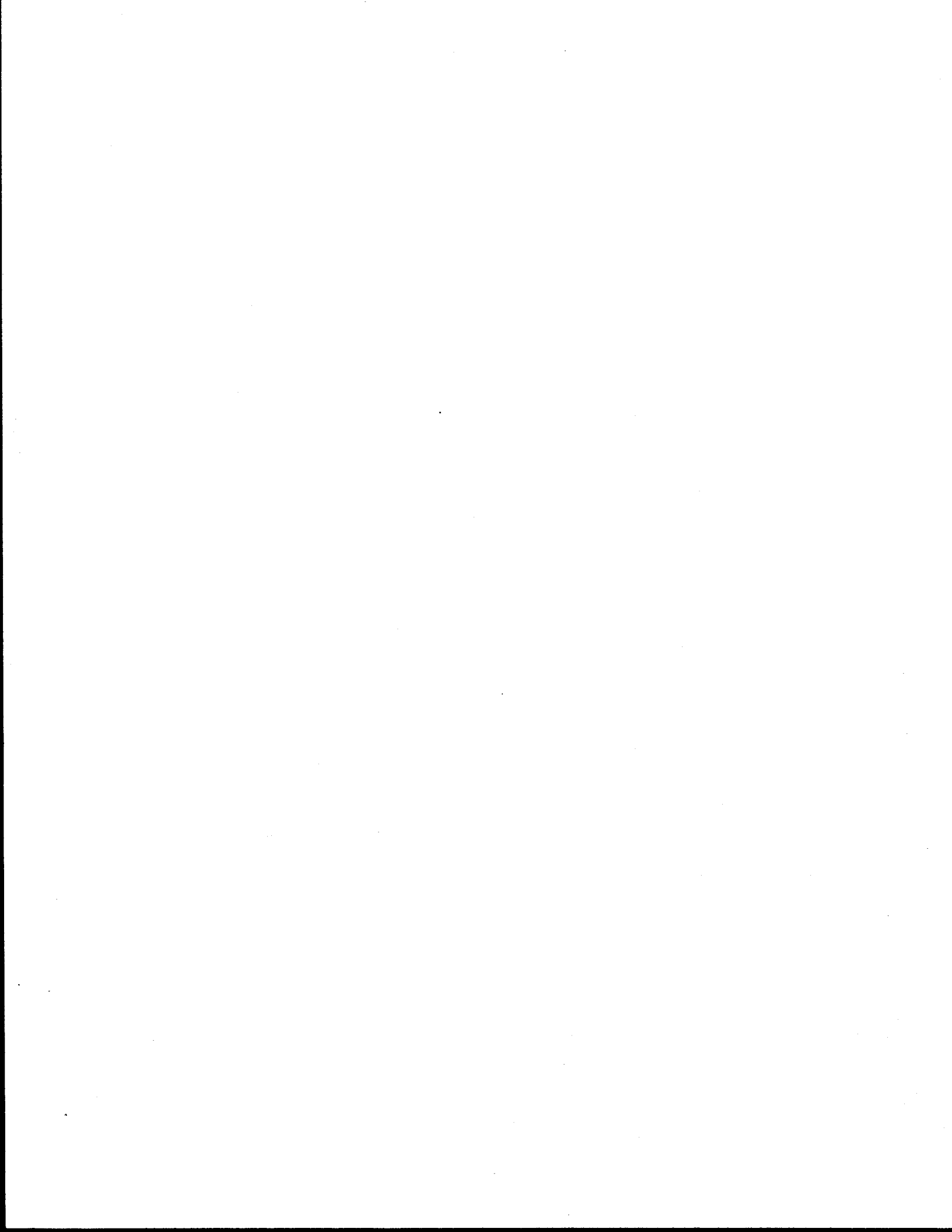


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**A COMPARISON OF MICROCOMPUTER PACKAGES
FOR
NETWORK-BASED HIGHWAY PLANNING**

by

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Study Supervisor**

Subarea Analysis Using Microcomputers

Research Report Number 1110-3

Research Study Number 2-10-87-1110

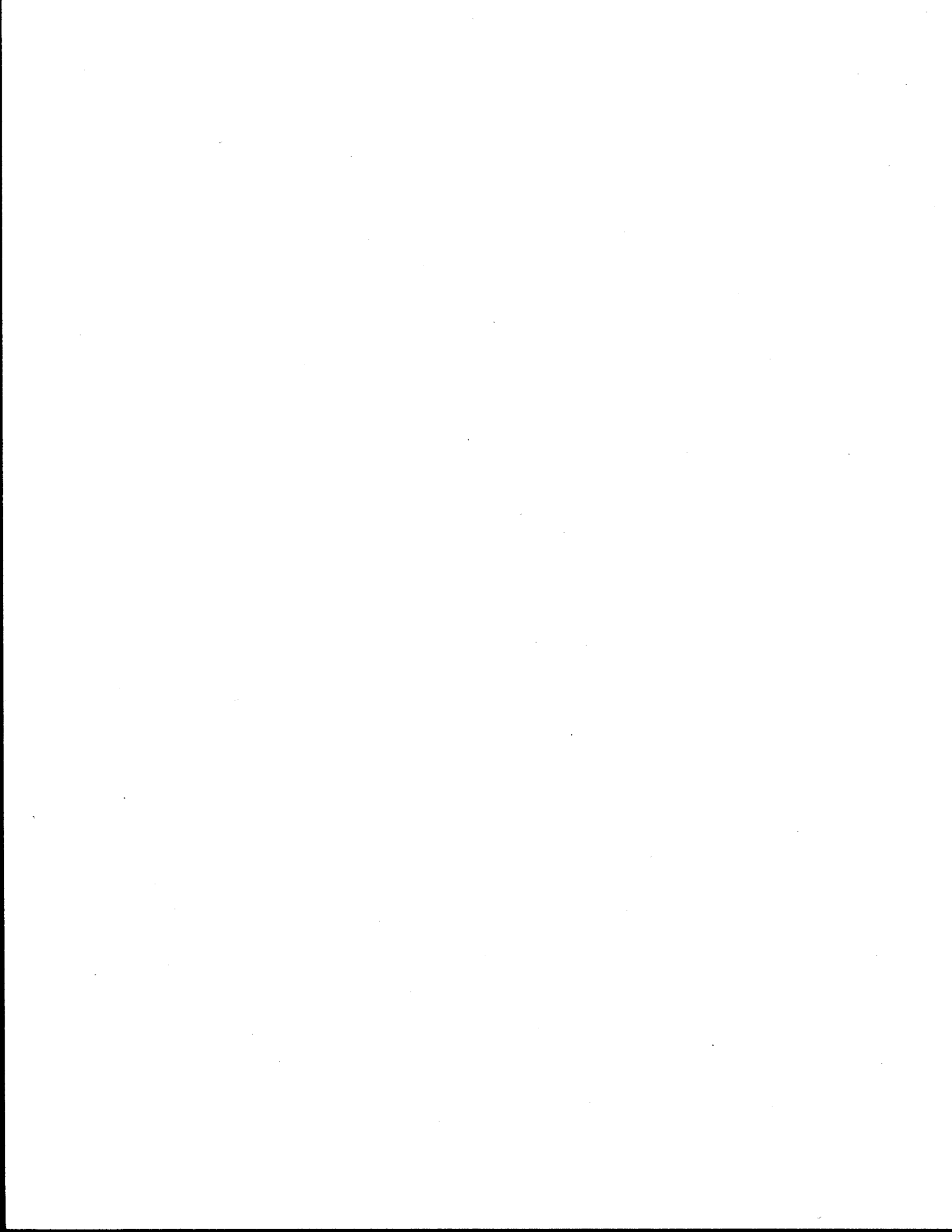
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**In Cooperation with the
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October 1988



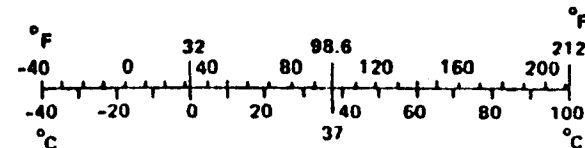
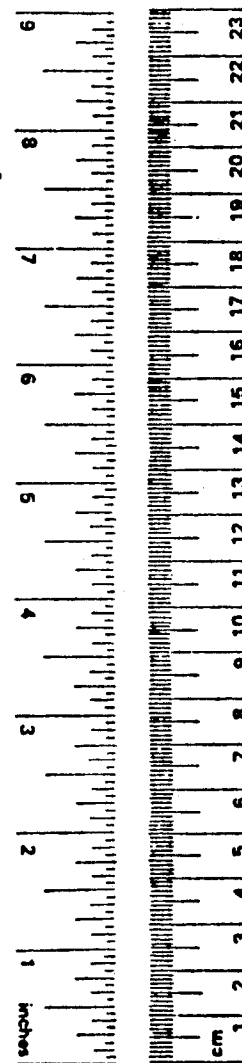
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

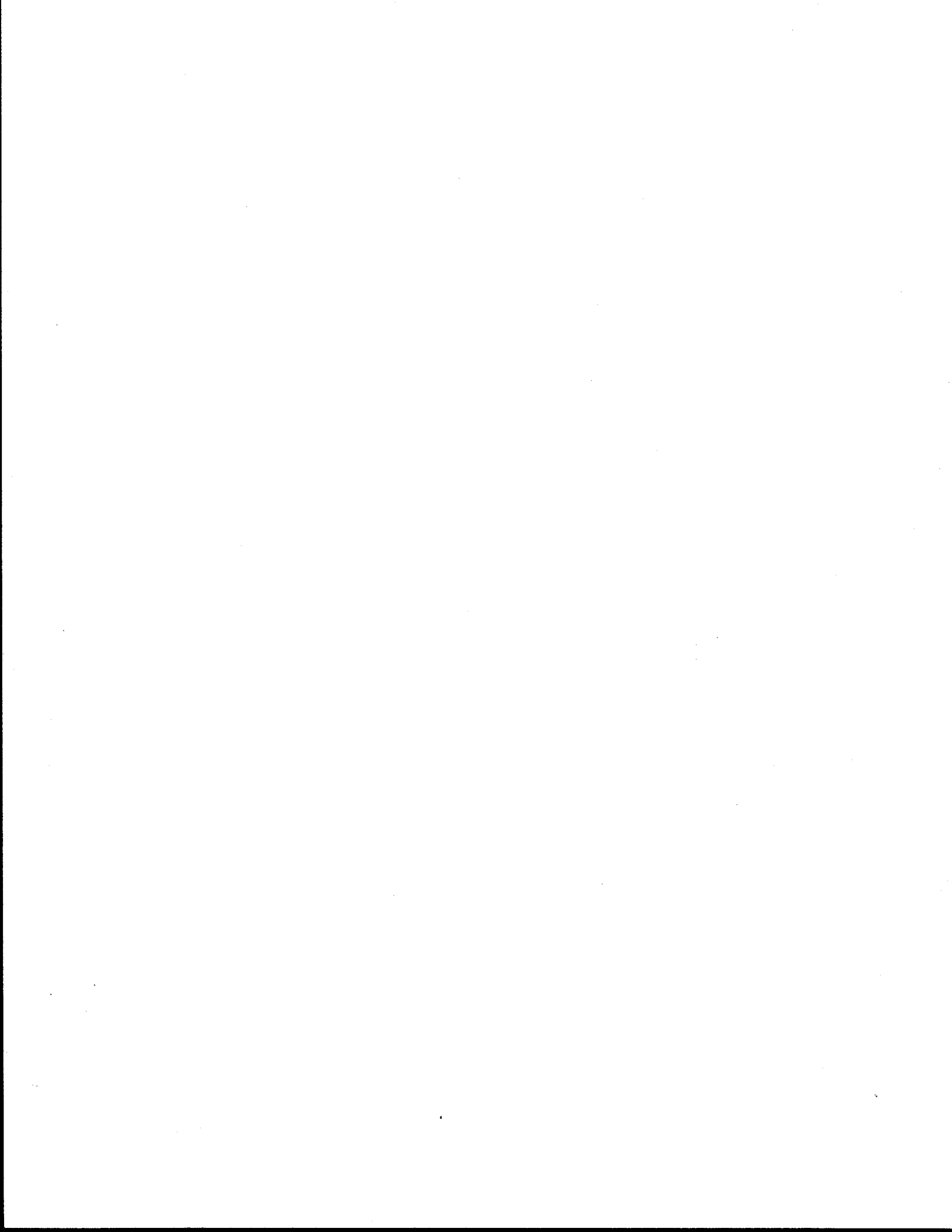
Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi 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

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	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	35	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



* 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.



ABSTRACT

In an effort to meet the increasing requirement to perform transportation studies for a small geographic area within a major urban area, existing microcomputer software was evaluated for suitability to perform subarea analysis and its compatibility with the output from the Texas Travel Demand Package. The initial phase of the study included a detailed literature and software search. Eleven potential transportation software packages were identified and five packages were chosen for further in-depth evaluation. They are: TRANPLAN/NEDS (11 program diskettes and user's manual); MicroTRIPS (9 program diskettes and user's manual); MINUTP (5 demonstration diskettes and user's manual); MOTORS (11 diskettes and user's manual); and TransPro (2 demonstration diskettes and user's manual). Information was provided by each vendor in January 1987.

TRANPLAN, MicroTRIPS, and MINUTP packages are the comprehensive software systems for transportation planning and parallel UTPS/PLANPAC in functional capability. However, MicroTRIPS and MINUTP are evaluated as being less compatible with the Texas Traffic Assignment Package and as having fewer capabilities than TRANPLAN. MOTORS package has limited network plotting capabilities and functional network building capabilities. TransPro package is too simple to be compatible with the network-based analysis used by the Texas Travel Demand Package. Finally, the TRANPLAN/NEDS packages were selected for suitability to perform subarea analysis and for compatibility with the output from the Texas Travel Demand Package.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the State Department of Highways and Public Transportation. This report does not constitute a standard, specification, or regulation.



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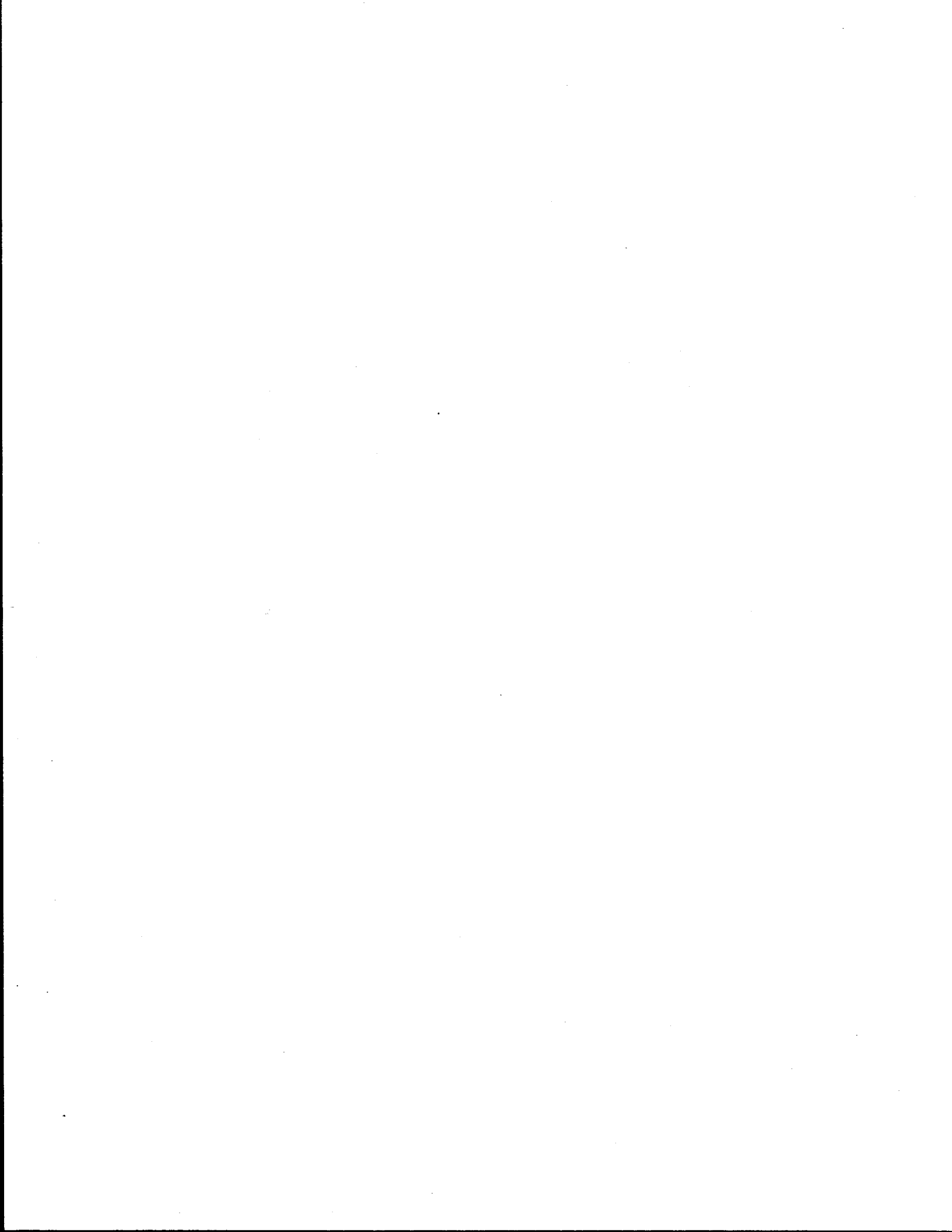
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CHAPTER 1. INTRODUCTION

There is an increasing requirement to perform transportation studies for small geographic areas within a major urban area. The level of network detail desired for these analyses is much greater than the network detail used for urban transportation studies. The subarea windowing and subarea focusing capabilities incorporated into the Texas Travel Demand Package are appropriate for some applications. However, because of the complexity of the Texas Travel Demand Package, the Package is not the most appropriate tool for all subarea applications; and because of the training required, only a limited number of people are able to use the Package.

Microcomputer technology is developing very rapidly. The hardware and software capabilities are improving and the costs are declining. Presently the microcomputer software packages designed for transportation network analysis and other transportation planning applications are in varying stages of development and maturity, and some are being modified to take advantage of recent improvements in operating systems. This rapid change makes evaluation of the packages more difficult. However, these packages are sufficiently advanced that purchase of an existing package is more cost effective than developing a new package.

1.1. OBJECTIVES

Objectives of the report are to evaluate existing microcomputer software for suitability to perform subarea analysis and for compatibility with the Texas Travel Demand Package. This report has been prepared not to attempt a critical evaluation and not to conduct rigorous performance evaluations. Transit route planning programs and plotting programs that use a network base were not considered for critical review.

1.2. PREPARATION OF THE REPORT

The initial phase of the study included a detailed literature and software search. As a result, the following eleven potential transportation software packages were identified:

- o QRS ----- Quick-Response Travel Estimation (COMSIS Corp.)
- o IRAP ----- Local Area Traffic Assignments - Interactive Routing Assignment Process (Roger Creighton Associates, Inc.)
- o ASSIGN -- Traffic Generation, Distribution & Assignment (CH2M Hill)
- o LinkOD -- (National Technical Information Service)
- o TMODEL -- Transportation Modeling System (Professional Solutions)
- o TRANPLAN/NEDS -- Transportation Planning Package (James Fennessy and Raif Kulunk for Deleuw, Cather & Co.)/Network Editing and Display System (Center for Urban Analysis and James Fennessy, DKS Associates)
- o MicroTRIPS -- (PRC Voorhees/RVA/MVA Systematica)
- o MINUTP -- (COMSIS Corp)
- o MOTORS -- (M.M. Dillon Ltd.)
- o EMME/2 -- (Centre de Recherche sur les Transports)
- o TransPro - (Transware Systems)

The Quick Response System II (QRS II) was developed in August 1987. QRS II is an entirely new implementation of the theory and philosophy found in the original NCHRP report; however, it was not available at the time the initial phase was performed.

A substantial portion of the material for this report comes directly or indirectly from the "Microcomputers in Transportation - Software and Source Book" published by UMTA (most recently in February 1987), from the draft report "Transportation Network Analysis Packages for Microcomputers" written by Multisystems, Inc. in January 1985, and from the information provided by software vendors. Package vendors were asked to provide a user's manual or comparable documentation, access to the package, and test data.

After an initial review of each package, the following five packages were chosen for further in-depth evaluation (information was provided by each vendor in January 1987):

- o TRANPLAN/NEDS (14 program diskettes and user's manual of TRANPLAN)
- o MicroTRIPS (9 program diskettes and user's manual)
- o MINUTP (5 demonstration diskettes and user's manual)
- o MOTORS (11 program diskettes and user's manual)
- o TransPro (2 demonstration diskettes and user's manual)

The draft report comparing the various microcomputer programs, "Detailed Evaluation of Microcomputer Packages for Network-Based Highway Planning," was completed in June 1987. The microcomputer programs and manuals received from various vendors of the software packages were returned. The Appendix of the draft report was also sent to each vendor (i.e., TRANPLAN, MicroTRIPS, MINUTP, MOTORS, and TransPro) for their review.

In the final phase of the review, information on the packages was obtained from each vendor. The draft report was corrected, modified, and enlarged based on their review; resulting in this final report.

1.3. PACKAGES ELIMINATED FROM FURTHER EVALUATION

The following packages were dropped from further consideration as they are incompatible with the objectives and/or the Texas Travel Demand Package:

- o QRS
- o IRAP
- o ASSIGN
- o LinkOD
- o TMODEL
- o EMME/2

The procedures of the QRS package are not compatible with the network based analysis used by the Texas Travel Demand Package. The maximum number of zones (50) is less than that required for intended application. The gravity model in the trip distribution process utilizes zone-to-zone travel times which are input directly or are converted from airline distances. The gravity model output (e.g., P's and A's) are never converted to O's and D's; therefore, data files must be laboriously re-entered each time the model is

run. The traffic assignment is non-network based; the QRS user must specify the links on which a given O-D movement is to be loaded. Although developed to be user friendly, it was found to be less user friendly than other packages (e.g., QRS uses NCI P-System which is different from IBM-DOS). Screen prompts and written documentation at times do not give sufficient guidance.

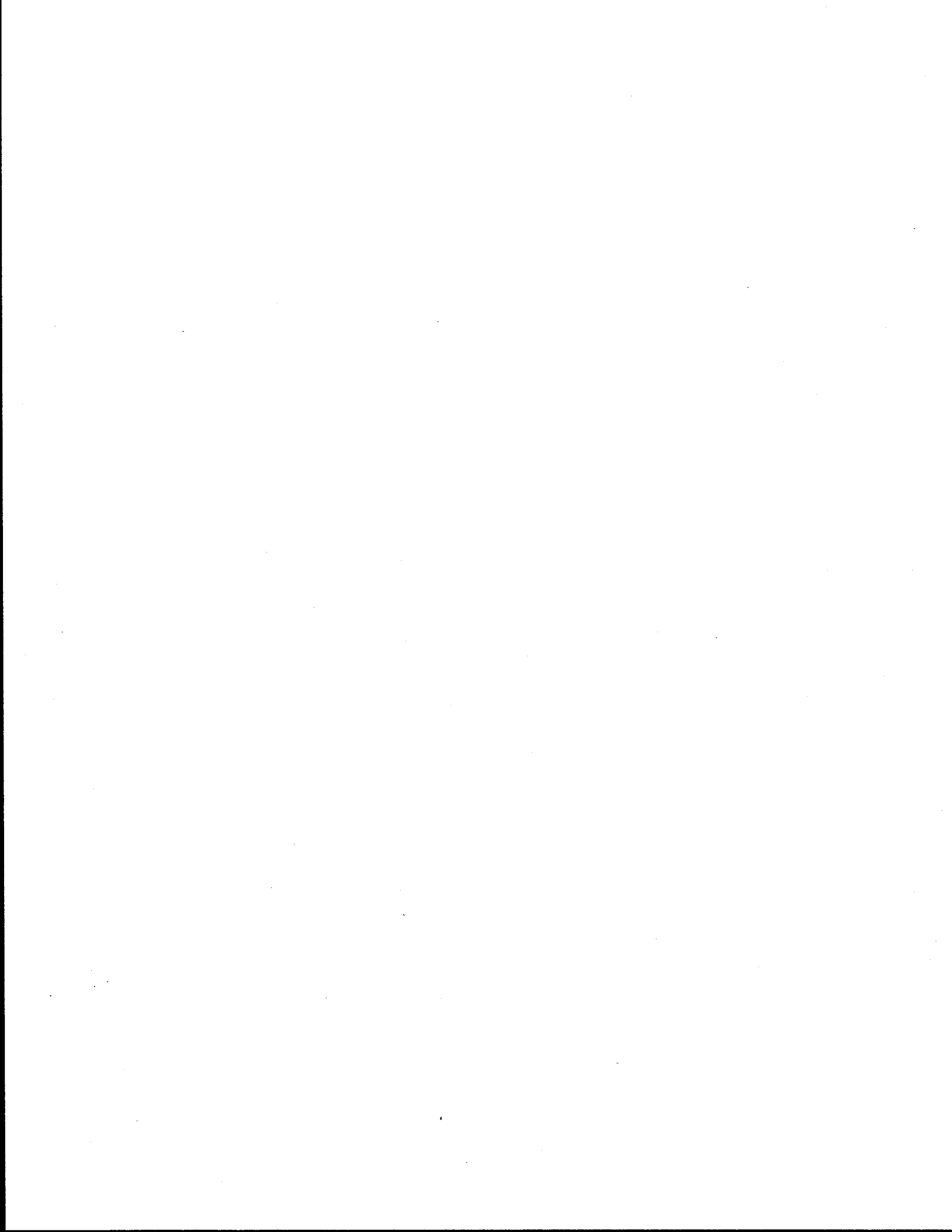
The IRAP package was designed for the analysis of micro-areas such as central business districts or shopping malls (e.g., the limitation of 50 zones is less than required); it was not designed for network analysis/evaluation of the type performed using the mainframe package. Specific deficiencies for regional networks include the following: minimum paths are calculated only from a specified origin to all destinations, paths are limited to 30 links, and trip distribution must be done manually since it does not have a trip generation program and a trip distribution capability.

The ASSIGN package has the limitation of 75 zones. The package has the following trip distribution deficiencies: it does not include the Fratar method, external-external trips are distributed by the gravity model, or they may be excluded and dealt with manually. Trip tables cannot be entered directly. Although trip tables can be created, the gravity model requires a user-defined exponent value rather than friction factors, as used in the Texas Travel Demand Package. Trip ends are assumed to be origins and destinations (not productions and attractions) and no conversion from P's and A's to O's and D's is provided. Thus, the gravity model is used to distribute O's and D's, a procedure not compatible with standard practice. The package also does not have a matrix handling capability.

The LinkOD program generates an estimated O-D table from link volumes. The process is not applicable to the standard trip generation, trip distribution, and traffic assignment processes where trip ends are calculated based upon socioeconomic-demographic variables and trip generation rates.

The TMODEL trips are loaded directly at the nodes rather than via centroid connectors as in the Texas Travel Demand Package procedure (i.e., there are no centroid connectors); therefore, a zone is defined as the area surrounding its link-like node number. Paths are always built through zone centroids. The package has no provisions for link type codes. Trips are simultaneously distributed and assigned; therefore, a gravity model is applied within the assignment module. Path building is also imbedded in the assignment module.

EMME/2 integrates the most recent advances in graphic displays. A very important graphic tool of EMME/2 is the graphic window. The window allows the user to view, change, and plot networks. Graphic windowing is accomplished several ways including using coordinates, a digitizing pad, previously designed windows, and centering on an individual node. However, EMME/2, which is the most expensive package and requires expensive hardware systems, was not evaluated.



CHAPTER 2. EVALUATION OF SELECTED MICROCOMPUTER PACKAGES

2.1. GENERAL INFORMATION

In an effort to meet the increasing requirement to perform transportation studies for small geographic area within a major urban area, existing microcomputer software was evaluated for suitability to perform subarea analysis and its compatibility with the output from the Texas Travel Demand Package. This report has been prepared not to attempt a critical evaluation and not to conduct rigorous performance evaluations. Transit route planning programs and plotting programs that use a network base were not considered for critical review.

HARDWARE REQUIREMENTS

The most common environments are microcomputers using the CP/M-80 operating system and the IBM/XT and compatible machines. In general, the packages run on the IBM-PC use PC-DOS or MS-DOS, version 2.0 or higher. Table 2-1 shows hardware requirements of the packages.

Table 2-1. Hardware Requirements

PACKAGES	Plotters	IBM-PC or Compatible	Math Co- Processor	Hard Disk/ Space	HR Color Monitor	Mouse/ Tablet
TRANPLAN	Y	Y	Y	Y/10MB	Y	Y
MicroTRIPS	Maybe	Y	Y	Y/10MB	Y	Maybe
MINUTP	Optional	Y	Y	Y/5MB	Optional	Optional
MOTORS	N	Y	Y	Y/8MB	N	N
TransPro	N	Y	Y	N	N	N

Note: Packages were received in January 1987.

TransPro and MINUTP may operate with a single floppy disk, but a second drive is desirable to minimize disk swaps during an analysis. While the TransPro package was initially designed for use on a computer system limited to two floppy disk drives, the trend in use of a hard disk is advantageous for using the larger packages which are stored on multiple diskettes. MINUTP is provided on four floppy disks (or five if plotting and interactive graphics are obtained) which require 700 KB program storage.

TRANPLAN, which is the largest, is distributed on 12 (13 if plotting) diskettes and acquires 3.5 MB of disk space only if all programs are on-line -- this is virtually never the case; therefore, 2.0 MB is sufficient to use for program storage. Both MicroTRIPS and MOTORS encompass eight floppy

disks which require 2.5 MB of storage on a hard-disk drive. In addition, all microcomputers have required at least 10 MB of mass data storage available and most have suggested 20 MB of the hard-disk environments.

Most packages operate with or without a math-coprocessor chip installed, which speeds up the functions in floating point arithmetic. Printer requirements are essentially not critical; only TRANPLAN requires 132-column printers, and they can be controlled by either carriage tape or software controls in most printers.

