204	190	700	191	707	192	706	193	579
194	578	195	1773	196	1774	197	699	198	1775
199	780	200	557	201	556	202	1868	203	2203
204	1812	205	1811	206	577	207	2137	208	576
209	2138	210	2139	211	564	212	565	213	1303
214	555	215	554	216	2115	217	2114	218	2142
219	2141	220	575	221	574	222	2140	223	382
224	378	225	379	226	2205	227	381	228	380
229	474	230	634	231	573	232	475	233	542
234	543	235	544	236	914	237	911	238	913
239	912	240	915	241	569	242	635	243	572
244	1285	245	571	246	525	247	405	248	406
249	407	250	552	251	408	252	409	253	568

TRANES EQUIVALENCY TABLE

CENSUS TRACT 201502

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
254	567	255	2042	256	1639	257	1898	258	1843
259	1314	260	1315	261	974	262	973	263	972
264	1313	265	1842	266	1844	267	1897	268	2197
269	2196	270	971	271	970	272	976	273	975
274	2216	275	2195	276	1501	277	1502	278	1431
279	1453	280	1452	281	155	282	2185	283	2184
284	2183	285	2186	286	1306	287	1305	288	752
289	1304	290	1885	292	1566	293	753	294	754
295	1854	296	2187	297	2198	298	2152	299	2151
300	2150	301	401	302	400	303	755	304	2189
305	2188	306	2190	307	2194	308	2193	310	1463
311	1467	312	611	313	104	314	610	315	1450
316	1459	317	1448	318	105	319	1625	320	106
321	107	322	1451	323	1449	324	1464	325	1458
326	549	327	108	328	109	329	110	330	2025

T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   T R A C T   202400

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
2	218	3	220	4	219	5	217	6	216
7	2080	8	1933	9	2079	10	2078	11	1932
12	2038	13	2039	14	627	15	626	16	625
17	638	18	639	19	624	23	214	25	460
26	207	27	459	28	1567	29	679	30	199
31	177	32	458	33	1684	34	1284	35	457
36	1283	37	170	38	169	39	1287	40	168
41	176	50	1229	51	167	52	479	53	1406
54	1658	55	1231	56	1230	57	478	58	166
68	164	69	165	79	163	80	1956	81	909
82	908	83	907	84	906	85	1340	86	1339
87	905	88	1830	89	1570	90	1829	91	869
92	870	93	162	94	161	96	171	119	172
120	173	121	174	122	175	123	190	124	2168
125	189	126	2167	127	180	128	188	129	616
130	410	131	202	132	194	133	192	134	187
135	185	136	183	137	179	138	181	139	182
0	184	141	186	142	191	143	193	144	201
145	2107	146	2106	147	2105	148	2066	149	197
169	195	170	196	172	821	173	342	174	310
175	1977	176	343	177	344	178	311	179	1759
180	1758	181	1277	182	1276	183	1275	184	1744
185	302	186	303	187	1628	188	1629	189	1630
190	1743	191	198	192	820	193	206	194	1690
195	213	196	205	197	1480	198	204	199	352
200	212	201	1360	202	1375	203	1371	204	1374
205	1373	206	1372	207	211	208	210	209	1779
210	1780	211	1914	212	2047	213	1370	214	1369
215	1915	216	2192	217	1235	218	1234	219	1233
220	1232	221	2191	222	209	223	203	224	348
225	349	226	350	227	351	228	1021	229	1020
230	1867	231	1736	232	1737	233	1026	234	1027
235	1019	236	1022	237	1018	238	1735		

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T R A N E S   E Q U I V A L E N C Y   T A B L E

C E N S U S   M A P   31

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
702	178	703	200	708	208	709	215	710	628
712	2037	713	2077						

C E N S U S   M A P   37

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
702	160	704	143	705	129	706	1483	707	1433
708	1482	709	1470	710	1481	711	78	712	71
713	1469	714	1430	715	1439	716	1500	717	969
718	122	719	570	720	566	721	1118	722	910
723	1638								

C E N S U S   M A P   38

DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
702	484	703	2175	704	2020	705	41	706	559
707	1883	709	34	713	61	714	118	715	139
716	154	717	153	718	152	719	151	720	150
721	149	722	148	723	147	724	146	725	145
726	144	727	558	728	1882	729	1881	730	1880
731	1879	732	1878	733	1950	734	1951	735	14
736	1952	737	27	738	1953	739	57	747	56
748	55	749	23	750	24	751	1945	752	1944
753	687	754	831	755	1943	756	1173	757	1872
758	686	759	685	760	684	761	683	762	682
763	681	764	989	765	1729	766	1325	767	1013
768	1877	769	1352	770	1754	771	1388	772	1534
773	1876	774	1222	775	1957	776	1958	777	35
778	1959	779	1593	780	1948	781	1250	782	1191
783	1763	784	1379						

T R A N E S   E Q U I V A L E N C Y   T A B L E

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C E N S U S   M A P   43

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DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE	DIME NODE	TRANES NODE
701	250	702	427	703	426	704	425	705	424
706	423	707	422	708	421	709	420	710	419
711	418	712	366	713	1327	714	841	715	1675
716	1674	717	1673	718	1672	719	1671	720	1201
721	1267	722	417	723	1670	724	1178	725	1571
726	1669	727	1668	728	1299	729	2091	730	1036
731	1035	732	1034	733	1033	734	1032	735	1031
736	1028	737	1029	738	919	739	1030	740	233
741	1411	743	241	744	1875	745	1293	746	1660
747	855	748	1121	749	1884	750	936	751	1841
752	1548	754	1252	755	1974	756	2057	757	2058
758	1130	759	863	760	290	761	259	762	260
763	261	764	262	765	263	766	264	767	265
768	295	769	1917	770	1125	771	1663	772	902
773	240	774	680	775	22	776	21	777	266
778	267	779	20	780	268	781	269	782	270
783	54	786	79	787	1616	788	1615	789	473
790	51	791	1407	792	1614	793	377	794	1045
)5	751	796	808	797	1613	798	1612	799	591
800	497	801	1081	802	496	803	495	804	494
805	493	806	1041	807	323	808	623	809	2102
810	509	811	510	812	511	813	728	814	586
815	729	817	2103	818	1816	819	587	820	1523
821	730	822	1576	823	1195	824	1620	825	1621
826	428	827	429	828	283	829	430	830	431
831	432	832	433	833	434	834	435	835	301
836	436	837	437	838	438	839	439	840	440
841	441	842	442	843	443	844	444	845	445
846	336	847	446	848	1622	849	1623	850	977
851	1624	852	762	853	465	854	1697	855	255
856	1698	857	1699	858	1397	859	791	860	2154
861	451	862	452	863	453	864	454	865	455
866	456	867	1479	868	1478	869	1477	870	731
871	732	872	733	873	734	874	735	875	736
876	737	877	738	878	739	879	740	880	741
881	742	882	743	883	744	884	745	885	531
892	698	893	2026	894	899	895	898	896	897
897	896	898	895	899	894	900	893	901	892
902	891	903	890	904	889	905	888	906	1529
907	1528	908	2082	909	326	910	1527	911	1526
912	968	913	7	914	1525	915	3	916	1524
917	1146	920	817	921	2027	922	2028	923	80
924	81	925	1475	926	1476	927	2029		

****

APPENDIX E

MICROTRANES

The microcomputer will be associated with transit agencies moore and more as time goes on and will significantly contribute to transit planning efforts in the future. MICROTRANES is an interactive microcomputer version of TRANES written in Microsoft BASIC for transit planners interested in accessing transit or census information at selected transit stops and providing summary information by individual transit route within a regional transit system. The program was written to make the task of analyzing transit information easier for the non-technical transit person who can use MICROTRANES to evaluate transit route alternatives for several different sets of input data.

One advantage of MICROTRANES is the ability to do a detailed analysis of transit routes on an individual transit stop basis with a minimal amount of actual coding and file building. The MICROTRANES program does not require an excessive amount of disk storage computer and the computer processing (CPU) time is low. This allows the transit planner to interactively examine many alternatives in a short period of time.

Finally, MICROTRANES reduces the need to have access to a mainframe computer and to code extensive transit networks in order to evaluate the performance of selected transit routes. The transit planner does not compete with other users for computer time or disk space and is limited only by the limitations of the microcomputer being used.

OVERVIEW

MICROTRANES is applicable to any city which has GBF/DIME files available for transit network coding. However, MICROTRANES will accept any geographic base coordinate system, thus making it accessible to any transit agency, even those lacking an established geographic base file. Cities without existing GBF/DIME files could establish and manually code the transit network. MICROTRANES can be utilized efficiently if the urban population is about 20,000 or more or if the fixed-route transit system consists of five or more vehicles. Cities without existing transit could utilize MICROTRANES for conducting feasibility studies of implementing a transit system.

The MICROTRANES programs are implemented through an interactive process of coding the geographic base file, coding the desired transit stop data, extracting the transit network, and analyzing different alternatives. MICROTRANES uses the dBASE II Database Management System (described in greater detail later) for coding the geographic base file and the transit stop data files. A MICROEXTRACT program selects that portion of the transit network desired by the user for analysis. The main MICROTRANES program is then used to link the transit network with the census information data.

There are four input files for MICROTRANES: a link pointer file, a node pointer file, a census file, and a command file. These four files respectively tell MICROTRANES: 1) where each node in the network is located, 2) what the impedance of each link is, 3) the start and end nodes for each link (A-NODE and B-NODE), and 4) the census information associated with each transit stop. Using this information, a path can be determined and census information assigned to each requested transit stop. The transit planner can analyze specific transit stops, transit route segements, or entire transit lines as desired.

The output from MICROTRANES consists of two reports, a transit stop report and a transit line report. The transit stop report prints out a summary of census information by transit stop for two accessibility limits as specified by the user. The first accessibility limit would normally be within one to three blocks of the transit stop, and the second accessibility limit could be an additional three to five blocks. If total population were used with accessibility limits of 1,300 and 2,600 feet for typical Oklahoma City street networks, the first summary tabulation would list the total population within a walking distance of approximately three blocks of each bus stop. The second summary tabulation would list the population residing an additional three blocks (1,300 to 2,600 feet in distance) away. Each summary tabulation can include three separate categories of census information, such as total population in three age ranges. A summary total for all the requested transit stops is printed out at the end of the transit stop report.

