

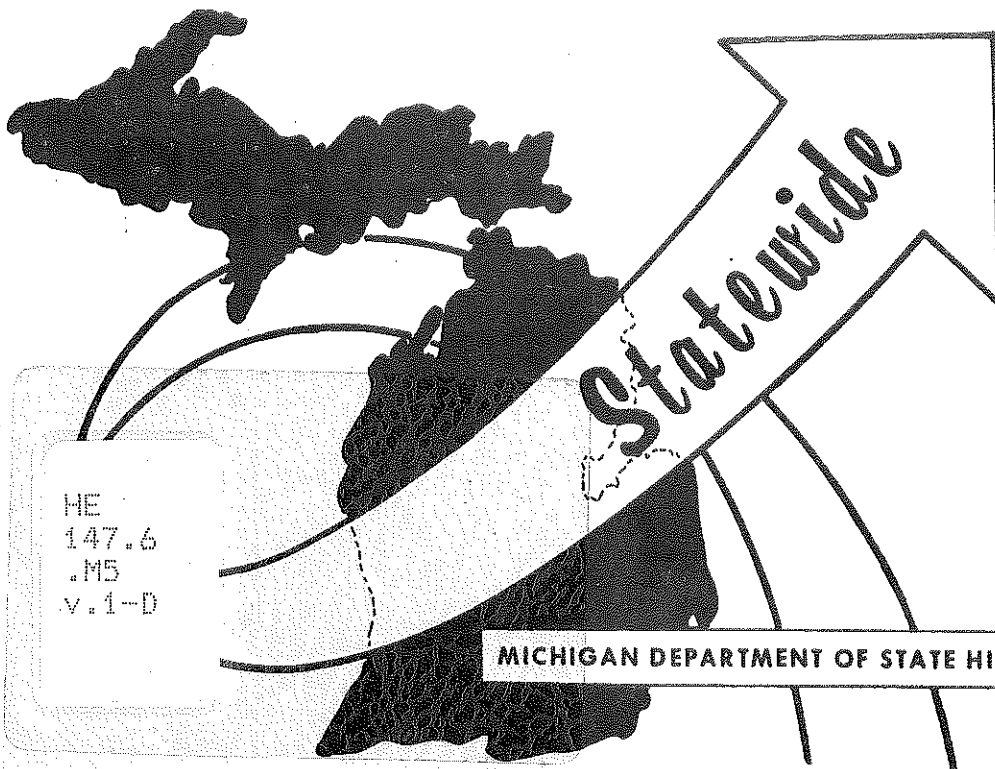
# Statewide ★ Transportation Analysis & Research