Four of the packages (TRANPLAN/NEDS, MicroTRIPS, MINUTP, and MOTORS) currently have network displaying and plotting capabilities which require high resolution monitors and a variety of plotters. However, MOTORS-PLOT produces hardcopy printouts using only a dot matrix printer. Digitizing tablets and Puck, or a serial port and a mouse system, are utilized for data input or cursor reading.

PACKAGE CAPABILITIES

TRANPLAN, MicroTRIPS, MINUTP, and MOTORS are comprehensive; they handle both highway and transit networks and offer a variety of travel estimation and matrix processing options. MOTORS has recently developed network plotting capabilities, but it has less plotting capabilities than other packages. TransPro is too simple to be compatible with the network based analysis used by the Texas Travel Demand Package. Also, TransPro has neither transit network features nor network plotting capabilities. Table 2-2 shows the design limits of the five packages.

Table 2-2. Network Size with 512K RAM and Package Limits

PACKAGES	Maximum Network Size			Trip Purposes	Trip Variables	Link Types
	Zones	Nodes	Links			
TRANPLAN	1500	8000	9000	15	25	10
MicroTRIPS	2000	9999	12000	3	18 w/6 types	32
MINUTP	Unlimited	8190	32300	9	26	63
MOTORS	400	2000	6000	3	108 types	4
TransPro	300	3000	3000	5	N.A.	100

Note: Packages were received in January 1987.

The several microcomputer packages have different network design limits (see Table 2-2). The network size limits also vary according to the amount of main memory available. TRANPLAN is designed for 3000 zones and 32000 links; however, 1500 zones, 8000 nodes, and 9000 links can be processed on 512K RAM microcomputer. MicroTRIPS is capable of processing 2000 zones,

9999 nodes, and a range of links. With 512K RAM, about 12000 links can be processed. MINUTP networks can contain up to 32300 directional links, and 8190 nodes. The number of zones is restricted to 8190, but MINUTP could function efficiently at the 800 to 1200 zone level. MOTORS can accommodate the maximum study size of 400 zones, 2000 nodes, and 6000 links. The current system capacities in TransPro are 300 zones, 3000 nodes, and 3000 links.

In TRANPLAN, an assignment group code (A/G value = 0 to 9) may be specified for each link to indicate which user-specified speed-column curve is to be applied during a capacity-restrained assignment. In addition, up to three sets of two-digit link group codes (L1, L2, and L3) can be assigned to each direction of the link. These codes can be used in macro-updating and in selecting links for network reports and summaries. A direction code (DIR ranging from 1 to 16) may be specified for each link; the codes are used to designate turn penalties.

A link type code (maximum value = 32) is used to indicate a default capacity and a volume-delay curve and to summarize network performance in MicroTRIPS. Speed class (1-63) and capacity class (1-63) may be used for the MINUTP link type codes. TransPro defines a set of facility codes which is used to describe a maximum of 100 types of network links.

All MOTORS links are assigned to one of only four different categories based on a capacity indicator (KAPCL); local links, intersection-delay links, arterial links, and dummy links.

STRUCTURE AND OPERATIONS

The microcomputer packages are operated basically by function (e.g., applying a trip generation model), option (e.g., print trip end), parameter (e.g., the number of iterations), and data file specifications (e.g., highway link input or output data files).

The possible ways in which a user runs a particular program within each package are as follows:

1. Specifying the command in an instruction or job control file that the user sets up for the package using a line or screen editor (i.e., control file or user job control file).
2. Choosing from a menu(s) or list(s) that the package displays on the terminal screen (i.e., screen prompt or menu choices).
3. Typing the function or program name on the keyboard (i.e., file-name, user specification, or scenario).

The interactive specification (i.e., screen prompt or menu choices) of parameters and options may help a new user, while an experienced user may find control files more efficient and flexible for analyses involving repetitious applications of the programs. Basic structure and operation of the packages are shown in Table 2-3.

Table 2-3. Basic Structure and Operation

PACKAGES	Function Selection	Option Selection	Parameter Specification	Data File Selection
TRANPLAN	Control File	Control File	Control File	Filename
MicroTRIPS	User Specify	Screen Prompt	Screen Prompt	Filename
MINUTP	User JCL	User JCL	User JCL	Scenario
MOTORS	User Specify	Screen Prompt	Screen Prompt	Filename
TransPro	User Specify	Screen Prompt	Screen Prompt	Scenario

Note: Packages were received in January 1987.

Unlike other transportation software, TRANPLAN uses English-like syntax and uniform specifications in all programs. The TRANPLAN user enters explicit commands (e.g., PRINT LINK LOADS). Therefore, TRANPLAN is easy to learn and operate. Recently, TRANPLAN has been interfaced with on-line, interactive graphics software for network editing and display (NEDS). NEDS is a menu-driven graphics package for the creation and maintenance of transportation planning networks, as well as for the display of network attributes and assignments.

The TransPro modeling package has been designed to simplify the application of the software system to transportation planning problems. The objective is to make it possible to calibrate and run models easily and quickly, so that no job control language (JCL) is involved, and data are entered directly on the microcomputer keyboard. The programs prompt the user for all variable run-time parameters in a self-explanatory, interactive manner and ask for confirmation of all run-time keyboard entries.

The MicroTRIPS programs are capable of operating in both an interactive or batch environment. Although the way in which the programs run in either of these two environments differs considerably, the program descriptions that follow attempt to reflect the needs of both types of user. However, batch mode operation is not recommended on microcomputer installations. The MicroTRIPS user specifies the job to be executed at run time by means of interactive questions/answers on a visual display terminal. No JCL is required for the interactive user. The terminal is dedicated to the user and the job will execute immediately. Therefore, the user supplies parameters and options by answering a series of prompted questions.

The models used in MOTORS are designed to simplify application in transport planning problems. The package provides a method of analyzing transport planning options which are "user friendly" and makes full use of the interactive capability of the microcomputer. The MOTORS programs are designed to be used in sequence and a standardized method of data file identification and management is used. Also, the programs prompt the user for all file names and parameters in a self-explanatory interactive manner.

The MINUTP system is designed to be run primarily as a batch job, but it can be run in a pseudo-interactive manner. Inter-program chaining is provided by a batch file generated by the MINUDR program if the user designates batch mode. If console mode is designated, the user controls module flow by entering the program commands directly. This package is the most difficult to learn and operate among the various microcomputer packages. Table 2-4 shows the degree of user friendliness, program language of the packages, and supplemental softwares for the packages.

Table 2-4. User Friendliness and Software

PACKAGES	Easy to Learn and Operate	Program Language	Plot/Interactive Editor
TRANPLAN	Very Easy	FORTRAN-77	PLOTNET/NEDS
MicroTRIPS	Easy	FORTRAN-IV	MVPLLOT/MVGRAF
MINUTP	Difficult	FORTRAN/ASSEM.	NETPLT/NETVUE
MOTORS	Easy	FORTRAN	MOTORS-PLOT
TransPro	Very Easy	"C" Language	N.A.

Note: Packages were received in January 1987.

PACKAGE PRICES

Table 2-5 summarizes the current (January 1987) list prices of the software packages. Source code is available from TRANPLAN only; the prices do not include source code. The prices in the table are subject to change.

Table 2-5. Package Prices

PACKAGES	Total	Highway Analysis	Transit Analysis	Plotting
TRANPLAN	5500	2000	1000	2500 (NEDS)
MicroTRIPS	7500	5000	1500	1000
MINUTP	5500	5000	Included	500
MOTORS	3700	2000	1000	700
TransPro	995	995	N.A.	N.A.

Note: Packages were received in January 1987.

2.2. NETWORK PREPARATION

The different procedures are available in each package for preparing and updating highway networks (i.e., adding, deleting, and changing links and nodes). MOTORS provides for interactive network data entry; MOTORS presents the user with formatted screen displays for entering and editing link (and node) data. The rest of the packages provide for batch entry of network data from a file prepared using a text editor or a program developed by the user.

The packages require two different principal options to create alternative configurations of a network: using the interactive procedures available for developing a base network and using a text editor to modify a copy of the card-image file that defined the base network. TRANPLAN and MINUTP do not require a copy of the base data be made prior to making changes, either using internal procedures or operating system commands. In other words, TRANPLAN and MINUTP allow the user to prepare a card-image file containing only the links to be changed.

Some of the packages allow certain network changes to be made on a more general basis. MicroTRIPS and MINUTP provide link type codes that may be used to assign capacities and speeds, and the user can modify these tables to analyze certain link improvements or different time periods. MOTORS and TRANPLAN also provide the user with procedures for analyzing different time periods; MOTORS allows capacities to be factored by link type, while TRANPLAN allows the user to code two speed and capacity values for each link.

In addition, MINUTP and TRANPLAN contain network updating features that allow the user to delete links or modify their characteristics using a series of commands that can contain conditional criteria. For example, in TRANPLAN, when a large set of links are to be modified or deleted according to some consistent pattern, rather than link by link, the MACRO HIGHWAY NETWORK UPDATE function should be used instead of the update option in BUILD HIGHWAY NETWORK function.

NODES

Nodes are defined by the user during the manual coding of a network and are identified to each package primarily as the end points of links. A separate file of node coordinates (with X and Y values) is set up for plotting networks, but otherwise, coordinates are not used.

Nodes must be numbered in the sequence of zones and other nodes in most packages for practical purposes; zones must be numbered sequentially without any gaps, but gaps are allowed in numbering other nodes with the exception of MOTORS which does not allow gaps. There may be gaps in the zone numbering scheme of MINUTP, but that practice is not recommended. TransPro does not require nodes to be numbered sequentially; numbering gaps is permitted. However, the package does require centroid or zone nodes to be numbered below 300.

LINKS

A link distance is specified in hundredths of a unit with certain maximum value for most packages. Either a speed or a travel time in hundredths of a unit may be specified as impedance information. However, MOTORS link distances and travel times are specified in tenths of a mile and tenths of a minute. If speeds and/or distances need to be coded to hundredths, then they should be factored by 10 before coding in MOTORS. MicroTRIPS link distances and impedances are specified in hundredths of units. In MOTORS and MicroTRIPS, the separation matrix is output in tenths of a minute; link impedances are also calculated in tenths of a minute.

In TRANPLAN, up to two time or speed values may be supplied for each directional link. An hourly capacity is entered for each link direction with maximum value of 999,999. Observed (directional) volumes may be coded, or the data fields may be used to enter alternative capacities.

In MINUTP, an hourly capacity per lane and the number of lanes on each link is specified as input instead of the capacity in the direction; and there is a provision for multiple time periods or operating conditions. MINUTP uses a parameter to assign the capacities at run time such that the user may change capacities with a simple command at the time assignment is run.

B-to-A values need not be coded for symmetrical links in most packages. A-to-B and B-to-A link data in MOTORS must be entered separately, but links of MOTORS entered interactively can be designated as two-way if characteristics are the same in both directions. In TRANPLAN, a table of opposite direction codes can be supplied in the network parameters.

As mentioned earlier in Package Capabilities of Section 2.1, in TRANPLAN up to nine assignment group codes may be specified for each link, and up to three sets of two-digit link group codes can be assigned to each direction of the link. A direction code (ranging from 1 to 16) may be specified for each link; the codes are used to designate turn penalties. A user identification field allows the user seven alpha-numeric characters to aid in identifying the particular link.

TransPro requires two separate files to build a highway network. A FCODE.DAT file defines a set of facility codes which are used to describe various types (maximum value = 100) of network links. The file is created by entering numbers in the following sequence to form a data group:

(facility code) (speed) (directionality) (capacity) (delay time)

A NETWORK.DAT file depicts the essential characteristics of each network link for analysis purposes. The file is created by entering numbers in the following sequence to form a data group:

(A node) (B node) (link distance) (facility code)

A link type code (maximum value = 32) is used to indicate a default capacity and a volume-delay curve and to summarize network performance in MicroTRIPS. Speed class (1-63) and capacity class (1-63) may be used for the MINUTP link type codes. All MOTORS links are assigned to one of only

four different categories based on a capacity indicator (KAPCL): local links, intersection-delay links, arterial links, and dummy links.

PATHS AND SEPARATION MATRICES

There are various tree-building options in each package. A test run of the tree-building program in each package may be performed to print trees for selected zones, but no path file is produced in MOTORS. Up to 25 trees may be built in a test run of MicroTRIPS.

TRANPLAN and MINUTP have a choice of direction which can be used if paths or impedances into origin zones for directional networks are needed. All packages have an option for building paths through the zone centroid except MOTORS. TRANPLAN and MINUTP have an option of building vines for minimum path determination.

TRANPLAN and MINUTP may build multiple paths (using Dial's algorithm) only as an integral part of a stochastic assignment; they cannot be stored, printed or skimmed. In MicroTRIPS, a variability factor can be used to spread trips and (in the aggregate) approximate a multi-path assignment.

TRANPLAN and MINUTP may build, trace and skim Zone-to-Zone and/or Node-to-Node trees from all or selected nodes. TRANPLAN may print paths for up to 20 selected nodes. TRANPLAN and MINUTP may display paths graphically, interactively, or can print paths as a report. However, MicroTRIPS and MOTORS cannot specify selected nodes as origins/destinations.

Separation Matrices are built from selected or all zones to all other zones in the network. The various components and weights are used in calculating link impedances used in each package. Link time or speed data coded in the network, or calculated in a previous assignment, are used in building paths for review, skimming, initial assignment, or all-or-nothing assignment. In a capacity-restrained assignment of TRANPLAN, the user may choose between applying the similar BPR formula and supplying volume delay curves. Each curve, which applies to one or more link assignment groups designated by the user, is specified as a series of points that define a linearly segmented curve. The "x" values are volume/capacity ratios, and the "y" values are ratios of congested to base travel time in TRANPLAN. MINUTP, MOTORS, and TransPro do not include curve option. The similar BPR formulas are used as follows once an initial assignment has been made:

$$T_n = T_{n-1} \text{ (or } T_0) \times [1.0 + 0.15(V/C)^4] \times 0.87 \text{ ===== TRANPLAN}$$

$$T_n = D \times T_0 \times [1.0 + 0.15(V/C)^4] \text{ ===== TransPro}$$

$$T_n = T_0 \times [1.0 + C_s \times D \times (V/C)^4] \text{ ===== MINUTP}$$

$$T_n = T_0 + (V/C)/[10(1-V/CQ)] = \text{MOTORS link times by intersection delay}$$

$$T_n = T_0 \times [0.75 + 0.25/(1-V/CQ)] = \text{MOTORS other link times}$$

where: T_n = travel time on loaded link (in minutes)
 T_{n-1} = travel time of the previous iteration (in minutes)
 T_0 = free-flow travel time (in minutes)

- V = assigned volume
- C = capacity specified in link data
- D = dampening factor (supplied as a program parameter)
- C_s = coefficient, defaults to 0.15
- Q = the multiple of capacity at which travel times becomes infinite (supplied through a screen prompt)

If capacity restraint is being applied in MicroTRIPS, speeds are calculated using the speed-flow curve specified for the link's type. A curve has three segments that are based on parameters specified by the user as follows:

1. Volume Factor: Link volumes are multiplied by the volume factor before determining their positions on the speed/flow curve.
2. Speed Factor: This is a dampening factor which regulates the amount of speed adjustment made after obtaining a speed value from the speed/flow curve. The new link speed is calculated using the following formula:

$$V_{\text{new}} = V_{\text{old}} + (V_{\text{curve}} - V_{\text{old}}) \times \text{Speed Factor}$$

3. Use of Over-Capacity Delay Curve: If a link is over capacity the link speed may be calculated using the following UK Department of Transport formula:

$$V = V_c / [1.0 + V_c(Q/Q_c - 1.0)/8L]$$

where: V = speed at flow Q
 Q = demand flow
 V_c = speed at capacity
 Q_c = volume at capacity
 L = link length

If this formula is not selected, then the speed of a link whose volume is over capacity is set to the capacity speed.

Link distances in most packages are used as specified in link data. However, distances in MOTORS are used as entered with link data or calculated by the network building program from speed and travel time data. To reflect tolls, the user has to code special links with either fixed impedances in MicroTRIPS and TRANPLAN, or high capacities and times (or distances) that are equivalent to the toll when weighted in MOTORS and MINUTP. Terminal times are also supplied as program parameters in MINUTP, and as a file read by the path skimming program in MOTORS.

In TRANPLAN, paths can be built using link "costs," which are added to the network using a special program. The cost may either be a weighted sum of time and distance, or obtained from a linearly-segmented curve relating cost per unit distance to speed. The weights and curves are specified by the user, and different weights and curves can be applied to different link and assignment groups. Two cost values can be stored in a network, and link times also may be modified using this procedure.

MINUTP can also build paths using link "costs," which are either a function of time and distance, or a computed link impedance from a linear

curve of mathematical equation. MINUTP is very flexible with the application of the impedances based upon user-definitions. In MicroTRIPS, variability may be added to weighted link impedances by specifying a coefficient of variation, which may vary from zero to 100 percent of the calculated value.

Weights may be applied to link times and distances in MicroTRIPS and TRANPLAN, and applied to link times, distances, and terminal times in MINUTP. In MOTORS, weights as a linear function of time and distance are entered in response to screen prompts in the path building program.

Intrazonal impedances are added to an impedance matrix using the matrix updating program in most packages. The maximum zone-to-zone impedances are $2^{31}-1$ (weighted) hundredths of minutes in TRANPLAN, 4000 tenths of minutes in MicroTRIPS, 32766 hundredths of minutes in MINUTP, and 32766 tenth of minutes in MOTORS.

2.3. TRIP GENERATION

Three of the packages (i.e., TRANPLAN, MINUTP, and MOTORS) allow the user to estimate trip productions and attractions as linear functions of zone characteristics. If the zonal variables are set up as household or other categories, the equation coefficients can be specified as trip rates to yield a category rate model. The users of MicroTRIPS and MOTORS can set up complex household classification schemes. MOTORS also allows the user to estimate rates from a survey data file. All packages allow the user to directly specify trip ends or to adjust estimated or specified values. The trip end file in TRANPLAN and MINUTP which is "card-image" can be prepared using a system editor or an alternative trip generation program developed by the user. Table 2-6 summarizes the different trip generation features of each packages.

Table 2-6. Trip Generation Features

PACKAGES	Equations	Category Rates	Automatic Balancing	Trip End Entry/Updating
TRANPLAN	Y	Y	Maybe	Y
MicroTRIPS	Y	Y	Y	Y
MINUTP	Y	Y	Y	Y
MOTORS	Y	Y	Y	Y
TransPro	N	Y	Maybe	Y

*Note: Packages were received in January 1987.
Maybe = No direct provision.*

MicroTRIPS automatically scale attractions to equal productions. In the old version of TRANPLAN, there is no explicit provision for production/attraction balancing in the generation program; however, TRANPLAN's gravity model will scale attractions to match productions. MINUTP can optionally scale productions to attractions or the user-defined control totals. The MOTORS user must balance trip ends within five percent prior to running a distribution model.

As shown in Table 2-3, productions and attractions can be calculated for up to 15 purposes in TRANPLAN, nine purposes in MINUTP, and five purposes in TransPro. With MicroTRIPS and MOTORS, a large number of different trip purposes is available because the trip generation program is run once for each trip purpose in MicroTRIPS and three purposes in MOTORS.

Generation equations of four packages (i.e., TRANPLAN, MINUTP, MOTORS, and MicroTRIPS) can be supplied for a specific time period. Alternatively, trip tables can be factored to produce hourly or analysis period tables.

The number of trips in each household by type and each auto ownership category is supplied in the zonal data. In MOTORS, category analysis allows the specification of trip rates for up to 108 different categories using three stratifying variables. In MicroTRIPS, six household type or size categories and three auto ownership levels may be defined. In MINUTP (26 variables) and TRANPLAN (25 variables), the different fields in the zonal data records can be used to stratify households or population.

2.4. TRIP DISTRIBUTION

Both a Fratar and a gravity model are provided in all packages except TransPro, which does not have the Fratar model. Trips may be distributed based on an historical trip matrix supplied by the user. The Fratar procedure is iterative, with distributed trip ends compared to input values at the end of each iteration. The user specifies the maximum number of iterations in response to a screen prompt in MicroTRIPS and MOTORS and as parameters in MINUTP. A gravity model of the following form may be applied to TRANPLAN, MOTORS, and MINUTP:

$$T_{ij} = \frac{P_i * A_j * f(C_{ij}) * K_{ij}}{\sum_{k=1}^n A_k * f(C_{ik}) * K_{ik}}$$

The gravity model program of MicroTRIPS uses the following form:

$$T_{ij} = a_i * b_j * P_i * A_j * f(C_{ij}) * K_{ij}$$

where: T_{ij} = number of trips from zone i to zone j
 P_i = number of trips produced by zone i
 A_j = number of trips attracted to zone j
 C_{ij} = impedance of travel between zones i and j
 K_{ij} = adjustment factor to account for special travel patterns
 n = number of zones
 a_i, b_j = balancing factors that are calculated internally
 $f(C_{ij})$ = friction factor based on impedance

In TRANPLAN, trip tables may be scaled using the Fratar method. A "card-image" file containing zonal growth factors, which may vary by trip purpose and direction, must be prepared using a system editor. The Fratar application program applies these factors to a trip table for a number of iterations specified by the user. Iteration summaries can be printed to check for convergence. Table 2-7 shows the trip distribution options for each package.

Table 2-7. Trip Distribution Features

PACKAGES	Fratar	Exponential Gravity	F-Factor Gravity	K-Factors	Gravity Self-Calibration
TRANPLAN	Y	N	Y	Y	Y
MicroTRIPS	Y	Y	Y	Y	Y
MINUTP	Y	N	Y	Y	N
MOTORS	Y	Y	N	Maybe	Maybe
TransPro	N	N	Y	N	N

*Note: Packages were received in January 1987.
Maybe = No direct provision.*

The procedure is iterative, with distributed attractions checked against input trip ends at the end of each iteration. A maximum number of iterations and an acceptable level of variation are specified by the user in response to screen prompts (MOTORS) or supplied as program parameters (TRANPLAN). The MINUTP user designates a number of iterations and/or a maximum percentage difference between attractions and distributed trips. The MicroTRIPS iterations end when the difference is less than 0.5 percent, or when the maximum number of iterations (up to 20) specified by the user have been performed.

K-factors (socioeconomic adjustment factors) in the gravity model may be supplied, by purpose, for ranges of origin and destination zones in TRANPLAN and MINUTP. They are applied on a zone-to-zone basis. K-factors in MicroTRIPS may be supplied in matrix format. The matrix modification program can be used to construct a K-factor matrix. MOTORS has no K-factor specifications in the trip distribution; however, the matrix programs can be applied to do this.

Different purposes can be modeled in a single run, but separate runs are needed for each time period (or impedance table) in TRANPLAN and MINUTP. The purposes may be stored in separate tables or merged into a single table. The cross classification trip end programs in MOTORS use a maximum three purposes in one run. In MicroTRIPS, a separate run of the trip distribution model is required for each purpose or time period. Trip productions of MicroTRIPS can be supplied for up to three auto ownership groups; however,

they can be distributed using different friction and K-factors. The distributed trips will be summed over these groups for balancing against a single set of trip attractions, but will be stored in separate trip tables (which can be added together using a matrix manipulation program in both MicroTRIPS and MOTORS).

The impedance use in the model may be from any table (e.g., cost, travel time, or weighted impedance) in the skim tree file supplied to the gravity model in most packages.

Friction factors of MicroTRIPS may take one of two forms. The first is a linearly segmented curve defined by the user in a separate card-image file read by the trip distribution program. Each record in the file contains an impedance value and the corresponding friction factors for up to three auto ownership classes. The second form is the following equation:

$$f(C_{ij}) = (C_{ij})^{X1} \times e^{X2(C_{ij})}$$

where: X1, X2 = parameters specified by the user (different parameters may be specified for each auto ownership group)

The F-factor parameters (X1 and X2) can be estimated using an iterative, maximum likelihood procedure. The user supplies a trip table, impedance matrix and initial parameter values, and the program produces an estimated trip table, parameters and calibration statistics.

The MOTORS F-factors are also determined in one of two ways:

$$f(C_{ij}) = 1/(C_{ij})^X \text{ ===== Power Function in MOTORS}$$

$$f(C_{ij}) = e^{-a(C_{ij})}/(C_{ij})^X \text{ ===== Exponential Function in MOTORS}$$

where: X,a = user-specified parameters supplied through screen prompts

An array of F-factors in TRANPLAN and MINUTP is supplied for each trip purpose for all integer values of impedance over the range occurring in the skim tables. However, the TRANPLAN program can calibrate a set of F-factors using a trip length distribution obtained from a survey or other source. The calibration is an iterative process, with least-squares used to estimate a log-linear friction function in each iteration.

In TRANPLAN, production/attraction tables may be converted to origin/destination tables by setting up a run that applies three of the matrix utility programs in series. TRNSPS transposes the production/attraction tables for each purpose, UTABLE is used to factor the original and transposed tables, and MTABLE adds the factored tables together to form origin/destination tables by purpose. Different factors can be applied to different purposes, and to different zone pairs (or ranges of pairs).

The matrix transposing programs in MOTORS (M45), MINUTP (MATBAL), and MicroTRIPS (MVMNIP) are provided to convert a production/attraction trip table into an origin/destination table. The MOTORS user specifies the fraction of trips that are to flow in the attraction to production direction, and the MINUTP user applies different percentages to P-to-A and A-to-P values in constructing the origin/destination table. When original

and transposed tables are combined in MicroTRIPS, a different factor can be applied to each. The MVMOD program of MicroTRIPS also can be used to apply different factors to different parts of a table.

Trip ends, trip tables, and trip length distribution are produced by all packages. The TRANPLAN Calibrate Gravity Model generates F-factor reports, trip length frequency graphs, and trip length summaries for each purpose and iteration, while MicroTRIPS produces calibration statistics. Only TRANPLAN can produce accessibility indices which are used when detailed information concerning the action of the gravity model is desired.

2.5. MODE SPLIT

Diversion curves, based on either ratios or differences of auto and transit costs or impedances, are supplied by TRANPLAN, MicroTRIPS, and MOTORS; however, the MINUTP Matrix program contains a binary logit modal only. Auto vehicle (or driver) trip tables can be developed as part of mode split or through matrix manipulation in all packages.

The TRANPLAN diversion curves may be supplied as part of a job control file prepared for the mode split program (MSPLIT). The curves can be based on any pair of variables in the highway and transit skim tree files can be read by the program. Several curves may be defined, with each applied to specific combinations of the following factors which affect the modal choice methodology in this program: trip purposes; production area characteristics (P-Code); attraction area characteristics (A-Code); and any two measures of interzonal travel impedance (i.e., two of cost, distance, or time). The program will accept up to 15 trip purposes, 8 P-Codes and 8 A-Codes (e.g., CBD or other employment center), and 8 second interzonal impedance ranges (e.g., cost difference for mode split curves based on travel time ratios); these allow considerable flexibility in associating the trip characteristics to diversion rationale.

The MINUTP modal split process can be defined by any series of mathematical expressions. The expressions can reference any zonal data fields for origin or destination, user computed variables, constants and matrix cells. The matrices can be any data, usually they are trips, and highway and transit level-of-services. The TRNPTH program allows up to 29 various level-of-service matrices to be extracted for each/any mode of access for selected I-J zones. The logit formulation is easily specified. A simplified exponential model is provided for those uses with no historical data.

The MicroTRIPS diversion curves can be supplied in either of two forms. The first is a linearly segmented curve relating the percentage of trips using one of the modes to the cost difference. The curve is defined as a series of points which are supplied through a card-image file prepared by the user. The second is a curve of the form using the mathematical function. The user should supply a diversion parameter, percentage of trips captive to each mode, and cost difference that generates an equal split of choice trips.

The MOTORS diversion curves, based on either travel impedance or cost ratios (transit/auto) or travel impedance difference (transit-auto), must be

supplied through a user-created file. This file consists of 32 values, each of which indicates the fraction of trips that will use transit at designated levels of the travel impedance ratio or difference. Different curves may be used for different trip purposes provided that separate trip tables are supplied for each purpose.

The TRANPLAN Variable A-Codes option specifies that attraction zone codes (A-Codes) are to be read from Table 15 on file TRSKIM. This capability is provided for models which do not have a specific attraction code but may have accessibility built in to the attraction code. The variable A-Codes are prepared by the user prior to executing the run. Dummy fixed attraction codes must be submitted at the time of execution for editing purposes.

TRANPLAN includes a program for calibrating diversion curves from transit and total person trip tables and from transit and auto impedance tables. CALIBRATE MODEL CHOICE function enables the user to systematically stratify modal split data sets to derive optimum estimating curves. Calibrated curves can be consolidated in subsequent runs of the calibration program.

2.6. TRAFFIC ASSIGNMENT

The various traffic assignment options are offered by the packages (see Table 2-8). The following techniques are available in highway trip assignment to determine which paths through the network are to be assigned trips between zones:

- o All-Or-Nothing or Multi-Path Assignment
- o Incremental or Iterative Capacity Restraint Assignment
- o Equilibrium Assignment

Table 2-8. Traffic Assignment Features

PACKAGES	Multi-Path	Incremental Capacity	Iterative Capacity	Equilibrium Assignment	Select Link	Select O/D
TRANPLAN	Y	Y	Y	Y	Y	Y
MicroTRIPS	Y	Y	Y	Maybe	Y	Maybe
MINUTP	Y	Y	Y	Y	Y	Y
MOTORS	N	Y	N	Y	Y	N
TransPro	N	Y	Y	N	Y	N

*Note: Packages were received in January 1987.
Maybe = No direct provision.*

ALL-OR-NOTHING AND MULTI-PATH ASSIGNMENTS

There are three basic types of path selection algorithms available:

1. All-or-nothing is the common traditional traffic assignment methodology which assigns all trips to the shortest path; if more than one exists, a method known as a tie breaker is used so that only one will be selected by either first-link-selection or last-link-selection;
2. All-shortest-path is the more realistic method which assigns trips to all the shortest paths equally if more than one shortest path exists; and
3. Stochastic method assigns trips to all "efficient" paths according to their probabilities of being used, based on the difference in impedance and a control value of probability function. At any point along a path, the tripmaker has the opportunity to choose any of the connecting links to continue his trip to the designated destination.