The transit line report sums up the census information for all of the transit stops along an individual transit route. It is also possible to estimate any service area overlaps between transit lines which have common route segments or run closely parallel by comparing the difference in the transit line totals and the transit stop totals. The difference in these totals provides the amount of double coverage of transit stops by different transit routes.

POTENTIAL APPLICATIONS

The primary application of MICROTRANES would be to estimate the number of potential passengers along transit route corridors. The success of a transit system can be measured by comparing the actual number of passenger-miles versus the number of vehicle-miles. These and other performance indicators can be useful in determining which transit routes are productive. Also, the transit planner could use MICROTRANSES to evaluate what changes could be made to existing non-productive transit routes to make them more productive.

MICROTRANES could also be used to collect "market-segment" information. A target market, such as population over 64 years of age, could be identified using transit stop reports from MICROTRANES. MICROTRANES thus could be used to evaluate the accessibility of existing transit routes and for designing new services to serve specific market segments.

MICROTRANES SOFTWARE REQUIREMENTS

CP/M 2.2 Operating System

CP/M, a widely used microcomputer operating system, was chosen for MICROTRANES because of its flexibility and speed compared to other operating systems. The dBASE II program which operates under CP/M is one of the fastest and most flexible database management systems on the market. Many transit agencies are now using CP/M-based microcomputers for their transit planning needs.

The advantages of using CP/M depend on the specific tasks to be accomplished with the microcomputer. Some brands of microcomputers have their own operating system and do not allow programs to be transferred from their system to another. This reduces the possibility of software piracy but it increases the system dependence of the user. This is not the case with a CP/M-based system. CP/M is available on many microcomputers, including the APPLE II, Radio Shack TRS-80, SUPERBRAIN, North Star, Heath, and Zenith. Microcomputer programs are transferable under CP/M as long as they are written in a higher level language, such as FORTRAN, BASIC, or COBOL. Furthermore, some programs written in assembler languages can be transferred by changing a few addresses or some of the operational codes.

The following system programs are contained on the CP/M master diskette supplied by the manufacturer and are used in conjunction with the dBASE II and MICROTRANES programs. For a more detailed explanation of their functions, the user is referred to a CP/M user's manual.

CAT.COM - is a program which allows the user to look at his catalog and the space occupied by each file;

APDOS. COM - is a program which allows the user to convert APPLE II text files to CP/M text files;

MFT.COM - is a program to copy files on a single disk drive system;

BOOT.COM - is a program used to boot the system for either a thirteen sector or sixteen sector diskette;

COPY.COM - is used to copy every file on one diskette to another diskette on a single or double disk drive system;

CPM60.COM - is a program used to upgrade diskettes from a 48K system to a 60 K system needed for dBASE II; and

AUTORUN.COM - is a program used in conjunction with compiled CP/M files so that when the operating system is booted, a program will automatically run without user intervention.

Microsoft BASIC

BASIC is an acronym for "Beginner's All-purpose Symbolic Instruction Code." This high level language was developed by Dartmouth College in the mid-1960's to teach beginning students how to program. Though BASIC was derived from FORTRAN, the leading professional engineering and scientific language, it has a simpler syntax and tends to be more understandable to the casual programmer. It is widely used in microcomputer programming.

There are two types of BASIC programs, an "interpretive" version and a "compiled" version. With the interpretive version the user types in a BASIC command and the computer immediately executes ("interprets") the instruction. If the command syntax is in error, the computer indicates the error, allowing the user to interactively correct lines of incorrect code. The compiled version is a machine language file which the computer can execute significantly faster and more efficiently than the interpreted version, assuming that all of the code is correct. The compiled version should be used only after the user is confident that all of the program commands and logic are correct.

MICROTRANES was written in Microsoft BASIC, a language developed and supported by the Microsoft Corporation of Bellevue, Washington. All of the MICROTRANES programs were initially developed in the interpretive mode and then later compiled with the Microsoft MBASIC compiler for faster execution and transit stop pathfinding.

dBASE II Database Management System

The dBASE II program, developed by Ashton-Tate of Culliver City, California, is a relational database management system which represents data in a two dimensional table with rows and column rather than as network heirarchies. The rows correspond to data "records" and the columns represent fields within each record. dBASE II is available on most CP/M-based microcomputers.
Relational data structures tend to be easier to understand because most people have a common and intuitive idea of what a table is. The dBASE II program is a versatile database management tool for the convenient manipulation of small and medium-sized data bases. With dBASE II it is possible to create data bases, modify and print or display the contents of each data set, manipulate data and perform mathematical computations, and generate data summary reports.

To run dBASE II, one types "dBASE" under the CP/M operating system and the microcomputer should respond with a query for today's date. Upon entering the correct date, a prompt appears on the terminal screen which looks like a period (.) and dBASE II is ready. To create a new database, type "CREATE." dBASE II will respond with an "ENTER FILENAME" query to which the user must reply with a file name. For example, a new GBF/DIME file might be named MINIDIME to ensure that the user and others can more readily remember and find the data file later.

Next the user must enter the data field name ("column" heading), the data type (alphanumerical characters such as a street name or numbers), and the field length for each field in the data base. After entering the last field, the user terminates the sequence by pressing the "return" button on the keyboard. This will save the file structure in a file called <filename.DBF> (e.g., MINIDIME.DBF). The dBASE II program will query the user with "INPUT DATA NOW (Y/N)?" which allows the user to immediately enter data ("Y" for "yes") or just save the empty file on disk. The user enters new data in an existing file by using the APPEND command.

In editing an existing dBASE II file the user must access the dBASE II program as indicated above and then enter the USE command, e.g. USE MINIDIME. The user then selects the record (a "row" in the data table) to be edited by entering "EDIT RECORD NUMBER" where the record number corresponds to the row number assigned by the user. If the user is not sure of the record number, the existing records can be viewed on the terminal screen with either the DISPLAY or LIST command. The DISPLAY command will display one record at a time and the LIST command lists every record in the file starting with the first one.

Saving a dBASE II file is accomplished by first accessing dBASE II (if not already done so) and the specific file (USE command). Next, the user types in the command COPY TO SDF. This creates a file with the file name <filename.TXT> (e.g., MINIDIME.TXT) which can be accessed by the BASIC programs.

MICROTRANES HARDWARE REQUIREMENTS

A 48K APPLE II computer was chosen for developing the MICRO-TRANES programs because: (1) it is a widely available machine, (2) it supports the BASIC language which is easy to program, thus facilitating the conversion of TRANES from FORTRAN to BASIC, (3) many transportation planning programs are available for the APPLE II and therefore, many transportation and transit agencies are likely to have access to an APPLE II, and (4) the dBASE II database management system runs under the CP/M 2.2 operating system on the APPLE II and this was an important element of the MICROTRANES development. The APPLE II is a versatile, 8-bit machine able to use either its own 6502 microprocessor for the APPLE DOS disk operating system or the Z-80 microprocessor for CP/M 2.2 programs.

A random access memory 64K RAM Card is required to operate the dBASE II program and all of the MICROTRANES programs. The 64K RAM Card essentially gives the user an additional 16K of memory to run programs or perform file manipulations.

An 80 Column Card expands the APPLE II screen column display width from 40 to 80 characters. The expansion allows the use of full screen formating with dBASE II. Also, the MICROTRANES output program display formats are set up for a full 80 columns. If a 40 column display is used the output tables will "wrap around" the screen in an almost unreadable fashion. The user can, if desired, modify the MICROTRANES output formats for 40 column display by changing the TAB functions in the program listings.

The Z-80 Card is the central processing unit (CPU) for the CP/M operating system. This card must be installed in order to run dBASE II or any of the MBASIC programs. The Z-80 processor also controls the CP/M system utilities described previously.

The minimum disk configuration for accessing dBASE II and the MICROTRANES programs would be one disk drive and controller. However, it is suggested that the user have two disk drives for additional storage and easy copying of diskettes. The job of inserting and removing diskettes becomes tedious with a single disk drive system.

Many alternative microcomputers are available on the market and can perform many functions for the transit planner, however, the one constraint that is most often faced it the initial capital cost of the microcomputer. The transit planner (in 1983) should be able to buy a reasonable microcomputer in a price range of $1000-$3000 which could be used to run dBASE II and MICROTRANES.

A second criterion would be the primary use of the microcomputer. If the microcomputer is dedicated to planning only and not word processing or business management programs then the transit planner should look for a computer with this in mind.

However, it is useful to have a good word processor available for program development and occasional documents. Word processing is more convenient with 80-column screen displays, the format suggested previously for a MICROTRANES hardware configuration.

A final criterion for microcomputer selection is the ability to expand the system in the future. Transit agency and personal computing requirements, while possibly small at first, likely will be much larger in the near future as the agency finds more uses for them. Microcomputers will continue to become smaller and less expandable. This is a marketing strategy used by the computer manufacturers to ensure that when the existing machine is outgrown it will be necessary to invest in a new machine. One advantage of the APPLE II computer, available since 1977, is that it can be expanded by simply replacing old circuit boards with appropriate new ones for new applications. The vigorous growth of the microcomputer industry has included the development of increasingly sophisticated software packages, a trend which should continue in the foreseeable future.

MICROTRANES PROGRAMS AND FILES

Menu of Capabilities

The purpose of the menu program, not included in this report, would be to allow the user to access any of the MICROTRANES programs with a single response. The menu displays all of the possible options to the user and then queries the user to select one of six options.

The first option would run the MICRO-EXTRACT program which creates the necessary files for MICROTRANES. The second option would run the interactive version of MICROTRANES and which produces a second menu of fifteen options the user may select from. The third option would run the batch version of MICROTRANES where the user must have previously created a COMMAND file which tells MICROTRANES which functions to perform. The fourth option would run the LIST program listing the equivalency tables between GBF/DIME File node numbers and the unique TRANES node numbers. The fifth option would access a census information demand file (created with dBASE II) and put it in binary format for use with MICROTRANES. And finally, the sixth option would allow the user to exit the MICROTRANES menu and return to the CP/M operating system.