MICHIGAN'S STATEWIDE  
TRAVEL MODELING  
SYSTEM

VOLUME I-D  
PROXIMITY ANALYSIS:  
SOCIAL IMPACTS OF ALTERNATE  
HIGHWAY PLANS ON PUBLIC FACILITIES

STATEWIDE STUDIES

REVISED MAY 1974



HE  
147.6  
.M5  
v.1-D

MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

**MICHIGAN DEPARTMENT**

**OF**

**STATE HIGHWAYS AND TRANSPORTATION**

**BUREAU OF TRANSPORTATION PLANNING**

**MICHIGAN'S STATEWIDE  
TRAVEL MODELING  
SYSTEM**

**VOLUME I-D  
PROXIMITY ANALYSIS:  
SOCIAL IMPACTS OF ALTERNATE  
HIGHWAY PLANS ON PUBLIC FACILITIES**

**STATEWIDE STUDIES**

**REVISED MAY 1974**

**STATE HIGHWAY COMMISSION**

**E. V. Erickson**  
Chairman

**Charles H. Hewitt**  
Vice Chairman

**Peter B. Fletcher**

**Carl V. Pellonpaa**

**DIRECTOR**

**John P. Woodford**

HIGHWAY COMMISSION

E. V. ERICKSON  
CHAIRMAN

CHARLES H. HEWITT  
VICE CHAIRMAN

PETER B. FLETCHER  
CARL V. PELLONPAA

STATE OF MICHIGAN



WILLIAM G. MILLIKEN, GOVERNOR

DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

STATE HIGHWAYS BUILDING - POST OFFICE DRAWER K - LANSING, MICHIGAN 48904

JOHN P. WOODFORD, DIRECTOR

May 9, 1974

Mr. Sam F. Cryderman, Deputy Director  
Bureau of Transportation Planning  
Department of State Highways and Transportation  
State Highways Building  
Post Office Drawer K  
Lansing, Michigan 48904

Dear Mr. Cryderman:

The Highway Planning Division is pleased to present an updated version of Volume I-D in the Statewide Travel Modeling System series. It documents a version of the Proximity Analysis process which is considerably more extensive than the original process described in the January, 1973 report labeled Volume I-D.

The new process is capable of relating an extensive facility file to any socio-economic data such as that catalogued in the 1970 Census, and to summarize these relationships both on a statewide and on a regional basis. The user may elect to analyze several sets of socio-economic data simultaneously, and some of the output may be directed without modification to both two- and three-dimensional computer mapping routines.

This report was prepared by Mr. Terry L. Gotts of the Statewide Interagency Procedures Research and Development Section, under the supervision of Mr. Richard E. Esch.