Three packages (TRANPLAN, MINUTP, and MicroTRIPS) allow multi-path assignment (stochastic) while the all-or-nothing option is offered by all packages. As mentioned earlier, the TRANPLAN and MINUTP multiple paths are built (using Dial's algorithm) only as an integral part of a stochastic assignment; they cannot be stored, printed or skimmed. MicroTRIPS offers a different approach for adding variability to multi-path assignment; the user specifies a coefficient of variation for travel time which is used to randomly adjust link travel times prior to building each tree.

The TRANPLAN Stochastic Highway Load function accepts a highway trip table and a highway network and performs a probabilistic multi-path traffic assignment. The MINUTP stochastic assignment may be applied by specifying a distribution parameter (THETA) value greater than zero (which results in an all-or-nothing assignment). A value of ten (the maximum allowed) distributes trips equally among multiple shortest paths. Trips are assigned to all "reasonable" paths between each origin and destination, each path receiving a fraction of interzonal trips which is proportional to:

$$P = \text{EXP} (-\text{THETA} \times \text{DELTA})$$

where: P = Probability function associated with THETA
THETA = User-specified diversion parameter
DELTA = Difference between the minimum path impedance and that of the alternate "efficient" path

When DELTA is 0 (equal to shortest path), P becomes one; and the path is on, or equal to, the shortest path. As DELTA increases, P gets much smaller, resulting in a lower probability that the user will use the alternate. The trips are then distributed to the routes based upon their relative probabilities. A large THETA provides minimal "spreading" of the trips over the network; a smaller THETA results in a greater spread.

CAPACITY-RESTRAINT ASSIGNMENT

Capacity restraint is the process of revising link impedances using the BPR formula or similar equations based upon the volume to capacity (V/C) ratio for the link. It is applied after all zone-to-zone interchanges have been assigned to the network using one of the previously described routing algorithms.

There are two modes to run with capacity restraint. One is the iterative method in which the link impedances are updated within some limitations after all the trips are assigned. Then paths are built again and the trips reassigned. The second is the incremental mode, in which only a portion of the trips are assigned before link impedances are adjusted. The link volumes are accumulated through all the increments. This latter mode approximates the way traffic gradually builds up and travelers divert to new travel paths.

Four packages (TRANPLAN, MicroTRIPS, MINUTP, and TransPro) have the full capability of a capacity-restraint assignment (i.e., both incremental and iterative options). In TRANPLAN, MicroTRIPS, and MINUTP, up to ten increments or iterations of capacity-restraint assignments may be specified in a single run, with varying fractions of triptable and preload volumes assigned in each. The TransPro capacity-restraint assignment continues for as many times as designated by the user. MOTORS has no iterative capacity-restraint assignment.

For each iteration in TRANPLAN incremental assignment, a user specified percentage of selected interzonal trips is loaded on the minimum paths determined during path building. This function has the capability of adjusting link times on the initial (base) network or on the network used during the previous iteration. The function, via user option, may or may not expand the accumulated volume to represent conceptually a 100 percent loading (ADJUST 100 option) during determination of the assigned volume/capacity ratio. Also in Incremental Loading, the user may specify that "undivertable" trips (notably very short and very long trips) are loaded along with the first specified percentage of "divertable" trips on the initial or "free" network and then Incremental Loading continues as described above on the remaining "divertable" highway trips.

In the TRANPLAN iterative-restraint assignment, all selected interzonal highway trips are loaded on the minimum paths of the input highway network. A loading of 100 percent is performed on paths built from the adjusted network for each iteration. In both TRANPLAN and TransPro, the adjusted time may optionally be dampened as only one-quarter of the time difference of T_n and T_{n-1} (DAMPING options). This has the effect of lessening the oscillation of loadings from one iteration to the next. The MicroTRIPS user can specify the fraction of previously assigned trips that are to be retained in each increment or iteration, enabling volume averaging and similar procedures to be performed. MINUTP has also dampening options as well as the option to restrict the overall time change due to capacity restraint.

In MINUTP, different assignment techniques (i.e., all-or-nothing, all-shortest-path, or stochastic) may be used in each iteration or increment. In addition, the NETMRG program can be used to selectively weight or combine

travel times calculated in previous assignments with the new values used as the starting point for a new assignment of any type.

The MOTORS incremental loading procedure determines the largest percentage of all unassigned trips which can be loaded without exceeding the capacity on any link. This percentage of the unassigned trip table is then loaded. Links at or near capacity are then eliminated from consideration in subsequent iterations by artificially increasing their travel time. The path building and assignment programs are then rerun until all trips have been assigned.

EQUILIBRIUM ASSIGNMENT

Finally, equilibrium assignment algorithms, utilizing standard mathematical programming techniques, have been shown to give more behaviorally realistic representations of the traffic patterns than standard all-or-nothing or capacity-restraint methods. The theory behind this process is commonly referred to as the following Wardrop Condition, which is "find the assignment of vehicles to links such that no traveler can reduce his or her travel time from origin to destination by switching to another path." A traveler first selects his path along the route he believes to be the minimum time. But other travelers also use parts of his path and the time increases. He then shifts to a different path (as other travelers). Then that path gets congested, and he selects another path (as others may also). Eventually, he cannot find a faster path, and the travel time on the final path is about the same as it would be on the congested original path. At that point, the system is close to equilibrium.

An automatic-iterative procedure under conditions of capacity restraint is used to achieve an equilibrium assignment in MOTORS. After each iteration, a golden section search technique is used to determine the linear combination of link volumes from the current and previous iteration that minimizes total impedance; and this combination is used to determine the link impedances used in the next iteration. The user has control over the maximum number of iterations and over the tolerance to which the search for equilibrium is to be conducted. Optionally, the program can be used to perform a simple non-iterative assignment to the network.

The EQUI control of the MINUTP Assign module indicates that equilibration assignment/adjustment is to be performed. When this statement is encountered, it immediately sets the iterative mode, no dampening, and equilibrium assignment on. At the end of each iteration, the module estimates a LAMBDA value to be used as a weighting factor in combining assignment volumes to arrive at a "balanced" system. In this module, the first THETA value, which should be 0 to process properly, represents the base assignment. The module allows user restrictions on link restraint. The calculation of link volumes is derived as follows:

$$VOL = LAMBDA \times (VOL) + (1-LAMBDA) \times (PVOL)$$

where: VOL = current link volume
LAMBDA = equilibration value
PVOL = accumulated volumes prior to this iteration

No automatic procedure is provided in MicroTRIPS, but the combined procedure can be used to approach an equilibrium. Summary statistics reported at the end of each iteration indicate how close a network is to equilibrium. Equilibrium assignment has recently been added to the TRANPLAN package. It was not available at the time the package was obtained for evaluation.

SELECT LINK ANALYSIS

TRANPLAN's Load Highway Selected Links function performs the selected link analysis element of the highway network loading process. It is inter-related with the Load Highway Network function and the loading options are the same. The three parameters (LOAD, ONE WAY, or TWO WAY SELECTED LINKS), which are the only differences from the Load Highway Network function, are used instead of the selected zones. A selected link history file is produced which is input to the various post-processor functions (e.g., Build Selected Link Trip Table and Extract Subarea Trip Table) and report functions (e.g., Analyze Multiple Selected Link Trip Tables and Report Complex Weaves). A loaded highway network history file is also produced by this function.

The Build Selected Link Trip Table function of TRANPLAN is the first in a series of selected link post-processors which manipulate the selected link history file to produce reports or trip table files for the analysis of loaded networks. The selected volume file is a merged trip table file of up to 15 tables, each is comprised of those trips which traversed one user-specified selected link (one-way). A trip end summary of the selected volume file may be reported optionally.

The Analyze Multiple Selected Links function of TRANPLAN is the second in a series of selected link post-processors which manipulate the selected link history file to produce reports or trip table files for the analysis of loaded networks. This particular post-processor analyzes trips which use "origin" links, "through" links, and "destination" links (specification of "through" links is optional) as DATA input.

The Extract Subarea Trip Table function of TRANPLAN, which is one of a series of selected link post-processors, manipulates the selected link history file to produce a trip table(s) of trips within, into, and out of the cordoned off area of the network. For example, the user may be interested in extracting a segment representing the downtown area of a regional highway network to perform more detailed investigation of traffic patterns within that area. MINUTP has a similar function to TRANPLAN, to extract a subarea trip table.

The MicroTRIPS MVROAD assignment must include the option to save a tree file if select link or subarea analysis is performed. A system editor is used to create card-image files of selected links or cordon links. The MVSELC program is then run for each of these special analyses, with file names, options and parameters supplied in response to screen prompts.

Zone-to-zone tables of trips that use sets of selected links may be produced using MicroTRIPS, with a separate table created for each set. Up to ten link sets can be specified in a run; these sets are lists of

unlimited numbers of links that can be specified either as AND lists (i.e., all links in the set must be traversed before trips are included in the table), or as OR lists (i.e., any link in the set may be traversed). The trees used in the analysis must have been saved during a previous assignment. If trees were saved after each increment or iteration, the user can specify any or all for use in the analysis and match different fractions of the input trip table to each set of trees. One output matrix is produced for each set of links that are specified.

A MicroTRIPS trip table for a subarea analysis can be extracted from a complete table and a set of trees from an assignment. A subarea in the network is defined by throwing a cordon around the desired zones. Cordon crossing points are defined by a set of one or more links. Trips in zones outside the subarea are reassigned to the appropriate cordon-crossing points. Zones internal to the cordon are renumbered sequentially, from one to highest subarea zone number. Cordon crossing points, which become the new external zones, are renumbered starting from the new highest subarea zone number plus one. Trees from different iterations or increments of a capacity-restrained assignment may be used in setting up the subarea table with different fractions of the input table assigned to each.

A selected link option in MINUTP is available only during all-or-nothing iterations of assignment. Two types of selections are available: an AND link selection in which all links in the set must be used in the path, and an OR link selection in which only one link of a set is required to meet the criteria. Up to 15 sets can be requested in one run, and the user can request individual or total matrices to be written to a file for later processing. Optionally, the total matrix can be assigned to the network or the selection can be obtained during a normal assignment. This analysis is very useful to determine which O-D movements use certain link(s).

A system editor is used to set up a job control file or interactive processing to apply the selected link option written onto the MINUTP ASSIGN program. The selected link option (SLNK A,W) is specified by two controls: A identifies what type of assignment will be made and W controls the output matrix.

In MOTORS, the Select Link Assignment Trip Matrix Creator (P95) is used to produce a trip matrix from the trip records of a select link assignment (which is performed using program P75). Records from up to nine select link assignments may be combined in one matrix.

It should be noted that the MOTORS select link matrices can be produced both from an incremental capacity-restraint assignment (P75) and from all-or-nothing assignment (P60). The links for which an origin-destination matrix is required are specified as part of the P75 run; a maximum of 50 links can be defined per run. P95 is then used to create a trip matrix from either a single or multiple P75 runs.

The TransPro program module SLINK provides the select link analysis capability. The analysis may be specific for a given direction of travel on the link or it may be for all volumes. The program is completely interactive in the setup mode -- no data file preparation is required. The program will prompt for the link to be analyzed and will ask if both directions of travel on the link should be considered. The analysis will

then proceed in much the same manner as for the determination of link volumes in program module VOLUME. One non-optional report is output from the SLINK program module. This report is output to file SLINK.RPT. The report is presented in two sections: one summarizes trip ends by zone, the other documents link volumes by route.

TURNING MOVEMENTS

For all types of loading in TRANPLAN, turn volumes may be saved during loading for up to 50 ranges of nodes. The Turn Penalties parameter specifies the turn penalty values to be applied during minimum path determination. The Save Turns parameter specifies a list of nodes at which assigned turn volumes are to be saved for subsequent reporting. Turn volumes for node configurations with up to four entry links and five exit links may be saved at each selected node for subsequent reporting. TRANPLAN utilizes a VINE builder, as opposed to the traditional TREE builders.

Turning movements of MicroTRIPS and MINUTP may be printed for a list of nodes specified by the user (in a card-image file set up using a system editor). The multiple tree option available for selected link analysis also can be applied to turning movements in MicroTRIPS. The number of nodes may be limited by core capacity, but multiple runs can be made, if necessary, to obtain turning movement information in MINUTP. In MOTORS, however, through and turning movements are saved only if separate links have been coded, either manually or using the automatic link generation program.

The TransPro program TURNS determines the turning movement counts at up to 100 user-specified intersection locations. The user simply specifies a list of the intersection nodes where the counts are desired in a data file. The configuration of each intersection is provided by the transfer file LINK.XFR and the counts are determined in much the same manner as link volumes are determined from route trees and trip matrices in program VOLUME. The turning counts are presented in a printed matrix report format. There are no restrictions on links entering or leaving the intersection; one-way links are permissible, such as at freeway ramps.

It should be noted that due to the path technique used, penalties/prohibitors sometimes prevent certain logical paths from being built. Penalties are not applied during stochastic assignment in all packages.

SELECTED ORIGINS/DESTINATIONS

A TRANPLAN assignment permits great flexibility and obviates the need for trip table adjustment for selecting zones prior to the loading process. The Selected Origins, Destinations, and ODS parameters specify the lists of origin and/or destination zones from which and/or to which trips will be loaded on the highway network. To be chosen for loading, a trip must have either its origin or its destination within the specified list. A hierarchy exists on these parameters: a trip is first checked if it originates at a selected origin, then if it terminates at a selected destination, and then if its origin or destination satisfies a selected OD.

There is no direct provision for assigning selected trips to a MicroTRIPS network, but a trip table containing non-zero values only for selected zone pairs can be assigned to a set of trees saved from a previous, complete assignment. A selected link, turning movement, or subarea analysis, however, can be restricted to trips from selected origin zones which are specified in a list that may include ranges.

The SEL control of the MINUTP ASSIGN program is used to select which zones are to be processed for certain reports. The zones are specified in ranges following the key word: the origin and/or destination zones to be processed (I,J); the origin zones for which path traces are to be formatted and reported (TI); the destination zones to which the TI traces are to be formatted (TJ); the origin zones for which the back nodes of the paths are to be formatted (PB); the origin zones for which the path impedances to all destination nodes are to be reported (PI); the origin zones for which the final impedance values are to be reported in standard matrix format (PT); and nodes at which turning volumes are to be accumulated (T).

MOTORS and TransPro do not have the selected origins/destinations analysis capabilities.

2.7. MATRIX UTILITIES

TYPES OF PROGRAMS

TRANPLAN contains seven matrix handling programs. UTABLE is designed to modify one or more tables in a single file, while MTABLE is used to merge or split tables from one or more files. TRNSPS simply transposes one or more tables. COMPRESS is used to create district-level tables, while EXPAND is used to split zones for detailed analysis. TRFARE can be used for transit cost inputs to modal choice analysis. BUILD accepts trip survey data in TRANPLAN format and allocates the trips to trip tables according to user-specified selection criteria.

MicroTRIPS contains three matrix manipulation programs. MVMOD is designed for cell-by-cell modification of one or more tables, and can be used to prepare tables. MVMNIP is designed to combine two or more tables, and also can be used to transpose a table, or to convert a table into a card-image matrix or trip end file. MVSQEX is used to split or combine zones.

MINUTP contains three matrix manipulation programs. MATRIX is a general purpose program that can create, combine, and/or modify tables using simple or complete arithmetic operations. MATBAL is used to convert P/A to O/D tables or to transpose matrices. It also performs several different types of mode split analyses (logit model, pivot point model, or most mathematically defined models). MATCON is used to modify matrices when zones are split, combined and/or renumbered.

MOTORS contains 10 matrix manipulation programs. The Matrix Builder (M10) program is used to read a sorted set of trip records and build a trip matrix. The Matrix Converter (M15) program is used to convert a trip matrix in any format to MOTORS format. The Highway Trip Matrix Estimator (M20) program is used to generate a trip matrix from observed traffic counts for

simple networks. The Matrix Manipulator (M40) program is used to add together several matrices. The Matrix Multiplier (M41) program is used to multiply a matrix by either a constant factor, by a row vector, or by another matrix, either on a cell-by-cell basis or in true matrix multiplication form. The Matrix Transposer (M45) program converts a Production/Attraction matrix to Origin/Destination form. The Matrix Printer (M50) program is used to print on the line printer, or display on the screen, stored matrix files. The Zone Compressor (M60) program compresses zonal matrices to district level. The Zone Splitter (M70) program is used to split trip matrices from district level to zone level. The Matrix Divider (M80) program divides one matrix by another on a cell-by-cell basis.

The TransPro Matrix program module receives as input one or more trip tables and allows the user to perform arithmetic operations (add, factor, etc.) with the matrices to output one or more resultant trip tables. The program presents a menu of program options. This program is also used to convert a P/A trip table to an O/D trip table.

MATRIX HANDLING CAPABILITIES

In TRANPLAN, MINUTP, and MicroTRIPS, any element, row, column, rectangular portion, or segment of the diagonal of a matrix can be modified by a constant using addition, subtraction, multiplication or replacement. Matrix updating operations can be made conditional on the value in a matrix element. A constant exponent can be applied to all cells of the only MicroTRIPS matrix for mathematical transformations. The MOTORS matrices can be factored as a whole or on a cell-by-cell basis, and a matrix can be modified by adding values to individual elements. The MOTORS conditional expressions can be used only in building a matrix.

In TRANPLAN, MicroTRIPS, and MINUTP, two or more tables can be combined, on a cell-by-cell basis, using addition, subtraction, multiplication or division. Any weighting must be performed in a separate step of TRANPLAN. Constants can be applied to input or intermediate tables during the MicroTRIPS or MINUTP process. In MOTORS, up to five matrices can be merged, and each can be factored by a different constant. Two matrices can be multiplied together, either on a cell-by-cell basis or using matrix multiplication.

In TRANPLAN, MicroTRIPS, MINUTP, and MOTORS, zones may be combined, split, renumbered, added or dropped. Different percentages may be applied in splitting inbound and outbound trips, and the user may use the percentages to increase or decrease matrix totals. The MINUTP commands for transforming the zone structure can be stored on disk and recalled for application to other matrices.

2.8. PLOTTING CAPABILITIES

Four of the packages (TRANPLAN/NEDS, MINUTP, MicroTRIPS, and MOTORS) currently have network plotting capabilities which are indicated in Table 2-9. TRANPLAN/NEDS can produce wide ranges of graphical displays. All packages require high resolution monitors and a variety of plotters for effective performance and better results. MOTORS produces screen plots of

MOTORS highway networks which may be reproduced on only a dot matrix printer.

Table 2-9. Network Plotting Capabilities

PACKAGES	Highway Paths	Zonal Data and Matrices	Windows, Posts, and Bandwidths	Select Display	Node Volumes and Displays
TRANPLAN	Y	N	Y	Y	Y
MicroTRIPS	N	N	Y	Y	N
MINUTP	Y	N	Y	Y	Y
MOTORS	N	N	Y	N	Y

Note: Packages were received in January 1987.

All packages allow the user to post link values. Bandwidth plots, where link widths are scaled according to an attribute selected by the user, can be also generated by all. Links can be color-coded to indicate ranges of attribute values using all packages. All five let the user define windows with coordinates, and MicroTRIPS will partition a network into as many as 16 sections for plotting.

MINUTP allows the user to limit a plot to links that meet user-specific criteria, and the latter package lets the user calculate values that can be plotted or used for selection purposes. MINUTP has recently added on-line graphics editor (NETVUE). The MINUTP vendor has stated that the network plotting program (NETPLT) and the network editing and displaying program (NETVUE) are quite flexible and capable.

Recently, TRANPLAN has been interfaced with on-line, interactive, graphics software (NEDS) for network editing and display. NEDS is an on-line, menu-driven graphics package for the creation and maintenance of transportation planning networks as well as for the display of network attributes and assignments. NEDS is also easy to learn because the menus are essentially self-explanatory.

The TRANPLAN Plotting program consists of the following modules: PLOTNET.EXE - Plot Highway Network, PLOTPATH.EXE - Plot Highway Paths, and PLOTNET.EXE - Plot Highway Load. NEDS programs include the following features: Interactive Network Editing, Color Displays, Bandwidth Displays, Volume/Capacity Analysis, Minimum Path Determination, Road Link Loading, Highway/Transit Networks, Transit Line Loadings, Alternate Host Computers, Network Zoom & Pan, High/Medium Resolution Monitors, User-Specified Restart, Hard Copy Options, and Restore Last Views.

2.9. REPORTING FEATURES

The various potential reports of a highway analysis are produced by the packages. Four basic reports (i.e., unloaded network, selected paths, link loads, and turning movements), which are shown in Table 2-10, are produced by most packages. The different formats of selected paths generally are reported as traces or backnode tables. Different program or memory limits of the packages constrain the number of nodes at which turning movements are reported.

Table 2-10. Potential Report Features

PACKAGES	Selected Paths	Link Loads	Turning Movement	Partial Network	Format Choice	Ground Comparison	VHT/VMT Summary
TRANPLAN	Y	Y	Y	Y	N	Y	Y
MicroTRIPS	Y	Y	Y	N	N	N	Y
MINUTP	Y	Y	Y	Y	Y	Y	Y
MOTORS	Y	Y	Y	Y	N	N	Y
TransPro	Y	Y	Y	N	N	N	N

Note: Packages were received in January 1987.

Most packages store assignment results as a disk file that can be printed at the user's convenience, and all packages except TransPro let the user select a portion of the network for printing. Both these options may be useful to users with large networks and slow printers. MINUTP gives the user a choice of report formats, and the package allows the user to design an assignment report that can compare assignments and include calculated values such as VMT. In the MOTORS program M50 (Matrix Printer), different options are available to the user in terms of selective printing of rows or columns.

As part of capacity-restraint assignment, some of the packages print summary statistics at the end of each iteration or increment, and four of these (TRANPLAN, MicroTRIPS, MINUTP and MOTORS) give the user the option of printing a complete network description after each step. Network summary measures such as total VMT also are printed by all packages except TransPro following any type of assignment, or they can be generated using special summary programs. Two packages (TRANPLAN and MINUTP) provide a field for counts in the link data and let the user compare assigned values to observed traffic.

In MINUTP, the selected link can be identified and traced as volumes (or the percentage of volume) on each link in the network. The packages (especially, TRANPLAN, MicroTRIPS, and MINUTP) produce various tabular reports such as zone to selected node, zone to zone via a selected link, and

selected link to selected link. The following Table 2-11 presents the potential reports from the select link analysis of the packages.

Table 2-11. Select Link Analysis Report Features

PACKAGES	Volume Traces	O-D's of Link Users	Link-to-Link Tables	Subarea Trip Tables
TRANPLAN	N	Y	Y	Y
MicroTRIPS	N	Y	N	Y
MINUTP	Y	Y	N.A.	N.A.
MOTORS	N.A.	Y	N.A.	N.A.
TransPro	N	N	Y	N

Note: Packages were received in January 1987.

MicroTRIPS and MINUTP allow the user to design groups of links in setting up the second of these tables and to select any link or all links in the group as a criterion for adding trips to the table. In setting up a link-to-link*table, TRANPLAN allows the user to specify one or more intervening links to examine weaving movements. A cordon of links can be converted into a set of external zones for a subarea network analysis in TRANPLAN and MicroTRIPS.

The report outputs of selected link analysis in MOTORS and TransPro are very simple. One non-optional report of TransPro is output from the selected link analysis program module. The report is presented in two sections: one summarizes trip ends by zone, the other documents link volumes by route. In the Print Selected Links option of the MOTORS program U20 (Network File Printer), links are singled out and printed one by one.

CHAPTER 3. SUMMARY EVALUATION

It should be noticed that objectives of the report are to evaluate existing microcomputer software for suitability to perform subarea analysis and for compatibility with the Texas Travel Demand Package. This report has been prepared not to attempt a critical evaluation and not to conduct rigorous performance evaluations. Transit route planning programs and plotting programs that use a network base were not considered for critical review.

3.1. CONCLUSION

TRANPLAN, MicroTRIPS, and MINUTP packages are the comprehensive software systems for transportation planning and parallel UTPS/PLANPAC in functional capability. However, MicroTRIPS and MINUTP are evaluated as being less compatible with the Texas Travel Demand Package and as having fewer capabilities than TRANPLAN.

MOTORS package has limited network plotting capabilities and functional network building capabilities. EMME/2, which is the most expensive package and requires expensive hardware systems, was not evaluated. TransPro package is too simple to be compatible with the network-based analysis used by the Texas Travel Demand Package.

Finally, the TRANPLAN/NEDS packages were selected for suitability to perform subarea analysis and for compatibility with the output from the Texas Travel Demand Package comparing the different microcomputer packages which were evaluated. Table 3-1 presents the limitations and package prices of the six software packages. Table 3-2 presents a summary of the features and capabilities of the five software packages.

3.2. SUMMARY OF COMPARISON

TRANPLAN is the most comprehensive, fully-integrated, and user-oriented package. Unlike other transportation software, TRANPLAN uses English-like syntax and uniform specifications in all programs; and it is extremely easy to learn and to apply. Recently, TRANPLAN has been interfaced with on-line, interactive graphics software (NEDS) for network editing and display. TRANPLAN provides selected link analysis with the equilibrium assignment.

In TRANPLAN, up to 15 purposes may be distributed in a run. The purposes may be stored in separate tables or merged into a single table. TRANPLAN includes a variety of select link analysis options. A trip table for a subarea analysis can be extracted from an assignment involving selected links. TRANPLAN gives the user the option of printing a complete network description after each step. The package provides a field for counts in the link data and lets the user compare assigned values to observed traffic.

As mentioned earlier, the MicroTRIPS link distances and impedances are specified in hundredths of units; however, the separation matrix is output in tenths of a minute; link impedances are also calculated in tenths of a minute. A separate run of the trip generation program and the trip distribution model is required for each trip purpose. MicroTRIPS offers a

different approach for adding variability to multi-path assignment. The package has no capability of selected nodes as O/D and no capability of ground count comparisons. Poor graphic capabilities are the most critical deficiency of MicroTRIPS in comparison with TRANPLAN/NEDS.

In MINUTP, complex Job Control Language (JCL) is required to run the program and the user's manual is difficult to understand. An hourly capacity per lane and the number of lanes on each link is specified as input instead of the capacity in the direction. The MINUTP gravity model has no self-calibration procedure. Selected link options are available during all-or-nothing iterations of assignment.

The MOTORS package lacks the network building procedures as follows: Nodes must be numbered in sequence without any gaps. The separation matrix is output in tenths of a minute; link impedances are also calculated in tenths of a minute. Only four different types of link codes, link classes, and jurisdictions can be entered interactively. A-to-B and B-to-A link data must be entered separately, but links entered interactively can be designated as two-way if characteristics are the same in both directions. The user must balance trip ends within five percent prior to running a distribution model. Separate runs must be used to distribute trips for more than three different purposes. There are no user-defined F-factors (F-factors are supplied by using a "power" function or an exponential function) and no self-calibration procedure for the gravity model. Other limitations include the following: no iterative capacity-restraint assignment or multi-path options; no specification of selected nodes as O/D.

TransPro does not require nodes to be numbered sequentially; numbering gaps is permitted. However, the package does require centroid or zone nodes to be numbered below 300. The package lacks trip distribution features such as calibration of gravity model, K-factors, and Fratar procedure. The package has all-or-nothing, incremental, and iterative capacity-restraint assignment capabilities. It does not have equilibrium assignment or multi-path options. Other limitations include the following: no transit analysis; no plotting capabilities; and only basic report printing capability.

TABLE 3-1. LIMITATIONS AND PACKAGE PRICES

ITEMS	TRANPLAN/NEDS	MicroTRIPS	MIMUTP	MOTORS	TransPro
A. Hardware Requirements:					
1. Plotters	Y	Maybe	Y	N	N
2. IBM-PC or Compatible	Y	Y	Y	Y	Y
3. Co-processor	Math Co.	Math Co.	Math Co.	Math Co.	Math Co.
4. Hard Disk/Desirable-Disk	Y/10 mb	Y/10 mb	Y/5 mb	Y/8 mb	N
5. High Resolution Color Monitor	Y	Maybe	Y	N	N
6. Digitizing Tablet or Mouse	Y	Maybe	Y	N	N
B. Network Size w/512K:					
1. Zones	1500	2000	Unlimited	400	300
2. Nodes	8000	9999	8190	2000	3000
3. Links	9000	12000	32300	6000	3000
C. Package Limits:					
1. Number of Trip Purposes	15	3 (Each Run)	9	3 (Each Run)	5
2. Trip Generation Variables	25	18 w/6 Types	26	10 w/108 Types	N.A.
3. Number of Link Type Coding	10	32	63	4 (Fixed)	100
D. Basic Structure and Operations:					
	Best	Good	Poor	Good	Best
1. Function Selection	Control File	User Specify	User JCL	User Specify	User
2. Option Selection	Control File	Screen Prompt	User JCL	Screen Prompt	Screen
3. Parameter Specification	Control File	Screen Prompt	User JCL	Screen Prompt	Screen
4. Data File Selection	Filename	Filename	Scenario	Filename	Scenario
E. Easy to Learn and Operate:					
	Very Easy	Easy	Difficult	Easy	Very Easy
F. Software:					
1. Program Language	FORTRAN-77	FORTRAN IV	FORTRAN/Assem.	FORTRAN	C Language
2. Plot/Interactive Editor	PLOTNET/NEDS	MVPLT/MVGRAF	NETPLT/NETVUE	MOTORS-PLOT	N.A.
G. Total Package Prices:					
1. Highway Analysis	5500	7500	5500	3700	995
2. Transit Analysis	2000	5000	5000	2000	995
3. Plotting	1000	1500	Included	1000	N.A.
	2500 (NEDS)	1000	500	700	N.A.

Note: Packages were received in January 1987.
 Prices are subject to change and do not include source code.
 Source code was provided from TRANPLAN only.