Interactive Version. The interactive version of MICROTRANES allows the transit planner to try several alternative plans without re-running the MICROTRANES program. The interactive version allows the transit planner to activate or deactive transit lines, transit stops, or classify transit stops. The transit planner can change any of the parameter values such as maximum impedance, first accessibility limit, or second accessibility limit at any time within the program. When these impedances are changed, however, the pathfinder routine must be run again with the new impedances. The planner may also change the transit stop classification and run the pathfinder routine again. When the transit planner runs the pathfinder routine, both a pathfinder report and a transit line report may be requested. The planner may also change the demand values and request a second transit stop or transit line report with the new values. This can be done as many times as desired with up to three different values at a time.

Batch Version. The batch version of MICROTRANES is very similar to the interactive version with the exception of the COMMAND file coding. In the batch version, the transit planner is required to code a command card as the last record in the COMMAND file. The command card is used to activate and deactivate transit lines, transit stops, and classify stops, to change parameters, stop classes, transit demand values and to output pathfinder, transit stop, and transit line reports. Some of these commands require numeric information after the command, e.g. when a transit line is activated or when transit demand values are changed. After the MICROTRANES program is run in the batch mode, the transit planner may make changes by accessing the COMMAND file with a word processor or text editor and changing the desired values.

MICROTRANES Data Files

The following data files are developed either prior to running MICROTRANES or are generated by the programs.

The MICRO-DIME file is used by the MICRO-EXTRACT program to create a link/pointer file and a node/pointer file for MICROTRANES. The MICRO-DIME File provides the street network, i.e. links and nodes, used to create the transit network for the pathfinding algorithm used in MICROTRANES. It is suggested that the user create this file interactively using dBASE II. However, the user may also download a small portion of a regional GBF/DIME file from a mainframe computer directly to the microcomputer if those capabilities are available.

The Link/Pointer file serves as a unique link file for the MICROTRANES program and a pointer to connected links. This is one of the main files used by MICROTRANES. The Node/Pointer file created by the MICRO-EXTRACT program is used by MICROTRANES as a unique node list which points to the link in the Link/-Pointer file containing a specific node that the pathfinder algorithm is searching for. When the first link is found the Node/Pointer file directs the pathfinder to other adjacent links with the same unique node number.

The Tract/Pointer file can be created using dBASE II interactively. The user must find the number of interior census tract nodes for each census tract that the user plans to use in the MICRO-EXTRACT program. The user can accomplish this by using the COUNT command to determine the unique interior tract nodes. These nodes represent all the unique GBF/DIME File nodes within the interior of each census tract for the desired study area.

The Map/Pointer file can also be created using dBASE II interactively. The user must find the number of census tract boundary nodes for each census map to be used in the MICRO-EXTRACT program. The user can accomplish this by using the COUNT command to determine the number of unique census tract boundary nodes. These nodes represent all the unique GBF/DIME file nodes located along census tract boundaries for the desired study area.

The Tract/Node file contains for each MICRO-DIME node, a unique MICROTRANES node number which provides an equivalency for the transit planner to code the existing or proposed transit lines. The file also contains the x-coordinate and y-coordinate of each node in the study area.

The Map/Node file gives the same equivalency as the Tract/-Node file except that the Map/Node file contains only census tract boundary nodes. The reason census tract boundary nodes are separated by map number is that they are unique for a specific map but not among the census tracts. Census tract boundary nodes numbers start at 700 and are numbered up to 49,999 within the same map but are never duplicated. The Map/Node file also contains the x-coordinate and y-coordinate of every census tract boundary node in the study area.

MICRO-EXTRACT Program

The purpose of the MICRO-EXTRACT program is to create pointer files and a subarea demand file for use in the MICROTRANES program. The MICRO-EXTRACT program also creates two equivalency tables used in the coding of the transit network. The equivalency tables list the MICRO-DIME file node numbers and their equivalent MICROTRANES code numbers.

MICRO-DEMAND Program

The purpose of the MICRO-DEMAND program is to create a set of census statistics which represent the demographic or socio-economic conditions along each individual transit line corridor. The MICRO-DEMAND program allocates census information to each unique MICRO-DIME street segment, i.e. the block face of the MICRO-DIME record. The demand file is then used in the MICRO-EXTRACT program to create a subarea census demand file.

The input data file requirements for the MICRO-DEMAND program are the MICRO-DIME file and a MICRO-DEMAND file, both created with dBASE II. The MICRO-DIME file is used to match census block records to individual MICRO-DIME segment records. The MICRO-DEMAND file must, therefore, contain data at the census block level of geography. The MICROTRANES program requires that each census data record be coded to a unique MICRO-DIME record number for random access of the segment or block face data.

The transit planner should consider using the ADMATCH computer program for the automated geocoding of data files if the program is available and the demand file contains address specific data. The ADMATCH program was created by the U.S. Bureau of Census as an address matching program to "provide the capability of geocoding computer readable records containing street addresses" . It has been used on IBM mainframe computers since the early 1970's with fairly good results.

The user of the MICROTRANES programs might consider implementing a version of ADMATCH on the microcomputer to do automated geocoding of data files. Either way, this procedure would give the best data for MICROTRANES, i.e. at the block face level of geography, rather than trying to disaggregate the census data files from the block level to block face.

An alternative approach to creating the demand file would be to manually geocode the data rather than using an automated procedure. The disadvantage of manual geocoding is the time that it takes to look up each record in a street address listing. However, if the data file is a reasonable size, say less than 100 records, then the manual geocoding approach could be used with satisfactory results.

MICRO-LIST Program

The purpose of the MICRO-LIST program is to provide a concise list of MICRO-DIME node numbers and their equivalent MICROTRANES node numbers. The list is then used to code the individual transit lines for input into MICROTRANES.

Main Program

The input for the main MICROTRANES program is the Link/Pointer file, the Node/Pointer file, the subarea Demand file, the Pathfinder file and the Command file. The Link/Pointer file and Node/Pointer file provide the network information used for pathbuilding. The Demand file provides the census or other data used for analysis of socio-economic, demographic, and potential ridership figures for each individual transit stop. The Pathfinder file is used to store the transit paths on the disk for later path skimming or flow assignment. The Command file contains the initial parameter codes, transit node, and transit line information used to control the program inputs, outputs, and pathbuilding.

OPERATIONAL USE OF MICROTRANES

The transit planner is assumed to have some familiarity with the transit system being analyzed. The transit planner thus would know essentially where to and where not to put transit lines within a particular study area. The planner should also know where the high density corridors are as far as population and employment and concentrate on transit demand in those areas. Much less work and fewer computer runs will be required if good assumptions are made in the initial stages of analysis.

Once the transit planner has laid out a tentative transit system, an initial transit stop report can be produced. By starting with transit stop reports rather than transit lines summaries those stops where there are no demographic characteristics (e.g., insufficient total population) can be eliminated. The transit planner can then begin transit line analysis with the remaining transit stops. It should be noted, however, that some "dummy" transit stops may be required where no transit or census data exist in order to achieve the maximum impedance criteria. The transit stop reports will give the transit planner an idea of the demographic profiles along the transit corridor and through further analysis, determine if those characteristics have any influence on actual passenger ridership. When a relationship between demographic characteristics and passenger demand is established, usually through regression or correlation, the transit planner may then estimate demand by using equations which represent this relationship.

Transit travel times, transit schedules, actual on-board passenger counts, travel costs, and operational costs are just a few of the other data files which could be analyzed by MICRO-TRANES. This would assume, of course, that the transit planner would have this data by transit stop or transit link within the network. The transit travel times on each link could be used along with distance to set the impedance value associated with the transit line. This would be more realistic than using just distance to determine impedances. The travel cost could be used to evaluate the overall performance of a transit line as far as productivity, i.e. transit lines heavily subsidized are not considered to be very productive. Finally, transit schedules could be compared with the computed total and individual transit travel times to determine if the schedules are realistic.

