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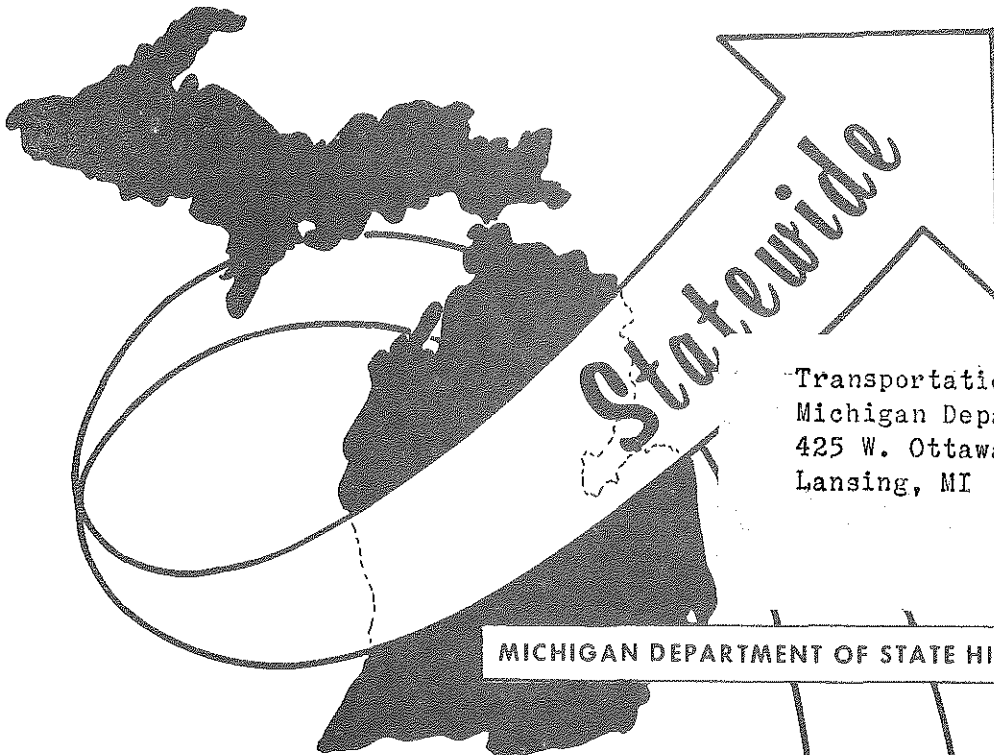
Statewide Transportation Analysis & Research

MICHIGAN'S STATEWIDE
TRANSPORTATION MODELING SYSTEM

TREE PLOTTING WITH INTERACTIVE GRAPHICS

STATEWIDE TRANSPORTATION
PLANNING PROCEDURES

VOLUME II-B
JANUARY, 1977



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January 31, 1977

Mr. Sam F. Cryderman, Deputy Director
Michigan Department of State
Highways and Transportation
Bureau of Transportation Planning
P.O. Box 30050
Lansing, Michigan 48909

Dear Mr. Cryderman:

The following report documents the development of interactive graphics as a systematic method of analyzing various transportation proposals and the impact they have on travel patterns. The principal benefit realized in this development is a phenomenal reduction in the elapsed time required to complete specific travel analysis. This allows the Department to more effectively answer questions frequently asked by the public. These are just two benefits derived from utilization of interactive graphics as a transportation planning tool. This same process of interactively plotting statewide travel paths will also allow the Bureau to reduce the calibration time on an updated statewide model by as much as forth percent. For a list of other reports in the statewide model series, consult the following two pages.

This report was prepared by Terry Gotts of the Statewide Procedures Section under the supervision of Richard E. Esch.

Sincerely,

William M. Lepczyk, Acting Administrator
Highway Planning Division



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TREE PLOTTING

WITH INTERACTIVE GRAPHICS

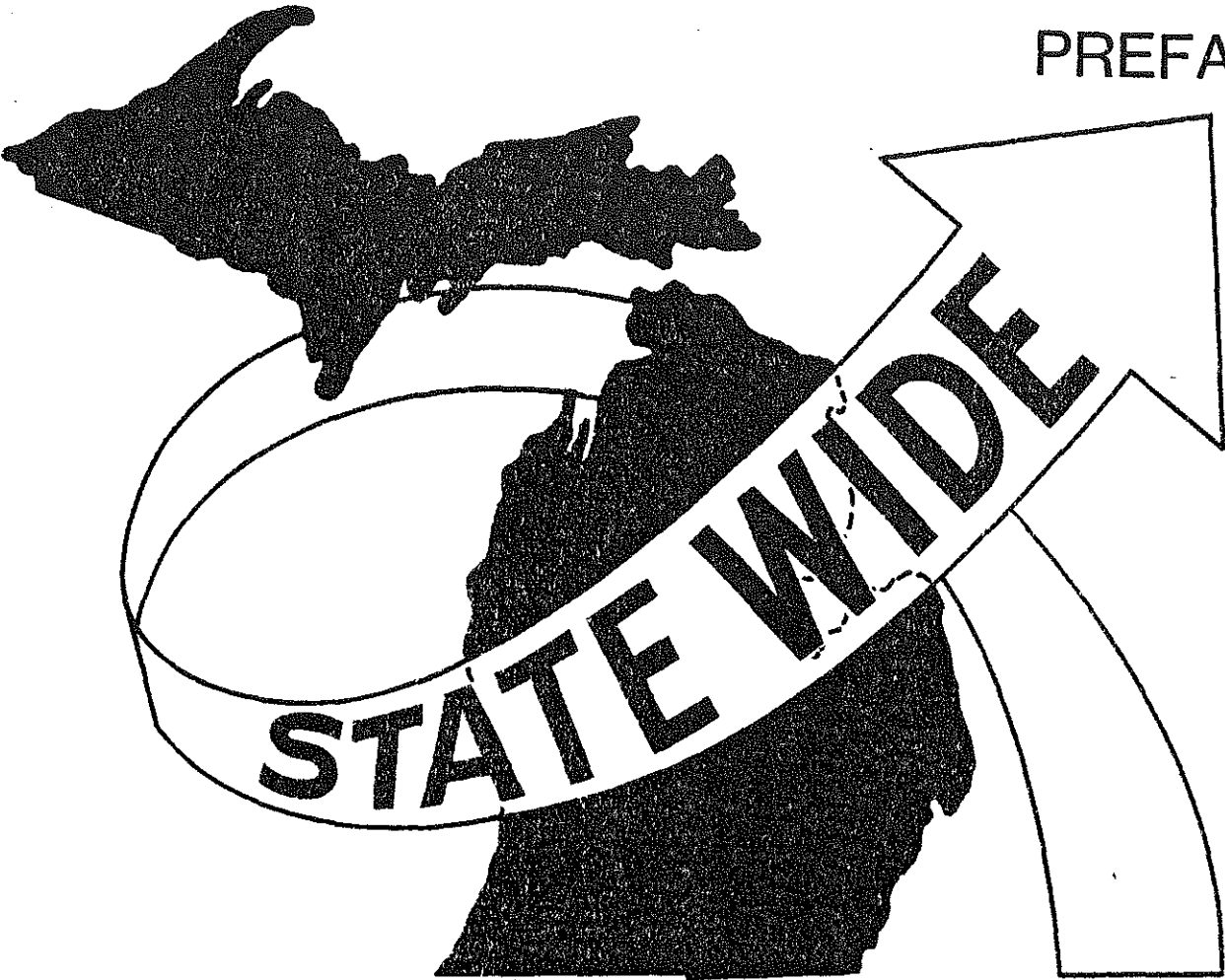
BY

TERRY GOTTS

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PREFACE



PREFACE

In any network calibration project, a large part of the job is checking to see that driving paths on the model reflect reality. The usual method of verifying that these paths or "trees" look correct is by submitting batch runs to create plotter tapes and then waiting until the plots are created off-line. Only the paths from one zone to all other zones can typically be plotted in one run. So if paths from a large number of zones need to be plotted, this adds up to a great many plots. This, coupled with the fact that most agencies have only one or two plotters to serve all users, results in a bottleneck situation. Often analysts must wait for days or weeks to verify that a few simple link changes have produced the desired effect. This seemingly insurmountable obstacle - delay time - has led many states to give up any hope of building a statewide transportation model.