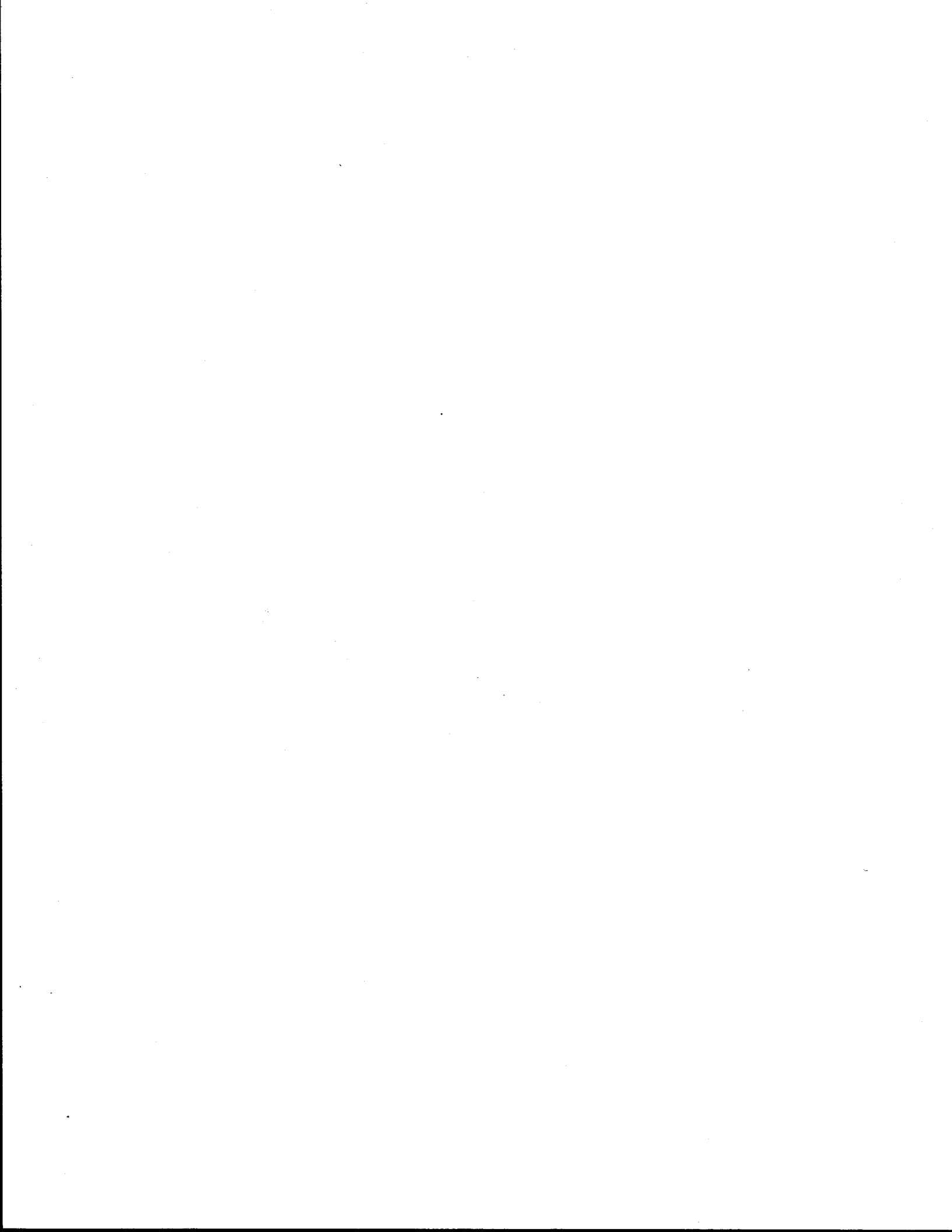
TABLE 3-2. FEATURES AND CAPABILITIES

ITEMS	TRANPLAM/MEDS	MicroTRIPS	MINUTP	MOTORS	TransPro
A. Trip Generation:	Good	Good	Good	Good	Poor
1. Equations	Y	Y	Y	Y	N
2. Category Rates	Y	Y	Y	Y	Y
3. Automatic Balancing	Maybe	Y	Y	Y	Maybe
4. Trip End Entry/Updating	Y	Y	Y	Y	Y
B. Trip Distribution:	Excellent	Excellent	Good	Good	Poor
1. Fratar	Y	Y	Y	Y	N
2. Exponential Gravity	N	Y	N	Y	N
3. Friction Factor Gravity	Y	Y	Y	N	Y
4. K-Factors	Y	Y	Y	Maybe	N
5. Gravity Self-Calibration	Y	Y	N	Maybe	N
C. Mode Split:	Excellent	Excellent	Good	Good	N
1. Binary Logit	N	Y	Y	N	N
2. Diversion Curves	Y	Y	N	Y	N
3. Flexibility	Y	Maybe	Y	Y	N
D. Traffic Assignment Options:	Excellent	Good	Good	Poor	Poor
1. All-or-Nothing	Y	Y	Y	Y	Y
2. Dial's Multi-Path	Y	Y	Y	N	N
3. Incremental Cap. Restraint	Y	Y	Y	Y	Y
4. Iterative Cap. Restraint	Y	Y	Y	N	Y
5. Volume Averaging	Y	Y	Y	N	N
6. Equilibrium Assignment	Y	Maybe	Y	Y	N
7. Select Link Analysis	Y	Y	Y	Y	Y
8. Selected Origins/Destin.	Y	Maybe	Y (Origin)	N	N
9. Turning Movements	Y	Y	Y	Y	Y
10. Build Vines	Y	Y	Y	N	N
E. Graphic Capabilities:	Excellent	Developing	Good	Poor	N
1. Highway Network and Loads	Y	Y	Y	Y	N
2. Highway Paths	Y	N	Y	N	N
3. Zonal Data and Matrices	N	N	N	N	N
4. Windows, Posting and Bandwidths	Y	Y	Y	Y	N
5. Selective Displays	Y	Y	Y	N	N
6. Node Volumes and Delays	Y	N	Y	Y	N
F. Report Printing:	Excellent	Poor	Good	Poor	Poor
1. Basic Reports	Y	Y	Y	Y	Y
2. Partial Networks	Y	N	Y	Y	N
3. Format Choice	N	N	Y	N	N
4. Ground Count Comparisons	Y	N	Y	N	N
5. VHT/VMT Summaries	Y	Y	Y	Y	N
6. Volume Traces	N	N	Y	N.A.	N
7. O-D's of Link Users	Y	Y	Y	Y	N
8. Link-to-Link Tables	Y	N	N.A.	N.A.	Y
9. Subarea Trip Tables	Y	Y	N.A.	N.A.	N

Notes: Y = yes, Maybe = no direct provision, and N = no.

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APPENDICES

The appendices include a general description of those microcomputer packages for which the vendors supplied software for evaluation. In some cases the vendor supplied an operational package of programs as requested. In these cases, the programs of interest to the project were executed using an actual urban transportation study data set. In other cases, a demonstration package was supplied; the data set supplied with the demonstration package was utilized. These are:

Appendix A: General Description of TRANPLAN

Appendix B: General Description of MicroTRIPS

Appendix C: General Description of MINUTP

Appendix D: General Description of MOTORS

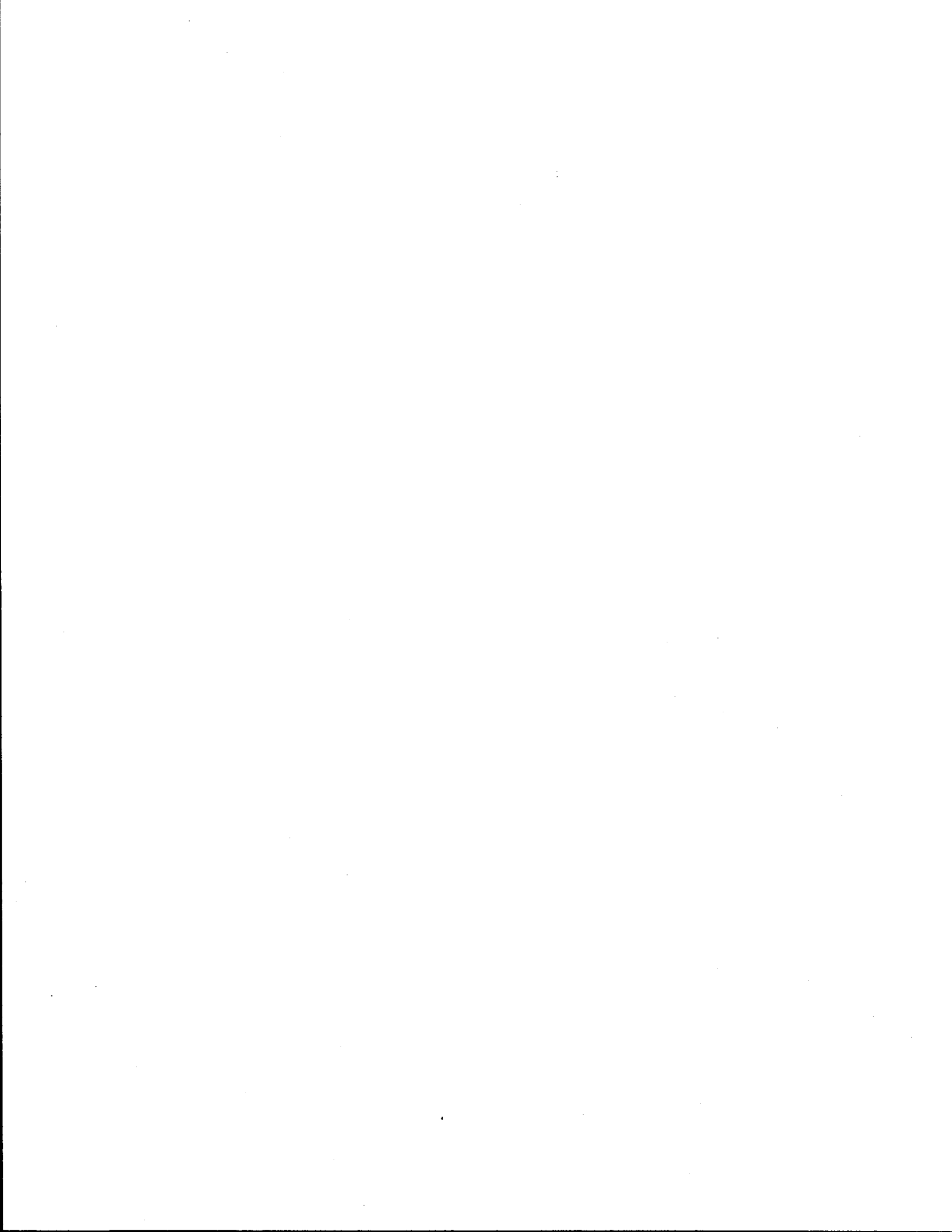
Appendix E: General Description of TransPro

Information on those packages which were considered but were not examined through actual application by the project research team are not included.

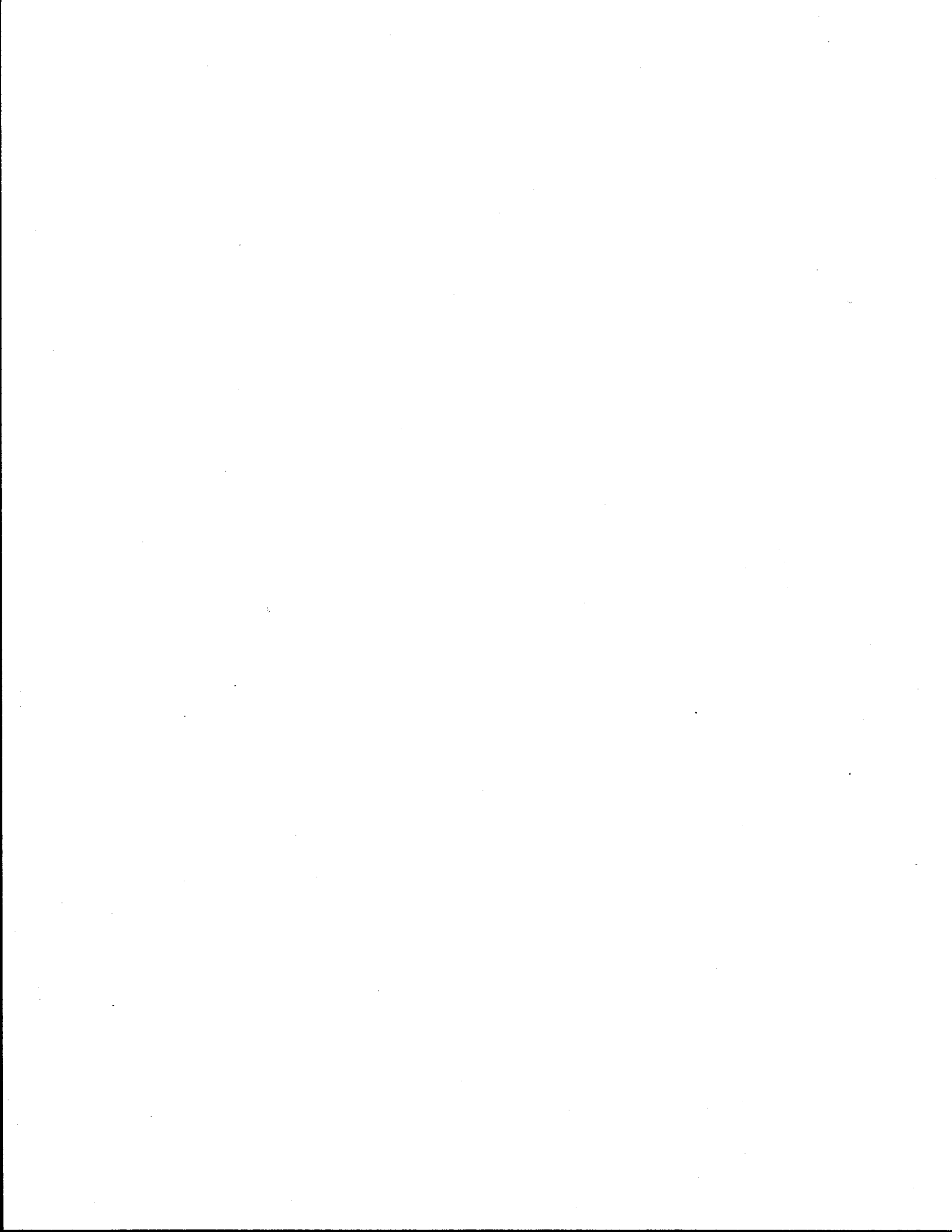


APPENDIX A

GENERAL DESCRIPTION OF TRANPLAN



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A.1. GENERAL INFORMATION

TRANPLAN is a comprehensive, fully integrated, and user-oriented system with highway and transit programs fully compatible, thus simplifying the procedures of multi-modal systems planning. Unlike other transportation software, TRANPLAN uses English-like syntax and uniform specifications in all programs.

Recently, TRANPLAN has been interfaced with on-line, interactive, graphics software (NEDS) for network editing and display. NEDS is an on-line, menu-driven graphics package for the creation and maintenance of transportation planning networks, as well as for the display of network attributes and assignments.

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ENVIRONMENT

The TRANPLAN package currently can be run with the following hardware and operating system configuration. For all the following computers, the package syntax is identical: IBM PC, IBM PC/XT, IBM AT or compatible under PC-DOS (or MS-DOS) version; PRIME (all models); MC 68000-based super-micro-computers; CDC CYBER's (all models); and DEC-VAX (750, 780, and Micro-VAX models).

NEDS is also written in structured FORTRAN77 and currently executes on PRIME and VAX minicomputers, UNIX-based MC 68000, MicroVAX computers and the IBM PC family of microcomputers. For all systems, a high resolution monitor option is available. For the IBM PC microcomputer, an EGA (Enhanced Graphics Adapter, 640x350 resolution) option is available. Although no processor board upgrade is required, a mouse system is necessary for cursor movement on the EGA monitor.

PACKAGE FEATURES

TRANPLAN is distributed on 12 (13 if plotting) diskettes, and requires about 3.5 mb of storage if all programs are transferred to a hard disk. The package is structured as a dynamic tool for the planner. The entire set of programs is separated into 42 modules, referred to as "FUNCTIONS," each of which has specific capabilities. The modular structure enables new and improved techniques to be incorporated without affecting existing modules of the library set. The package consists of the following modules (programs) from the PC versions of TRANPLAN:

- o Distribution/Modal Choice Models
 1. GMODEL.EXE - Gravity Model and Calibrate Gravity Model
 2. FRATAR.EXE - Fratar Model
 3. MSPLIT.EXE - Modal Choice
 4. SPLTCAL.EXE - Calibrate Modal Choice

- o Networks
 - 1. HWYNET.EXE - Build Highway Network
 - 2. MACNET.EXE - Macro Highway Network Update
 - 3. CUNET.EXE - Build Cost User Network
 - 4. HUDNET.EXE - Build Transit Network
 - 5. EXNET.EXE - Extract Subarea Network
- o Paths
 - 1. SLCTSM.EXE - Highway Selected Summation
 - 2. HUDPATH.EXE - Build Transit Paths
 - 3. HUDPSUM.EXE - Transit Selected Summation
 - 4. IZTIME.EXE - Build Intrazonal Impedances
- o Loading
 - 1. HWYLOD.EXE - Load Highway Network and Load Highway Selected Links
 - 2. TRLOAD.EXE - Load Transit Network
 - 3. TRSTOS.EXE - Load Transit Station to Station
 - 4. POST1.EXE - Build Selected Link Trip Tables
 - 5. POST2.EXE - Analyze Multiple Selected Links
 - 6. STOCH.EXE - Stochastic Highway Load
 - 7. SUBAREA.EXE - Extract Subarea Trip Table
- o Matrix Utilities
 - 1. UTABLE.EXE - Matrix Update
 - 2. MTABLE.EXE - Matrix Manipulate
 - 3. COMPRESS.EXE - Matrix Compress
 - 4. TRNSPS.EXE - Matrix Transpose
 - 5. EXPAND.EXE - Matrix Expand
 - 6. TRFARE.EXE - Build Fare Matrix
 - 7. BUILD.EXE - Build Trip Table
- o Reporting
 - 1. RPTNET.EXE - Report Highway Network
 - 2. RPTPAT.EXE - Report Highway Paths
 - 3. RTABLE.EXE - Report Matrix
 - 4. RPTLOD.EXE - Report Highway Load
 - 5. TRPRAS.EXE - Report Transit Load
 - 6. CORDOR.EXE - Report Corridor Volumes
 - 7. RVOLCOM.EXE - Report Matrix Comparison
 - 8. RWEAVE.EXE - Report Complex Weaves
 - 9. RVLSUM.EXE - Report Highway Network Summary
 - 10. RINCSM.EXE - Report Highway Incremental Summary
 - 11. RNTACC.EXE - Report Network Accessibility
 - 12. TLFREQ.EXE - Report Trip Length Frequency
- o Plotting
 - 1. PLOTNET.EXE - Plot Highway Network and Plot Highway Load
 - 2. PLOTPATH.EXE - Plot Highway Paths
- o Trip Generation
 - 1. TRIPGEN.EXE - Trip Generation

NEDS programs include the following features:

- | | |
|-----------------------------------|----------------------------|
| o Interactive Network Editing | o Color Displays |
| o Bandwidth Displays | o Volume/Capacity Analysis |
| o Minimum Path Determination | o Road Link Loading |
| o Highway/Transit Networks | o Transit Line Loadings |
| o Alternate Host Computers | o Network Zoom & Pan |
| o High/Medium Resolution Monitors | o User-Specified Restart |
| o Hard Copy Options | o Restore Last Views |

PACKAGE INSTALLATION AND OPERATION

Although the TRANPLAN syntax is virtually identical, regardless of the computer environment utilized, the computer operating systems do vary. The basic commands/instructions are presented to access and execute TRANPLAN on IBM PC/XT, IBM AT or compatible under PC-DOS (or MS-DOS) version. The method of installation and operation described below is direct and fairly simple:

1. Establish a working directory for executing TRANPLAN.
2. Ensure that the executable TRANPLAN file "TRNPLNXT.EXE" and all required executable modules are in the working directory.
3. Copy any input TRANPLAN data files to the working directory (or on a DOS "PATH").
4. Create a TRANPLAN input control file on "TRNPLN.IN."
5. Type in "TRNPLN" to execute TRANPLAN.

TRANPLAN is operated through a control file named TRNPLN.IN that can be set up using a system editor. The file contains commands that specify which program or programs are to be run, the files, parameters and options to be used by each program, and any special report headers. These functions have a set of controls which are uniform in concept and format. However, differences exist in the details of each function in the user manual; these are given in individual write-ups of each function. A user could create a series of these files for different operations, store them under different names, and copy the appropriate file into TRNPLN.IN prior to execution. The following general control structure applies to all TRANPLAN function.

```

$Function Name
$FILES
    INPUT FILE = Filename, USER ID = $Identification$
    OUTPUT FILE = Filename, USER ID = $Identification$
$HEADERS
$OPTIONS
$PARAMETERS
$DATA
$END TP FUNCTION
    
```

The control file is executed by entering TRNPLN on the keyboard. The package checks to see if all specified programs and input files are stored on disk, then executes the programs in sequence. Output files specified in the control files are stored under names specified by the user, and reports are stored on disks under a file name TRNPLN.OUT. The print or type commands can then be used to access the stored reports.

NEDS is a user-orientated, menu-driven system which is easy to learn because the menus are essentially self-explanatory. A user manual is available which details each menu selection item. The user manual contains precise installation instructions.

For example, DISPLAY POSITIONING OPTIONS are the first set of options in the menu. These options allow the user to display different portions of the network within the NEDS viewport window. The entire network may be drawn with the "DRAW NETWK" option/selection. "ZOOM" permits the user to define a rectangular area to be enlarged in order to view a subarea of the network in detail. "PAN" allows the user to move the view of the network in any direction with respect to the current display. "PAN BY CRD" permits the user to specify a window with specific coordinate values. "LAST VIEW" displays the preceeding network views; the "NEXT VIEW" option/selection returns the "Next" (in a circular buffer of seven views) network view. These display positioning options provide the user quick and easy ways of locating the desired window into the network.

DOCUMENTATION

TRANPLAN documentation is available in hard copy. It can also be obtained on disk files (three diskettes for TRANPLAN/NEDS). Each program is described in a separate file which reviews its capabilities, identifies required and optional files, defines parameters and options, presents the format of any 80-character ASCII data records, and provides one or more examples of a control file. In addition, there are files describing the installation and overall operation of the package, including the execution of demonstration files.

DATA ENTRY AND STORAGE

There are two methods of job or run data entry in TRANPLAN; they are the use of \$FILE and \$DATA specifications in the job control file. Data files, such as a link data file (the file name = NETDATA), can be created separately; these files are in fixed format. They can then be accessed using the \$FILE specification. Other files, such as a highway network file (the file name = HWYNET), are created by a TRANPLAN program; all of these file specifications are in free format. Input files in the \$FILES control, including job control files, are ASCII records that can be created and modified using a text editor.

The \$DATA control indicates that one or more data records immediately follow. Data requirements are given in detail in each applicable function write-up. The data are specified in one of two ways: fixed format and free format.

If more than one option, parameter, or datum is specified on the same record (line), they must be separated by commas. Commas need not be used if separate records are used for each statement. Blanks may be left between letters and numbers of any single statement. Many parameters and data are specified as lists of numeric values. In any such case, all desired values should be put in one list and ascending order, recommended for readability, unless otherwise indicated. Ranges of values may be specified within a list in lieu of declaring each particular value. Data files that are created by TRANPLAN programs for use by other programs generally are unformatted files

written and read using FORTRAN's unformatted option. A subroutine is available for reading and writing matrix files, and the user's manual illustrates its use.

A.2. BUILD HIGHWAY NETWORK

A TRANPLAN network is similar to a UTPS or PLANPAC network. Network link data, turn penalty data and/or turn prohibit data, and node coordinates may be input. Extensive network data edit capabilities exist for the user. All edit messages are descriptive for convenient and quick interpretation. A full listing of the network data may be optionally reported; otherwise, only records with errors are listed. An existing highway network may be updated by any of three methods: deletion of existing network components; insertion of new components; and modification of existing links. When a large set of links is to be modified or deleted according to some consistent pattern, rather than link by link, the MACRO HIGHWAY NETWORK UPDATE function should be used instead of the update option in BUILD HIGHWAY NETWORK function.

NODES

Nodes must be numbered in the sequence -- zones followed by other nodes. Zones (internal zones followed by external stations) must be numbered sequentially without gaps; however, gaps are allowed in numbering other nodes. The network builder permits up to 31 exits at a node. However, if turn prohibitors are used at a node, only eight exits are permitted. Also if turns are to be saved during loading, only four exits should be used at any node. Node coordinates are optional; values may range from -9999 to 99999. With the LARGE COORDINATE option, eight-digit ($2^{31} - 1$) coordinates may be utilized; therefore, they will permit State Planner Coordinate Systems applicability.

LINKS

A link distance is specified in hundredths of a unit with a maximum value of 40.95. Either a speed (in hundredths of a unit, maximum value = 99.99) or a travel time (in hundredths of a unit, maximum value = 40.95) may be specified as impedance information. Up to two time or speed values may be supplied for each directional link. Capacity is entered in the first field for each link direction with a maximum value of 999,999. Observed (directional) volumes may be coded in the second data field, or the field may be used to enter alternative capacities. B-to-A in the second data field values need not be coded for symmetrical links. In addition, a table of opposite direction codes can be supplied in the network parameters.

An assignment group code (A/G value = 0 to 9) may be specified for each link to indicate which user-specified speed-column curve is to be applied during a capacity-restrained assignment. In addition, up to three sets of two-digit link group codes (L1, L2, and L3) can be assigned to each direction of the link. These codes can be used in macro-updating and in selecting links for network reports and summaries. A direction code (DIR ranging from 1 to 16) may be specified for each link; the codes are used to designate macro-turn penalties. A user identification field allows the user seven alpha-numeric characters to aid in identifying the particular link.

A.3. BUILD HIGHWAY PATHS AND SEPARATION MATRICES

HIGHWAY SELECTED SUMMATION

This function allows the user to skim either all or selected minimum impedance paths to produce interzonal impedance matrices. The minimum paths may be generated based on Cost, Distance, either of two time fields (Time 1,2), or User-specified network parameters. As the minimum paths are built based on one impedance, the values for the other impedances may also be accumulated. Up to seven (four on the IBM PC version) interzonal matrices may be built in one run. Paths may be printed for up to 20 selected nodes as origins.

BUILD INTRAZONAL IMPEDANCES

This function allows the user to generate intrazonal impedances for any skim table based on the nearest zone(s). The program calculates the intrazonal impedance as one-half the average impedance to the adjacent zone(s) as specified by the user. Two alternate forms of adjacency may be specified: the user may explicitly input the adjacent zones for each zone (by ZONE and ADJACENT ZONES data specifications), or the user may specify a number of adjacent zones (by NUMBER OF ADJACENT ZONES parameter) for the program to analyze. In the latter case, the program determines the adjacent zone(s) and calculates half the average impedance to the adjacent zone(s). Intrazonal impedances are generated for all skim tables on the input file.

A.4. TRIP GENERATION

TRIP GENERATION function accepts Traffic Analysis Zone data such as population, dwelling units, employment, and socio-economic data, and applies user-supplied linear relationships to generate Productions and Attractions for input to the Gravity Model. The P's and A's are generated in TRANPLAN format and may be merged into a TRANPLAN control stream or placed on the file, and input directly to the Gravity Model.

The function permits up to 25 independent variables and up to 26 coefficients or generation rates. Default formats exist for both data types; however, the user may optionally specify the formats for reading the data sets by using the USER FORMAT option. All generated data are checked, and all negative results are flagged and made equal to zero.

A.5. TRIP DISTRIBUTION

GRAVITY MODEL

GRAVITY MODEL function accepts the interzonal skim impedances and zonal trip end productions/attractions stratified by class of trip (purpose), travel impedance factors, zone-to-zone travel indices, and K-factors (optional), and generates a zone-to-zone trip table file from the Gravity Model distribution formula. The function also checks the acceptability of computed attractions, and if necessary, adjusts the calculated attractions to each zone to equal the input attractions.

The impedance used in the model may be from any table (e.g., cost, travel time, or weighted impedance) in the skim tree file supplied to the Gravity Model program. Friction factors are supplied, by trip purpose, for all integer values of impedance over the range occurring in the skim tables. The classical gravitational formula is restructured for computer users.

When the user desires to balance attractions, the number of iterations (by the number of ITERATIONS ON ATTRACTIONS parameter) and the convergence criteria (by the percentage of ATTRACTION CLOSURE parameter) are specified, and the model iterates until either convergence or the number of iterations specified by the user is met. Attraction iterations are based on individual zonal level adjustments.

Adjustment K-factors may be supplied, by purpose, for ranges of origin and destination zones. They are applied on a zone-to-zone basis. P/A tables may be converted to O/D tables by setting up a run that applies three of the matrix utility programs (TRNSPS, UTABLE, MTABLE) in series.

This function optionally prints trip ends, attractions, trip length statistics, and accessibility indices. All reports can be printed after each iteration of a trip distribution or only at the end of a run.

CALIBRATE GRAVITY MODEL

This function generates gravity model distribution rates (F-Factors) from origin-destination survey data. In essence, the model is calibrated by an interactive process during one computer run, thereby eliminating the need for multiple runs and laborious hand calculations between runs.

A trip length frequency distribution of the survey data, associated productions and attractions, and F-Factors (initially set to 100) are input on a Gravity Model History File. The calibration is an iterative process, with least-squares used to estimate a log-linear friction function in each iteration. The user controls the number of iterations and sets convergence criteria. SMOOTH PERCENTAGE parameter allows the user to specify the percentage of time (impedance) intervals at the high end which are considered less reliable than those at the low end. For example, if the maximum time were 100 minutes and smooth percentage were 40.0, then that portion of the trip length frequency from 61 to 100 minutes would be smoothed.

FRATAR MODEL

FRATAR function will update a trip table according to an iterative Fratar expansion process. Generally, it is used to expand a base year trip table based on zonal origin and destination growth factors. An expanded trip table file is generated. This file contains the same number of zones as the input file and the number of purposes as specified by the user. If the PRINT TRIP END option is selected, the REPORT MATRIX function is automatically called to produce a trip end summary report. If the PRINT ALL ITERATIONS option is selected, growth factor summaries are reported for each iteration.