Sincerely,

R. J. Lilly, Administrator  
Highway Planning Division



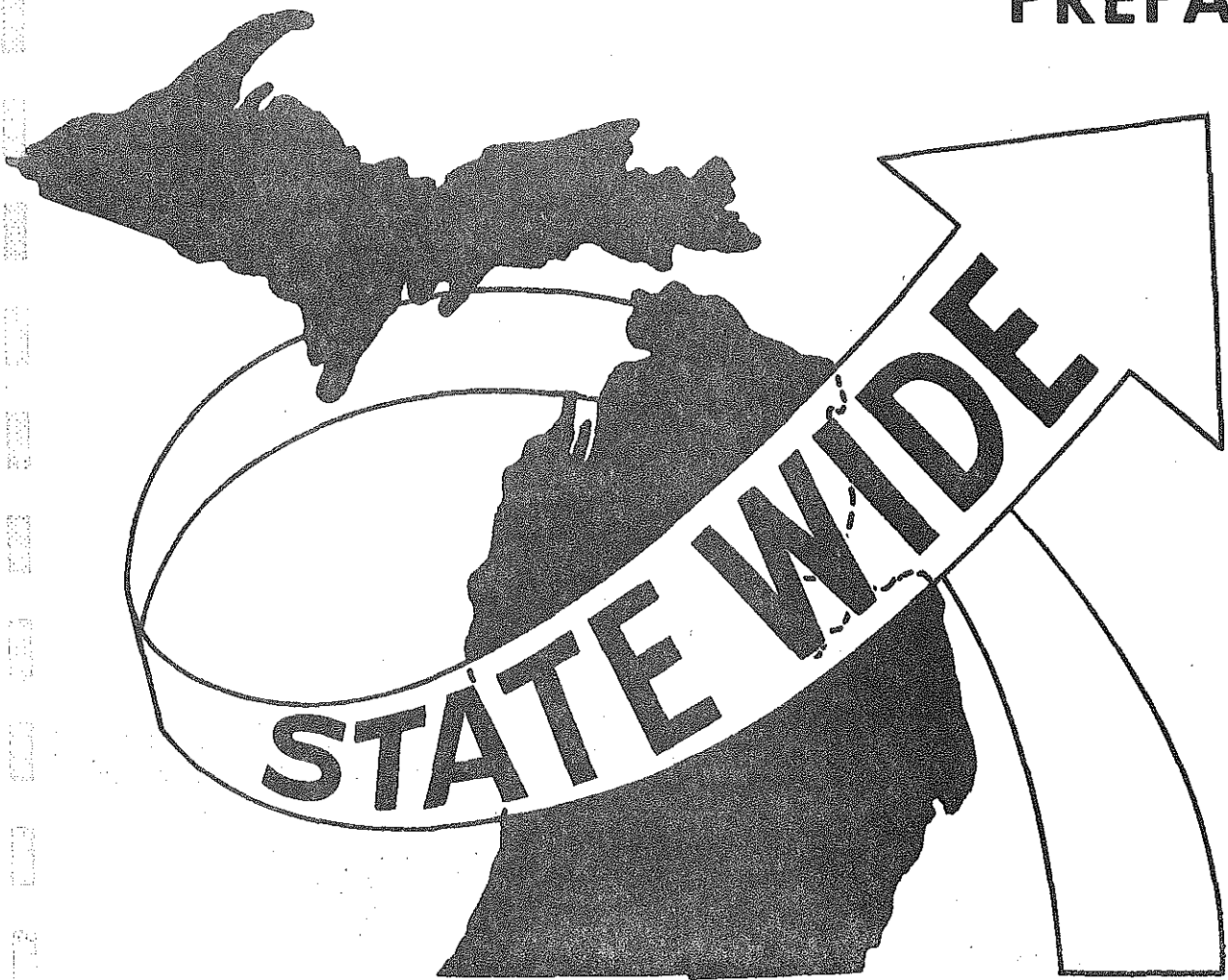
--- TABLE OF CONTENTS ---

PROXIMITY ANALYSIS:  
SOCIAL IMPACTS OF ALTERNATE  
HIGHWAY PLANS ON PUBLIC FACILITIES

by  
Terry L. Gotts

	page
PREFACE . . . . .	1
INTRODUCTION . . . . .	3
PROGRAM OPERATION . . . . .	8
PROGRAM DEFINITION . . . . .	17
APPLICATIONS . . . . .	23
EXAMPLES OF PROGRAM OUTPUTS . . . . .	24
CONCLUSION . . . . .	40
APPENDIX A: RUNNING THE PROXIMITY ANALYSIS PROGRAM . . . . .	42
APPENDIX B: BIBLIOGRAPHY OF TEST PROJECT REPORTS . . . . .	50

# PREFACE



# PREFACE

This is the fourth in a series of reports dealing with applications of Michigan's Statewide Traffic Forecasting Model. The entire series is as follows:

Volume	I	---	Objectives and Work Program
Volume	I-A	---	Region 4 Workshop Topic Summaries
Volume	I-B	---	Single and Multiple Corridor Analysis
Volume	I-C	---	Model Applications: Turnbacks
Volume	I-D	---	Proximity Analysis; Social Impacts of Alternate Plans on Public Facilities
Volume	I-E	---	Model Applications: Cost-Benefit Analysis
Volume	I-F	---	Air and Noise Pollution System Analysis Model
Volume	I-G	---	Transportation Planning Psychological Impact Model
Volume	I-H	---	Level of Service Systems Analysis Model; A Public Interaction Application
Volume	I-J	---	Service-Area Model
Volume	I-K	---	Effective Speed Model; A Public Interaction Tool
Volume	II	---	Development of Network Models
Volume	III	---	Multi-Level Highway Network Generator ("Segmental Model")
Volume	III-A	---	Semi-Automatic Network Generator Using a "Digitizer"
Volume	V	---	Part A--- Travel Model Development; Reformation-Trip Data Bank Preparation Part B--- Development of the Statewide Socio-Economic Data Bank for Trip Generation-Distribution
Volume	VI	---	Corridor Location Dynamics
Volume	VI-A	---	Environmental Sensitivity Computer Mapping
Volume	VII	---	Design Hour Volume Model Development
Volume	VII-A	---	Capacity Adequacy Forecasting Model
Volume	VIII	---	Statewide Public and Private Facility File
Volume	IX	---	Statewide Socio-Economic Data File
Volume	X-A	---	Statewide Travel Impact Analysis Procedures
Volume	X-B	---	Statewide Social Impact Analysis Procedures
Volume	X-C	---	Statewide Economic Impact Analysis Procedures
Volume	XI	---	Computer Run Times - An Aid in Selecting Statewide Travel Model System Size