This report documents the development of a program to plot trees interactively on a graphic computer terminal. As will be shown, the use of interactive graphics offers many advantages, the greatest of which is the ability to reduce turn-around from days to minutes. In doing so, it brings projects within the realm of possibility which might never have been attempted with traditional methods.

The interactive tree plotter is a companion process to the interactive network editor described in Statewide Transportation Modeling Series Volume II-A, Efficient Network Updating Using Interactive Graphics. The combination of the two programs provides a powerful "tool kit" for network calibration and the rapid evaluation of travel pattern changes resulting from various regional transportation plans.

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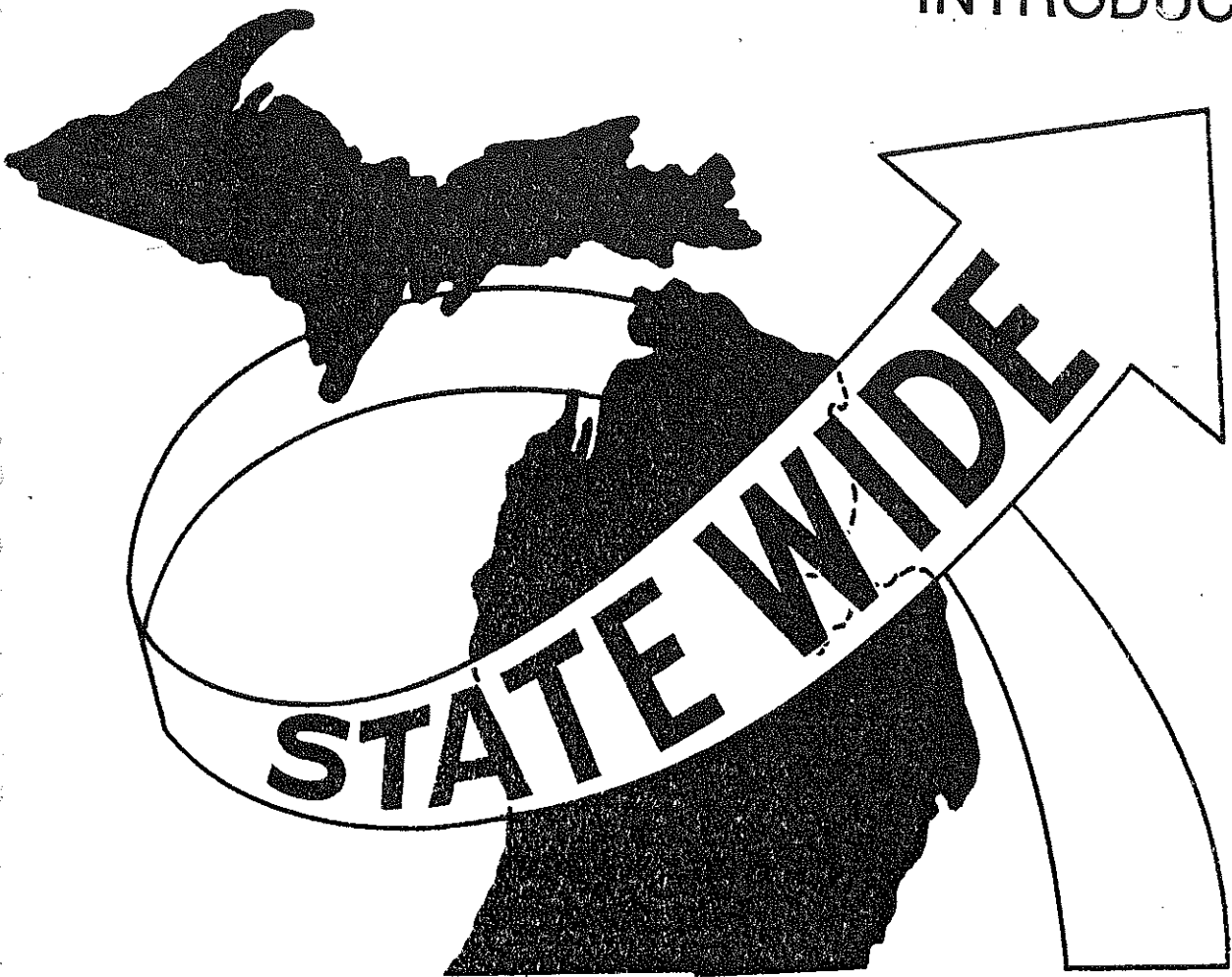
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INTRODUCTION

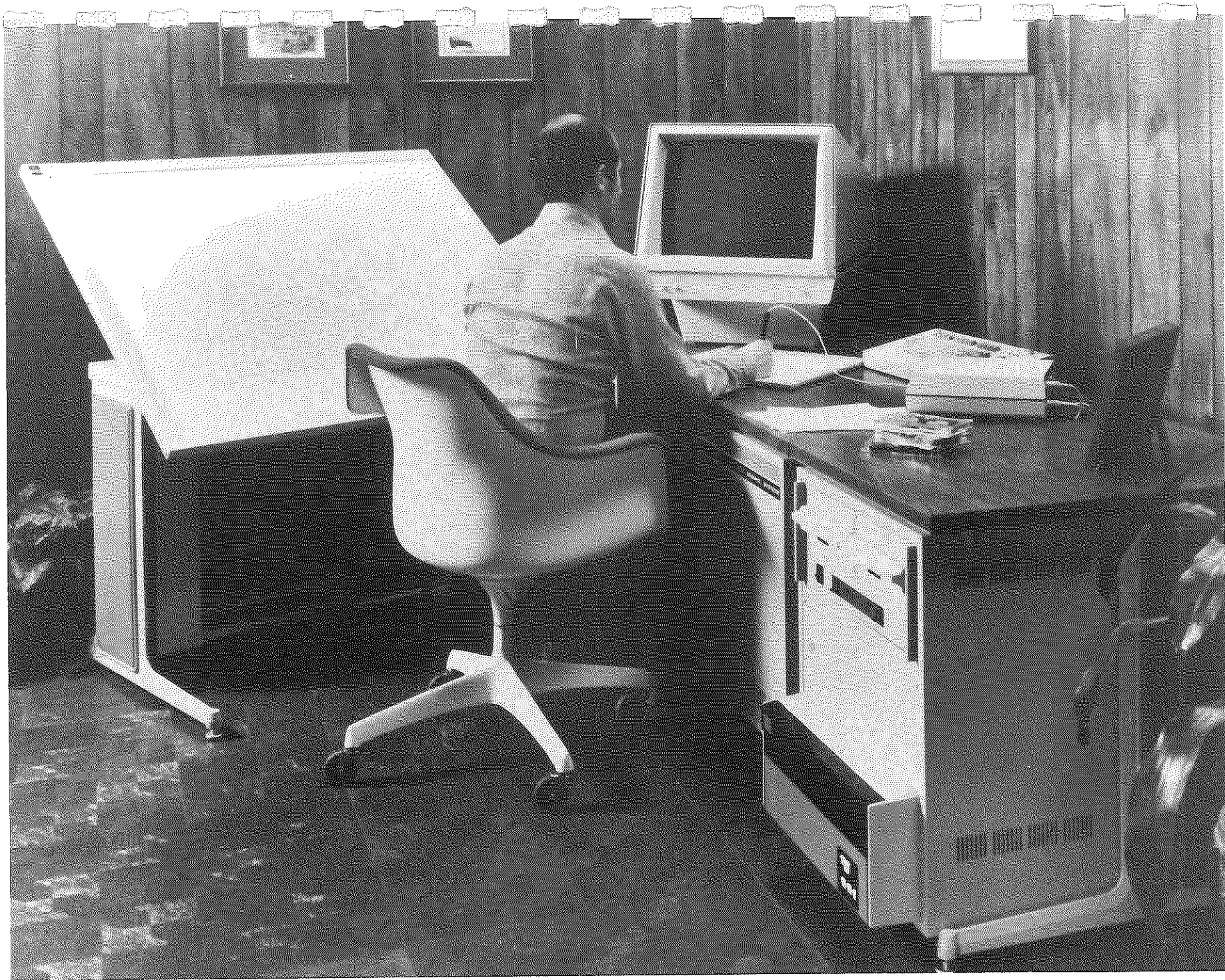


INTRODUCTION

Interactive graphics is a relatively new development in computer technology. It involves drawing pictures on a special cathode-ray-tube computer terminal instead of on paper. Such a terminal is shown in the photograph in Figure 1. The one in the picture is a Tektronix 4014-1 with an extended graphics module. The unit in the foreground is a printer-plotter, a type of hard-copy device (an electrostatic hardcopier is also available). It allows the operator to make a Xerox-like picture of what appears on the screen. This is a very handy device for doing before-and-after comparisons of network model speed changes or for keeping a working log of the effects of network changes. The board at the back of the picture is a digitizer tablet. Its applications are documented in Statewide Volume III-B, Automatic Network Generator Using Interactive Graphics.