APPENDIX F

MICROTRANES COMPUTER PROGRAM LISTING

M I C R O - E X T R A C T   P R O G R A M

WRITTEN BY KEN MORRIS

MARCH 1983

```
1000 REM
1002 REM DIMENSION AND INITIALIZE VARIABLES
1004 REM
1006  OPTION BASE 1
1010  DIM NEWMAP(400),LP(400),LD(400)
1020  DIM NEWPT2(400),NEWPTR(400),NP(400)
1030  DIM IBMAP(2),ITRC(2),NODES(2),IY(2),IX(2)
1040  DIM ITRACT(10),LOW(10),IHIGH(10)
1050  DIM MAPP(10),MLOW(10),MHIGH(10)
1060  DIM LINKER(2)
1070  DIM DM9(9),DM9$(9),IDMD9T(9)
1080 PRINT CHR$(12)
1090 PRINT : PRINT : PRINT
1100 PRINT TAB(20);" E X T R A C T O R   P R O G R A M"
1110 PRINT
1120 PRINT TAB(20);"      Please wait for menu ! "
1130 REM  ******INPUT FILES ******
1140 REM  1- LINKTEST (INPUT TO PREP)
1150 REM  4- DEMAND FILE
1160 REM  5- TRACT/NODES
1170 REM  6- MAP/NODES
1180 REM  7- DIMECON
1190 REM ****** OUTPUT FILES ******
1200 REM  2- LINKPT
1210 REM  3- NODPAC
1220 REM  8- TNODES
1230 REM  9- MNODES
1240 REM **************************************************************
1250 REM *                          S T E P  # 1                       *
1260 REM *                READ CONTROL CARDS AND TABLES                *
1270 REM *                     IOPT =0 FOR FULL RUN                    *
1280 REM *                     IOPT =1 FOR MAIN PROGRAM ONLY           *
1290 REM *                     IOPT =2 FOR SUBROUTINE PREP ONLY        *
1300 REM **************************************************************
1310 OPEN "O",1,"LINKTEMP"
1320 OPEN "O",2,"LINKPTR"
1330 OPEN "O",3,"NODEPTR"
1340 OPEN "R",4,"DEMAND"
1350 OPEN "I",5,"TRACNODE"
1360 OPEN "I",6,"MAPNODE"
1370 OPEN "I",7,"DIMECON"
1380 OPEN "O",8,"T-NODE"
1390 OPEN "O",9,"M-NODE"
1400 FIELD #4, 6 AS DM9$(1),6 AS DM9$(2),6 AS DM9$(3),6 AS DM9$(4),
1402 6 AS DM9$(5),6 AS DM9$(6),6 AS DM9$(7),6 AS DM9$(8),6 AS DM9$(9)
```

```
1404 REM
1406 REM CLEAR SCREEN AND PRINT MENU
1408 REM
1410   PRINT CHR$(12)
1420   PRINT "CHOOSE ONE OF THE FOLLOWING OPTIONS"
1430   PRINT "         0 - FULL RUN"
1440   PRINT "         1 - MAIN PROGRAM ONLY"
1450   PRINT "         2 - SUBROUTINE PREP ONLY"
1460   PRINT TAB(20);:INPUT "YOUR CHOICE (0-2) ",IOPT
1470   IF IOPT <> 2 THEN 1560
1480 REM
1490 REM              READ THE NUMBER OF LINKS AND NODES(NEXT) FOR PREP
1500 REM
1510    PRINT
1520    INPUT "NUMBER OF LINKS IN FILE: ",LINKS
1530    PRINT
1540    INPUT "NUMBER OF NODES IN FILE: ",NXT
1550   GOSUB 3400 : END
1560     NXT = 1
1570     PRINT
1580     INPUT "NUMBER OF CENSUS TRACTS IN TRNODE FILE: ",NTRAC
1590     PRINT
1600     INPUT "NUMBER OF CENSUS MAPS IN MAPNODE FILE:  ",NMAP
1610     PRINT
1620   FOR I = 1 TO NTRAC
1630   INPUT #5,B$
1640   ITRACT(I) = VAL(MID$(B$,1,6))
1650      LOW(I) = VAL(MID$(B$,7,3))
1660    IHIGH(I) = VAL(MID$(B$,10,3))
1670   NEXT I
1680   FOR I = 1 TO  NMAP
1690   INPUT #6,C$
1700    MAPP(I) = VAL(MID$(C$,1,2))
1710    MLOW(I) = VAL(MID$(C$,3,3))
1720   MHIGH(I) = VAL(MID$(C$,6,3))
1730   NEXT I
1740 REM **************************************************************
1750 REM *                            S T E P  # 2                    *
1760 REM *                  READ LINKS AND RENUMBER NODES             *
1770 REM **************************************************************
1780   INPUT "NUMBER OF DIME FILE SEGMENTS IN DIMECON FILE: ",NDIME
1790  FOR JJ = 1 TO NDIME
1800       K = 1
1810 IF EOF(7) THEN 3190
1820   INPUT #7,A$
1830     NUM = NUM + 1
1840    ITRC(K) = VAL(MID$(A$,53,6))
1850   IBMAP(K) = VAL(MID$(A$,71,3))
1860   NODES(K) = VAL(MID$(A$,74,4))
1870       IX(K) = VAL(MID$(A$,81,4))
1880       IY(K) = VAL(MID$(A$,88,4))
1890  ITRC(K+1) = VAL(MID$(A$,62,6))
```

```
1900 IBMAP(K+1) = VAL(MID$(A$,92,3))
1910 NODES(K+1) = VAL(MID$(A$,95,4))
1920    IX(K+1) = VAL(MID$(A$,102,4))
1930    IY(K+1) = VAL(MID$(A$,109,4))
1940         JD = VAL(MID$(A$,113,6))
1950      ITYPE = VAL(MID$(A$,119,1))
1960   IF JJ = 1 THEN JDLOW = JD
1970      JD = JD - JDLOW + 1
1980 REM                    STEP 2.1    SKIP NON STREET LINKS,
1990 REM                                SKIP TRACTS AND NODE = 0
2000 REM                                CREATE COORDINATE FILE FOR PLOTTING
2010   IF ITYPE > 0 AND ITYPE < 8 THEN 3140
2020   IF ITRC(1) = 0 OR ITRC(2) = 0 THEN 3110
2030   IF NODES(1) = 0 OR NODES(2) = 0 THEN 3110
2040   IF IX(1) = 0 AND IY(1) = 0 THEN 2070
2050   IF IX(2) > 0 AND IY(2) > 0 THEN 2080
2060      IB = IB + 1
2070   PRINT TAB(10);"NO COORDINATES FOR RECORD NUMBER: ";NUM
2080 REM
2090 REM                    STEP 2.2  RENUMBER ALL NODES
2100 REM
2110   FOR I = 1 TO 2
2120    IROW = 0
2130    ICOL = 0
2140   IF NODES(I) >= 700 AND NODES(I) < 5000 THEN 2600
2150 REM
2160 REM                    STEP 2.2.1 RENUMBER TRACT NODES
2170 REM
2180    KPTR = 1
2190 REM     SEARCH ITRACT TABLE FOR THIS CENSUS TRACT
2200   IF KPTR > NTRAC THEN 2760
2210   IF ITRACT(KPTR) = ITRC(I) THEN 2240
2220    KPTR = KPTR + 1
2230      GOTO 2200
2240      ND = NODES(I)
2250 REM        REDUCE NODES ABOVE 4999
2260      IF NODES(I) >= 5000 THEN ND = 700 + (NODES(I)-4999)
2270 REM        NODPTR IS THE NODE NUMBER PLUS THE LOWEST NUMBER
2280 REM          IN THAT TRACT IN SEQUENTIAL ORDER FOR ALL TRACTS.
2290 REM          THEN SUBTRACT 1.
2300      NODPTR = ND + LOW(KPTR) - 1
2310      IF NODPTR > IHIGH(KPTR) THEN 3160
2320 REM          IF NEW NUMBER ABOVE 400 MUST GO TO NEW ARRAY FOR SPACE
2330      IF NODPTR > 400 THEN 2480
2340 REM          ELEMENT OF NEWPTR ARRAY IS ASSIGNED NEXT AVAILABLE
2350 REM          NUMBER IF NOT ALREADY ASSIGNED
2360      IF NEWPTR(NODPTR) <> 0 THEN 2440
2370      NEWPTR(NODPTR) = NXT
2380 REM          CONVERT X AND Y TO GRIDS FOR LATER INTERACTIVE TRANES
2390      IF IX(I) = 0 OR IY(I) = 0 THEN 2410
2400      IROW = (IY(I)-13400) / 2000 + 1
2410      PRINT #8,ITRC(I);",",NODES(I);",";NXT;",";IX(I);",";IY(I)
```

```
2420 REM         INCREMENT NEXT AND ASSIGN NEW NUMBER TO LINKER