A.6. MODE SPLIT

MODE CHOICE function performs the "splitting" of trips between two competing modes of transportation according to previously determined curvilinear diversion relationships between the modes. The program also requires two files that contain the transit travel impedances and the highway travel impedances to be utilized by this function. The program creates the following output files: the transit passenger trip table, the highway person trip table, and the auto driver table.

The split is achieved through diversion curves which specify the percentage of transit travel as a function of the ratio or difference between one of the following factors which affect the modal choice methodology in this program: trip purposes; production area characteristics (P Code); attraction area characteristics (A Code); and any two measures of interzonal travel impedance (i.e., two of cost, distance, or time).

The program will accept up to 15 trip purposes, 8 P Codes and 8 A Codes (e.g., CBD or other employment center), and 8 second interzonal impedance ranges (e.g., cost difference for mode split curves based on travel time ratios); these allow considerable flexibility in associating the trip characteristics to diversion rationale.

TRANPLAN includes a program for calibrating diversion curves from transit and total person trip tables and from transit and auto impedance tables. CALIBRATE MODAL CHOICE function enables the user to systematically stratify modal split data sets to derive optimum estimating curves. Calibrated curves can be consolidated in subsequent runs of the calibration program.

A.7. TRAFFIC ASSIGNMENT

A job control file would be prepared to run an assignment program optionally followed by appropriate analysis or reporting programs. If no select link analysis were to be performed, the file would include FILE names, OPTIONS and PARAMETERS for the basic assignment program, followed by similar information for either the network or assignment reporting programs. Job control information for the general (RVLSUM = Report Highway Network Summary) or incremental assignment (RINCSM = Report Highway Incremental Summary) summary programs also could be included in the file.

LOAD HIGHWAY NETWORK

LOAD HIGHWAY NETWORK (HWYLOD) function has essentially three types of loading with some types having many user options:

All-or-Nothing - All selected interzonal highway trips (by SELECTED PURPOSES, ORIGINS, DESTINATIONS, or ODS) are loaded on the minimum paths (based on time, distance, cost, or user impedances) of the input highway network. This is a free-flow assignment with no consideration given to the type of links or link capacities.

Incremental Loading - For each iteration, a user-specified percentage of all interzonal highway trips is loaded on the minimum paths determined

during path building. This function has the capability of adjusting link times on the initial (base) network or on the network used during the previous iteration. The function, via user option, may or may not expand the accumulated volume to represent conceptually a 100 percent loading (ADJUST 100 option) during determination of the assigned volume/capacity ratio. Also in Incremental Loading, the user may specify that "undivertable" trips (notably very short and very long trips) are loaded along with the first specified percentage of "divertable" trips on the initial or "free" network. Incremental Loading continues as described above on the remaining "divertable" highway trips.

Restraint Loading - As above, all selected interzonal highway trips are loaded on the minimum paths of the input highway network. A loading of 100 percent is performed on paths built from the adjusted network for each iteration. Up to 10 iterations may be performed.

The following features exist in both Restraint Loading and Incremental Loading. The network parameter, time, is adjusted link by link according to user-specified volume/capacity time adjustment curve data or the modified BPR capacity restraint formula. The adjusted time may be optionally dampened by a user-specified parameter (e.g., as only one-quarter of the time difference). The counted volume may be taken as the capacity (CAPACITY 2 option) for assigned volume/capacity ratio determination. For each Assignment Group, minimum and maximum speeds (MINIMUM and MAXIMUM SPEEDS options) may be specified within which the adjusted speed on a link must lie after adjustment.

For all types of loading, turn volumes may be saved during loading for up to 50 ranges of nodes. Turn volumes for node configurations with up to four entry links and five exit links may be saved at each selected node for subsequent reporting. TRANPLAN utilizes a VINE builder, as opposed to the traditional TREE builders.

LOAD HIGHWAY SELECTED LINKS

This function performs the selected link analysis element of the highway network loading process. It is interrelated with the LOAD HIGHWAY NETWORK function and the loading options are the same. The three parameters (LOAD SELECTED LINKS, ONE WAY SELECTED LINKS, and TWO WAY SELECTED LINKS), are the only differences from the previous function.

A selected link history file is produced which is input to the various post-processor functions (e.g., POST1 = Build Selected Link Trip Table and SUBAREA = Extract Subarea Trip Table) and report functions (e.g., POST2 = Analyze Multiple Selected Link Trip Tables and RWEAVE = Report Complex Weaves). A loaded highway network history file is also produced by this function. Therefore, the user need not run the LOAD HIGHWAY NETWORK function if he is doing selected link analysis.

BUILD SELECTED LINK TRIP TABLE

This function is the first in a series of selected link post-processors which manipulates the selected link history file generated by the LOAD HIGHWAY SELECTED LINKS function to produce reports or trip table files for the analysis of loaded networks. The selected volume file is a merged trip

table file of up to 15 tables; each is comprised of those trips which traversed one user-specified selected link (one-way). A trip end summary of the selected volume file may optionally be reported by the PRINT TRIP ENDS option.

ANALYZE MULTIPLE SELECTED LINKS

This function is the second in a series of selected link post-processors which manipulates the selected link history file to produce reports or trip table files for the analysis of loaded networks. This particular post-processor analyzes trips which use "origin" links, "through" links, and "destination" links (specification of "through" links is optional) as DATA input.

Up to 15 sets (or tables) of analysis conditions may be specified during each execution of this function. The number of links in each set is restricted only by the amount of available memory. The function produces an origin link to destination link matrix report for each set and optionally produces a trip table (by the SELECTED VOLUME FILE option) with links replacing zones for each set. This trip table would logically be generated only if there were many links specified per set and could be compressed with MATRIX COMPRESS to summarize groups of links within each set.

EXTRACT SUBAREA TRIP TABLE

This function manipulates the selected link history file generated by the LOAD HIGHWAY SELECTED LINKS function to produce trip table(s) of trips within, into and out of the cordoned off area of the network. For example, the user may be interested in extracting a segment representing the downtown area of a regional highway network to perform a more detailed investigation of traffic patterns within that area.

The function generates a trip table for a subarea of a network defined by links on the boundary and zones within the boundary. Each zone within the boundary becomes a renumbered zone, and each link crossed by the cordon line also becomes a new zone. Trips crossing the link inbound become the new zone productions (or origins), and trips crossing outbound become the new zone attractions (or destinations). The internal zones of the extracted subarea are renumbered sequentially (by INTERNAL ZONE CORRESPONDENCE data) from one on a one-to-one basis according to user instructions.

The output from this routine is a new trip table, SUBVOL, corresponding to the selected subarea and external stations. Only those purposes on the original file which are selected by the user are written onto SUBVOL. This trip table may be assigned to a subarea highway or transit network, or it may be further manipulated to refine the subarea zone system with the MATRIX EXPAND utility.

STOCHASTIC HIGHWAY LOAD

This function accepts a highway trip table and a highway network and performs a probabilistic multipath traffic assignment. Trips are assigned to all "reasonable" paths between each origin and destination. The program may use five "standard" impedances (e.g., COST, DISTANCE, TIME1, TIME2, OR USER) or an adjusted time from a restrained loading on a loaded highway

network history file. The user has the capability of selecting origins from which, and destinations to which, trips may be loaded on the network. The program contains a loaded network report and optionally produces a loaded highway network history file which can be reported by the REPORT HIGHWAY LOAD function. However, selected link options are not available using this assignment procedure.

EQUILIBRIUM ASSIGNMENT

Equilibrium assignment has recently been added with the REPORTING program to the TRANPLAN package (July 1987 version). It was not available at the time the package was obtained for evaluation. However, the developer has stated that the equilibrium assignment in TRANPLAN will also permit selected link analysis.

A.8. MATRIX UTILITIES

TRANPLAN contains seven matrix handling programs. MATRIX UTABLE is designed to modify one or more tables in a single file, while MATRIX MANIPULATE is used to merge or split tables from one or more files. MATRIX TRANSPOSE simply transposes one or more tables. MATRIX COMPRESS is used to create district-level tables, while MATRIX EXPAND is used to split zones for detailed analysis. BUILD FARE MATRIX can be used for transit cost inputs to modal choice analysis. BUILD TRIP TABLE accepts trip survey data in TRANPLAN format and allocates the trips to trip tables according to user-specified selection criteria. Any element, row, column, rectangular portion, or segment of the diagonal of a matrix can be modified by a constant using addition, subtraction, multiplication or replacement. Matrix updating operations can be made conditional on the value in a matrix element.

A.9. REPORTING

REPORT HIGHWAY NETWORK

This function allows the user to report all or part of a highway network file. Link descriptions, prohibited turns, node coordinates and unused node numbers may all be reported in a single run if desired. This link description report can be presented in either a detailed format for which the full link description is given, or in an abbreviated format for which only the major link characteristics are given in order to minimize the amount of report output.

Two selective link options are available for reporting only portions of a network: an "AND" option, where both ANODE and BNODE must be selected for the link description to be included in the report, and an "OR" option where only the ANODE or BNODE need be selected. Prohibited turns are always indicated within the network description report. Additionally, they are also listed in a turn prohibitor report for easy scanning. Node coordinates may be reported in an ordered list if they have been coded in the network. A report of all unused node numbers (up to the maximum node number) can also be requested.

REPORT HIGHWAY PATHS

This function allows the user to selectively report paths of minimum impedance for a standard highway network or loaded highway network history file. Two types of reports can be produced: non-destructive tree traces in which the path to each destination zone is traced back to each selected origin zone, and destructive tree traces for which the path to each destination zone is traced back only until a path which has been previously traced is encountered.

Paths, which are automatically built within this function, may be based upon any one of the five standard impedance measures: Time 1, Time 2, Cost, User, Distance. Optionally up to 256 Turn Penalty values may be used in the building of paths if Direction Codes (ranges 1-16) have been specified in the highway network. Another option allows minimum paths to be built through centroids (by THROUGH CENTROIDS option), where applicable.

The user may select any number of origin zones as well as up to 20 origin nodes to report paths. Normally the paths for all selected origin zones or nodes are traced only up to the maximum zone number for the network; alternatively, paths may be traced up to the maximum node number if desired. If a loaded highway network history file is being reported, path impedances may be taken from any iteration or iterations of the file. Each selected iteration will generate a separate report.

REPORT MATRIX

This function allows the user to report a trip end summary, selectively to report a trip table, or to report a selected summation (skim) table. It is called by the user option from any other function which produces a trip table or trip end file and generates a trip end summary report. The function permits the selection of specific tables (purposes or skim impedances) and specific origin/production zones. For skim tables, it accumulates origin zone row totals as a measure of zonal accessibilities and inserts decimal points, as scaled by the user, into the reports.

REPORT HIGHWAY LOAD

This function allows the user to report assigned volumes from any iteration(s) and any purpose(s) of a loaded highway network history file. Each iteration and each purpose results in a separate report. Any combination of link volumes and turn volumes can be reported in the same run.

For a link volume report, ANODE, BNODE, assigned volume, reverse direction (if link is two-way), and total two-way volume are reported for each link, three nodes per printed line. Link volume reports may be generated for the complete file or for selected links from the file.

The printing of all links having assigned volumes equal to zero can be suppressed by MINIMUM REPORT option. Additionally, the printing of link volumes can be totally suppressed by the SUPPRESS LINKS option if only turning movement reports are desired. If the loaded highway network history file is multipurpose, then a single report which adds volumes from any number of selected purposes may be generated for each selected iteration by means of a simple option by the ADD PURPOSES option.

If turn volumes were saved during loading of the network, these may be reported within the body of the link volume report by PRINT TURNS option. Alternatively, the user may select a subset (up to 50 ranges) of the nodes for which turn volumes were saved or suppress printing of all turn volumes. To speed up manual plotting of assigned volumes during analysis, an option is available to round reported two-way link volumes to the nearest hundred in link and turn volume reports by the ROUND VOLUMES option.

REPORT CORRIDOR VOLUMES

This function permits the user to report one-way trip interchanges between selected groups of zones on a multipurpose trip table file. Zones may be included in more than one group by NUMBER OF GROUPS parameter or excluded from all groups. When reporting trip interchanges between overlapping groups, the user has the option of including trips between zones common to both groups and also of setting intrazonal volumes to zero by ZERO INTRAS option.

The user, by selectively rearranging the zone groupings (by GROUP, ZONES data specifications), has an extremely versatile tool for measuring the trip interchange activity in a corridor. This capability is especially useful in analyzing potential transit corridors.

REPORT MATRIX COMPARISON

This function compares cell entries of two trip table files or two selected summation files and reports the comparison in any of four ways: differences and ratios between zone-to-zone volumes or impedances for selected origin (production) zones of the two files; frequency distribution of the differences in the zone-to-zone volumes or impedances stratified by volume/impedance groups; statistical summaries; and differences and ratios between zonal trip ends such as productions, attractions, totals and intrazonal trip ends.

REPORT COMPLEX WEAVES

Like other selected link post-processors, this function manipulates the selected link history file(s) generated by the LOAD HIGHWAY SELECTED LINKS function and produces reports for the detailed analysis of specific sections of loaded networks. A typical application of this particular function is to determine the movements of trips entering and exiting a section of freeway.

No options and parameters are specified for this function except the SELECTED PURPOSE parameter specification. Up to 20 weave link sets may be reported in a single run. Each set is defined by entry and exit links (by ENTRY and EXIT LINKS data specifications) restricted only by the number of selected links which can be specified while generating the selected link history file.

REPORT HIGHWAY INCREMENTAL SUMMARY

This function produces three types of reports which describe the time and speed changes on a highway network during each iteration of incremental loading. A detailed report, by link(s) selected, of the time, speed, and

Loaded volume changes for each successive iteration is produced by PRINT LINK SUMMARY option. Frequency distributions of links, stratified by (a) ratios of projected volume/capacity and (b) time/speed differences between each iteration and the base network are produced by PRINT CHANGE DISTRIBUTIONS option. A Ground Count Comparison Report produces various summary statistics which are useful in evaluating the ability of the highway network to reproduce counted traffic volumes (by PRINT GROUND COUNT COMPARISON option).

REPORT HIGHWAY NETWORK SUMMARY

This function reports summaries of highway network characteristics stratified by link class (i.e., link group and assignment group code values). The summary report may be one-, two- or three-dimensional tables, depending on how many link classes specified. Also, selected values of link classes may be reported to reduce the amount of printing.

The network characteristics may be summarized (i.e., Cost, Distance, Time, User, Vehicle Cost, Vehicle-Distance, Vehicle-Hours, Vehicle User, Capacity Time, Capacity Distance, Volume/Capacity) (by ID and UNITS data). Up to 20 such tables (by the number of TABLES data) may be reported in a single run of this function. COST and DISTANCE UNITS parameters specify the name of the unit to be printed in all reports.

In addition, the function permits specification of up to 1000 one-way links to be summarized as screenlines from a loaded highway network (by SCREENLINE and LINKS data specifications). Incremental directional volumes crossing each link are reported for each selected iteration together with the screenline totals.

REPORT HIGHWAY NETWORK ACCESSIBILITY

This function reports the "accessibility" of selected origin zones of a highway or transit network. Accessibility is defined here as the distribution of some defined activity measure versus the travel impedance to reach that activity from the selected zone(s). The activity measure may be population, employment, or the like and may be expressed in terms of trip end frequencies. Each selected origin zone and each "purpose" produces a separate accessibility report. Activity measures may be included for any or all of the destination zones.

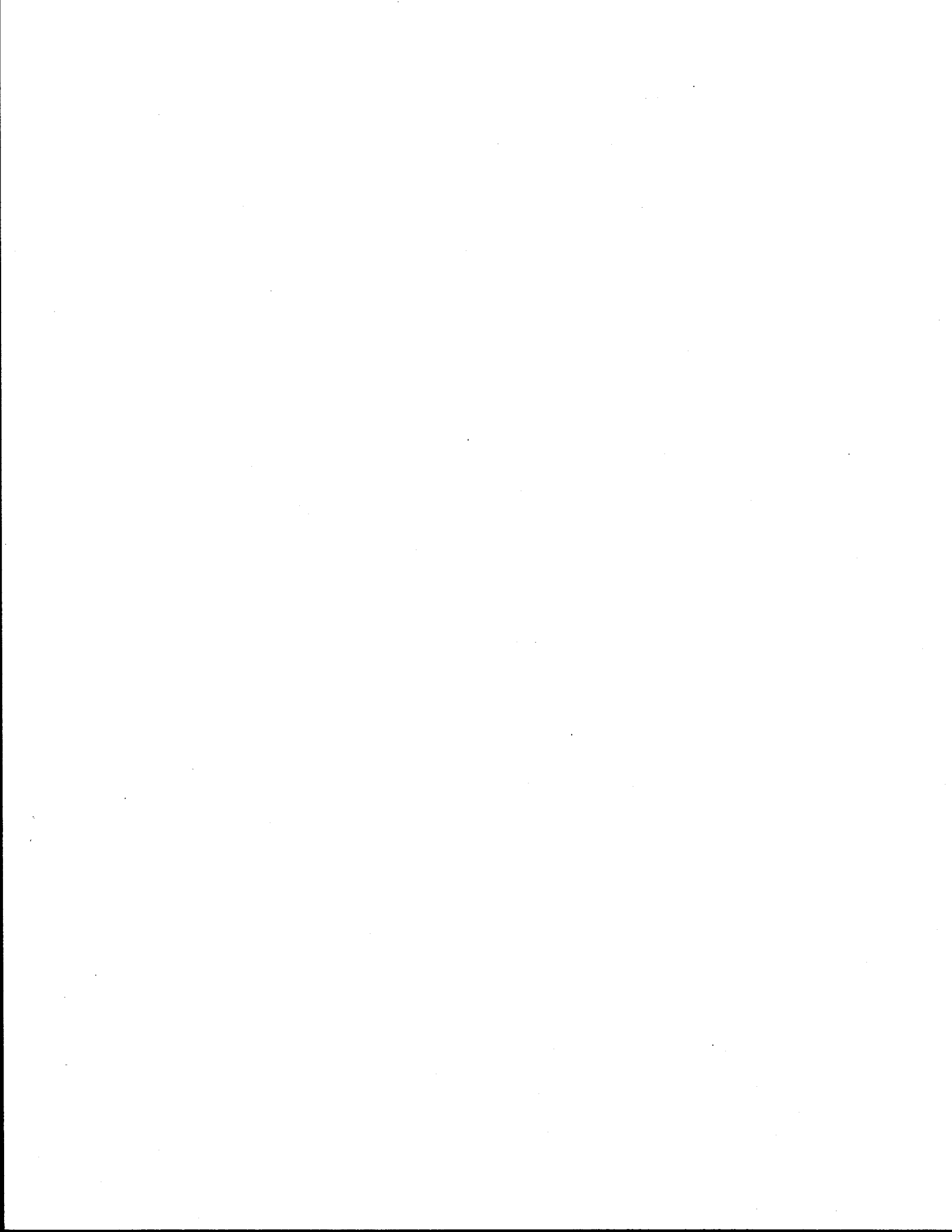
REPORT TRIP LENGTH FREQUENCY

This function reports the trip length frequency statistics for an input trip table merged with an input selected summation (skim) file. A trip length frequency report is generated for each purpose. Trip length histograms, both for each impedance increment and for the accumulated trips up to each impedance increment, are displayed, along with average statistics.

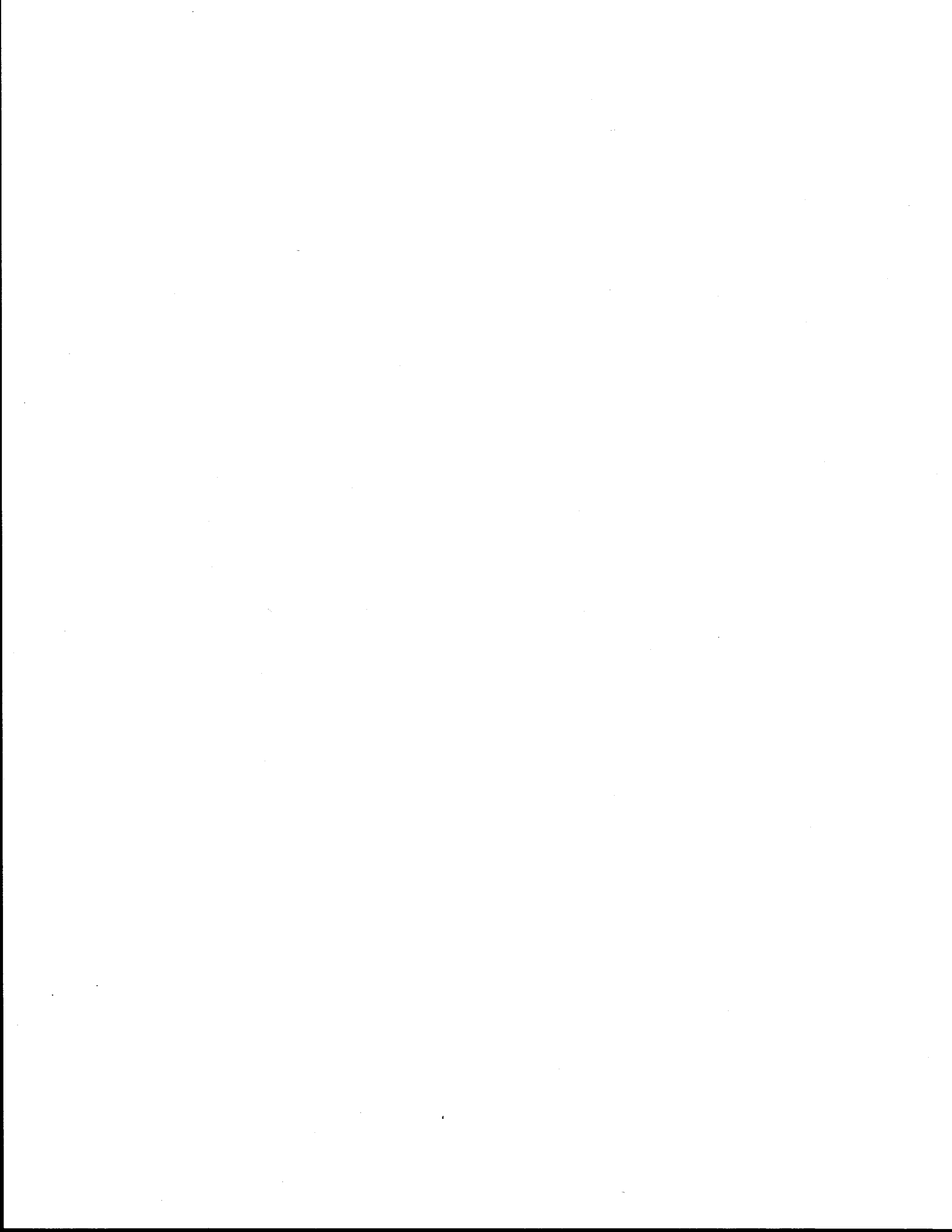
Note: TRANPLAN plotting capabilities were not reviewed at this time.

APPENDIX B

GENERAL DESCRIPTION OF MicroTRIPS



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B.1. GENERAL INFORMATION

MicroTRIPS is a comprehensive software system for transportation planning paralleling UTPS/PLANPAC in functional capability. MicroTRIPS programs are menu-driven, can be operated interactively or through pre-stored command files, and can be interfaced with UTPS and Database Management programs.

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ENVIRONMENT

The MicroTRIPS package operates on microcomputers using the PC-DOS/MS-DOS operating system, version 2.0 or later. Most users have implemented the package on the IBM PC/XT or PC/AT. Operation of the programs from a hard disk offers substantial benefits to the user allowing quicker execution times and simplified file management. A minimum of 256K of core memory is required; 640K is recommended.

A new screen graphics program allows users to view networks (by supplying a binary network file and node coordinate file) or plot file produced by the plotting program (MVPLOT). The program works under Digital Research's GSX or GEM, and for best results should be used with a Hercules Graphics card. Support for higher resolution monitors, such as the Wyse WY-700, is also provided. Plots can also be directed, if desired, to a printer or plotter. The package works with most serial and parallel printers available for microcomputers.

PACKAGE FEATURES

MicroTRIPS is composed of a battery of programs, written in portable FORTRAN. If all of the programs in the package are installed on a hard disk, approximately 2.5 MB of space is required. The package uses free disk space as work space, although there is no set requirement; the program uses as little or as much space as available. The package consists of the following programs and features:

o Roadway Analysis

1. MVHNET - Edits and builds a highway network; up to 32 link types
2. MVROAD - Builds, stores, or reads generalized cost trees; uses minimum cost or multiple routing; skims generalized costs; loads matrices; uses capacity restraint with either incremental, iterative, or volume averaging methods; performs all-or-nothing assignments
3. MVSELC - Selected Link Analysis; subarea matrix generation; junction turning flows
4. MVPLOT - Plots networks with bandwidths and link annotations

o Forecasting Models

1. MVGRAM - Calibrates or runs a distribution; either mathematical or empirical curves; up to three person types; partial matrix technique; growth factoring on up to three matrices
2. MVSPLT - Modal choice for up to three person types; uses mathematical or empirical curves
3. MVTEND - Trip end estimation program; two-way trip rate categorization; two linear variables in each category; six attraction rates; adjustments for non-home based trips

o Matrix Handling

1. MVTRIP - Builds trip matrices from trip records, or restores a matrix from card image matrix file
2. MVMNIP - Manipulates up to ten matrices to give up to ten new matrices; transposes matrices; creates trip end file from matrices; creates card image matrix file
3. MVMOD - Modifies cells conditionally in up to ten matrices; modifies cell diagonals; merges matrices into one file; generates test matrices
4. MVSQEX - Expands or compresses up to ten matrices
5. MVPRIN - Prints matrices in a variety of formats; compares matrices; prints trip end summaries; prints trip cost distributions

o Public Transit

1. MVPNET - Edits and adds transit characteristics to network built using MVHNET
2. MVPATH - Builds transit paths, with multi-routing allowed
3. MVPASS - Assigns trips to network; prints loads
4. MVPSKM - Skims component elements of transit generalized cost matrix

PACKAGE INSTALLATION AND OPERATION

When running any of the MV series of programs interactively, it is first necessary to configure the software to the terminal screen that is being used. This is because different terminals have different screen handling commands. This operation need only be done for the first time that a terminal is used.

The programs can be operated in an interactive mode, with prompts for all requested information, or from a batch mode. The batch mode is similar to UTPS (and MTAP), and is therefore familiar to experienced users. The programs display a status message of the program run at all times, enabling the user to check on the progress of the run. The output of the programs, in the form of a listing, can be directed to the screen, the printer, or a file (for delayed or remote printing).

In the interactive mode, the names and locations of data files to be read or created are entered in response to prompting messages appearing on the screen. Options and parameters also may be entered in this manner, or may be stored in a control file created using a system editor or other data entry utility. The cursor is programmed to allow only consistent sets of

options to be selected and only relevant parameters to be entered; therefore, some experience is necessary before control files can be set up without making mistakes. At the end of most screen displays, the user is given the option of reentering parameters to correct errors. The program runs once all necessary information has been supplied.

DOCUMENTATION

A user's manual distributed with the package contains general operating instructions for the package and detailed write-ups on each program. The latter contains lists of required files, definitions of options and parameters, format requirements for any card-image data files, notes on various applications of the program, documentation of output binary files, and an example of a control file.

DATA ENTRY AND STORAGE

Input files, including job control files, consist of "card-image" records that can be created and modified using system text editors and utilities. The user's manual specifies the formats required for these files, which include the following: zonal household data, Friction Factors, matrix modification commands, highway and transit network link data, and transit route definitions. An alternative for preparing and maintaining these files, recommended by the vendor, is a commercial data base manager such as dBASE II or III.

Data files that are created by MicroTRIPS programs for use by other programs generally are binary files written and read using FORTRAN's unformatted option (e.g., trip tables, network files, and impedance tables). These files are documented in the user's manual to aid a user in writing supplementary programs; in addition, a subroutine library is available which contains routines for reading and writing matrices. A naming convention is applied to all MicroTRIPS files. They must have a unique identifier of up to eight characters, followed by .DAT (for data files), .CTL (for control files), or .PRN (for print files).

B.2. BUILD HIGHWAY NETWORK

A MicroTRIPS network is similar to a UTPS or PLANPAC network. Network link data and optional turn penalty data are entered as card-image records that can be prepared and updated using a system editor or other utility. Copy and rename commands can be used to store modified versions of a network.

NODES

Nodes must be numbered in the sequence zones followed by other nodes. Zones (internal zones followed by external stations) must be numbered sequentially without gaps; however, gaps are allowed in numbering other nodes. Up to eight links may enter a node, and up to eight links may leave it. A separate file of node coordinates is set up for plotting networks, but otherwise, coordinates are not used; values may range from 1 to 999,999.

LINKS

A link distance is specified in hundredths of a unit with a maximum value of 327.00. Either a speed (in hundredths of a unit, maximum value = 327.00) or a travel time (in hundredths of a unit, maximum value = 327.00) may be specified as impedance information. A capacity-restrained assignment procedure is used, free-flow and other speeds are supplied by link type, and these link impedance values are ignored.

A capacity may be supplied for a link, or a default value supplied by link type may be used. In cases where both options are used, a link-specified value will override the default. A preload volume may be supplied. B-to-A values need not be coded for symmetrical links. A link type code (maximum value = 32) is used to indicate a default capacity and a volume-delay curve, and to summarize network performance.

B.3. BUILD HIGHWAY PATHS AND SEPARATION MATRICESPATH BUILDING CONSIDERATIONS

MVROAD builds paths through the highway network by attempting to minimize the generalized costs along links between zone pairs. The costs for a link is calculated as (Link Distance x Distance Factor) + (Link Time x Time Factor), and by setting either of the two factors to zero, it is possible to build paths purely on time or distance only. Only one set of paths from each zone is constructed per iteration; up to 25 trees may be built in a test run. The user has the choice of requesting an all-or-nothing tree build or one where a degree of randomization of link times based on the Burrell technique is allowed.

Turn penalties into network are expressed in generalized cost units and applied between node triplets. When a path is built through such a defined node triplet, the turn penalty is added into the total cost for the path. These turn penalties are used to ban prohibited turning movements or to add to the cost of making a particular movement, e.g. turning right, at a busy junction. However, the use of turn penalties can lead to illogical routing due to the properties of the path building algorithm. They must be used with care.