Moreover, an interactive environment gives the analyst a degree of flexibility he can get in no other way. He may, if he desires, selectively enlarge portions of the tree to study in more detail. He may wish to add node numbers to identify a group of links more precisely, or he may need to correct a mistake in his directions to the program, or perhaps he might wish to choose another region to enlarge or another tree to plot. With an interactive program such as this, these changes can be made in seconds and the results displayed immediately. There is no need to wait a day or two to see whether the region chosen for a blow-up was the correct one or whether the scale was too small to separate the node numbers so they can be seen.

This advantage of drastically reducing elapsed time cannot be emphasized too



strongly. Suppose, for example, that an analyst needs to plot ten trees on a system of 500 or so zones. Once the proper jobstreams have been set up and executed, each tree will take approximately forty-five minutes to plot. That amounts to almost an entire working day of plotting, just for one such request. If each of only ten analysts made a similar request, it would be apparent that some alternative means of checking trees is needed. The program described here is just such an alternative.

GENERAL CONCEPTS



GENERAL CONCEPTS

For the purposes of this report, the reader will be assumed to have a working knowledge of the following basic network concepts:

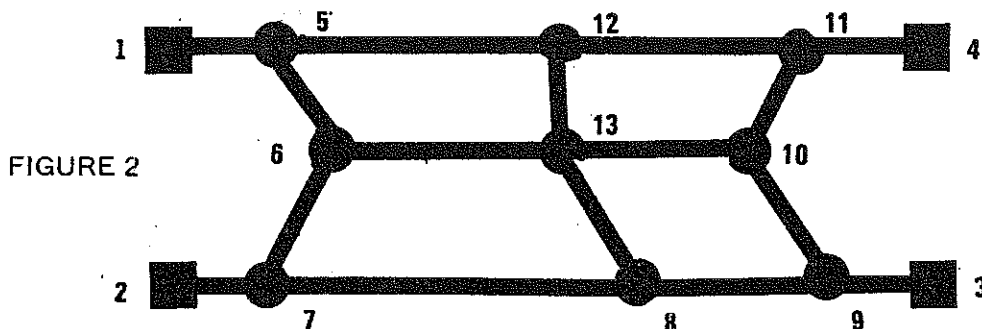
1. Zone - A subdivision of the area to be modeled - usually constructed to be as homogeneous as possible in trip-making characteristics.
2. Link - A segment of the modeling network.
3. Node - An endpoint of a link - a pair of nodes uniquely identifies a link.
4. Centroid - The "center of mass" of a zone at which all population is assumed to lie.
5. Centroid Link - Pseudo-link connecting a centroid to the transportation network.

Readers unfamiliar with these notions are urged to read Statewide Transportation Modeling System Volume X-A, Statewide Travel Impact Analysis Procedures.

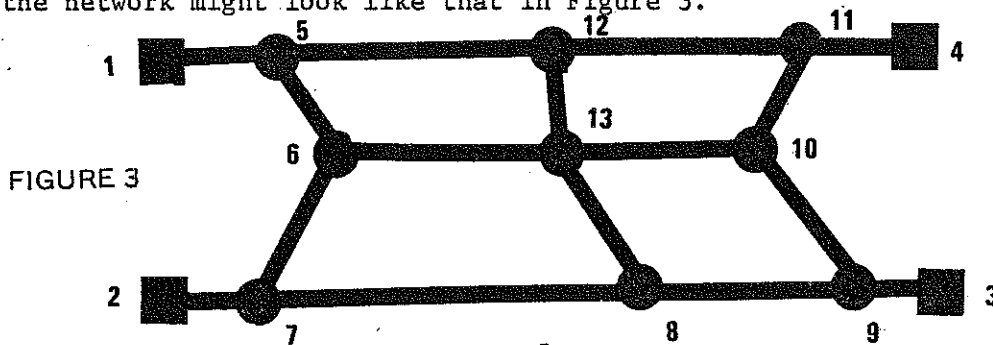
Given this framework, the concept of a "tree" deserves a little exploration.

A tree is a set of minimum-impedance paths from one zone to every other zone.

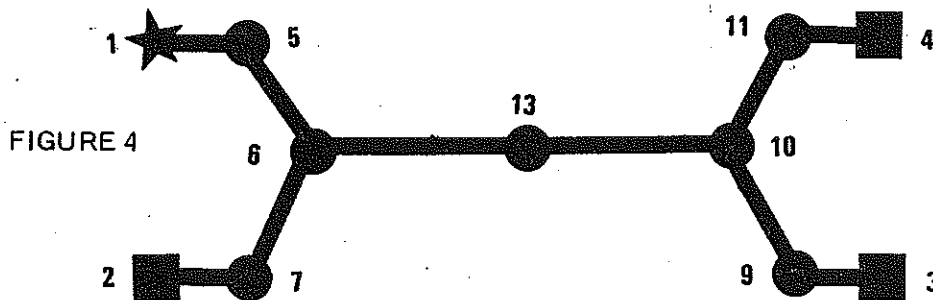
To visualize it, consider the following very simple 4-zone network in Figure 2.



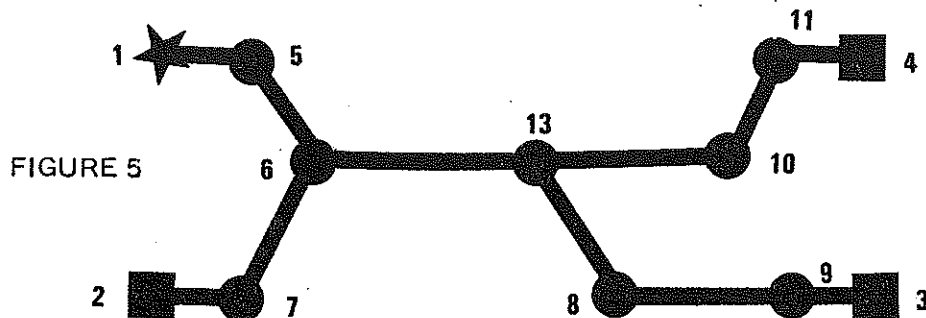
Now assume that we wish to build minimum-time trees. Displaying along each link the number of minutes needed to drive from one endpoint to the other, the network might look like that in Figure 3.



Consider the tree from Zone 1. Obviously, the shortest path from Zone 1 to Zone 2 is through the node sequence 1-5-6-7-2. It can easily be seen that the fastest path to Zone 3 is 1-5-6-13-10-9-3, and the one for Zone 4 is 1-5-6-13-10-11. So a plot of the tree for Zone 1 would appear as shown in Figure 4.



Now suppose that link 8-9 is improved so that it only takes 0.8 minutes to travel over it instead of 2 minutes. Then the path 1-5-6-13-8-9-3 takes only 5.8 minutes as opposed to 6 minutes for path 1-5-6-13-10-9-3. Now the tree for Zone 1 is as shown in Figure 5.



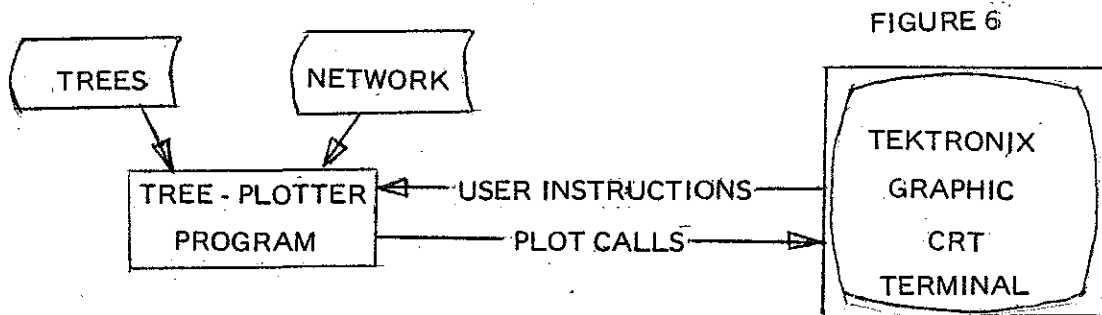
Admittedly, this example is very simplistic, but this is just the type of question that comes up frequently. For that reason, a method of providing a quick answer is essential.