2430      NXT=NXT+1
2440      LINKER(I) = NEWPTR(NODPTR)
2450      GOTO 2760
2455 REM
2460 REM        THE FOLLOWING STEP ARE SIMILAR TO THOSE ABOVE
2470 REM         EXCEPT THE ARRAY NEWPT2 IS USED FOR SPACE
2480      NODPTR = NODPTR - 400
2490      IF NEWPT2(NODPTR) <> 0 THEN 2560
2500      NEWPT2(NODPTR) = NXT
2510      IF IX(I) = 0 OR IY(I) = 0 THEN 2540
2520      IROW = (IY(I)-13400) / 2000 + 1
2530      ICOL = (IX(I)-15870) / 2000 + 1
2540      PRINT #8,ITRC(I);",";NODES(I);",";NXT;",";IX(I);",";IY(I)
2550      NXT = NXT + 1
2560      LINKER(I) = NEWPT2(NODPTR)
2570      GOTO 2760
2580 REM                   STEP 2.2.2 RENUMBERMAP NODES
2590 REM              CONVERT ALPHA MAPS TO NUMBERS
2600      IMAP = 1
2610      IF IMAP > NMAP THEN 2760
2620      IF IBMAP(I) = MAPP(IMAP) THEN 2660
2630      IMAP = IMAP + 1
2640      GOTO 2610
2650 REM        THIS PROCESS IS THE SAME AS ABOVE EXCEPT FOR MAPS
2660      NODPTR = (NODES(I)-700) + MLOW(IMAP) - 1
2670      IF NODPTR > MHIGH(IMAP) THEN 3180
2680      IF NEWMAP(NODPTR) <> 0 THEN 2750
2690      NEWMAP(NODPTR) = NXT
2700      IF IX(I) = 0 OR IY(I) = 0 THEN 2730
2710      IROW = (IY(I)-13400) / 2000 + 1
2720      ICOL = (IX(I)-15870) / 2000 + 1
2730      PRINT #9,IBMAP(I);",";NODES(I);",";NXT;",";IX(I);",";IY(I)
2740      NXT = NXT + 1
2750      LINKER(I) = NEWMAP(NODPTR)
2760      NEXT I
2770 REM                  CALCULATE LINK DISTANCE,PACK DATA
2780 REM                  WRITE LINK FILE(2) AND DEMAND FILE(3)
2790      IDIST = 0
2800      IF IX(1) = 0 OR IX(2) = 0 OR IY(1) = 0 OR IY(2) = 0 THEN 2840
2810      IXDIST = IX(2) - IX(1)
2820      IYDIST = IY(2) - IY(1)
2830       IDIST = INT(SQR((IXDIST*IXDIST) + (IYDIST*IYDIST)) + .5)
2840      IF IDIST <= 0 OR IDIST > 5280 THEN 2860
2850      GOTO 2880
2852 REM
2854 REM  ERROR MESSAGES FOR INCORRECT DISTANCE ON
2856 REM  RECORDS PROCESSED BY MICRO-EXTRACT
2858 REM
2860      PRINT "RECORD NUMBER ";JD;"HAS A DISTANCE OF ";IDIST
2870      IDIST = 300
2880      PRINT #1,IDIST;",";LINKER(1);",";LINKER(2)
```

```
2890      LINKS = LINKS + 1
2892 REM
2894 REM  COMPUTE SUBAREA DEMAND AND CREATE SEPERATE FILE
2896 REM
2900      IF JD > 32000 THEN 3020
2910      GET #4,JD
2920      DM9(1) = CVS(DM9$(1))
2930      DM9(2) = CVS(DM9$(2))
2940      DM9(3) = CVS(DM9$(3))
2950      DM9(4) = CVS(DM9$(4))
2960      DM9(5) = CVS(DM9$(5))
2970      DM9(6) = CVS(DM9$(6))
2980      DM9(7) = CVS(DM9$(7))
2990      DM9(8) = CVS(DM9$(8))
3000      DM9(9) = CVS(DM9$(9))
3010      GOTO 3070
3020      INODEM = INODEM + 1
3030      PRINT "NO DEMAND FOR RECORD NUMBER ";NUM;" LINK NUMBER ";JD
3040      FOR I = 1 TO 9
3050      DM9(I) = 0
3060      NEXT I
3070      FOR KK = 1 TO 9
3080      IDMD9T(KK) = IDMD9T(KK) + DM9(KK)
3090      NEXT KK
3100      GOTO 3180
3110      PRINT "NO POINTER FOR RECORD ";NUM;" CENSUS TRACT ";ITRC(I);
3120      PRINT " NODE ";NODES(I)
3130      GOTO 3180
3140      NONST = NONST + 1
3150      GOTO 3180
3160      PRINT "HIGH POINTER--RECORD NUMBER ";NUM;" HPOINTER ";NODPTR;
3170      PRINT " MAP # ";IBMAP(I);" TRACT # ";ITRC(I);" NODE # ";NODES(I)
3180      NEXT JJ
3190      NXT1 = NXT - 1
3200 REM ************************************************************
3210 REM *                    S T E P  # 3                           *
3220 REM *         WRITE INFO AND GO TO PREP IF IOPT NOT EQUAL TO 1  *
3230 REM ************************************************************
3240      PRINT "NUMBER OF LINKS ";LINKS;" HIGHEST NODE NUMBER ";NXT1
3250      PRINT "NUM = ";NUM
3260      PRINT "NUMBER OF RECORDS WITH : "
3270      PRINT "NO COORDINATES ";IB;
3275      PRINT "NO DEMAND ";INODEM;" NON-STREET ";NONST
3280      PRINT "CENSUS ITEMS 1-9 TOTALS ";
3290      FOR I = 1 TO 9 : PRINT IDMD9T(I); : NEXT I
3300      PRINT
3310      IF IOPT = 1 THEN 3330
3320      GOSUB 3400
3330      END
```

```
3350 REM ****************************************************************
3360 REM *                          S T E P  # 1                         *
3370 REM *                READ LINKS AND UNPACK THEM                      *
3380 REM *                INITIALIZE NP WITH NEGATIVES                    *
3390 REM ****************************************************************
3400   CLOSE 1
3410   OPEN "I",1,"LINKTEMP"
3420      FOR JJ = 1 TO LINKS
3430      J = JJ * 2
3440      I = J - 1
3450      INPUT #1,LD(JJ),LP(I),LP(J)
3460      NEXT JJ
3470      NUMNOD = NXT - 1
3480      FOR  MM = 1 TO NUMNOD
3490      NP(MM) = - MM
3500      NEXT MM
3510      LN = 2 * LINKS
3520 REM ****************************************************************
3530 REM *                          S T E P  # 2                         *
3540 REM *                THIS LOOP DOES THE ACTUAL POINTER CREATIONS    *
3550 REM ****************************************************************
3560      FOR I = 1 TO LN
3570      II = LP(I)
3580      LP(I) = NP(II)
3590      NP(II) = I
3600      NEXT I
3610 REM
3620 REM     CLOSE THE POINTER LOOP
3630 REM
3640      FOR I = 1 TO LN
3650      IF LP(I) > 0 THEN 3680
3660      II = -LP(I)
3670      LP(I) = NP(II)
3680      NEXT I
3690 REM ****************************************************************
3700 REM *                     S T E P  # 3                              *
3710 REM *           DIVIDE DISTANCE BY 10,MAKE B NODE NEGATIVE          *
3720 REM *           FOR TRANES ,WRITE LINK INFO TO FILE 4 AND NODE      *
3730 REM *           POINTER INFO TO 7. THEN RETURN.                     *
3740 REM ****************************************************************
3750   FOR JJ = 1 TO LINKS
3760   J = JJ * 2
3770   I = J - 1
3780   IC = INT(LD(JJ) / 10)
3790   LDK = -LP(J)
3800   PRINT #2,IC;",";LP(I);",";LDK
3810   NEXT JJ
3820   FOR  I = 1 TO NUMNOD
3830   PRINT #3,NP(I)
3840   NEXT I
3850   RETURN
```