Unless capacity-restrained assignment is being applied, travel times or speeds coded in the network file are used in building paths. If capacity restraint is being applied, speeds are calculated using the speed-flow curve specified for the link's type. A "curve" has three different segments that are based on parameters specified by the user. Intrazonal values are added to an impedance matrix using the matrix updating program.

BUILDING SEPARATION MATRICES

A weighted impedance matrix can be produced as part of any tree-building or assignment application of MVROAD, except building test trees. Minimum time or distance paths also may be built and skimmed. If time and/or distance values along minimum impedance paths are desired, then MVROAD must be run twice. In the first run, minimum impedance trees are built and stored; in the second they are skimmed for time or distance. A

card-image file containing intrazonal values and any changes is prepared using a system editor, and the MVMOD program is run to modify the impedance tables produced by MVROAD.

B.4. TRIP GENERATION

Trip estimation may be performed using estimation equations, household category trip rates, or a combination of these techniques, depending on the options chosen for the following steps:

1. In preparing zonal data, households can be divided among up to three auto ownership groups.
2. Households also can be distributed along a second dimension using a series of equations that are based on variables in the zonal data. A matrix balancing procedure is used to allocate households in each zone among cells in the classification table.
3. Zonal trip productions are estimated for each cell using equations defined by the user and aggregated by auto ownership group. The variables in these equations can be zonal data or cell values.
4. Zonal trip attractions are estimated using equation(s) supplied by the user.

As many as six household type or size categories and three auto ownership levels may be defined. The number of households in each auto ownership category is supplied in the zonal data. The number of households by type also may be supplied in the zonal data or calculated using a series of equations supplied by the user. In the latter case, a matrix balancing procedure may be employed to distribute households among the up to 18 possible classes.

Generation equation can be supplied for a specific time period. Alternatively, trip tables can be factored to produce hourly or analysis period tables. Estimated attractions are automatically scaled to match production. If non-home-based trips are being estimated, attractions in each zone optionally can be set equal to productions.

B.5. TRIP DISTRIBUTION

The MVGRAM program is used for applying a Fratar, a gravity model, or calibrating a gravity model. Prior to applying the program, a system editor may be used to prepare a control file, and/or a file of friction factors for a gravity model. Matrix programs also would be used to prepare an observed trip table for a Fratar application or a K-factor matrix for a gravity model application. Both a Fratar and a gravity model operate on a file of trip ends created for a single trip purpose, either directly by the user or using a trip generation program. The trip end file contains a single value of attractions to each zone and up to three values of productions. A trip table is produced for each auto ownership group.

The trips to/from external zones may be distributed along with internal trips, distributed in a separate run and merged using a matrix manipulation program, or entered directly in a trip table using the matrix update program. Production/attraction tables may be converted to origin/destina-

tion tables in a series of runs of the MVMNIP program. When original and transposed tables are combined, a different factor can be applied to each. The MVMOD program also can be used to apply different factors to different parts of a table.

GRAVITY MODEL

The Gravity Model distribution formula of MicroTRIPS, which applies the balancing factors that are calculated internally, is different from the traditional gravitational formula. The impedance used in the model may be from any table (e.g., cost, travel time, or weighted impedance) in the skim tree file supplied to the gravity model program. Friction factors may take one of two forms. The first is a linearly segmented curve defined by the user in a separate card-image file read by the trip distribution program. Each record in the file contains an impedance value and the corresponding friction factors for up to three auto ownership classes. The second form is the exponential equation using two parameters (X1 and X2) specified by the user. Different parameters may be specified for each auto ownership group.

A separate run of the trip distribution model is required for each purpose or time period. Trip productions can be supplied for up to three auto ownership groups, however, and can be distributed using different friction and K-factors. The distributed trips will be summed over these groups for balancing against a single set of trip attractions, but will be stored in separate trip tables (which can be added together using a matrix manipulation program).

The convergence procedure is iterative, with distributed attractions checked against input trip ends at the end of each iteration. The iterations end when the difference is less than 0.5%, or when the maximum of iterations (up to 20) specified by the user have been performed. Adjustment K-factors may be supplied in matrix format. The matrix modification program (MVMOD) can be used to construct a K-factor matrix.

This function prints convergence summary and trip length distributions. The printing program (MVPRIN) must be used to produce trip tables, trip ends, table comparisons, and distributions. Trip tables can be formatted with a print line containing either part of a matrix row or the corresponding cells of up to eight matrices.

CALIBRATE GRAVITY MODEL

The friction factor parameters (X1 and X2) can be estimated using an iterative, maximum likelihood procedure. The user supplies (all or part of) a trip table, impedance matrix, and initial parameter values; and the program produces an estimated trip table, parameters, and calibration statistics. This function prints calibration statistics.

FRATAR

Trips may be distributed based on an historical trip matrix supplied by the user. The procedure is iterative with distributed trips ends compared to input values at the end of each iteration. The user specifies the maximum number of iterations in response to a screen prompt.

B.6. MODE SPLIT

Diversion curves based on differences between transit and auto impedances or costs can be supplied in either of two forms. The first is a linearly segmented curve relating the percentage of trips using one of the modes to the cost difference. The curve is defined as a series of points which are supplied through a card-image file prepared by the user. The second is a curve of the parameter L (a diversion parameter), CAPT (percentage of trips captive to mode 1), and D (cost difference that generates an equal split of choice trips) supplied by the user. Different parameter values or curves may be supplied for different auto ownership groups. The mode split program estimates trips by mode for each auto ownership group, but only produces a single trip table for each mode.

The MVSPLT program is applied to prepare auto and transit trip tables. If diversion curves are used, a system editor would be applied prior to the run to prepare or update a file containing the curves. In addition, the MVMOD program would be used to add auto terminal times and intrazonal transit times to the impedance matrices used in the splitting process, if these steps had not been performed earlier. MVSPLT would then be loaded, and file names and other information entered in response to screen prompts.

B.7. TRAFFIC ASSIGNMENT

MVROAD program is used to build all trees throughout the network for use in assignment. Having obtained a trip matrix, the analyst can either specify a simple all-or-nothing assignment or a more complicated capacity-restraint assignment. This is where an attempt is made to balance the flow of traffic to the speeds along the links by using defined speed-flow relationships. The attempt at achieving a balanced network can be made by using iterative, incremental, or volume averaging assignment techniques. At any stage of the assignment procedure, generalized cost matrices can be saved, as can tree files.

CAPACITY-RESTRAINED ASSIGNMENT

Up to ten increments or iterations of capacity-restrained assignment may be specified in a single run with varying fractions of trip table and preload volumes assigned in each. The user can specify the fraction of previously assigned trips that are to be retained in each increment or iteration, enabling volume averaging and similar procedures to be performed.

SELECTED LINK, TURNING MOVEMENT, OR SUBAREA ANALYSIS

If selected link, turning movement, or subarea analysis is to be performed, the MVROAD assignment must include the option to save a tree file. A system editor is used to create card-image files of selected links, cordon links, or nodes selected for turning movements. The MVSELC program is then run for each of these special analyses, with file names, options and parameters supplied in response to screen prompts.

Zone-to-zone tables of trips that use sets of selected links may be produced with a separate table created for each set. Up to ten link sets can be specified in a run; these sets are lists of links that can be

specified either as "and" lists or as "or" lists. The trees used in the analysis must have been saved during a previous assignment.

MVSELC can be used to examine in greater detail the turning volume flows at any junction or determine the origin/destination pairs of trips using a particular link or set of links in the network. This program can also be used to produce a subarea matrix of trips if more detailed analyses are required for a particular subarea. For the generation of a subarea trip matrix, the same input files as MVROAD program are required, except that the user supplied data file must contain information that describes the subarea to be examined and zone renumbering data.

For a turning volume analysis, MVSELC requires a tree file, a trip matrix file, and a file containing a list of node numbers at which turning volumes are required. The output files generated by this program always contain matrices. These will either be the origin/destination matrices for the trips identified to use selected links or the condensed subarea trip matrix. Any other reports are directed to the line printer.

MULTIPLE PATHS (STOCHASTIC) AND EQUILIBRIUM ASSIGNMENTS

A multiple path algorithm is not included in the package, but the SPREAD parameter can be used to add a random component into path selection and approximate a multipath assignment. No automatic equilibrium assignment procedure is provided, but the combined procedure can be used to approach an equilibrium. Summary statistics reported at the end of each iteration indicate how close a network is to equilibrium.

B.8. MATRIX UTILITIES

MVTRIP is a trip matrix building program. It can build matrices from one of two data sources, namely from trip records sorted on origin zone or by reconstructing matrices that are in a character format to a binary format.

MVMOD is a general purpose matrix cell modification program which is capable of several basic functions. It can modify matrix cells, merge into one file matrices which originate from different files, generate new matrices, and expand or truncate existing matrices. Combinations of the listed functions are also possible. The program can perform a number of mathematical operations on all or part of the input and/or generated matrices.

MVMNIP is used to manipulate whole matrices. This program may be used in one of four ways in any one run: transpose a single matrix, create a trip end file from up to three matrices, manipulate matrices in various ways to create new matrices, or dump a matrix to card image records.

MVPRIN is a matrix printing program which is capable of producing several different kinds of reports. These reports allow matrices to be analyzed in several different ways. This program can be used to print the contents of up to ten matrices in a row-by-row fashion, print the contents of up to eight matrices side by side in a columnar fashion reporting on each non-zero origin-destination zone pair, produce a frequency plot (histogram)

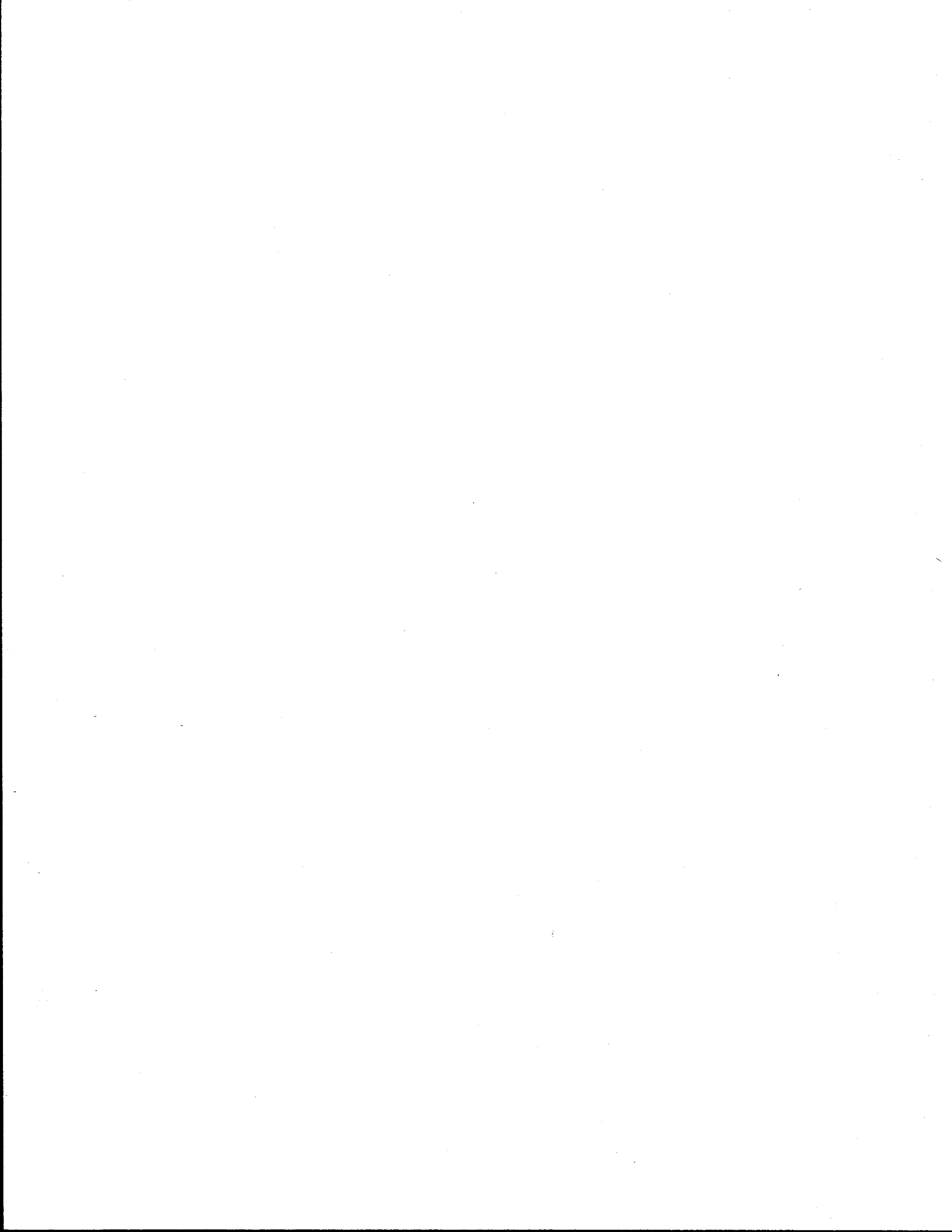
or up to two matrices against a third, compare statistically two matrices, or print trip end summaries for up to ten matrices.

MVSQEX can be used either to expand up to ten matrices from district to zone level or to compress up to ten matrices from zone to district level. It can also be used to selectively remove zones from a matrix or to reorder the positions of zones within a matrix. Up to ten matrices originating from one or two input files may be processed in a single run of the program.

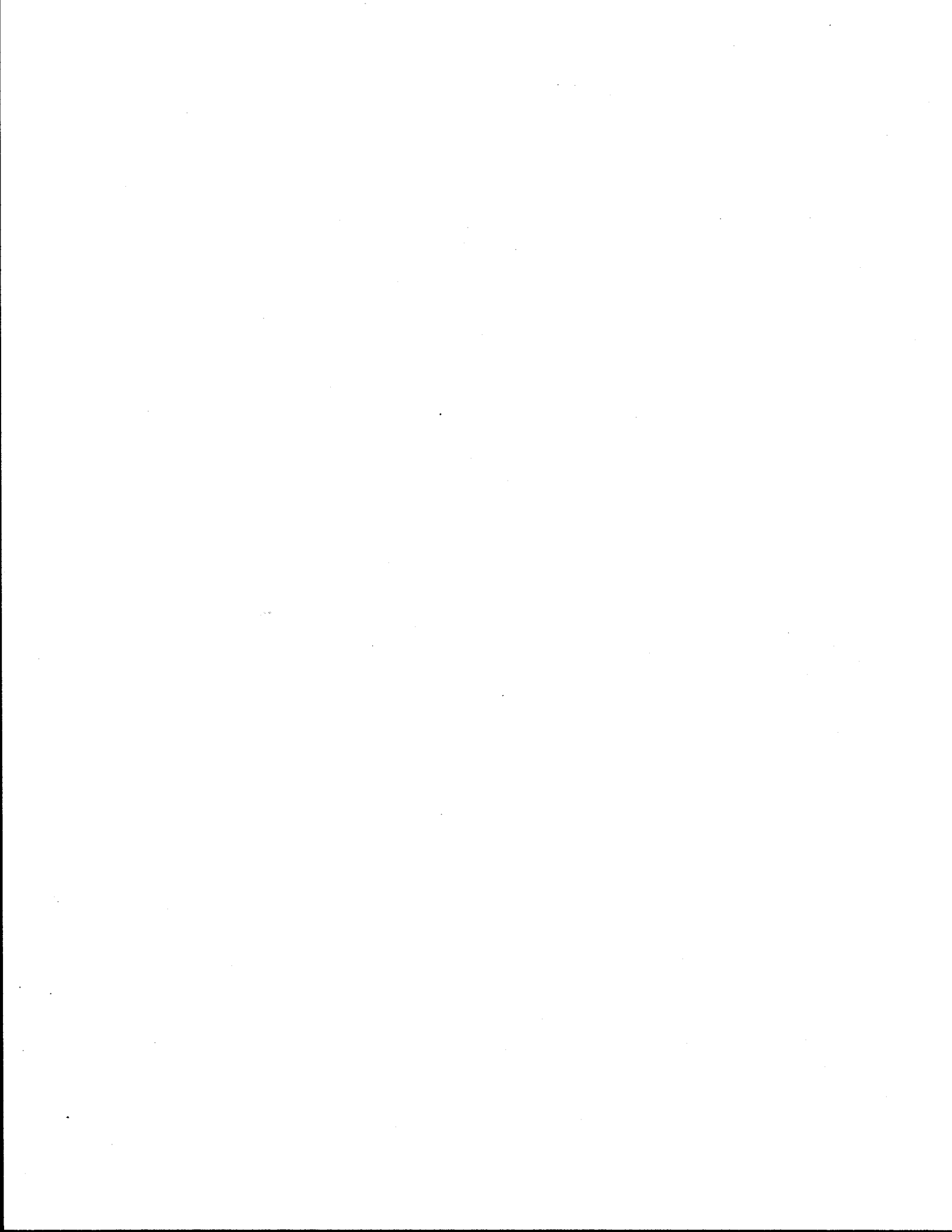


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GENERAL DESCRIPTION OF MINUTP



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C.1. GENERAL INFORMATION

MINUTP is a comprehensive software system for transportation planning paralleling UTPS/PLANPAC in functional capability. MINUTP programs operate independently, but can be linked into a sequential run by setting up a job control file.

DEVELOPER/CONTACT

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ENVIRONMENT

MINUTP runs on any PC/MS-DOS compatible personal microcomputer. It will function on a two-floppy system, but a hard disk based is highly recommended. The memory requirements (RAM) are dynamic with each module. A 640K PC is recommended for maximum performance. For problem sizes greater than 500 zones, a higher speed (80286 base) computer, such as an "AT" is suggested. Some of the modules perform some functions in floating point arithmetic. The use of a math-coprocessor (8087 or 80287) will speed up those functions. The gravity model and stochastic assignment processes are helped considerably with the math coprocessor.

Special hardware is required if the user wishes to utilize the optional graphics package. The on-line interactive network editor/display module (NETVUE) requires either a monographics ("Hercules" compatible) display adaptor, or a standard 256K Enhanced Graphics Adapter (EGA). The monographics option functions in 720x348 resolution on a monochrome monitor, while the EGA option functions in 640x350 resolution in 16 colors on an EGA monitor. The network off-line graphics module (NETPLT) prepares plots for direct use on Houston Instruments (DMPL) and Hewlett Packard (HPGL) compatible plotters from A to E size. A conversion program provides for plotting on CalComp Plotters.

PACKAGE FEATURES

MINUTP is distributed on five diskettes, and requires approximately 700 KB of storage if all programs are transferred to a hard disk. The system is written in MS-Fortran and has some assembly language support routines. The support routines are used to provide specific capabilities and efficiencies not available in the high level processor languages that run on the IBM-PC. MINUTP is an integrated package consisting of the following programs:

- o Highway Network Analysis
 - 1. NETBLD - Build Highway Network
 - 2. PTHBLD - Build and Skim Trees
 - 3. ASSIGN - Assign Trips
 - 4. NETPLT - Plot Network
 - 5. NETMRG - Combine Multiple Networks and Print Network Reports
 - 6. NETVUE - Edit and Display Networks

- o Trip Estimation
 1. LUNCON - Aggregate or Disaggregate Zonal (and Link) Data Files
 2. TRPGEN - Generate Trip Ends
 3. TRPDST - Distribute Trips (using Gravity Model)
 4. FRATAR - Distribute Trips (using Fratar Model)
- o Matrix Handling
 1. MATRIX - Build or Manipulate Matrices, Perform Modal Split
 2. MATBAL - Balance Matrices
 3. MATCON - Compress, Expand, or Renumber Matrices
- o Transit Network Analysis
 1. TRNPTH - Build Networks, Build Skim Paths, and Assign Trips to Transit Network

PACKAGE INSTALLATION AND OPERATION

To run MINUTP, the user boots the microcomputer using the appropriate operating system and prepares any data files needed for the analysis. Once these files are stored, control is transferred to the disk drive containing the data files. If the package is on floppy disks, the user inserts disk #1 into the other drive and types its location and "MINUTP" on the keyboard. The package responds with a display on which the user identifies (1) the name of the job control file, (2) the device (console, printer or disk) to which program reports are to be transferred, (3) the disk drive to be used for reading MINUTP programs, and (4) a four character identifier of the data files read and written during the run.

If a job control file is specified, the package checks to see if all programs required by the process are accessible. Once the check is complete, the user types "MUTP" to execute the run, and responds to messages requesting different disks. If console entry is specified, the user inserts the appropriate program disk, types the name of the program to be run, and enters control information at the keyboard.

MINUTP programs operate independently, but can be linked into a sequential run by setting up a job control file that contains: (1) commands to invoke specific programs, (2) any necessary or optional parameters to be applied in their execution, and (3) any DOS commands to aid in file management. The user also may supply parameters and options directly to each program, but in doing so loses the ability to link runs and to store and modify control information for use in subsequent runs. The sequence of program application in a run is limited primarily by a logical flow of data, and any or all programs can be applied as long as their required data have been developed.

DOCUMENTATION

Set-up instructions, a demonstration data set, and a user's manual are distributed on the program disks. In addition, the disks contain "help" files that can be listed during program use to assist in specifying parameters. The user's manual contains general operating instructions for the package, instructions for preparing control files, and write-ups on each program that define its options, parameters, and any card-image input files.

DATA ENTRY AND STORAGE

Input files, including job control files, consist of free-format "card-image" records that can be created and modified using system text editors and utilities. Data files that are created by MINUTP programs for use by other programs generally are binary files. They are documented in the user's manual. The individual programs perform I/O operations on various files. These files are all named xxxxn.DAT, where xxxx is the file prefix as specified to the MINUDR program, and nn is a two digit number representing the logical unit as noted in Figure C-1. Optionally, the user may supply a unique name for each file as it is opened by setting the DATA FILE PREFIX to ????, or by supplying a unique name in each program.

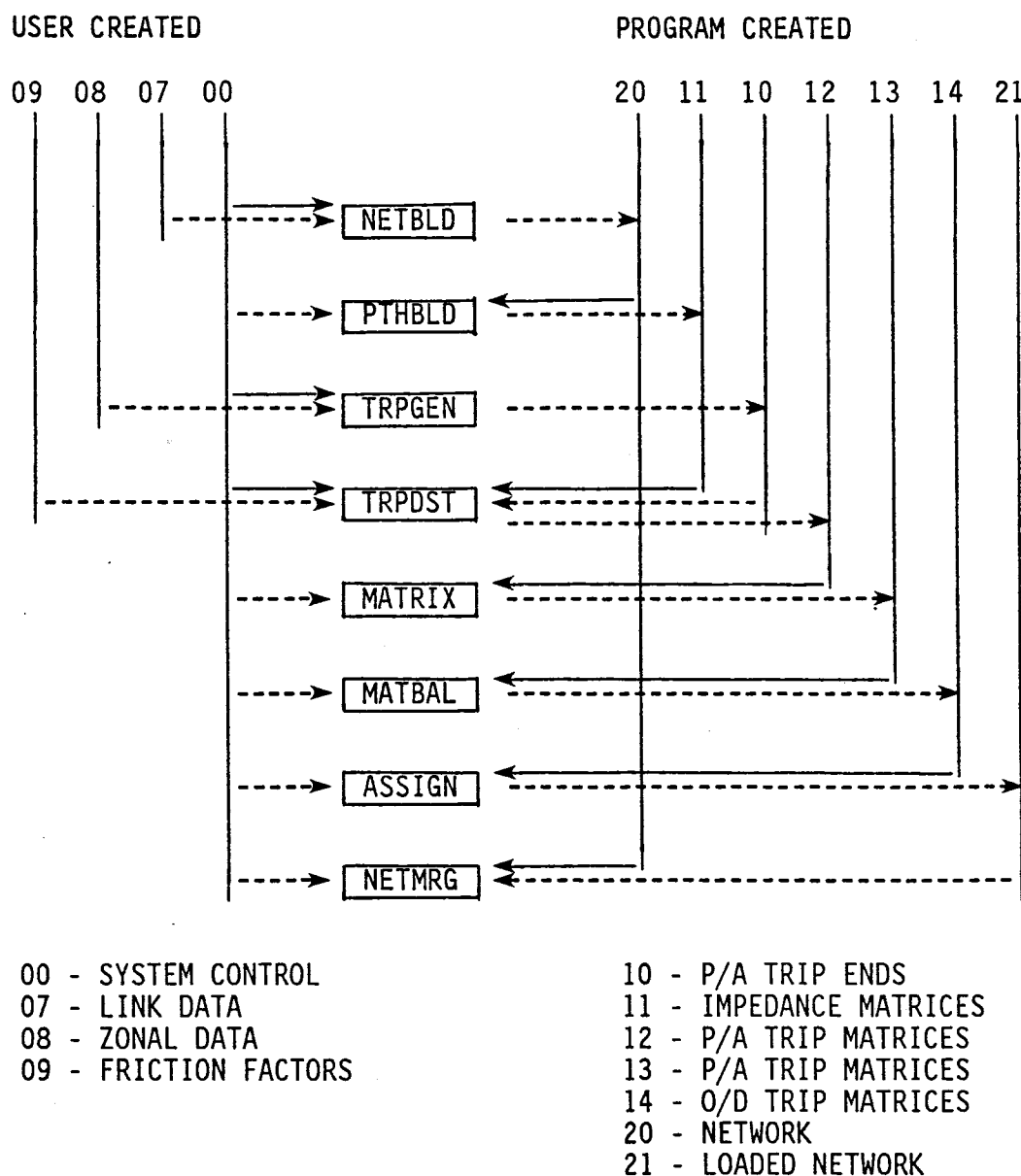


Figure C-1. Normal System Flow

Figure C-1 depicts the interrelationship of the programs. The system is executed modularly to allow the user to stop the flow at any point to examine the results at that time. The process then can be restarted from that point, or even from a previous point if it is necessary to rerun a particular module. The only requirement for restart at a point other than the beginning is that all required files are available to the restart point. The figure illustrates only a simple, traditional process; actual applications could be considerably more complex.

C.2. BUILD HIGHWAY NETWORK

A MINUTP network is similar to a UTPS or PLANPAC network. Network link data and optional turn penalty data are entered as card-image records that can be prepared and updated using a system editor or other utility. Copy and rename commands can be used to store modified versions of a network. Alternatively, the NETMRG program can be used to update node coordinates, speed and capacity tables, and/or link data. In updating link data, the user can draw on data for equivalent links in up to seven supplementary network files and perform calculations using these data. Links can be selectively modified using data or calculated values, or deleted from the network using selection criteria based on the data or values.

NODES

Nodes must be numbered in the sequence zones followed by other nodes. There may be gaps in the zone numbering scheme, but that practice is not recommended. Gaps are also allowed in numbering other nodes. If a node connects to more than eight links, only the first eight are formatted in the assignment report (due to paper size restrictions). X-Y coordinates may be supplied as positive integers (maximum value = 32767).

LINKS

Each link is coded with anode, bnode, dist, direction, observed speed (or time), speed class, capacity class, lanes, and count (or optional data); user-specified variables may be added. Only anode, bnode, distance and speed or speed class are required. The NETBLD program can be run without any control parameters supplied by the user.

A link distance is specified in hundredths of a unit with maximum value of 99.99 miles. Either a speed (in tenths of miles per hour, maximum value = 99.9) or a travel time (in hundredths of minutes, maximum value = 9.99) may be specified as impedance information. Alternatively or additionally, an index to a speed table containing up to 63 values may be supplied. If both a value and an index are supplied, the user may select which is used for path building and assignment. In iterative and incremental assignment, the specified or table value is treated as representing free-flow conditions. A coded travel time is treated as a fixed value, and not adjusted in capacity-restrained assignment.

An hourly capacity per lane and the number of lanes by direction are specified by supplying an index to a table containing up to 63 different values. Ground count volumes (in hundreds of vehicles, maximum value =

99900) may be supplied for comparison purposes. B-to-A values need not be coded for symmetrical links.

C.3. BUILD HIGHWAY PATHS AND SEPARATION MATRICES

The PTHBLD program builds paths for selected origin nodes. It functions in two basic modes: path building and path loading. In the former mode, it determines the minimum impedance path from each selected node. The impedance may be any network variable or some weighted combination of time and distance. Intrazonal values may be computed or set directly by the program and inserted into the generated impedance matrix. Origin and destination terminal impedances may also be applied. Optionally, the program also can write out matrices for distance and time along the minimum impedance path. All matrices, path traces, and predecessor node tables may be selectively formatted for aid in debugging the network. Turn penalty/prohibitor values may be restrained by coding a maximum capacity and a delay function or by specific intersections.

In the path loading, or assignment mode, the program builds the minimum path and loads trips from the input trip matrix to the links along the paths. Turning volumes may be accumulated at intersections. The assignment can be made using all-or-nothing, multipath (stochastic), or equilibration techniques.

C.4. TRIP GENERATION

The TRPGEN program reads a zonal data file containing up to 13 fields of production variables (usually dwelling units), up to 13 fields of attraction variables (such as land use and employment), special generator values (optional), and external station counts (or weights). It applies user supplied rates and equations to compute production and attraction trip ends for each zone up to nine trip purposes. Optionally, internal-external and external-internal trip ends may be estimated by supplying production rates and a percentage of attractions. These values are combined with the station weights to provide two more trip purposes. The different fields in the zonal data records can be used to stratify households or population. The user also may supply a file of trip ends directly to the trip distribution program.

The production variable records may contain a zonal index (such as income) which can point to user-supplied distribution curves to stratify the production units into various trip-making categories. Attractions and productions are balanced according to user specifications, and non-home based productions are set equal to attractions on a zone-by-zone basis. Special generator values may be applied. IF/ENDIF controls provide the capability for controlling operations.

Trip rates can be adjusted to produce trip ends for a specific time period, or trip tables (produced by the TRPDST program) can be factored (using the MATRIX program) to convert, for example, from daily to analysis period tables. A conversion from daily to period trips also can be accomplished (using the MATBAL program) as part of a conversion to an O/D table.