PROGRAM OPERATION



PROGRAM OPERATION

There are three basic inputs to the tree plotter: 1) a network file which contains the node coordinates, 2) a tree file or selected tree file which holds the numeric representation of the paths to be examined, and 3) user instructions entered interactively. The data flow is shown in Figure 6.



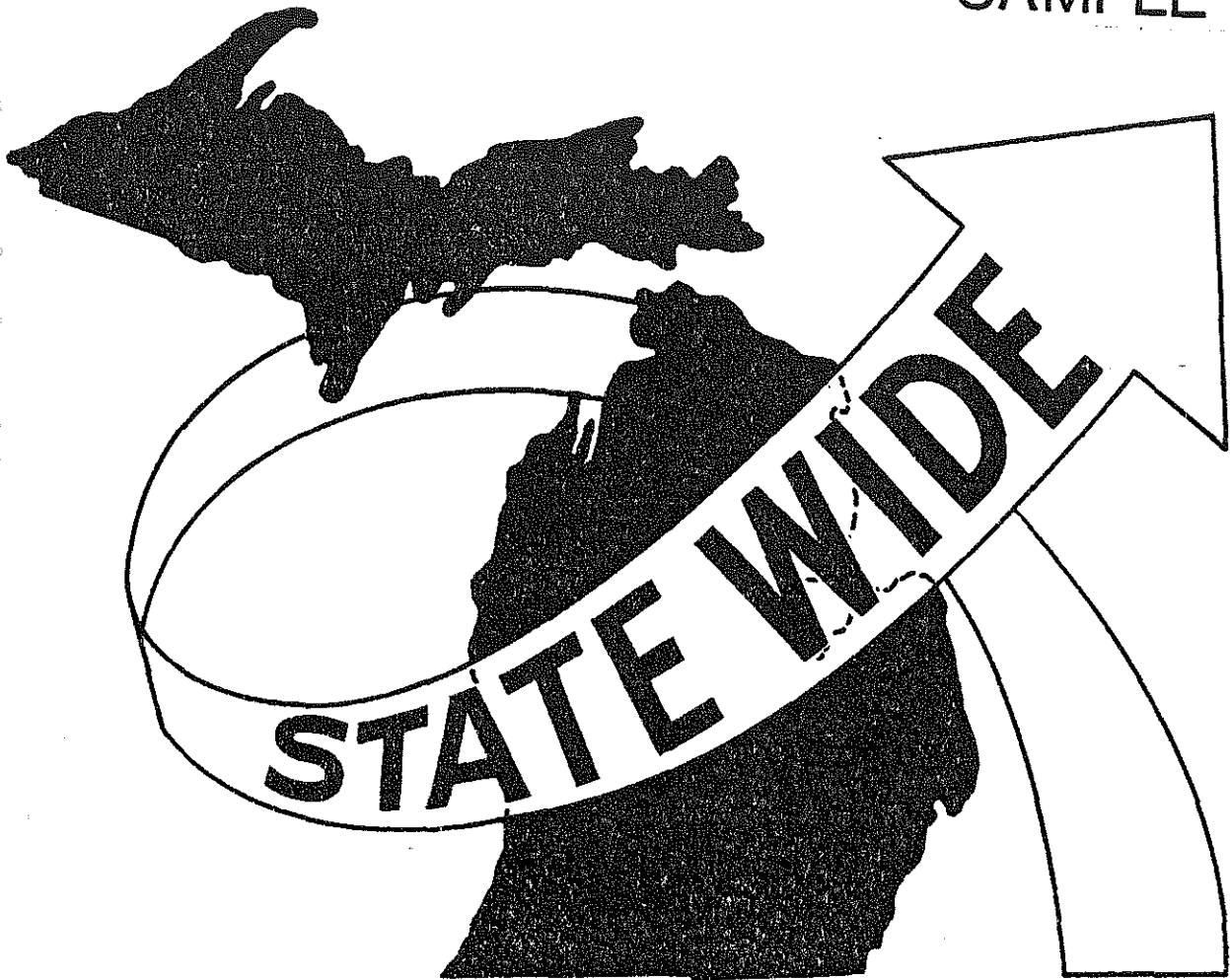
Note that the file of trees must be created independently of the plotting program. Although this is an apparent drawback, it actually becomes a time-saver because one batch of selected trees can be created while another batch is being plotted. At present, network and tree files are expected to be of the form output by the Transportation Planning ("TP") Package of computer programs operational on Burroughs machines. However, the program is modular enough to allow relatively easy conversion to other formats such as those used by the FHWA package or DeLeuw, Cather's DCO/TRANPLAN.

Through user instructions entered interactively, the analyst may control what he sees on the screen. More importantly, he may decide what to plot next based upon what he sees now. He may:

- enlarge a portion of the picture, zoom back to a wider view, or move the window to an entirely different portion of the state,
- display node numbers on the plot either for all nodes or for zone centroids only,
- annotate cumulative times from the origin zone along the links of the tree,
- select a new tree to be displayed without leaving program control.

These commands will be illustrated further in the section entitled "Sample Run" of this report.

SAMPLE RUN



SAMPLE RUN

The following illustration is taken from an investigation of driving paths on an actual proposed highway alternate. The figures were produced on the type of hard copy device attached to the tube in Figure 1. For this example, the basic framework is the statewide 547-zone system shown in Figures 7a and 7b with the accompanying highway network shown in Figure 8.

In Figure 9, the analyst initiates running of the program. The program inquires about his line speed and type of terminal. If he had answered negatively, it would have asked him to enter his terminal type and line speed and adjusted its internal parameters accordingly.

In Figure 10, the program asks the analyst to input the name of the network header, tree file, and network coordinate file. After each file has been opened, the program prints out the parameters read from the file so that the analyst can confirm that the files are the correct ones to use for this run.

The program then asks for an origin zone - the "base" of the tree - and the analyst responds that he wants to see the tree from Zone 151 (Traverse City). He initially wishes to display the entire tree, so he answers "no" when the program asks if the virtual window (in user coordinates) should be restricted. If he had answered "yes", he would have been asked to give the minimum and maximum X-and-Y-coordinates of the rectangle to be displayed. The resulting view is shown in Figure 11.

Now in order to zoom in on a portion of the plot, the analyst enters an "EN-LARGE" command (Figure 12). After the prompt "POSITION CURSOR", he places