MICRO-TRANES PROGRAM
WRITTEN BY KEN MORRIS
MARCH 1983

```
00005 REM DIMENSION AND INITIALIZE VARIABLES
00010 REM *****************************************************
00020     * DIM NET(3,150),NP(150),ISQ(150),NK(150),LSN(150)        *
00030     * DIM LIPO(150),LST(150),LR(16),LX(9),ICC(3)              *
00040     * DIM LLN(150),LLY(6,150),LSY(6,150),NR(6),JA(4),LIN(20)*
00050      * DIM IDIGIT(10),IA(4),IB(4),IC(4)                       *
00060     * DEFINT I-N                                              *
00070 REM *****************************************************
00140 REM FILE 1=LINKPT
00150 REM FILE 2=NODPAC
00160 REM FILE 3=DEMAND
00170 REM FILE 4=PATHS
00180 REM FILE 5=CARD INPUT
00190       JI=0
00200 REM
00210 REM  DEFLAULT THE CENSUS INFORMATION TO 1-TOTAL POPULATION
00220 REM                                      2-POPULATION UNDER 16
00230 REM                                      3-POPULATION OVER  64
00240        ICC(1)=1
00250        ICC(2)=2
00260        ICC(3)=3
00265 REM
00270 REM   I N P U T
00280 REM
00290        INPUT #5,LINKS,MNODE,NODES,MAXD,LIMF,LIMS
00300        PRINT USING "####.#";LINKS,MNODE,NODES,MAXD,LIMF,LIMS
00310         IF MAXD > 0 THEN 330
00320       MAXD=3000
00330       FOR I = 1 TO NODES
00340        INPUT #5,N,NK(N):NEXT I
00350       KHT=0
00360 REM
00370 REM  T R A N S I T  L I N E  I N P U T
00380 REM  READ DATA, FIRST NEG. DATA IS TRANSIT LINE FOLLOWED BY NODES
00390 REM
00400       K=0
00410       PRINT "TRANSIT LINES"
00420        FOR I = 1 TO 16 :INPUT #5,LR(I): NEXT I
00430       IF LR(1) = 0 THEN 970
00440       FOR I = 1 TO 16:PRINT USING "####.#";LR(I);:NEXT I:PRINT
00450       II=1
00460       IF LR(1) < 0 THEN 880
00470       FOR I = II,16
00480       IF LR(I) = 0 THEN 500
00490       NEXT I
00500       KK=I-II
```

```
00502 REM
00510 REM    TRANSIT LINE CODING EXPANSION
00512 REM
00520        KY=0
00530        FOR I = 1 TO KK
00540        KY=KY+1
00550        J=I+II-1
00560        IF LR(J) > 0 THEN 810
00570        KI=-LR(J)
00580        KA=LR(J-1)
00590        KB=LR(J+1)
00600        LA=LIPO(KI)
00610        FOR  JK = 1 TO JI
00620        IF LIN(JK) = KI THEN 660
00630        NEXT JK
00640        PRINT "ERROR IN REFERENCING COMMON TRANSIT LINE"
00650        GO TO 4260
00660        LB=LIPO(LIN(JK+1))-1
00670        FOR L = LA TO LB
00680        IF LST(L) = KA THEN 740
00690        IF LST(L) = KB THEN 730
00700        NEXT L
00710        PRINT "ERROR IN REFERENCING COMMON TRANSIT LINE"
00720        GO TO 4260
00730        KB=999
00740        LLCK=L+1
00750        FOR M = LLCK TO LB
00760        LST(K+KY)=LST(M)
00770        IF LST(M) = KB THEN I=I+1
00780        IF LST(M) = KB THEN 820
00790        KY=KY+1
00800        NEXT M
00810        LST(K+KY)=LR(J)
00820        NEXT I
00830        K=K+KY
00840        GO TO 420
00850 REM
00860REM DETERMINE POINTERS,THEN RETURN TO PLACE NODE SEQUENCE INLIST
00870 REM
00880        LL=-LR(1)
00890        LIPO(LL)=K+1
00900        II=2
00910        JI=JI+1
00920        LIN(JI)=LL
00930        GO TO 470
00940 REM
00950 REM   FILL IN EMPTY POINTER SPACES
00960 REM
00970        IF LL = 0 THEN 1190
00980        LL=LL+1
00990        KK=K
01000        LIPO(LL)=K+1
```

```
01010          LLCK=LL-1
01020          FOR I = 1 TO LLCK
01030          J=LL-I
01040          IF LIPO(J)  > 0 THEN 1190
01050          LIPO(J)=LIPO(J+1)
01060          NEXT I
01070          PRINT "THE NUMBER OF NODES IN THE LIST ARE ";LIPO(LL)
01080          LIPOLL=LIPO(LL)
01090           FOR I = 1 TO LIPOLL STEP 16 : FOR J = 0 TO 15
01092          PRINT USING "#####.";LST(I+J);:  PRINT:NEXT J:  NEXT I
01100 REM
01110 REM   C O M M A N D   L I N E   I N P U T
01111 REM
01120REM        SCANS LINES TO INTERPRET NUMERIC COMMAND,
01130 REM        ALSO OBTAINS NEXTVALUE (MF) OR VALUE RANGE (MF,MS)
01160 REM
01170 REM   READ COMMAND DATA
01180 REM
01190          MF=0
01200          MS=0
01210          GOSUB 4270 : REM CALL INPUT (ICODE,IDIGIT)
01220          IF ICODE = -1 THEN 4260
01230          IF ICODE =  2 THEN IKS=0
01240          IF ICODE =  9 THEN IKL=0
01250          IF ICODE < 12 THEN 1320
01260          ICODCK = ICODE - 11
01270          ON ICODCK GOTO 2220,2480,2640,2640,3590,3930
01280          GO TO 4260
01290 REM
01300 REM   CHECK WHETHER COMMAND EXPECTS VALUES
01310 REM
01320          IF IDIGIT(1) = 0 THEN 4260
01330          JJ=0
01340          JJ=JJ+1
01350          IF IDIGIT(JJ) = 0 THEN 1210
01360          MF=IDIGIT(JJ)
01370          IF IDIGIT(JJ+1) >= 0 THEN 1400
01380          MS=-IDIGIT(JJ+1)
01390          JJ=JJ+1
01400          ICODCK=ICODE-1
01410          ON ICODCK GOTO 2380,2320,1520,1760,1850,1940,2050,2540
01420 REM
01430 REM   REINITIALIZE VALUES
01440 REM
01450          MF=0
01460          MS=0
01470          GO TO 1340
```

```
01480 REM
01490 REM  A C T I V A T E   L I N E S
01500 REM  ACTIVATE LINE(S) IDENTIFIED BY VALUE OR VALUE RANGE
01510 REM
01520       IF MS = 0 THEN MS=MF
01530        FOR I = MF TO MS
01540 REM
01550 REM  ACTIVATE LINE UNLESS ALREADY ACTIVATED
01560 REM
01570       IF LIPO(I) < 0 THEN 1710
01580       K=LIPO(I)
01590       KE=LIPO(I+1)-1
01600       IF KE < 0 THEN KE = -KE - 2
01610       LIPO(I) = -LIPO(I)
01620       IF KE < K THEN 1710
01630       FOR IJ = K TO KE
01640 REM
01650 REM  AND ALSO ACTIVATE STOPS ON LINE
01660 REM
01670       NS=LST(IJ)
01680       IF NK(NS) > 1000 THEN 1700
01690        NK(NS)=NK(NS)+1000
01700       NEXT IJ
01710       NEXT I
01720       GO TO 1450
01730 REM
01740 REM  A C T I V A T E   N O D E S   B Y   N A M E
01750 REM
01760       IF MS = 0 THEN MS=MF
01770        FOR I = MF TO MS
01780       IF NK(I) > 1000 THEN 1800
01790       NK(I) = NK(I) + 1000
01800       NEXT I
01810       GO TO 1450
01820 REM
01830 REM  A C T I V A T E   N O D E S   B Y   C L A S S
01840 REM
01850       IF MS = 0 THEN  MS=MF
01860        FOR I = 1 TO MNODE
01870       IF NK(I) < MF OR NK(I) > MS THEN 1890
01880       NK(I) = NK(I) + 1000
01890       NEXT I
01900       GO TO 1450
01910 REM
01920 REM  D E A C T I V A T E   N O D E S   B Y   C L A S S
01930 REM
01940       IF MS = 0 THEN MS=MF
01950        FOR I = 1 TO MNODE
01960       IF NK(I) < 1000 THEN 2000
01970       NK(I) = NK(I) - 1000
01980       IF NK(I) >= MF AND NK(I) <= MS THEN 2000
01990       NK(I) = NK(I) + 1000
```

```
02000         NEXT I
02010         GO TO 1450
02020 REM
02030 REM     D E A C T I V A T E   L I N E S
02040 REM
02050         IF MS = 0 THEN MS=MF
02060          FOR I = MF TO MS
02070         IF LIPO(I) > 0 THEN 2170
02080         KE=LIPO(I+1)-1
02090         IF KE < 0 THEN  KE = -KE - 2
02100         LIPO(I)  =  -LIPO(I)
02110         K  = LIPO(I)
02120         IF KE < K THEN 1450
02130         FOR IJ = K TO KE
02140         NS  =  LST(IJ)
02150         IF NK(NS) < 1000 THEN 2170
02160         NK(NS)  =  NK(NS)  - 1000
02170         NEXT IJ : NEXT I
02180         GO TO 1450
02190 REM
02200 REM     D E A C T I V A T E   A L L   S T O P S   A N D   L I N E S
02210 REM
02220          FOR I = 1 TO MNODE
02230         IF NK(I) >= 1000 THEN NK(I)  =  NK(I)  - 1000
02240         NEXT I
02250         FOR I = 1 TO LL
02260         IF LIPO(I) < 0 THEN LIPO(I) = -LIPO(I)
02270         NEXT I
02280         GO TO 1210
02290 REM
02300 REM      D E A C T I V A T E   N O D E S   B Y   N A M E
02305 REM
02310         IF MS = 0 THEN MS=MF
02320          FOR I = MF TO MS
02330         IF NK(I) < 1000 THEN 2350
02340         NK(I)  =  NK(I)  - 1000
02350         NEXT I
02360         GO TO 1450
02365 REM
02370 REM      S E T   N E W   N O D E   C L A S S
02375 REM
02380         IF IKS <> 0 THEN 2410
02390         IKS=MF
02400         GO TO 1450
02410         IF MS = 0 THEN MS=MF
02420          FOR I = MF TO MS
02430         ISS=0
02440         IF NK(I) > 1000 THEN ISS=1000
02450         NK(I)  =  IKS + ISS
02460         NEXT I
02470         GO TO 1450
02480          REM ICODE = 2 AND IKS = 0
```

```
02490 REM    ************
02500        GOSUB 7540 :  REM CALL SUBROUTINE LINKER(KHT,KNT,KNL,KLS)
02510 REM    ************
02520        KX=0
02530        GO TO 1210
02540        IF MS = 0 THEN MS=MF
02550         FOR I = MS TO MF
02560        IKL=IKL+1
02570         ICC(IKL)=I
02575        NEXT I
02580        IF IKL = 3 THEN 1190
02590        GO TO 1450
02600 REM
02610 REM   O U T P U T   A L L O C A T I O N   T O   S T O P S
02620 REM   CLEAR ACCUMULATORS, IF NECCESSARY
02630 REM
02635         OPEN "R",3,FILE3$
02637        FIELD #3,9 AS C1$,9 AS C2$,9 AS C3$,9 AS C4$,9 AS C5$,9 AS C6$
02640        FOR J = 1 TO KNT
02650        FOR I = 1 TO 6
02660        LSY(I,J)=0
02670        NEXT I : NEXT J
02680        FOR I = 1 TO LINKS
02690        IF NET(3,I) < 0 THEN 2850
02700        GET #3,I
02710         J=NET(1,I)
02720        LCD=NET(2,I)
02730         LCH=NET(3,I)
02740         IF LCD > LIMF THEN 2770