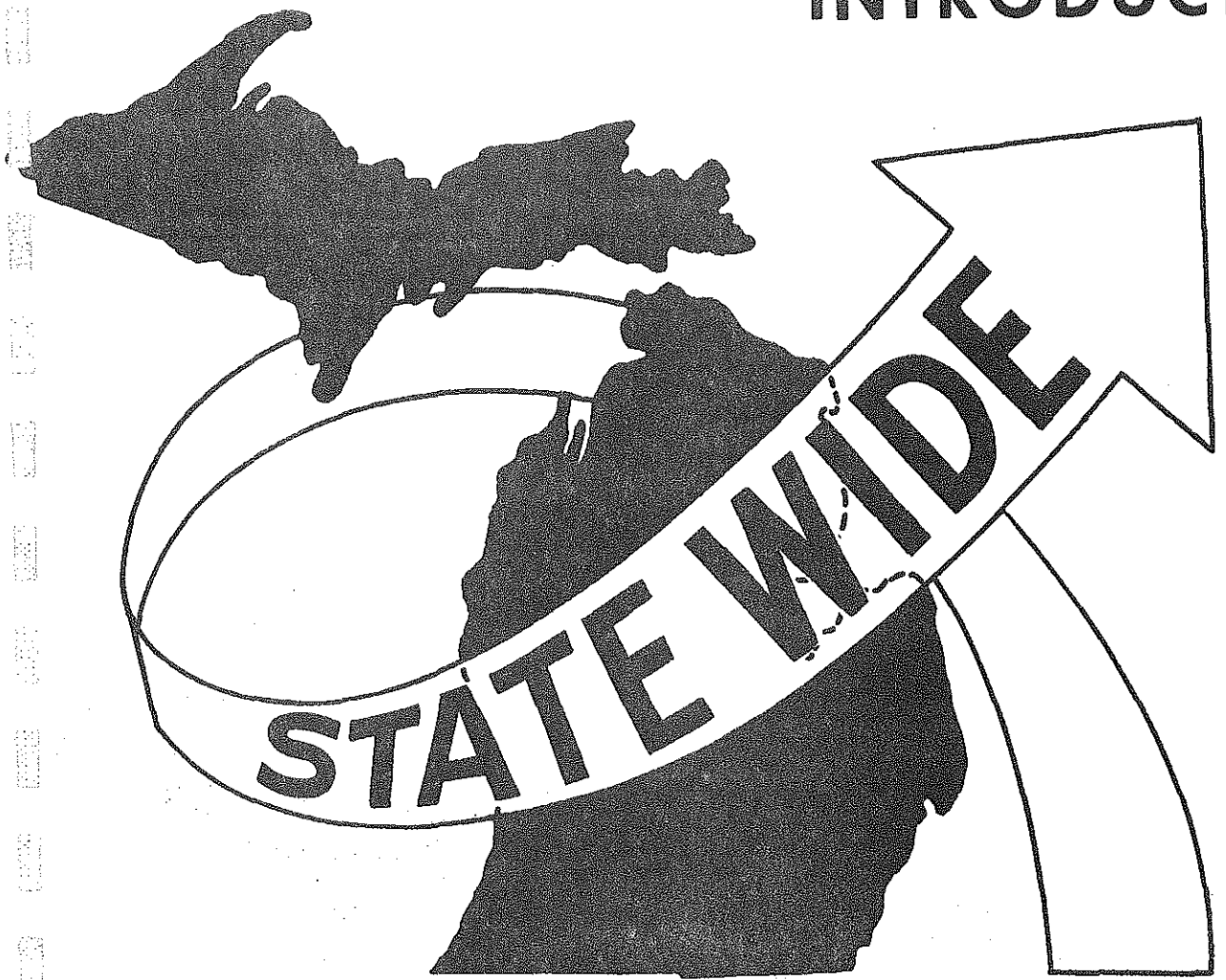
This report is Volume I-D. It deals with an automated routine to measure the social and economic impacts of a highway network at the system level by calculating to what extent the network makes public services accessible to people. Using this technique, alternative highway plans can be compared by the degree to which they bring people closer to public services.