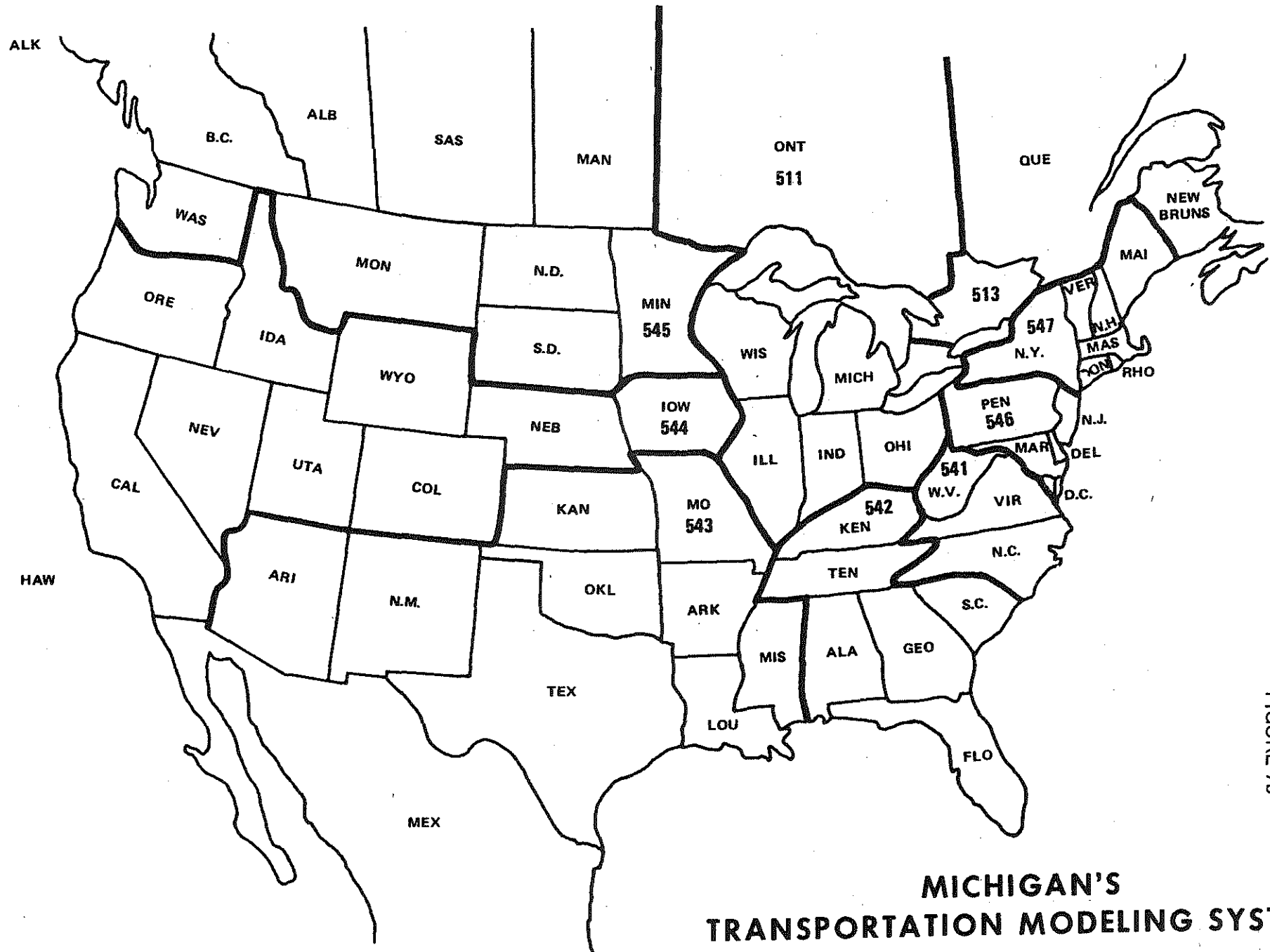


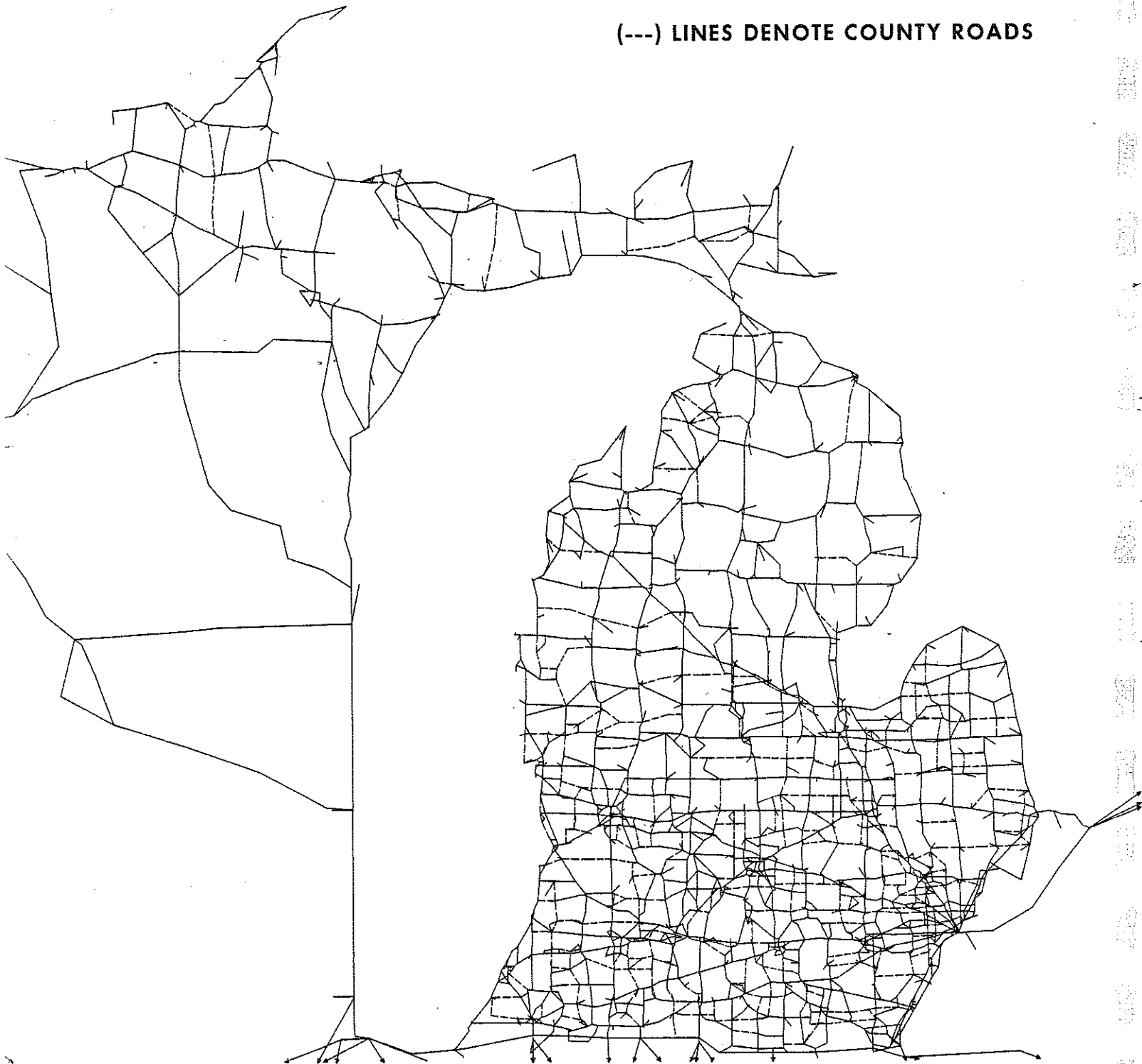
FIGURE 7b

**MICHIGAN'S
TRANSPORTATION MODELING SYSTEM**
547 ZONE
NORTH AMERICA ANALYSIS ZONES

MICHIGAN'S STATEWIDE TRANSPORTATION MODELING SYSTEM

1970 HIGHWAY NETWORK

(---) LINES DENOTE COUNTY ROADS



RUN STLG/TRELOT/BOUND9
BRUNING 6892
87

PROGRAM ASSUMES YOU HAVE A 960-CPS LINE AND A 4014-
TYPE TERMINAL WITH EXTENDED GRAPHICS. IF THIS IS TRUE,
ANSWER YES, OTHERWISE NO.
YES

NAME OF NETWORK FILE? (END WITH ".")
ALT/A0301/UTF/BASENET/N1.

NET HAS NODES= 5275, ZONES= 547
NAME OF TREE FILE? (END WITH ".")
ALT/A0801/UTF/SELTREE.

TREE HAS NODES= 5275

NAME OF COORDINATE FILE? (END WITH ".")
ALT/A0801/UTF/BASENET/2.