02750        IU=0
02760        GO TO 2820
02770         IF LCD > LIMS THEN 2850
02780        IU=3
02790 REM
02800 REM ADD TO APPROPRIATE ACCUMULATOR, BASED ON FIRST ORSECONDLIMIT
02810 REM
02820         FOR K =1 TO 3
02830         LSY(K+IU,J)  =  LSY(K+IU,J)  +  LX(ICC(K))
02840         NEXT K
02850         NEXT I
02855 REM
02860 REM   OUTPUT ALLOCATION RESULTS
02870 REM
02880          PRINT "T R A N S I T   S T O P   R E P O R T"
02890          PRINT "************************************"
02892         PRINT "FIRST LIMIT = ";LIMF;" SECOND LIMIT = ";LIMS
02902        FOR I = 1 TO 6: PRINT SPC(5);"CENSUS";:NEXT I : PRINT
02904         FORI = 1 TO 6: PRINT SPC(5);TITLE$(I);:NEXT I:PRINT
02910         FOR J = 1 TO 6
02920          NR(J)=0
02922         NEXT J
02930         FOR I = 1 TO KNT
```

```
02932        FOR J = 1 TO 6
02940         PRINT USING "###,###.";I,LSN(I),LSY(J,I)
02945 REM
02950 REM    SUM TOTALS
02955 REM
02970         NR(J)=NR(J)+LSY(J,I)
02980        NEXT J : NEXT I
02990        PRINT "GRAND TOTAL IS";
02992         FOR J = 1 TO 6 :PRINT USING "###,###.",NR(J); : NEXT J
03000        MF=0
03010        IF ICODE = 14 THEN 1210
03020 REM
03030 REM   O U T P U T   A L L O C A T I O N   T O   L I N E S
03040 REM   IDENTIFY ACTIVE LINES AND CLEAR ACCUMULATORS
03045 REM
03050        J=0
03060        FOR I = 1 TO 100
03070        IF LIPO(I) >= 0 THEN 3100
03080        J = J + 1
03090        LLN(J) = I
03100        NEXT I
03110 REM
03120 REM   REMEMBER NO. OF ACTIVE LINES
03130 REM
03140        KNL = J
03150        FOR I = 1 TO KNT
03160         IU = LSN(I)
03170        NP(IU) = I
03180        NEXT I
03190        FOR J = 1 TO KNL
03200        FOR I = 1 TO 6
03210        LLY(I,J) = 0
03220        NEXT I
03230        LI = LLN(J)
03240        K = LIPO(LI)
03250        KE = LIPO(LI+1) - 1
03260        IF K < 0 THEN  K = -K
03270        IF KE < 0 THEN KE = -KE - 2
03280 REM
03290 REM   IDENTIFY STOPS ON LINE BY SEQUENCE NO. OF STOP
03300 REM
03310        IF KE < K THEN 3450
03320         FOR M = K TO KE
03330        MM = LST(M)
03340        IU = NP(MM)
03350 REM
03360 REM   CHECK IF STOP IS ACTIVE
03370 REM
03380        IF NK(MM) < 1000 THEN 3440
03390        FOR I = 1 TO 6
```

```
03400 REM
03410 REM  ACCUMULATE ALLOCATIONS TO ALL STOPS ON LINE
03420 REM
03430         LLY(I,J) = LLY(I,J) + LSY(I,IU) / 4
03435        NEXT I
03440        NEXT M
03450        NEXT J
03460 REM
03470 REM   OUTPUT ALLOCATION RESULTS
03475 REM
03480         PRINT "T R A N S I T  L I N E  R E P O R T"
03490        PRINT "************************************"
03500        PRINT "FIRST LIMIT = ";LIMF;" SECOND LIMIT = ";LIMS
03505        FOR I = 1 TO 6: PRINT SPC(5);"CENSUS";:NEXT I : PRINT
03507        FORI = 1 TO 6: PRINT SPC(5);TITLE$(I);:NEXT I:PRINT
03510        FOR I = 1 TO KNL
03512        FOR J = 1 TO 6
03520         PRINT USING "###,###.";I,LLN(I),LLY(J,I)
03530        NEXT J : NEXT I
03540        MF = 0
03550        GO TO 1210
03560 REM
03570 REM   O U T P U T   P A T H F I N D E R
03580 REM
03590         PRINT "P A T H F I N D E R  R E P O R T"
03600        IF KNT = 0 THEN 3900
03610        PRINT " LINK   DIST   STOP N    LINK   DIST    STOP N";
03612        PRINT " LINK   DIST   STOP N    LINK   DIST    STOP N"
03620        KK=1
03630        FOR I = 1 TO LINKS
03640        IF NET(3,I) < 0 THEN 3860
03650        IB(KK)=NET(1,I)
03660         IA(KK)=NET(2,I)
03670        IC(KK)=NET(3,I)
03680 REM    *****************PROGRAM CHANGE**********************
03690 REM    THE FOLLOWING STATEMENTS HAVE TO BE ACTIVATED TO OUTPUT
03700 REM       STOP NODE NAME RATHER THAN SEQUENTIEL STOP NUMBER
03705 REM    *****************************************************
03710 REM    KJ = IB(KK)
03720 REM     IF KJ <= KNT THEN 3770
03740 REM     PRINT "IB(KK) = ";IB(KK);" IC(KK) = ";IC(KK);" LINK # = ";I
03750 REM    IB(KK) = 999999
03760 REM    GO TO 3800
03770 REM    IB(KK) = LSN(KJ)
03775 REM
03780 REM    OPEN FILE FOR SAVING PATHS
03790 REM
03795         OPEN "O",4,FILE4$
03800        JA(KK) = I
03810        KK = KK + 1
03820        IF KK <= 4 THEN 3860
03830        FOR KI = 1 TO 4
```

```
03832         PRINT USING "####.";JA(KI),IA(KI),IB(KI),IC(KI);
03840          PRINT #4,JA(KI),IA(KI),IB(KI),IC(KI);
03842         NEXT KI
03850         KK=1
03860         NEXT I
03870         FOR KI = 1 TO 4
03872          PRINT USING "####.";JA(KI),IA(KI),IB(KI),IC(KI);
03880         PRINT #4,JA(KI),IA(KI),IB(KI),IC(KI);
03882         NEXT KI
03884         CLOSE 4
03900         MF=0
03910         GO TO 1210
03912 REM
03920 REM      R E A D  N E W   P A R A M E T E R S
03922 REM
03930         INPUT #5,MDIST,LIMF,LIMS
03932         PRINT "NEW PARAMETERS ARE ";
03940         PRINT USING "#####.";MDIST,LIMF,LIMS
03950         GO TO 1210
04240         PRINT "VALUE EXPECTED AFTER COMMAND"
04260         END
```

```
04262 REM
04270 REM    SUBROUTINE INPUT(ICODE,IDIGIT)
04272 REM
04280        DIM IERROR$(80),IDIGIT(50)
04390        II=0
04400        JJ=0
04410        FOR I = 1 TO 50
04420        IDIGIT(I) = 0
04422        NEXT I
04440        IF INDX <= 80 THEN 4510
04442        IF EOF(1) THEN 7390
04450        INPUT #5,IDATA$
04460        INDX=1
04480 REM
04490 REM       LOOK FOR FIRST NON-BLANK CHARACTER.
04500 REM
04510        IF MID$(IDATA$,INDX,1) <> "" THEN 4570
04520        INDX=INDX+1
04530        GO TO 4440
04540 REM
04550 REM       IF FIRST CHARACTER NOT ALPHA IT'S AN ERROR.
04560 REM
04570        IF MID$(IDATA$,INDX,1) = "A" THEN 4950
04580        IF MID$(IDATA$,INDX,1) = "C" THEN 4950
04590        IF MID$(IDATA$,INDX,1) = "D" THEN 4950
04600        IF MID$(IDATA$,INDX,1) = "O" THEN 4950
04610        IF MID$(IDATA$,INDX,1) = "R" THEN 4950
04620 REM
04630REM IT'SAN ERROR. SCAN FOR NEXT OP CODE THEN PRINT EVERYTHING
04640 REM       PREVIOUS AS BAD DATA.
04650 REM
04660        IPTR=0
04670        ISAVE=INDX
04680        INDX=INDX+2
04690        IF MID$(IDATA$,INDX,1) = "A" THEN 4850
04700        IF MID$(IDATA$,INDX,1) = "C" THEN 4850
04710        IF MID$(IDATA$,INDX,1) = "D" THEN 4850
04720        IF MID$(IDATA$,INDX,1) = "O" THEN 4850
04730        IF MID$(IDATA$,INDX,1) = "R" THEN 4850
04740        INDX = INDX + 1
04750        IF INDX <= 80 THEN 4690
04760        INDX2 = INDX - 1
04780        IPTR = IPTR + 1
04790        IERROR$(IPTR) = MID$(IDATA$,ISAVE,INDX2-ISAVE+1)
04810        INPUT #5,IDATA$
04820        INDX = 1
04830        ISAVE = 1
04840        IF NOT EOF(1) THEN 4690
04850        IF ISAVE = INDX THEN 4910
04860        INDX2 = INDX - 1
04880        IPTR = IPTR + 1
04890        IERROR$(IPTR) = MID$(IDATA$,ISAVE,INDX2-ISAVE+1)
```

```
04910         IF IPTR <= 0 THEN 4940
04920         FOR I = 1 TO IPRT:PRINT "ERROR ";IERROR$(I):NEXT I
04930         IF EOF(1) THEN 7390
04940         IPTR = 0
04950         II$ = MID$(IDATA$,INDX,1)
04960         IF INDX < 80 THEN 5040
04970         IPTR=0
04980         NFLD=0
04990         IERROR$(1) = "NONE"
05000         INPUT #5,IDATA$
05010         IF EOF(1) THEN 7270
05020         INDX = 0
05040         JJ$ = MID$(IDATA$,INDX+1,1)
05050         IF II$ = "A" THEN 5170
05060         IF II$ = "C" THEN 5440
05070         IF II$ = "D" THEN 5710
05080         IF II$ = "O" THEN 6040
05090         IF II$ = "R" THEN 6310
05100 REM
05110 REM          IT'S AN ERROR.
05120 REM
05130         GO TO 4660
05140 REM
05150 REM     THE FIRST CHARACTER IS AN A.  NEXT MUST BE C, L, N OR S.
05160 REM
05170         IF JJ$ = "C" THEN 5250
05180         IF JJ$ = "L" THEN 5300
05190         IF JJ$ = "N" THEN 5350
05200         IF JJ$ = "S" THEN 5400
05210         GO TO 4660
05220 REM
05230 REM          THE SECOND CHARACTER IS A C.
05240 REM
05250         ICODE=6
05260         GO TO 6520
05270 REM
05280 REM          THE SECOND CHARACTER IS AN L.
05290 REM
05300         ICODE=4
05310         GO TO 6520
05320 REM
05330 REM          THE SECOND CHARACTER IS AN N.
05340 REM
05350         ICODE=5
05360         GO TO 6520
05370 REM
05380 REM     THE SECOND CHARACTER IS AN S.  ** NOT YET IMPLEMENTED **.
05390 REM
05400         GO TO 4660
05410 REM
05420 REM          THE FIRST CHARACTER IS A C.  NEXT MUST BE A, C,D OR P.
05430 REM
```

```
05440        IF JJ$ = "A" THEN 5520
05450        IF JJ$ = "C" THEN 5560
05460        IF JJ$ = "D" THEN 5610
05470        IF JJ$ = "P" THEN 5660
05480        GO TO 4660
05490 REM
05500REM THE SECOND CHARACTER IS AN A.  ** NOT YET IMPLEMENTED **.
05510 REM
05520        GO TO 4660
05530 REM
05540 REM         THE SECOND CHARACTER IS A C.
05550 REM
05560        ICODE=2
05570        GO TO 6520
05580 REM
05590 REM      THE SECOND CHARACTER IS A D
05600 REM
05610        ICODE=9
05620        GO TO 6520
05630 REM
05640 REM         THE SECOND CHARACTER IS A P.
05650 REM
05660        ICODE=17
05670        GO TO 6470
05680 REM
05690 REM THE FIRST CHARACTER IS A D. NEXT MUST BE A, C, L, N OR S.