According to the Federal-Aid Highway Act of 1970, the evaluation of each proposed Federal-aid highway project must include an analysis of the socio-economic effects of the project. In addition, Section 109(h) stipulates that final decisions on highway projects must be made in the best overall public interest; impacts on the public services are among the effects which must be monitored.

In formulating an Action Plan, each agency must set down a procedure for deriving up-to-date information on socio-economic effects. These impacts should be able to be monitored quickly, so that impact information keeps pace with the process of planning alternative courses of action. Then the effects of an alternate can be monitored as soon as the alternate is formulated. In this way, immediate feedback can be used in the actual planning of alternatives, rather than having alternates selected months before concrete evidence of their impacts is obtainable. Furthermore, the guidelines insist that highway departments monitor impacts at the system level.

This report presents a tool for quickly and systematically monitoring the social and economic impacts of highway networks at the system level. Such a technique is necessary if the department is to be able to efficiently supply the information required by the 1970 Federal-Aid Highway Act.

# INTRODUCTION





# INTRODUCTION

In the trip-generation equations presently used in the Statewide Traffic Forecasting Model, trips are a function of two variables: (1) the population of the zone and (2) the "surrounding population" of the zone. To get "surrounding population" for a zone, it is necessary to know the time required to travel from that zone to every other zone along the shortest - time path; this vector of times will hereafter be referred to as a "skimmed tree" for the zone. One then separately calculates the population lying within 0-20, 20-30, and 30-40 minutes of the zone. Finally, "surrounding population" is defined to be the first (0-20) total plus half of the second (20-30) total plus one-fourth of the third (30-40) total.

In updating the trip generation-distribution equations, it was discovered that for a few zones, surrounding population as defined above is not a good predictor of trips. It was possible that the definition of surrounding population was itself at fault. The investigation necessitated the creation of a computer routine which would have four basic qualities:

- (a) It must use existing inputs (skimmed trees, population totals) in order to eliminate data preparation and minimize implementation time;
- (b) It should be simple in structure to minimize programming and facilitate possible future modifications;
- (c) It should be quick (i.e., cheap) to run;
- (d) It must have enough built-in flexibility to be able to satisfy the requirements of several different users.

The routine described here, as well become evident, fulfills all four conditions.

Moreover, the techniques and methods involved here are most definitely not restricted to the exclusive domain of traffic and traffic forecasting. They relate very heavily to many areas of planning, such as the planning of

recreational areas, state facilities (such as hospitals and schools), critical services (such as ambulance and police installations), and maintenance services for the highway network.

Finally, the techniques involved here are intertwined with the Statewide Network modeling process in order that the model development may serve many additional purposes. The input data comes from the Statewide Socio-Economic Data Bank and the Statewide Public and Private Facility File, and the whole process is made possible through the existence of the Statewide network model.<sup>1</sup> The three basic files are shown in Figures 1, 2, and 3.

Moreover, since the same type of network building occurs in urban origin-destination simulation studies, the transition can easily be made to urban networks. This process could be adapted to regional studies such as TALUS. The same sort of analyses could be made as in the statewide case, with proximity analysis being done on any zone characteristic which can be measured.