XMIN= 22.00, XMAX= 343.00, YMIN= 25.00, YMAX= 247.25

ORIGIN ZONE?
151

RESTRICT WINDOW?
NO

COMMAND-

TREE FROM ZONE 151

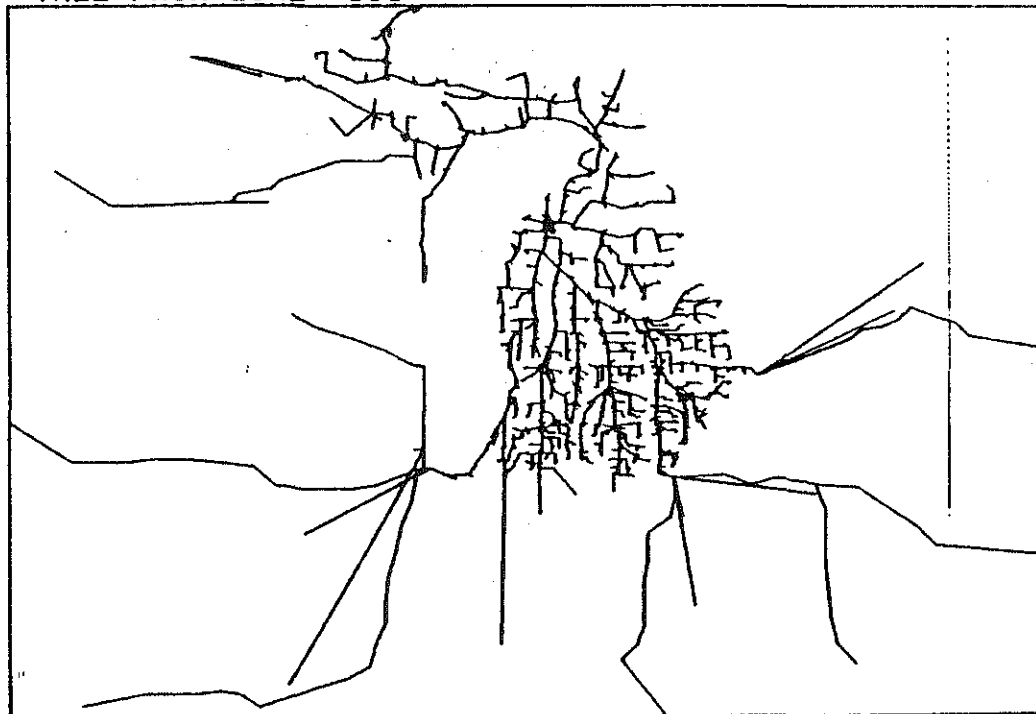


FIGURE 11

the crosshair cursor at one set of opposing corners of the rectangle he wishes to enlarge. Since the cursor cannot be Xeroxed, these points are marked by heavy black crosses in the picture. The program responds first with the coordinate of the corners then with the minima and maxima.

Figure 13 shows the resulting enlargement. In Figure 14, the command "CENTROIDS" puts the zone number at the end of each centroid link.

After one further blowup, the analyst gives the commands for centroid numberings and then cumulative driving times from Zone 151 (Figure 15). For example, he sees that it takes 26.7 minutes to get to Zone 153 starting from Zone 151.

After a little study, the command "NEW" is given to display a new tree (Figure 16). This time the analyst asks for Zone 236, Grand Rapids. He also elects to restrict the X-and-Y-coordinates of his plot to lie between 100 and 245. The resulting plot is shown in Figure 17.

The analyst has the plots he needs, so he exits the program. His turn-around time looks like this:

Build two selected Trees	
(External to Program)	= 2 minutes
<u>Interactive Plotting</u>	<u>= 3 minutes</u>
TOTAL	= 5 minutes

Contrast this with at least one day's turn-around to get the same results with batch processing and off-line pen plotting.