C.5. TRIP DISTRIBUTION

If a gravity model is being used, a system editor is used to set up a Friction Factor file and a job control file to apply the TRPDST program. For a Fratar application, a job control file for the FRATAR program and any matrix processing needed to prepare the historical trip table is set up using an editor. The MINUTP package then would be invoked.

The TRPDST is a traditional gravity model which reads an impedance matrix, a trip end file, and a friction factor file, and performs a multi-iteration distribution. Up to seven purposes may be distributed in a single run, but separate runs are needed for each time period (or impedance table). The output is a set of trip matrices. Iterations continue until a specified number have been performed or convergence is reached.

Internal/external and external/internal trips are separate purposes and can be distributed using the gravity model. Through trips can be added to a trip table using MATRIX program commands from an external file. A production/attraction table can be converted to an origin/destination table using the MATBAL program. Different percentages can be applied to p-to-a and a-to-p values in constructing the O/D table. The TRPDST program reports include trip length distribution curves and trip attraction comparisons. Zone-to-zone K-factors may be input.

The FRATAR applies the Fratar growth techniques to up to seven purposes simultaneously based on a historical trip table. The user may specify unique production and attraction factors or desired control totals for each zone and purpose. The program may be used as a distribution model and is quite suitable for through trip expansion.

C.6. TRAFFIC ASSIGNMENT

A system editor is used to set up a job control file to apply the ASSIGN program. The program operates on a network file and a trip table. If a user wants a special network report, commands and parameters for the NETMRG program also would be included in the job control file. The MINUTP package then would be invoked to execute the run.

The ASSIGN program allows Dial's multi-path algorithm applied by specifying a distribution parameter (theta) value greater than zero (which results in an all-or-nothing assignment). A value of ten (the maximum allowed) distributes trips equally among multiple shortest paths.

CAPACITY-RESTRAINED ASSIGNMENT

After each complete assignment, capacity restraint is applied. The user has control over many of the restraint functions. Final assignments can be obtained from averaging all assignments, or by using the final loading directly. ASSIGN allows incremental assignment in which only a portion of the trips are assigned between restraints, thus providing restraint based upon traffic buildup.

Up to ten increments or iterations of capacity-restrained assignment may be specified in a single run, with varying percentages of trips assigned in each. Different assignment techniques (i.e., all-or-nothing, all-shortest-path, or stochastic) may be used in each iteration or increment. In addition, the NETMRG program can be used to selectively weight or combine travel times calculated in previous assignments, with the new values used as the starting point for a new assignment of any type.

Iteration or increment summary tables are reported by using program parameters. The report displays V/C ratios and VMT (by capacity class) at the end of each assignment increment or iteration. The user-defined network report contains data on individual links in the network. It is generated using the NETMRG program, which contain parameters that let the user calculate additional variables for some or all links, specify the variables to be printed, supply column headings, and set conditions for suppressing links from the report. The program also lets the user combine and compare link values for up to eight loaded network files, and to selectively sum and cross-tabulate variables. IF/ELSE conditions allow selective processing.

SELECTED LINK, TURNING MOVEMENT, OR SUBAREA ANALYSIS

Selected link option allows the user to extract up to 15 trip matrices (sets of links) based upon various combinations of link usage specified by the user. Each matrix can be designated as an "and" list or an "or" list. Link volume reports and trip tables can be produced for each set. Selected link options are available only during all-or-nothing iterations of assignment. Link travel times resulting from a previous assignment, however, can be used as a basis for the select link assignment. Turn penalties and prohibitors may be utilized at specified nodes. These options function only in minimum path mode.

A subarea network and a matrix of associated trips can be extracted by specifying the subarea cordon with selected links. The subarea network is written to a link data file. All nodes can be optionally recoded. The subarea trip matrix zones can be renumbered. Selected link processing can be performed during any iteration where all-or-nothing routing is performed. A set of matrices for each iteration can be extracted, along with the total of all matrices.

The LUNCON program reads land use and/or link data records and recodes all zone numbers to a new numbering system. The new system is developed by providing zonal equivalences which allow for aggregation and/or disaggregation based upon production/attraction percentage allocations. By providing representative zone indicators, the network links can be dropped or recoded for inclusion in the output network. Any nodes can be deleted from the network in order to reduce the size of the network. The user can request the program to renumber all new zones to a more efficient number system (nodes can also be renumbered). This program is useful in subarea or corridor analysis where the user wishes to begin analysis at the trip generation/distribution step. In effect, the subarea can be processed at sub-zonal level, the surrounding zones at normal level, and the outlying zones at aggregate level; external zones can be maintained at station, or combined station level.

EQUILIBRIUM ASSIGNMENTS

An equilibration process is also available. The theory behind this process is formed on the following scenario. A user first selects his path along the route he believes to be the minimum time. But other users also use parts of his path and the time increases. He then shifts to a different path. Then that path gets congested, and he selects another path. Eventually, he can't find a faster path, and the travel time on the final path is about the same as it would be on the congested original path. At that point, the system is close to equilibrium. To exercise this option, the user must issue the EQUI control statement in the ASSIGN program.

C.7. MATRIX UTILITIES

The MATRIX program is the workhorse utility for manipulating matrices. The program develops an operations stack based upon user-supplied commands and then processes the stack in a sequential manner for each origin zone. The following types of operations can be performed:

- o Full math operations between matrices and zonal data
- o Replace or modify selected cells with a constant
- o Compute or substitute intrazonal values
- o Build matrices from source data records
- o Unbuild matrices to data records
- o Format summarize matrices/trip frequency distributions
- o Perform modal split (exponential model)

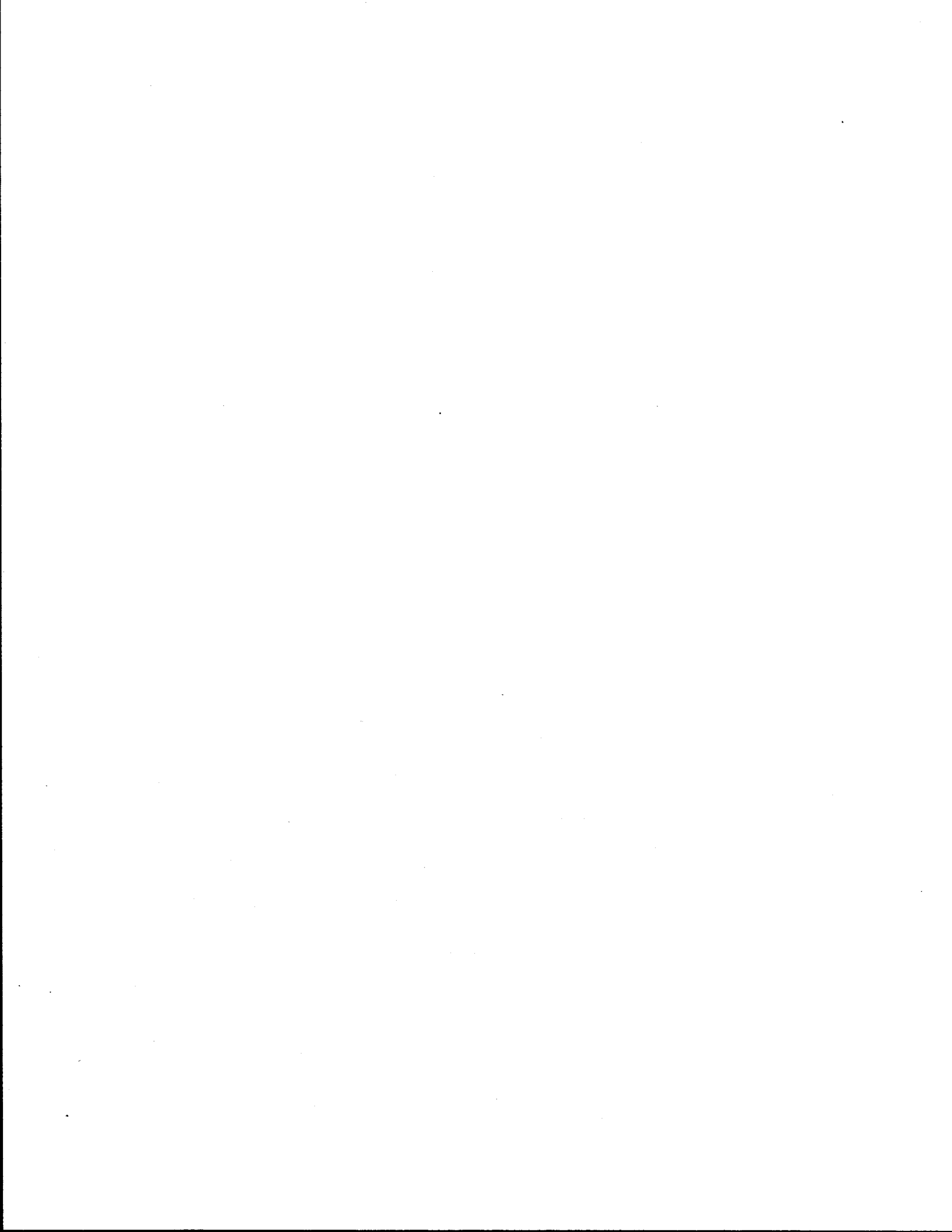
Most of these operations can be performed based upon origin, destination, and cell value specifications. The build and unbuild options allow for easy transfer of matrices from/to other systems. MATRIX is quite efficient; running times are dependent upon the size of the files and the number of operations to be performed. Up to 50 internal matrices may be processed in a given run.

The MATBAL program is used to apply origin and destination factors to a production/attraction matrix to obtain an origin/destination matrix. It can be used to convert daily matrices to peak-hour, and to transpose a matrix (switch rows and columns). Row and trip end reports may be obtained during processing.

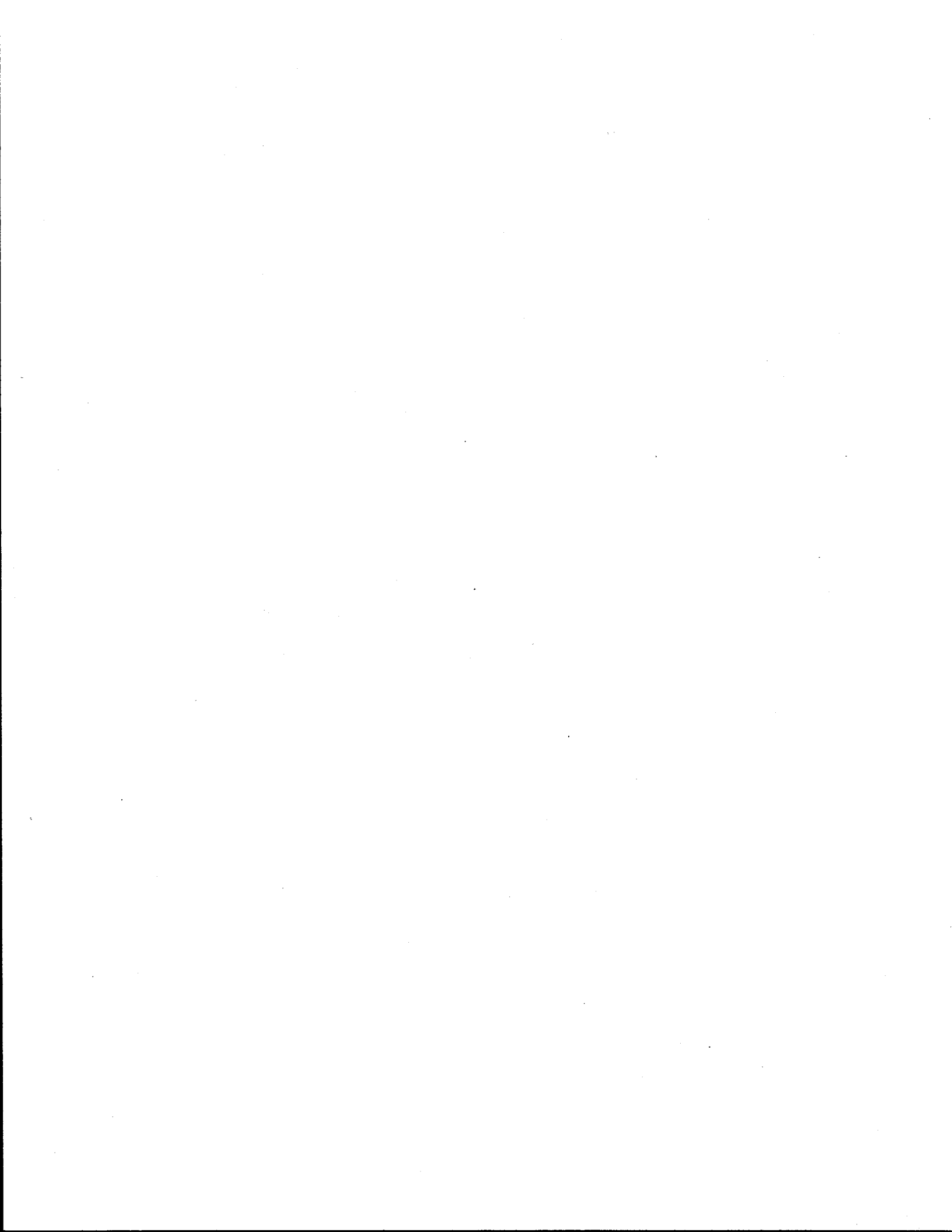
The MATCON program is used to compress, expand, and/or renumber a matrix. It can perform expansion and compression in a single application. Zonal equivalence tables may be input in free-form and/or read from a separate data file. Row and trip end reports may be obtained during processing.

APPENDIX D

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D.1. GENERAL INFORMATION

MOTORS is an integrated package of programs designed to cover the whole range of multi-modal transportation planning functions. The package allows the full benefits of the microcomputer to be realized, and in combination they provide a method of analyzing transport planning options which is "user friendly" and makes full use of the interactive capability of the microcomputer.

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ENVIRONMENT

MOTORS has been written under the MS-DOS operating system, enabling it to be run on the IBM-PC (or XT or AT) and on any IBM compatible personal microcomputer. It will function on a two-floppy system, but a hard disk drive unit is highly recommended.

PACKAGE FEATURES

MOTORS is distributed on nine diskettes, and requires approximately 2.5 MB of storage if all programs are transferred to a hard disk. Forty fully compatible modules cover the requirements of the transport analyst in a package designed for simplicity of use. Programs are designed to be used in sequence, and a standardized method of data file identification and management is used. The program names, together with their reference-identifiers, are as follows:

- o Demand Modeling Programs
 - D10 Regression Analysis - calibrate trip generation equations
 - D15 Regression Analysis: Zonal Trip Ends - apply trip generation
 - D20 Category Analysis I: Trip Rate Calculator - calculate trip rates
 - D30 Category Analysis II: Zonal Trip Ends - apply category rate model
 - D35 Trip End File Merger - merge into a MOTORS type file
 - D40 Gravity Model - apply gravity model
 - D50 Fratar Model - apply Fratar model
 - D60 Trip Cost Frequency Tabulator - tabulate trip time or cost
 - D70 Modal Split - estimate mode splits
- o Highway Network Programs
 - P1 Highway Data Editor/Sorter - interactively enter and update data
 - P5 Highway Data Formatter - reformat link data file
 - P10 Highway Network Checking - verify network data
 - P11 Turning Movement Link Generator - generate turning links
 - P20 Highway Network Building (Peak Hour) - build peak hour network
 - P30 Highway Network Building (24-Hour) - build 24-hour network
 - P40 Highway Minimum Path Tree Building - build trees
 - P50 Highway Minimum Path Cost Skimming - skim trees

P60 Highway All-or-Nothing Assignment - perform all-or-nothing
P65 Highway Network Preloading - preload traffic volume
P75 Highway Automatic Incremental Loading Assignment
P80 Highway Automatic Equilibrium Assignment
P90 Highway Network Evaluation - summarize network performance
P91 Turning Movement Printer - print turning movements
P95 Select Link Assignment Trip Matrix Creator

o Matrix Programs

M10 Matrix Builder - build a table
M15 Matrix Converter - reformat a table
M40 Matrix Manipulator - combine tables
M41 Matrix Multiplier - multiply tables
M45 Matrix Transposer - transpose a table
M50 Matrix Printer - print table (or selected rows or windows)
M60 Zone Compressor - compress a table
M70 Zone Splitter - expand a table
M80 Matrix Divider - divide one matrix by another on a cell-by-cell

o Transit Network Programs

T10 Transit Network Building
T20 Transit Minimum Path Tree Building
T30 Transit Minimum Path Cost Skimming
T40 Transit Route Assignment
T50 Transit Link Assignment

o Utility Programs

U10 Data File Header Reader - display file header
U20 Network File Printer - print network file

PACKAGE INSTALLATION AND OPERATION

To run MOTORS, the user boots the microcomputer using the appropriate operating system and prepares any data files needed for the analysis. Once these files are stored, control is transferred to the disk drive containing the data files. If the package is on floppy disks, the user inserts the disk containing the desired program into the other drive and types its location and name on the keyboard.

The package responds by displaying the program name and function, and asks the user to continue or quit. The user is then prompted to specify options, parameters, and file names. The program header information is displayed, and the user is asked to accept or reject the file. The program runs once all necessary information has been supplied.

In a typical work session, two or more programs will be operated in a logical series of steps. The user is responsible for setting up a sequence of program runs and keeping track of data files, but can use file headers and the display utility to help with this task. Default values are provided for many parameters.

DOCUMENTATION

MOTORS is distributed with a manual that discusses the overall system as well as each program in the package. Each program is described in terms

of its function, screen prompts, reports generated, error messages, required input data formats, and technical procedure used. The manual also includes test data files for some programs that can be used for trial program runs.

DATA ENTRY AND STORAGE

Data are supplied to MOTORS in "card-image" files that are prepared and modified using system text editors. The user's manual specifies the formats required for the files and provides coding sheets for some. The package contains programs that can be used to convert other link data and table files into the formats required by MOTORS.

User-created data files include: zonal land use data, highway zone terminal times, mode split diversion curve, highway, and transit network link data, and transit route definitions. Files produced by MOTORS are binary files written and read using FORTRAN's unformatted option, and cannot be directly modified by the user. These files have a standard header to identify them which includes a 75-character description (supplied by the user in response to a screen prompt) as well as information on mode, file type, the program which created the file, and parameters used in its creation. The files include: category trip rates, production and attractions, trip tables, highway and transit network files, and impedance matrices. MOTORS files must be named with a unique identifier of up to eight characters followed by ".DAT". File names for input and output files are entered for each program run in response to screen prompts.

D.2. BUILD HIGHWAY NETWORK

A MOTORS network is similar to a UTPS or PLANPAC network. Link data can be entered interactively in fields displayed on the screen after each pair of end nodes is specified. Once data for a link are entered and/or corrected, the card-image record(s) produced by the program can be displayed. Alternatively, the interactive entry/update program can be used to add, modify, or delete links.

Network link data and optional turn penalty data also can be entered as card-image records that can be prepared and updated using a system editor, other utility, or a program developed by the user; and copy and rename commands can be used to store modified versions of a network. Link data records prepared in this manner are one-way links which must be sorted on A-node, B-node using the sort routine in program P1, prior to running the subsequent network checking and network building programs.

Nodes can be detailed only by coding each turning or through movement as a separate one-way link. The turning link (P11) program, however, may be used to generate these links at specified nodes where certain conditions are met. Eligible nodes cannot be connected to a centroid, no nodes connected to the specified link can be directly connected to each other, and adjacent nodes cannot be specified.

A network checking (P10) program is provided for locating the following possible errors: node and link limits, missing data, data in allowable ranges, unconnected nodes, duplicate links, and other checks. All changes, however, must be made outside the MOTORS P1 programs, using

whatever system editor is available. While the P10 program is used to check the data, network building is handled by running the P20 or the P30 program. File names, network size, and other parameters are entered in response to screen prompts.

NODES

Nodes must be numbered in the sequence zones followed by other nodes. Zones (internal zones followed by external stations) must be numbered sequentially without gaps. No gaps are allowed in numbering other nodes; however, dummy links can be used to attach nodes held in reserve for alternative configurations of a network.

LINKS

Each link is coded with node from, node to, link length, link speed (peak), link capacity (vehicles per hour), KAPCL (capacity class indicator), Capex code, and link speed (off peak). The user may code more than one speed (e.g., peak and off-peak speed), but only one is required. Data allocated to node from, node to, KAPCL, and Capex code are expected to be in integer format. Other fields are real, either read in with an explicit decimal point, or otherwise assumed to have one decimal place.

A link distance is specified in tenths of a unit with maximum value of 99,999.9 miles. Either a speed (in tenths of miles per hour, maximum value = 999.9) or a travel time (in tenths of minutes, maximum value = 4,999.9) may be specified as impedance information.

Links may be coded based on a capacity indicator (KAPCL) as centroid connectors (KAPCL = 1), intersection-delay links (links with representing movements through an intersection where capacity limitations may reduce speed and increase time, KAPCL = 2), link-delay links (links with delay caused by traffic along the length of the link, KAPCL = 3), and dummy links (links with no length, travel time, or capacity). Capacities (in vehicles per hour) are entered only for the types of delay links. Maximum capacity is 9,999,999 vph.

Different network building programs allow link data to be prepared for a peak hour or an all-day analysis. For a peak hour analysis, capacities entered with the link data are used. For an all-day analysis, 24-hour capacities are determined by dividing the hourly capacity by the percentage of traffic in the peak hour. Peak hour percentages on each link are indicated in the link file using an index (Capex Code). When the network building program for all-day analysis is run, ten peak hour percentages corresponding to the ten values of the index are entered after a screen prompt.

D.3. BUILD HIGHWAY PATHS AND SEPARATION MATRICES

The Highway Minimum Path Tree Building (P40) program is run to trace trees from selected zones. If errors are found, the system editor is used to correct the link data file and the network is rebuilt using the P20 or P30 program. The program is applied to an unloaded or loaded link file to produce a tree file used for skimming and assignment. File names and parameters are entered in response to screen prompts.

A separate program, Highway Minimum Path Cost Skimming (P50) program, is used to skim a tree file created by the P40 program and to prepare separation matrices. A test run of the tree-building program may be performed to print trees for selected zones, but no path file is produced. In MOTORS, minimum impedance paths are built from all zones (or selected zones) to all other zones in the network. The following components and weights are used in constructing these paths: link times, link distances, tolls, terminal times, weights as a linear function of time and distance, or intrazonal impedances. The skimmed impedance is a linear function of time and distance, but the weights used need not be the same as those used in building the trees. The weights as well as input and output file names are entered in response to screen prompts. Terminal times and changes in impedance values may be entered through user-created files set up prior to running the P50 program.

D.4. TRIP GENERATION

There are essentially three different trip 'types' which are modeled, as internal to internal trips (I-I), internal to external and external to internal trips (I-E and E-I), and external to external trips (E-E). No matter which methods are utilized within MOTORS to model each of these trip types, all zones (both internal and external) must be included in the dimensions of all files created. For example, if a separate model is to be developed for the E-E trips, then all trips pertaining to internal zones would be set to zero. These may be files containing P's and A's, or trip matrices. In this way, separate trip tables produced for different travel components can later be amalgamated using simple matrix manipulation programs.

MOTORS offers the user a choice of two techniques to derive zonal estimates of trip productions at the trip generation level; the choice lies between regression analysis or category analysis. They both yield trip ends which can then be input into the trip distribution stage, utilizing either a gravity model or a Fratar model.

REGRESSION ANALYSIS

Regressions are generally developed either from individual household trip records (derived from a home interview survey), or from zonal totals or averages.

The Regression Analysis (D10) program is used to carry out multiple regression analysis on a set of data records. The program is very general and can be used for trip generation and attraction modeling and for other applications. D10 can handle up to 30 variables in a single regression. The Regression Analysis - Zonal Trip Ends (D15) program may then be used to input the regression coefficients produced by D10 together with the zonal averages or totals for the independent variables. The output of D15 is a set of zonal trip productions.

CATEGORY ANALYSIS

This method differs from the regression technique in that no functional relationship is developed between the dependent variable (trips/household)

and the independent variables (household socio-economic characteristics). Households are categorized according to levels of each of several pre-specified stratifying variables (for up to 108 different categories using three stratifying variables).

Average trip rates, usually by purpose, are calculated for each household category, using the Category Analysis I - Trip Rate Calculator (D20) program. The source of data for input to D20 is usually a home interview survey, since this will provide information on each household's characteristics and the number of trips which that household makes. The Category Analysis II - Zonal Trip Ends (D30) then requires as input a set of trip rates (calculated either by D20, or a user-produced set), together with the breakdown of households in each zone into the categories specified. Output is a set of zonal productions.

TRIP ATTRACTIONS AND FILE MERGING

Trip attractions may also be calculated using either the regression or category analysis techniques, although the availability of suitable data is usually more of a problem in modeling attractions. The Trip End File Merger (D35) program is used to create a composite file of P's and A's. The program also allows several files of P's, and several files of A's to be added, if required, before creating the merged file. Since it is most unlikely that the P's and A's will balance, D35 also performs this, allowing the user to specify whether P's are to be balanced to A's, or vice-versa.

D.5. TRIP DISTRIBUTION

GRAVITY MODEL

The Gravity Model (D40) program is executed and file names and parameters are entered in response to screen prompts. A single-purpose trip table is produced for each production/attraction file entered, and a trip length distribution is printed for checking the model. A standard gravity model formulation is applied in MOTORS. Friction factors are determined in one of two ways: a "power" function or an exponential function. User-specified parameters are supplied through screen prompts.

FRATAR MODEL

Historical trip tables may be converted from any existing file on another system using the Matrix Converter (M15) program or may be entered in a file prepared using a system editor with the Matrix Builder (M10) procedure being applied. The Fratar Model (D50) program is executed to distribute a file of productions/attractions with file names and parameters entered in response to screen prompts. The procedure is iterative with distributed trips ends compared to input values at the end of each iteration. A separate run of D50 is needed for each trip purpose.

External/internal trips may be distributed along with internal trips or in a separate program run and merged with internal trips using the matrix manipulation program. Through trips must be estimated manually and entered into a user-created trip table that can be merged with tables produced by the gravity model.

D.6. MODE SPLIT

Two techniques can be applied in MOTORS to undertake a split of total trips into trips by each mode. Using the Trip End Modal Split method, trips are modeled for each separate mode directly from the trip generation stage. Since this technique takes no account of the relative times or costs by each mode, it is naturally insensitive to changes in the modal characteristics. Consequently, it is generally used only where little change is expected in the various modes between base and future years.

In the Post-Distribution Modal Split method, trip generation and distribution is undertaken for all person trips combined regardless of their mode. Following the trip distribution stage, the resultant all-modes trip matrix is then split among the competing modes.

A system editor is used to prepare files containing auto terminal times and diversion curves. The Modal Split (D70) program is run with file names and parameters supplied in response to screen prompts. Separate runs can be made for each trip purpose, or trip tables for different purposes can be combined prior to the run (using the M40 program). Highway and transit person-trip tables are stored under names supplied by the user.

Diversion curves, based on either travel impedance or cost ratios (transit/auto) or travel impedance differences (transit - auto), must be supplied through a user-created file. This file consists of 32 values, each of which indicates the fraction of trips that will use transit at designated levels of the travel impedance ratio or difference.

D.7. TRAFFIC ASSIGNMENT

Three assignment techniques are available within MOTORS: all-or-nothing (P60) assignment, incremental capacity restraint (P75) assignment, and equilibrium (P80) assignment. The Highway Network Evaluation P90 program is used to sum vehicle-miles and vehicle-hours of travel in a network and to indicate roughly the proportions of total travel on arterials taking place at different levels of service. Subtotals are calculated for arterial links (KAPCL 2 and 3) in six "level-of-service" classes. Travel on local street links (KAPCL = 1) is subtotaled separately.

The Turning Movement Printer P91 program is used to print turning movement links and the volumes assigned to these links by P60, P70, or P80. This will produce all the turning movements occurring at all intersections specified by the user in program P11. The program reports a table giving the links involved in each turning movement and the traffic volume assigned to each turning movement.

INCREMENTAL CAPACITY RESTRAINT ASSIGNMENT

The Highway Incremental Loading Assignment (P75) program is used to perform an incremental assignment on the transportation network. Initially trips are loaded onto the network with an all-or-nothing assignment technique. The program then determines the proportion of all trips which can be loaded on the network without the volume of any arterial link exceeding its capacity. These trips are loaded, and new travel times for

arterial links are calculated based on their V/C ratios. Links loaded to, or almost to, capacity are removed from the network for future iterations. The resulting network is stored in a file and can be printed using U20.

The capacity restraint procedure is the following: (1) assign all unassigned trips to the current set of minimum paths, (2) determine the percentage of these trips that can be assigned and still keep all links operating below capacity, (3) assign that percentage, (4) recalculate link times, and (5) add 500 minutes to all links at or within a user-specified percentage of capacity to exclude them from receiving trips in subsequent iterations. Removing the critical and almost-critical links forces the finding of entirely new routes in the next iteration unless, of course, no alternative route exists. For the first iteration, programs P20, P40 and P75 must be run; for each succeeding iteration, programs P40 and P75 must be run. It is suggested that "almost-critical" be defined as being 98% or 99% of capacity. However, this method needs considerable further experimentation and testing, and other figures may be worth trying.

The efficiency of the incremental loading assignment cycle can be maximized by batch processing of P40 and P75. The purpose of batch processing is to free the user from the necessity of repetitively running the program and responding to the screen prompts interactively. In a batch run, the steps of building highway network trees and loading these trees are performed iteratively in sequence by means of a controlling batch processor program. An additional MOTORS diskette entitled "Batch Processing Program Disk" is available to perform this function.

SELECT LINK ASSIGNMENT

The P75 program also has the capacity to perform a select link assignment. This procedure involves storing those trips which traverse a user-specified link in a data file from which a trip matrix may be created using program P95, the Select Link Assignment Trip Matrix Creator. Records from up to nine select link assignments may be combined in one matrix.

With respect to the select link assignment procedure, data files created in iteration 1 are used throughout the iterative cycle of assignment to store the trip records for the chosen link. Hence for iterations greater than 1, the program asks for an existing select link assignment data file, which has been produced in the previous iteration. It is then updated by the increment of traffic assigned in the latest iteration. It should be noted that if links have been preloaded (using P65), then the preloaded volumes will not be included in the select link assignment trip matrix. This is because their O/D pattern is not recorded.