05700 REM
05710        IF JJ$ = "A" THEN 5800
05720        IF JJ$ = "C" THEN 5850
05730        IF JJ$ = "L" THEN 5900
05740        IF JJ$ = "N" THEN 5950
05750        IF JJ$ = "S" THEN 6000
05760        GO TO 4660
05770 REM
05780 REM         THE SECOND CHARACTER IS AN A.
05790 REM
05800        ICODE=12
05810        GO TO 6470
05820 REM
05830 REM         THE SECOND CHARACTER IS A C.
05840 REM
05850        ICODE=7
05860        GO TO 6520
05870 REM
05880 REM         THE SECOND CHARACTER IS AN L.
05890 REM
05900        ICODE=8
05910        GO TO 6520
05920 REM
05930 REM         THE SECOND CHARACTER IS AN N.
05940 REM
05950        ICODE=3
```

```
05960        GO TO 6520
05970 REM
05980 REM  THE SECOND CHARACTER IS AN S.  ** NOT YET IMPLEMENTED **.
05990 REM
06000        GO TO 4660
06010 REM
06020 REM  THE FIRST CHARACTER IS AN O. NEXT MUST BE A, L,P OR S.
06030 REM
06040        IF JJ$ = "A" THEN 6120
06050        IF JJ$ = "L" THEN 6160
06060        IF JJ$ = "P" THEN 6210
06070        IF JJ$ = "S" THEN 6260
06080        GO TO 4660
06090 REM
06100REM THE SECOND CHARACTER IS AN A. ** NOT YET IMPLEMENTED **.
06110 REM
06120        GO TO 4660
06130 REM
06140 REM        THE SECOND CHARACTER IS AN L.
06150 REM
06160        ICODE=15
06170        GO TO 6470
06180 REM
06190 REM        THE SECOND CHARACTER IS A P.
06200 REM
06210        ICODE=16
06220        GO TO 6470
06230 REM
06240 REM        THE SECOND CHARACTER IS AN S.
06250 REM
06260        ICODE=14
06270        GO TO 6470
06280 REM
06290 REM        THE FIRST CHARACTER IS AN R.  NEXT MUST BE P OR S.
06300 REM
06310        IF JJ$ = "P" THEN 6370
06320        IF JJ$ = "S" THEN 6420
06330        GO TO 4660
06340 REM
06350 REM        THE SECOND CHARACTER IS A P.
06360 REM
06370        ICODE=13
06380        GO TO 6470
06390 REM
06400REM THE SECOND CHARACTER IS AN S.  RUN STOP-GO TO EOF ROUTINE.
06410 REM
06420        IEOF=1
06430        GO TO 7390
06440 REM
06450 REM        INCREMENT POINTER BEYOND CURRENT COMMAND
06460 REM
06470        INDX = INDX + 2
```

```
06480          RETURN
06490 REM
06500 REM          NOW LOOK FOR FOLLOWING NUMBERS.
06510 REM
06520          INDX = INDX + 2
06530          ISAVE = INDX
06540          GO TO 6560
06550          INDX=INDX+1
06560          IF INDX <= 80 THEN 6640
06570          INPUT #5,IDATA$
06580          INDX = -1
06590          IF EOF(1) THEN 7270
06600          GO TO 6520
06610 REM
06620 REM          LOOK FOR A DIGIT
06630 REM
06640          IF MID$(IDATA$,INDX,1) = "" THEN 6550
06650          KEY = ASC(MID$(IDATA$,INDX,1))
06660          IF KEY > 89 AND KEY < 101 THEN 6800
06750          GO TO 7270
06770 REM
06780 REM          DIGIT FOUND - CONTINUE SEARCHING
06790 REM
06800          NFLD = 0
06810          NDIG = 0
06820          MINUS = 0
06830          IDIGIT(1) = 0
06840          NDIG = NDIG + 1
06850          IF NDIG > 1 THEN 6890
06860          NFLD = NFLD + 1
06870          IDIGIT(NFLD+1) = 0
06875          KEY = ASC(MID$(IDATA$,INDX,1))
06890          IDIG = KEY - 91
06990          IDIGIT(NFLD) = IDIGIT(NFLD) * 10 + IDIG
07000          INDX = INDX + 1
07010          IF INDX <= 80 THEN 7050
07020          INPUT #5,IDATA$
07030          INDX = 1
07040          IF EOF(1) THEN 7240
07050          KEY = ASC(MID$(IDATA$,INDX,1))
07060          IF KEY > 90 AND KEY < 101 THEN 6840
07150          NDIG = 0
07160          IF MINUS = 0 THEN 7200
07170          IF MINUS > NFLD THEN 7200
07180          IDIGIT(NFLD) = -IDIGIT(NFLD)
07190          MINUS = 0
07200          IF MID$(IDATA$,INDX,1) = "" THEN 7000
07210          IF MID$(IDATA$,INDX,1) <> "-" THEN 7240
07220          MINUS = NFLD + 1
07230          GO TO 7000
07240          IF MINUS = NFLD THEN IDIGIT(NFLD) = -IDIGIT(NFLD)
07250          IF NFLD > 0 THEN 7400
```

```
07260    GO TO 7390
07270    IPTR = 2
07280    IF NFLD <= 0 THEN 7350
07290    IF INDX = ISAVE THEN 7350
07300    INDX2 = INDX - 1
07320    IPTR=IPTR+1
07330    IERROR$(IPTR) = MID$(IDATA$,ISAVE,INDX2-ISAVE+1)
07350    FOR I = 1 TO IPRT:PRINT "ERROR ";IERROR$(I):NEXT I
07360    IPTR=0
07370    IF EOF(1) THEN 7390
07380    GO TO 4442
07390    ICODE=-1
07400    RETURN
```

```
07410 REM
07540 REM    SUBROUTINE LINKER(KHT,KNT,KNL,KLS)
07550 REM
07560        OPEN "I",1,FILE1$
07570        OPEN "I",2,FILE2$
07590        IP=0
07610        KLS=0
07620        FOR I = 1 TO LINKS
07625        FOR J = 1 TO 3
07627        IF EOF(1) THEN 7650
07630        INPUT #1,NET(J,I)
07635        NEXT J
07640        NEXT I
07650        CLOSE 1
07660        FOR  I = 1 TO MNODE
07665        IF EOF(2) THEN 7690
07670        INPUT #2,NP(I)
07680        NEXT I
07690        CLOSE 2
07700 REM
07710 REM    INITIALIZE SEQUENCE TABLE, COUNTERS,POINTERS
07720 REM
07730        FOR I = 1 TO MAXD
07740        ISQ(I)=0
07745        NEXT I
07750        KHF = 0
07760        KHT = 0
07770        LIS = 0
07780 REM
07790 REM    CHECK FOR INCORRECT POINTERS- TO BE ADDED LATER
07800 REM
07810 REM
07820 REM    ALLOCATE LINKS AT STOPS
07830 REM    FIND ACTIVE TRANSIT STOPS AND ALLOCATE ADJACENT LINKS
07840 REM
07850        KNT=0
07860        FOR J = 1 TO MNODE
07870        IF NK(J) < 1000 THEN 8300
07880        I = NP(J)
07890        KNT = KNT + 1
07900        LSN(KNT) = J
07910 REM
07920 REM    ACTIVE STOP FOUND DETERMINE ADJACENT LINK
07930 REM
07940        L = (I+1) / 2
07950        LAB = 1
07960        LD = NET(1,L)
07970        LPA = NET(2,L)
07980        LPB = NET(3,L)
07990        IF (I - I/2 * 2) = 0 THEN LAB = 0
08030 REM
08040 REM    BY-PASS IF ALREADY ALLOCATED
```

```
08050 REM
08060        IF NET(3,L) < 0 THEN 8130
08070        LD = LD + 2000
08080        NET(1,L) = LD
08090        NET(2,L) = LPA
08100        IF LPA >= I THEN 8300
08110        I = LPA
08120        GO TO 7940
08130        LPB = -LPB
08140        LST = KNT
08150        NET(3,L) = ISQ(LD)
08160        ISQ(LD) = L
08170        LIS = LIS + 1
08180        IF LAB = 0 THEN 8220
08190        LPP = LPA
08200        LPA = LPB
08210        LPB = LPP
08220        NET(1,L) = LST
08230        NET(2,L) = LPA
08240 REM
08250 REM    FIND OTHER ADJACENT LINKS
08260 REM
08270        IF LPB >= I THEN 8300
08280        I = LPB
08290        GO TO 7940
08300        NEXT JI
08440        IF KNT = 0 THEN 9250
08450 REM
08460 REM     P R O C E S S   R E M A I N I N G   L I N K S
08470 REM        CHECK WHETHER IT COMPLETES LOOP AROUND NEW LINE
08480 REM        INCREMENT POINTER AND CHECK FOR EXIT CONDITIONS
08490        IP=IP+1
08500         IF IP > MAXD THEN 9260
08510        IF LIS = 0 THEN 9260
08520        IF ISQ(IP) = 0 THEN 8490
08530 REM
08540 REM   EXTRACT LINK AT NEW DISTANCE,SET HOOK,DETERMINE ADJACENT LINK
08550 REM
08560        KHT = ISQ(IP)
08570        NEW = KHT
08580        LIS = LIS - 1
08590        LST = NET(1,NEW)
08600        I = NET(2,NEW)
08610        LCH = NET(3,NEW)
08620        KLS = KLS + 1
08630 REM
08670        NP(KLS) = NEW
08680        IF KLS = IDIM THEN 9230
08685 REM
08690 REM      LIST OF LINKS IN SEQUENCE REACHED IS SAVED IN VECTOR NP
08700 REM     IDIM MUST BE SET TO MAXIMUM DIMENSION OF NP
08710 REM
```

```
08720         IF LST < 2000 THEN 8780
08730         LST = LST - 2000
08740         NET(3,NEW) = 0
08750         NET(1,NEW) = LST
08760         NET(2,NEW) = IP
08770         GO TO 9200
08780          L = (I+1) / 2
08790          IF L = NEW THEN 9160
08800          LD = NET(1,L)
08810         LPA = NET(2,L)
08820         LPB = NET(3,L)
08830         IF NET(3,L) < 0 THEN 8890
08840         LD = LD + 2000
08850         NET(1,L) = LD
08860         NET(2,L) = LPA
08870         I = LPA
08880         GO TO 8780
08890         LPB = -LPB
08900         LID = IP + LD
08910         IF (I/2*2) = I THEN 8980
08920         LPP = LPA
08930         LPA = LPB
08940         LPB = LPP
08950 REM
08960 REM     MAKE SURE LINK IS NOT OUTSIDE SEQUENCE TABLE BOUND
08970 REM
08980         I = LPB
08990          IF LID > MAXD THEN 8780
09000 REM
09010REM    PLACE LINK IN SEQUENCE TABLE, SWITCHCHAIN,INCREMENT COUNTER
09020 REM
09030          JJ = ISQ(LID)
09040          NET(3,L) = JJ
09050          ISQ(LID) = L
09060          LIS = LIS + 1
09070          NET(1,L) = LST
09080          NET(2,L) = LPA
09090 REM
09100 REM      FIND ANOTHER ADJACENT LINK
09110 REM
09120          GO TO 8780
09130 REM
09140 REM      CHECK WHETHER LAST LINK AT THAT CUMULATIVE IMPEDANCE
09150 REM
09160          NET(3,NEW) = 2
09170          IF (I/2*2) = I THEN NET(3,NEW) = 1
09180          NET(1,NEW) = LST
09190          NET(2,NEW) = IP
09200          IF LCH = 0 THEN 8490
09210          NEW = LCH
09220          GO TO 8580
09230        PRINT "INSUFFICIENT SPACE FOR MICRO-TRANES"
```

```
09240     GO TO 9260
09250     PRINT "NO ACTIVE NODE"
09260    PRINT KLS;" LINKS WERE REACHED, MAXIMAL IMPEDANCE WAS";MAXD
09330     RETURN
```

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