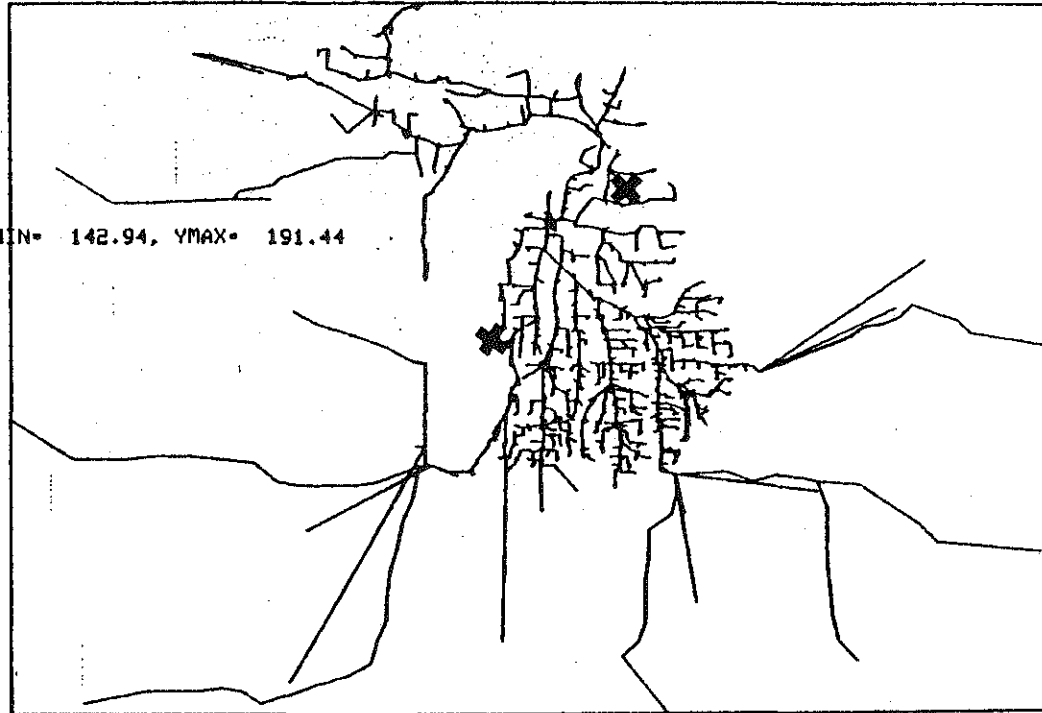
COMMAND-
ENLARGE

##POSITION CURSOR-

TREE FROM ZONE 151

X= 214.60, Y= 191.44
XMIN= 172.28, XMAX= 214.60, YMIN= 142.94, YMAX= 191.44

X= 172.28, Y= 142.94



COMMAND-

TREE FROM ZONE 151

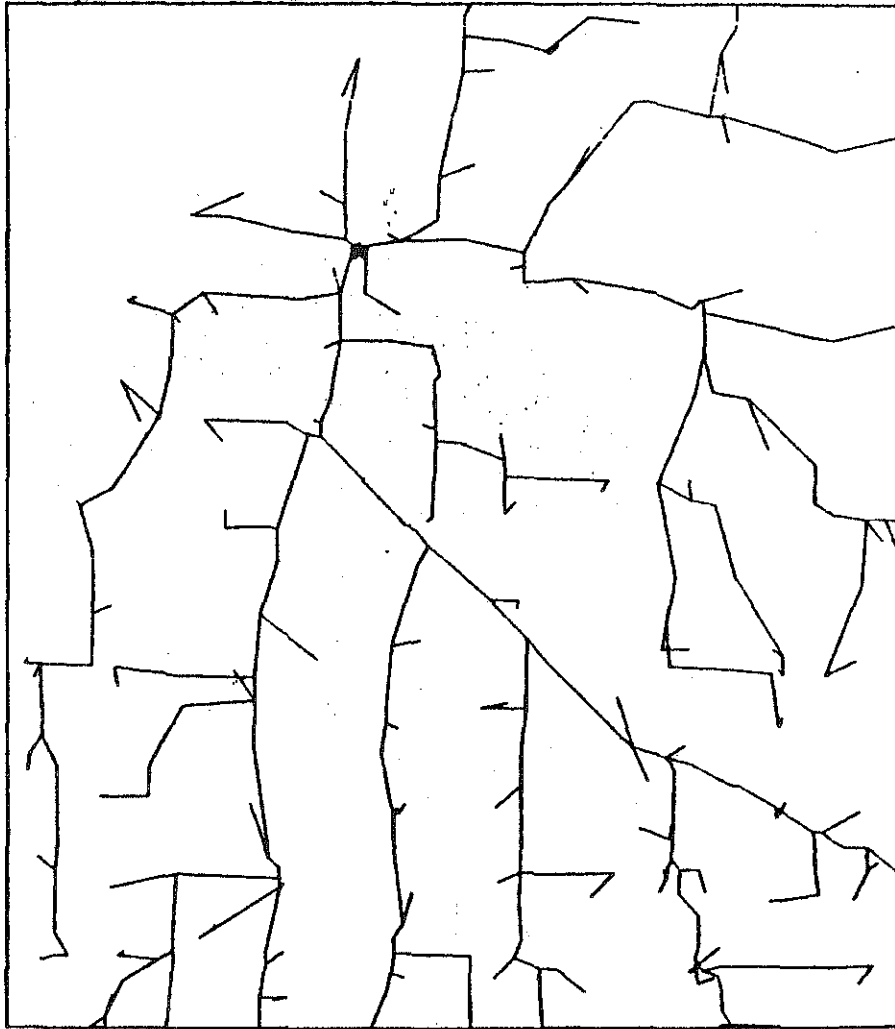


FIGURE 13

TREE FROM ZONE 151

COMMAND-
CENTROIDS

COMMAND-

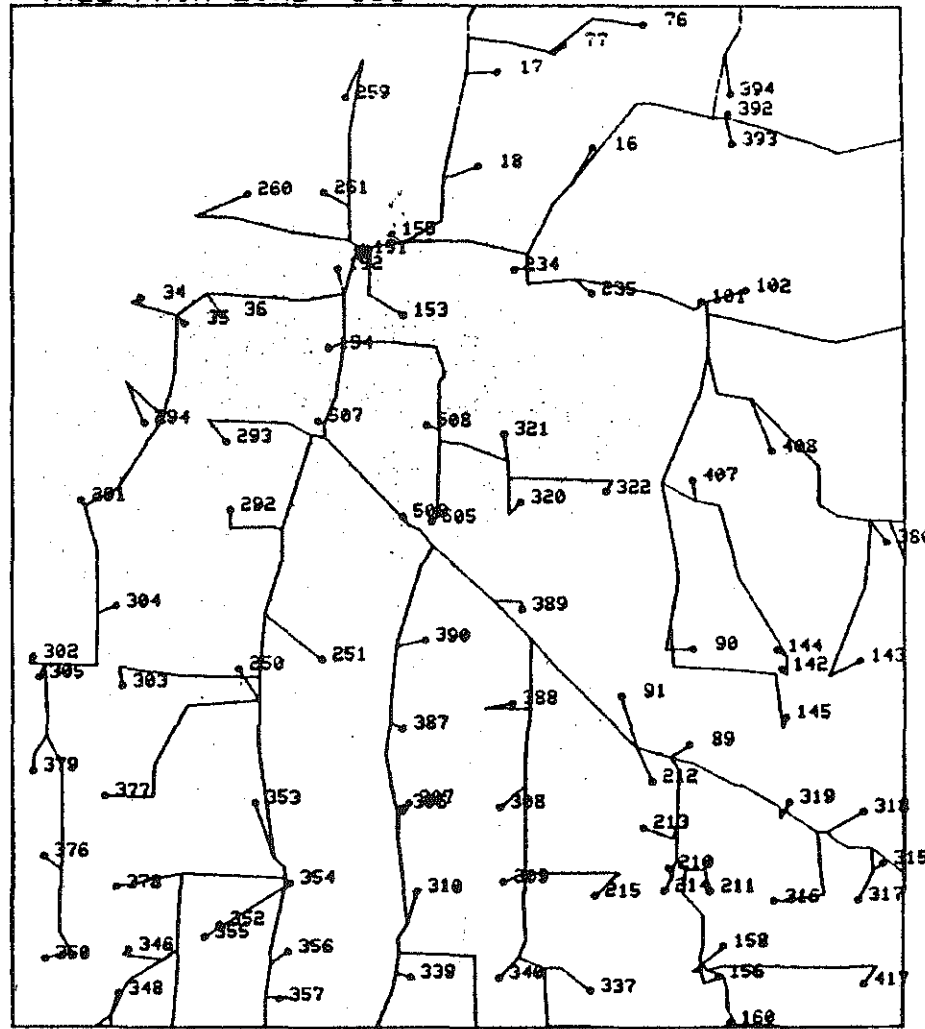


FIGURE 14

COMMAND-
CENTROIDS

COMMAND-
TIMES

COMMAND-

TREE FROM ZONE 151

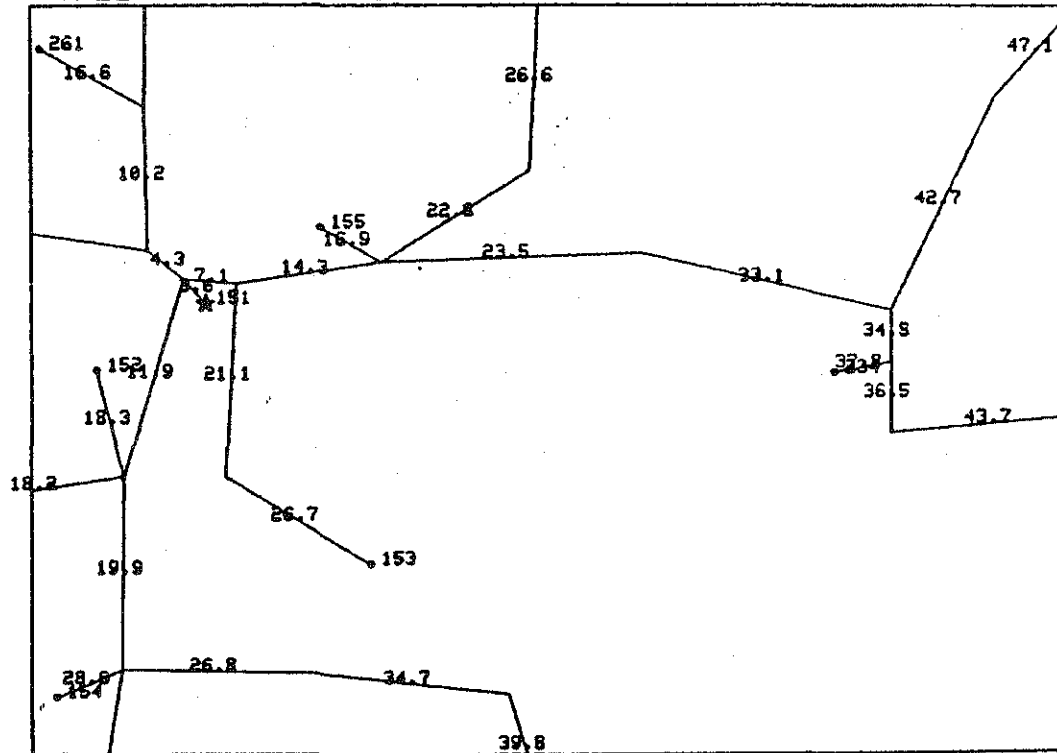


FIGURE 15

COMMAND-
NEU

XMIN= 22.00, XMAX= 343.00, YMIN= 25.00, YMAX= 247.25

ORIGIN ZONE?
236

RESTRICT WINDOW?
YES

ENTER MINX, MAXX, MINY, MAXY SEPARATED BY COMMAS.
100,245,100,245

TREE FROM ZONE 151

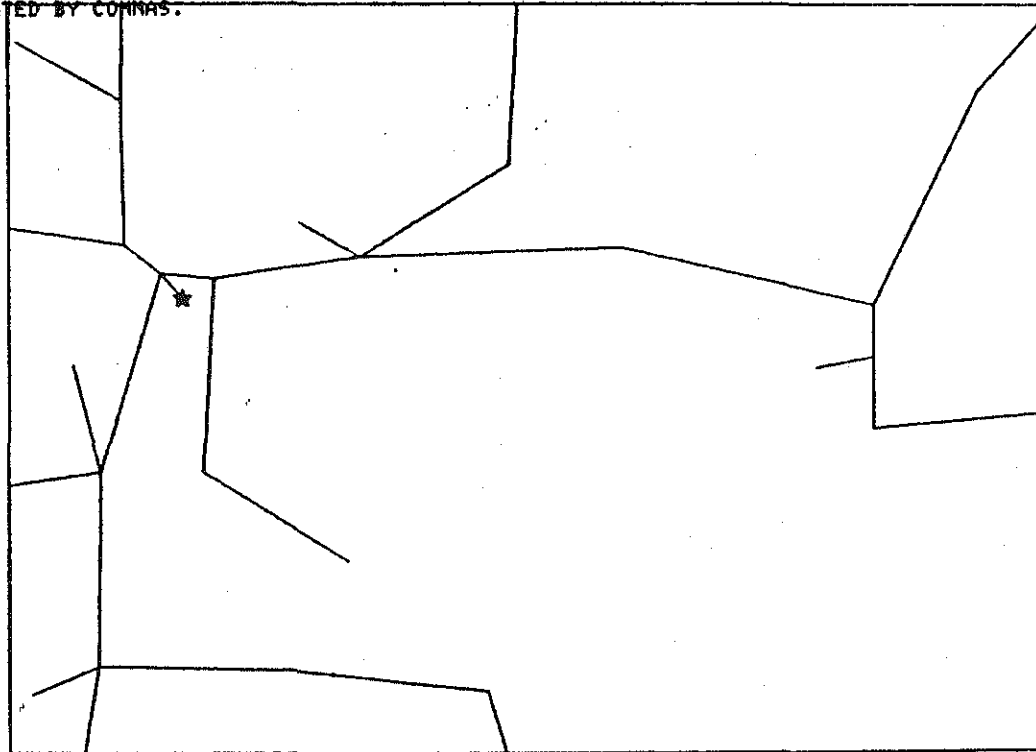


FIGURE 16

COMMAND-

TREE FROM ZONE 236

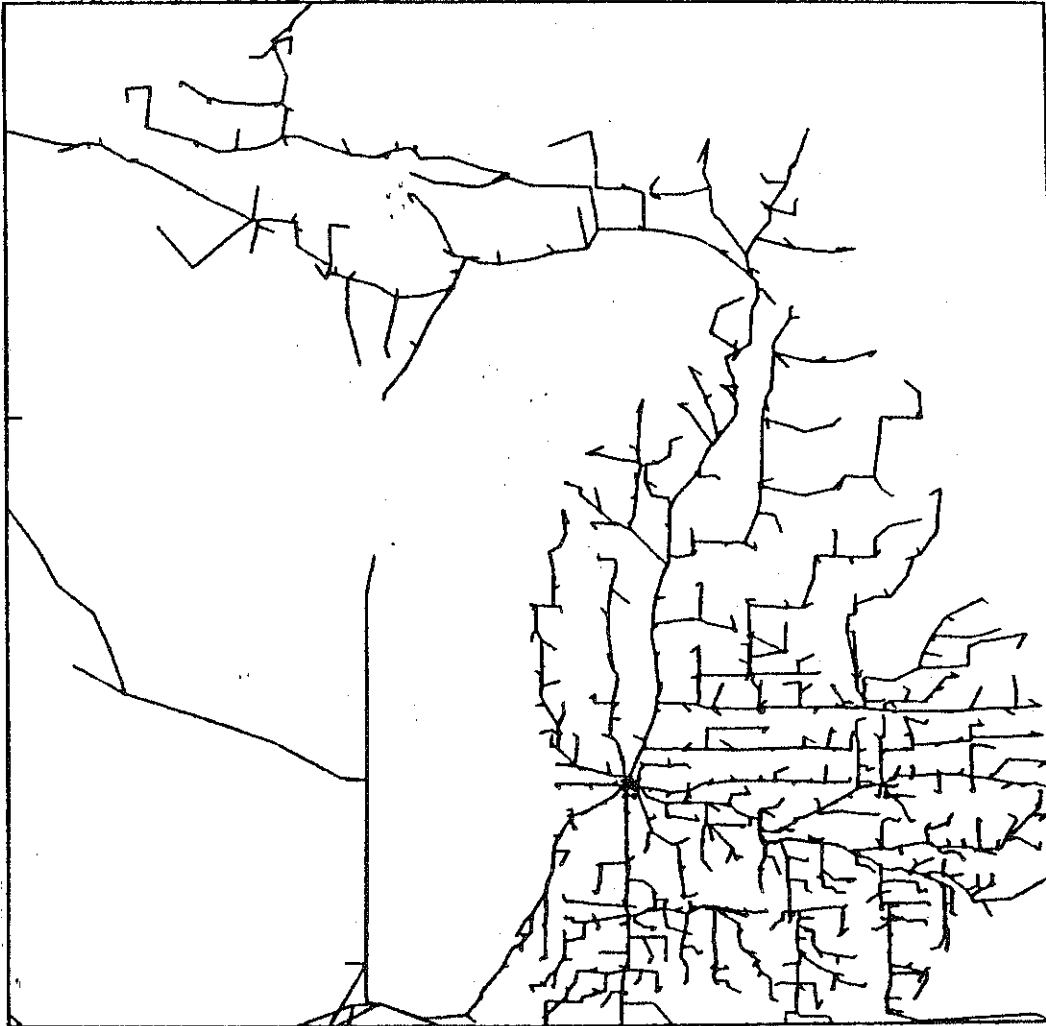


FIGURE 17

The most recent extension to the tree plotter is the ability to plot links in different line types, depending on parameters carried on the link itself. Figure 18 