EQUILIBRIUM ASSIGNMENTS

Equilibrium is produced only when vehicles are assigned to links such that no traveller can reduce his time from origin to destination by switching to another path. The Equilibrium Assignment program P80 satisfies the above objectives, within predefined convergence criteria. Normally, five iterations are adequate to ensure convergence within 1%. The program is used to assign trips to the network, using automatic iteration to find equilibrium loading under conditions of capacity constraint. The user has control over the maximum number of iterations and over the tolerance to

which the search for equilibrium is to be conducted. Optionally, the program can be used to perform a simple non-iterative assignment to the network.

D.8. MATRIX UTILITIES

The Matrix Builder (M10) program is used to read a sorted set of trip records and build a trip matrix. The user defines in the control file the fields of the trip records that contain the origin and destination zones, as well as the field to be entered in the trip matrix, where appropriate. The program includes the "calculator" facility, which enables a value to be calculated from different fields for inclusion in the matrix, rather than directly read from the records. The Matrix Converter (M15) program can also be used to convert a trip matrix in any format to MOTORS format in order to use it as input for other MOTORS modules.

The Highway Trip Matrix Estimator (M20) program is used to generate a trip matrix from observed traffic counts for simple networks. Vehicular or passenger origin and destination trip totals are used, together with a set of allowable movements, to produce a matrix based on the principle of maximum likelihood.

As mentioned earlier, the Matrix Manipulator (M40) program can be used to add together several matrices (e.g., those for internal-internal and for external-internal trips, and/or those representing different trip purposes). Also it can be used to add through trips and external-internal trips (if calculated manually). Person trips are converted to vehicle-trips, if necessary.

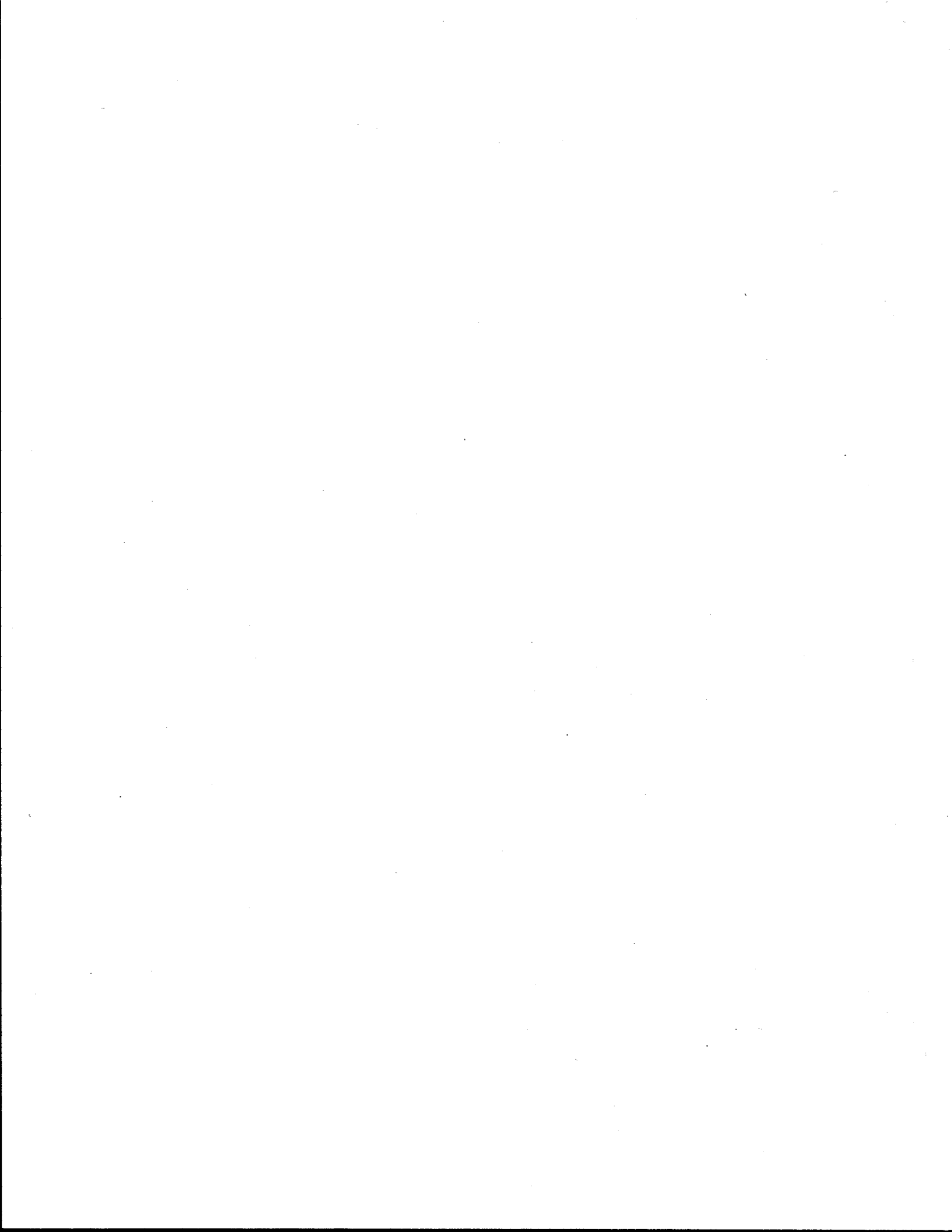
The Matrix Multiplier (M41) program is used to multiply a matrix by either a constant factor, by a row vector, or by another matrix, either on a cell-by-cell basis or in true matrix multiplication form.

The Matrix Transposer (M45) program converts a Production/Attraction matrix to Origin/Destination form, ready for input to modal split or directly for assignment to the network.

The Matrix Printer (M50) program is used to print on the line printer, or display on the screen, stored matrix files. Different options are available to the user in terms of selective printing of rows or columns.

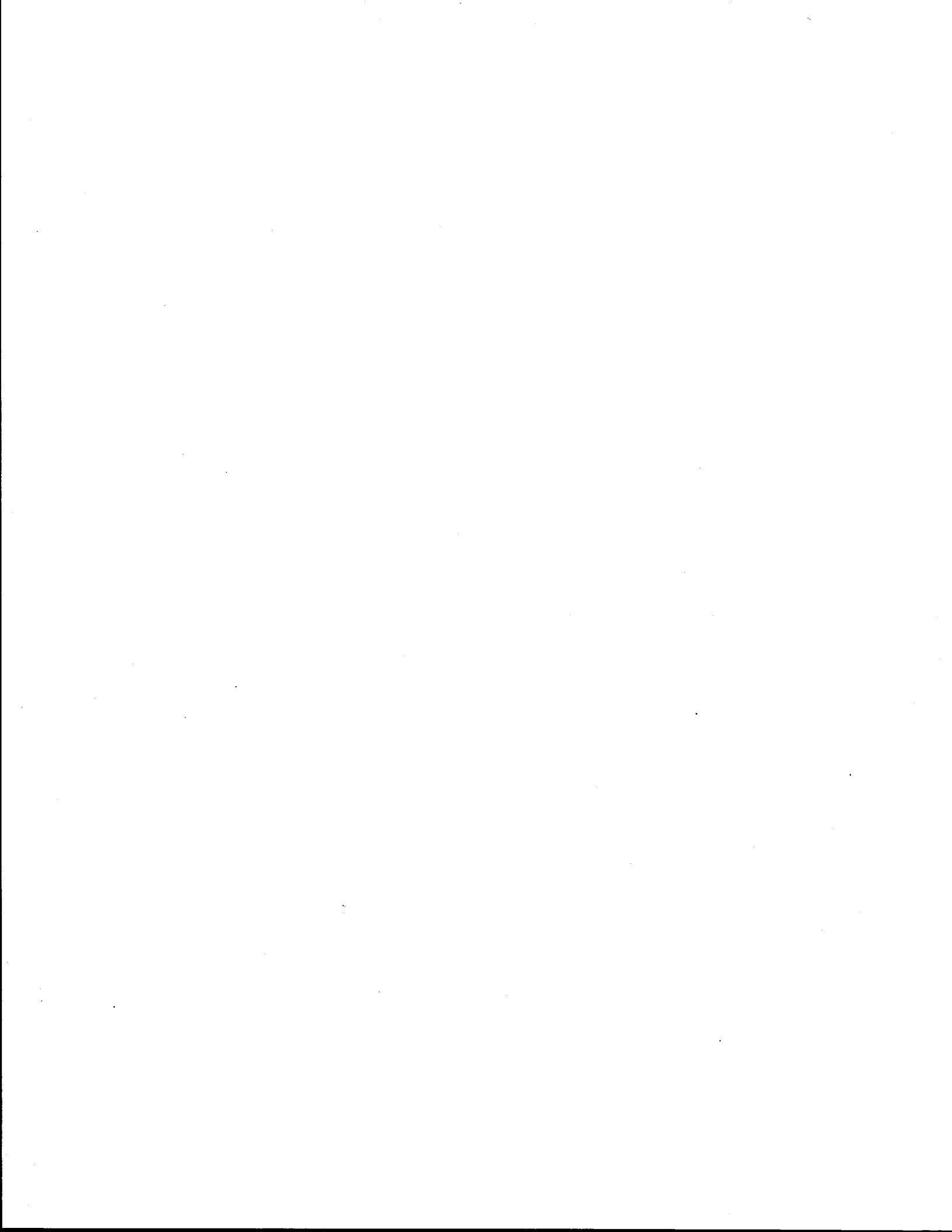
The Zone Compressor (M60) program compresses zonal matrices to district level. It reads a trip matrix together with a set of zone-to-district equivalence tables. The Zone Splitter (M70) program is used to split trip matrices from district level to zone level (or more generally, from one zone system to another finer-level system). It reads a trip matrix together with a set of district-to-zone equivalence tables.

The Matrix Divider (M80) program divides one matrix by another on a cell-by-cell basis. The program also has the capability to divide by row, column and overall totals of one matrix by those of a second matrix.

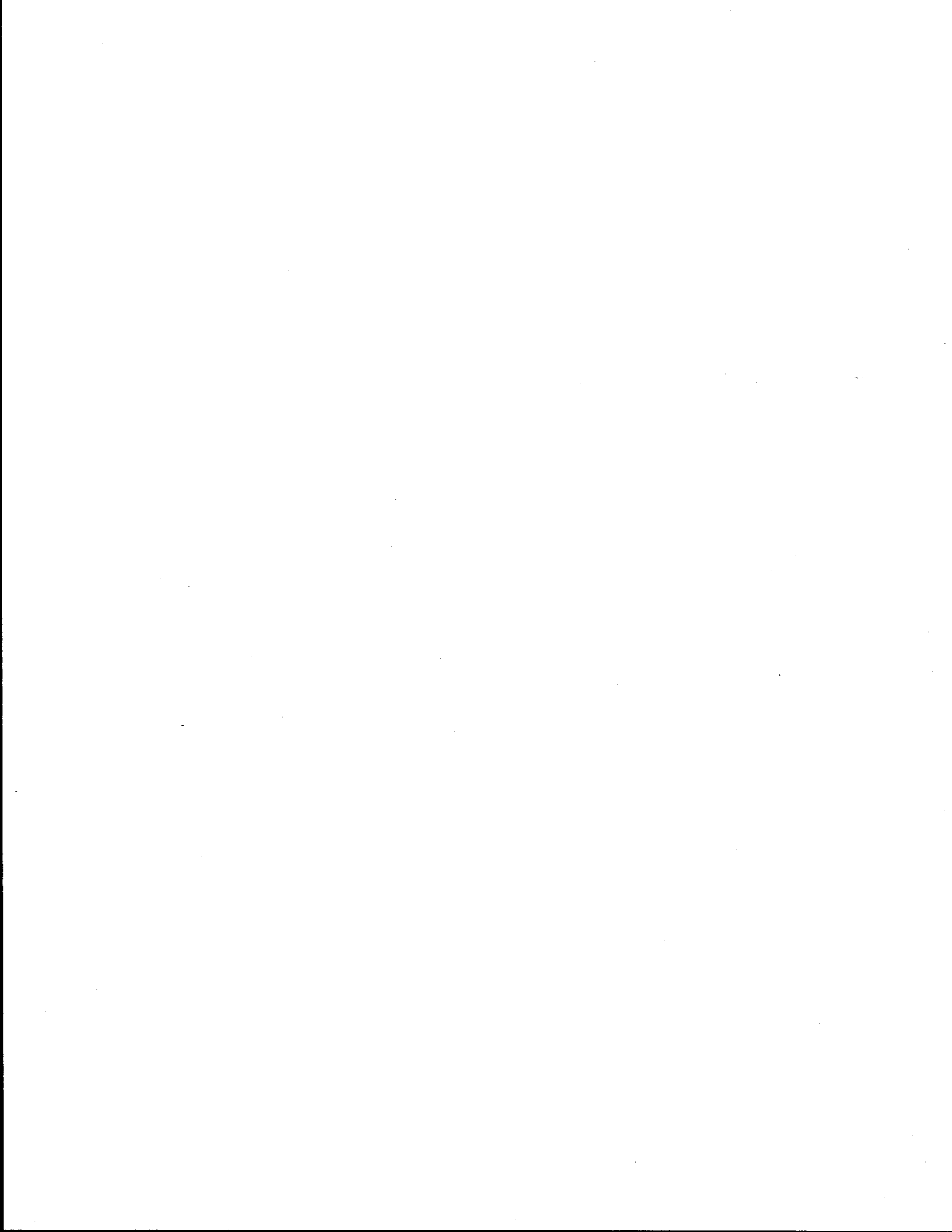


APPENDIX E

GENERAL DESCRIPTION OF TransPro



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E.1. GENERAL INFORMATION

TransPro is an integrated package of programs designed for area or subarea analysis of highway networks. It performs transportation planning functions which parallel UTPS or PLANPAC, but with easy setups. No job control language (JCL) is involved and data is entered directly on the microcomputer keyboard. The package is designed to make it possible to calibrate and run models easily and quickly so that more emphasis can be placed on the evaluation of alternatives. The one-on-one relationship of the user to a microcomputer provides a simpler environment where communication is easier and mistakes are less costly.

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ENVIRONMENT

TransPro has been written under the MS-DOS operating system enabling it to be run on the IBM-PC (or XT or AT) and on any IBM compatible personal microcomputer with Version 2.0+ or higher of PC-DOS. It will function on a two-floppy system, but a hard disk based system is highly recommended.

PACKAGE FEATURES

The TransPro modeling system consists of a modular package of 13 programs which process the network data in logical steps. The programs of the package relate to one or more of the following three analytical categories: Network Analysis, Demand Estimation, and Matrix Manipulation.

Network analysis pertains to network coding for computer input, the identification of minimum paths through the network, and other network evaluation procedures. Network analysis programs in the TransPro package include the program modules SORTER, TREES, ROUTES, and PHASER.

Demand estimation focuses on trip generation, distribution, and assignment. Demand estimation programs in the TransPro package include the program modules GENER, GMODEL, VOLUME, DIVERT, TURNS, and SLINK.

Additionally, the process may require a good deal of matrix manipulation which entails calculation, restructuring, modification, and disclosure of the contents of the many matrix data files required in transportation planning, such as zone-to-zone trip tables and travel time matrices. Matrix manipulation programs in the package include the program modules TIMES, MATRIX, and SUM. A brief description of each program modules follows:

o Network Analysis Program Modules

1. SORTER - network organization module
2. TREES - tree builder module
3. ROUTES - path display module

4. PHASER - network phasing builder module
- o Demand Estimation Program Modules
 1. GENER - trip end generation module
 2. GMODEL - gravity model trip distribution module
 3. VOLUME - link volume assignment module
 4. DIVERT - capacity restraint network modification module
 5. TURNS - intersection turning counts module
 6. SLINK - select link analysis module
 - o Matrix Manipulation Program Modules
 1. TIMES - traveltime display and modification module
 2. MATRIX - trip table display and modification module
 3. SUM - link volume summation module

FILE TYPES

Three general types of files are involved in the operation of TransPro programs: data, transfer, and report files. In addition, there are several special-purpose files which are variations of the above file types. These are created by various TransPro programs by appending a special file extension to the files for the purpose of identification. These files are usually renamed by the user before input to other program modules. The general relationship of input and output files to various modules is illustrated in each user manual section where the particular program module is discussed.

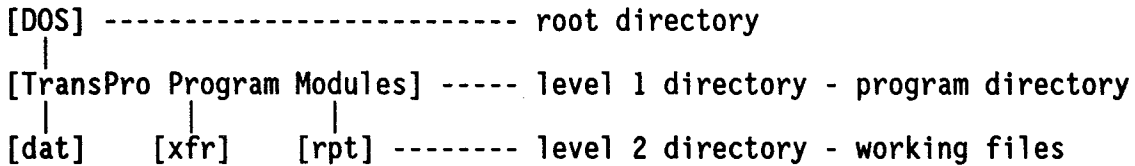
Data files are character-type files which are created by the user and submitted to a single program module as input. They are created by using a text editor such as provided with the DOS operating system. Names of data files take the form "FILENAME.DAT," where ".DAT" is a suffix called a file extension common to all data files. When the data file is created using the text editor, data is not inserted into specific column positions; only the ORDER of data is important.

Transfer files are data storage files created as output by the program modules; they are not created directly by the user. When used as inputs, they are the mechanism for passing information from one program to another. They are often used as the primary input to program modules which generate reports. The names of transfer files take the form "FILENAME.XFR" where the file extension ".XFR" is common to all transfer files.

Report files are character-type files in the same manner as data files, but they are only created as output by various program modules. Their purpose is to store reports in file form for printout at a later time. Producing reports in this form increases the running speed of programs and prevents the loss of report data in the event of a printer malfunction. After a program has finished execution, the user can create the printed report at his discretion using the DOS commands PRINT or COPY. Report files are named by programs in the same general format as other files except report files share the common file extension ".RPT."

PACKAGE INSTALLATION AND OPERATION

All TransPro data, transfer, and report files may be redirected to each of their own sub-directories if desired. These sub-directories are usually created immediately below the current directory when program execution begins. A typical directory tree would look like this:



To run a program, the user simply enters the name of the program followed by the [ENTER] key. If the user is using 8087 program versions, and the programs have not been renamed on the working diskette or hard disk to eliminate the "87" in the program names, the program name must be entered with the 87, as GMODEL87. The programs will first examine the KEYS file for the current configuration and version data. If the KEYS file cannot be found or is not compatible with the current program version, an error message is displayed and the program will not continue. The KEYS file is specific to the current release of the programs; a KEYS file furnished with a previous release is not compatible with the latest release.

After the programs load, they present the user with a uniform greeting identifying the program being run. All subsequent user operations are fully prompted. The programs present a continuous stream of messages to the user identifying each processing step.

DOCUMENTATION

TransPro is distributed with a clear concise user manual that discusses the overall system as well as each program module in the package. Each module is described in terms of its overview, program functions, data file preparation, transfer files, and report option. The documentation also represents various flow charts and sample module inputs and outputs that are very helpful to the user.

E.2. BUILD HIGHWAY NETWORK

The SORTER program module reads a user-prepared data file describing the roadway network, edits for various error conditions, and outputs a link transfer file in a format acceptable to both the TREES and VOLUME program modules. Data used to describe the transportation system are of two kinds: (1) data describing the physical components of the system (nodes and links) and (2) data describing the system's use and performance in use (link attributes).

The physical system is described as a network consisting of nodes which are the facilities connecting nodes with one another. Each analysis zone in the study area must contain at least one centroid node. These centroids serve as the interface between the area-based land use characteristics of the zones and the network-based characteristics of the transportation system.

The most significant attributes of the links are their capacities to carry traffic, their prevailing speeds, their directionality, and traffic control delays caused by stop signs or signals at link nodes. The program will allow any number of links to be connected to a node. Link distances are coded directly, and link speeds are specified by use of look-up tables based upon facility codes. Link capacity, directionality, and average traffic control delay time are also provided for by using facility codes.

TransPro requires two separate files to build a highway network. A FCODE.DAT file defines a set of facility codes which are used to describe various types (maximum value = 100) of network links. The file is created by entering numbers in the following sequence to form a data group:

(facility code) (speed) (directionality) (capacity) (delay time)

A NETWORK.DAT file depicts the essential characteristics of each network link for analysis purposes. The file is created by entering numbers in the following sequence to form a data group:

(A node) (B node) (link distance) (facility code)

TransPro does not require nodes to be numbered sequentially; numbering gaps are permitted. It is useful for describing links which occur at different times in the phasing of a network. The package does require ZONE or CENTROID nodes to be numbered below 300, but they do not need to be numbered sequentially like intersection nodes.

E.3. BUILD HIGHWAY PATHS AND SEPARATION MATRICES

The TREES program module reads the link transfer file created by SORTER or DIVERT and builds the minimum impedance paths from each zone to all other zones based on a theory called the Moore Algorithm. Both a zone-to-zone time/impedance matrix and a path/tree matrix are output as transfer files to be used by other program modules.

Most traffic assignment techniques developed to date assume that the vehicle operator desires to use the "easiest" route between his origin and destination. The easiest route is generally defined as the one comprising the shortest traveltime. However, link travel times may be adjusted based upon volume-to-capacity ratios using the DIVERT program module.

The ROUTES program module reads TREE files from the TREES program module and reports minimum traveltime paths for evaluation by the user. The paths may be displayed interactively on the monitor screen or may be output to a report file. The program presents a menu of program options. One report file, PATH.RPT, shows the links used to travel from selected origin zones to all other zones along minimum traveltime paths. The information presented in this report enables the user to trace paths between zones and to check for network coding errors in the NETWORK.DAT or FCODE.DAT file. The reported paths can also be used for assessment of zone access patterns.

E.4. TRIP GENERATION

GENER is a flexible trip-end generation program which is currently designed to provide production and attraction data for up to five trip purposes. The module estimates total productions and attractions for each zone. Normally, three purposes are chosen for stratification of the productions and attractions.

The primary level of data collection for GENER is the existing and/or proposed land use or population and employment in each zone throughout the study area. Zonal data are classified by type of generator or "generator code" (e.g., residential, commercial, industrial, population, or employment) and number of units (e.g., dwelling units, acres, square feet, occupants, or employees), and filed in the appropriate zone system. GENER then develops trip-end generation estimates for each zone based upon rates specified by the user.

At least two procedures may be utilized for estimating the number and type of trip ends generated in each zone: land use based generation in which trip rates derived from previous studies or samples in the area are applied to each land use in order to compute trip ends, and population and employment based generation in which average trip rates are applied to the population and employment levels in each zone in order to compute P's and A's by trip purpose. Population can be stratified by income level, auto ownership, etc. using the generator codes. Employment can also be stratified by retail, non-retail, etc. using the generator codes.

Attractions of TransPro are essentially weighting factors for the allocation of productions in the trip distribution process. Attraction estimates for all zones may be low or high depending upon the total amount of productions internal and external to the study area. External productions to internal attractions and internal productions to external attractions may be generated based upon user-provided values as part of the data file input to the GMODEL module. Another method for handling internal-external traffic is to generate these trips as a separate trip purpose.

Three types of data files are required to run the GENER program. ZONE.DAT contains the number of units of various types of generators by "generator code" in each zone. PRATE.DAT contains the trip production rates by trip purpose for each generator code. The user may wish to determine the total productions for each generator code and a percentage for each trip purpose first. However, the percentages must then be converted to individual production rates for each trip purpose. ARATE.DAT contains the trip attraction rates by trip purpose for each generator code.

PHASER, the network phasing builder module, reads the data files input to programs GENER and SORTER which represent the ultimate configuration of the network and land use and modifies them for use in an intermediate analysis year. The user need only create the large primary data files once and then specify facility phasing schedules for when new facilities come on-line in the model. The user then specifies a year to PHASER earlier than the ultimate year which represents the current analysis year. PHASER will remove links and land uses from the ultimate data files which will exist later than the current analysis year.

E.5. TRIP DISTRIBUTION

GMODEL adapts a gravitational concept to the problem of distributing traffic throughout a study area. The program module reads the zonal attraction and production file output by program GENER and distributes trips to all zones using the gravity model equation. Other files needed for this module are the time/impedance matrix, traveltime factors, and cordon station data. This is done individually for each of the purposes.

An iterative procedure is employed to refine calculated interchanges until actual attraction totals converge to the desired results. The convergence is controlled by the number of iterations specified by the user. The calibration term, F_{ij} , is usually a function of trip time. Its usage is generalized, however, by using a table rather than a formula to obtain values for F_{ij} . The user thus supplies a table of F-factors for each trip purpose. On the last iteration, it outputs trip matrix transfer files containing estimated trips for each zonal pair for each of the trip purposes. Up to five trip purposes are allowed.

Through (external to external) trips are sometimes handled by the application of growth factors to surveyed through trips. These growth factors may be developed based on forecasts of transportation facility development which may add or subtract from the attractiveness of travel through the study area. A cordon station-to-cordon station matrix of through trips can be added to the trip table using the MATRIX program module prior to assigning traffic using the VOLUME program module.

The FACTOR.DAT file, which contains the F-factors or traveltime factors for each unit of time/impedance, is essential for execution of the GMODEL program module, while the other two data files, P.DAT and A.DAT, are optional. The data group of FACTOR.DAT is repeated for each unit of time/impedance up to 60 units (i.e., 60 minutes). Values must be supplied for all 60 units. The optional P.DAT and A.DAT files contain user-specified trip productions and attractions by trip purpose for selected zones. These data files add to or replace values in the production/attraction transfer files from the GENER program module, or may be used as a replacement for the transfer files.

The report file SUMMARY.RPT is output by GMODEL. SUMMARY.RPT shows the trip production and attraction totals by trip purpose for each zone following each iteration of the gravity model. The "desired attractions" and "adjusted attractions" are also shown for each zone. If total attractions and/or productions have been scaled up or down as desired by the user, this is also presented as part of the report.

E.6. TRAFFIC ASSIGNMENT

The VOLUME program module reads a trip matrix from the GMODEL or MATRIX module and assigns the trips to the network. This is accomplished by routing the zone-to-zone trips along logical paths between the origin and destination zones. As it does this, volumes are accumulated on the links being used in the travel paths. In this process the module builds the paths as defined by the path tree from the TREES program module by selecting the string of links connecting any two centroids.

Assignment can also be run with capacity restraint in several ways. One is the iterative method in which the link impedances are updated by the DIVERT program module within some limitations after all the trips are assigned. Then paths are built again and the trips reassigned. Another is the incremental mode in which only a portion of the trips are assigned before link impedances are adjusted. The link volumes are accumulated through all the increments. This latter mode approximates the way traffic gradually builds up and travelers divert to new travel paths.

Vehicle work trips may be assigned to paths based on peak hour traffic speeds, and vehicle non-work trips may be assigned to paths based on off-peak speeds. Furthermore, vehicle-trip assignments to network links may be determined separately for the peak and off-peak conditions. These can be merged by the SUM program module to give an estimate of total daily traffic.

CAPACITY RESTRAINT ASSIGNMENT

The DIVERT program module enables the user to incorporate an iterative technique in which resultant loadings are analyzed to determine whether an initial estimate of the traveltime on a link should be changed, and to what degree this should be done. The module begins its operation by first reading into storage the traveltimes and volumes for each link as output by the VOLUME program module. Then the volume assigned to each link on the loaded system is compared with the capacity of that link.

Incremental assignment is the process of assigning only a scaled portion of the total trips to the network. After all scaled trips are assigned, capacity restraints are applied to all the links. Following capacity restraint, another incremental portion of the trips is assigned and added onto the previous link volumes. Capacity restraint follows, as does another assignment. This process continues for as many times as designated by the user. This module outputs a new link file with the congested impedance for each link. The SPEED.RPT report file output by the DIVERT program module tabulates the adjusted A to B speed and traveltime for each roadway link.

SELECT LINK ASSIGNMENT

The SLINK program module provides an analysis of which zones are responsible for loading volumes to a particular roadway link. The analysis may be specific for a given direction of travel on the link, or it may be for all volumes. The program is completely interactive in the setup mode; therefore, no data file preparation is required. The program will prompt for the link to be analyzed and will ask if both directions of travel on the link should be considered. The analysis will then proceed in much the same manner as for the determination of link volumes in program module VOLUME (i.e., the program reads the trees transfer file produced by the TREES program module, and the trip table transfer file produced by the program modules GMODEL or MATRIX).

One non-optional report is output from the SLINK program module. This report is output to file SLINK.RPT. The report is presented in two sections: one summarizes trip ends by zone, the other documents link volumes by route.

TURNING MOVEMENT COUNTS

Program TURNS determines the turning movement counts at up to 100 user specified intersection locations. The user simply specifies a list of the intersection nodes where the counts are desired in a data file. The configuration of each intersection is provided by the transfer file LINK.XFR and the counts are determined from route trees and trip matrices in program VOLUME. The turning counts are presented in a printed matrix report format. There are no restrictions on links entering or leaving the intersection; one-way links are permissible as at freeway ramps.

One data file is required. The data file TURN.DAT is prepared by the user for input to the program and specifies the intersection nodes where counts are to be determined. One non-optional report is output from the TURN program module. This report is output to file TURNS.RPT showing the turning movement counts from node to node.

E.7. MATRIX UTILITIES

TIMES, the traveltime display and modification module, adds intrazonal times and terminal times and also replaces interzonal times with user-specified values if desired. A time/impedance matrix is written out for input to other programs. The TIMES module can read a trip table from the GMODEL or MATRIX module and report the resulting trip length frequency distribution.

MATRIX, the trip table display and modification module, reads selected input trip tables and manipulates and/or modifies them according to user-supplied parameters. Trip tables can be added together or individual elements in the matrices can be modified by application of replacement, addition, and multiplication factors for selected origin and destination zonal pairs. The module can also compress a zone-to-zone trip table to a district-to-district trip table, or convert a production/attraction matrix into an origin/destination matrix for input to network assignment.

SUM, the link volume summation module, adds traffic assignments from the VOLUME module, such as peak and off-peak loadings, with different network/path characteristics.