shows a tree from a multi-modal network. Solid lines denote state trunkline; dashed lines are county roads; cross-hatched lines are rail links; and lines marked with triangles are rail-to-highway connectors.

88 COMMAND-

TREE FROM ZONE 183

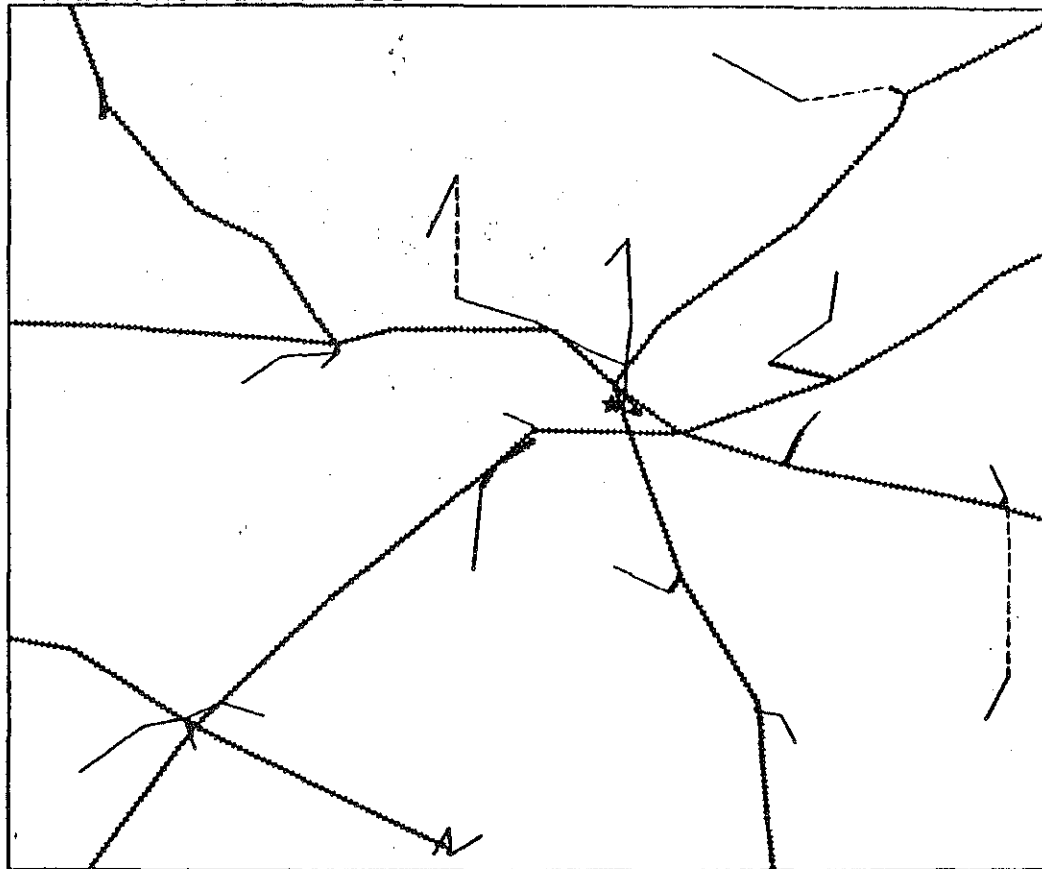


FIGURE 18

CONCLUSION



CONCLUSION

Interactive tree plotting has been developed as one solution to the bottleneck which occurs at off-line plotters in many agencies. It can be shown to reduce turn-around time by 90% or more in network calibration. As a result, more projects could be shifted from the "cannot do" category to the "done" column. When it is used in combination with interactive network updating, it becomes a powerful tool in the analysis of transportation proposals for various regional transportation plans.

Statewide welcomes any questions, comments, or suggestions regarding the interactive tree-plot process. Please address correspondence to:

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