A final word on terminology should be added. Since many applications of this process have to do with one zone serving others, as in the example of the maintenance garage, the terms "analysis zone" and "facility zone" will be taken to mean the same thing in the ensuing discussion. If there is more than one facility unit in a facility zone--two garages in one zone, for instance--each will be termed a "facility". Finally, the "service capacity" of a zone will denote that zone's potential for providing service: if the aforementioned two garages each contain fifteen snowplows, say, and if one were speaking of winter service, the capacity of the zone containing the two garages would be  $15+15 = 30$  snowplows.

---

<sup>1</sup>The reader is referred to Statewide Transportation Analysis and Research Reports Volume VIII (Statewide Public and Private Facility File) and Volume IX (Statewide Socio-Economic Data File).

## FIGURE 1

# STATEWIDE FACILITY FILE

AIRPORTS  
AMBULANCE SERVICE  
BUS TERMINALS  
CAMP GROUNDS, PUBLIC AND PRIVATE  
CERTIFIED INDUSTRIAL PARKS  
CITIES OVER 30,000 POPULATION  
CITIES OVER 5,000 POPULATION  
CIVIL DEFENSE TERMINALS  
COLLEGES, NON-PUBLIC  
COLLEGES, PUBLIC COMMUNITY  
COLLEGES AND UNIVERSITIES, PUBLIC 4 YEAR  
CONVENTION CENTERS  
GAME AREAS  
GOLF COURSES  
HIGH SCHOOLS  
HISTORIC SITES  
HOMES FOR THE AGED  
HOSPITALS  
MAJOR COMMERCIAL CENTERS  
MANUFACTURERS  
MENTAL HEALTH CENTERS  
NEWSPAPERS, DAILY  
NEWSPAPERS, WEEKLY AND BIWEEKLY  
NURSING HOMES  
PORTS  
RAIL TERMINALS  
SECRETARY OF THE STATE OFFICES  
SEWAGE TREATMENT FACILITIES  
SKI RESORTS  
SNOWMOBILE TRAILS  
STATE PARKS  
STATE POLICE POSTS  
TOURIST ATTRACTIONS  
TREASURY OFFICES  
TRUCK TERMINALS  
UNEMPLOYMENT OFFICES  
WEATHER SERVICE STATIONS-NATIONAL  
WHOLESALE TRADE CENTERS

# STATEWIDE HIGHWAY NETWORK

## LINK FILE

### CONTENTS OF EACH HIGHWAY SEGMENT OR LINK

AVERAGE SPEED

DISTANCE

URBAN-RURAL DESIGNATION

TYPE OF ROUTE

TRAFFIC VOLUME CAPACITY

AVERAGE ANNUAL DAILY TRAFFIC VOLUME

COMMERCIAL TRAFFIC VOLUME

DESIGN HOUR VOLUME

ACCIDENT FATAL RATE

ACCIDENT INJURY RATE

ACCIDENT RATE

NUMBER OF LANES

LANE WIDTH

SURFACE CONDITION

RIGHT OF WAY

SIGHT RESTRICTION

FIGURE 2

# STATEWIDE SOCIO-ECONOMIC DATA FILE \*

## GENERAL CHARACTERISTICS OF POPULATION

SCHOOL ENROLLMENT BY TYPE OF SCHOOL  
YEARS OF SCHOOL COMPLETED  
CITIZENSHIP BY AGE

## INCOME CHARACTERISTICS OF POPULATION

FAMILY INCOME  
INCOME BY OCCUPATION AND SEX  
RATIO OF FAMILY INCOME TO POVERTY LEVEL

## LABOR FORCE CHARACTERISTICS OF POPULATION

EMPLOYMENT BY AGE  
EMPLOYMENT BY OCCUPATION AND SEX  
EMPLOYMENT BY INDUSTRY AND SEX

## SOCIAL CHARACTERISTICS OF POPULATION

AGE BY SEX  
TYPE OF FAMILY  
MARITAL STATUS

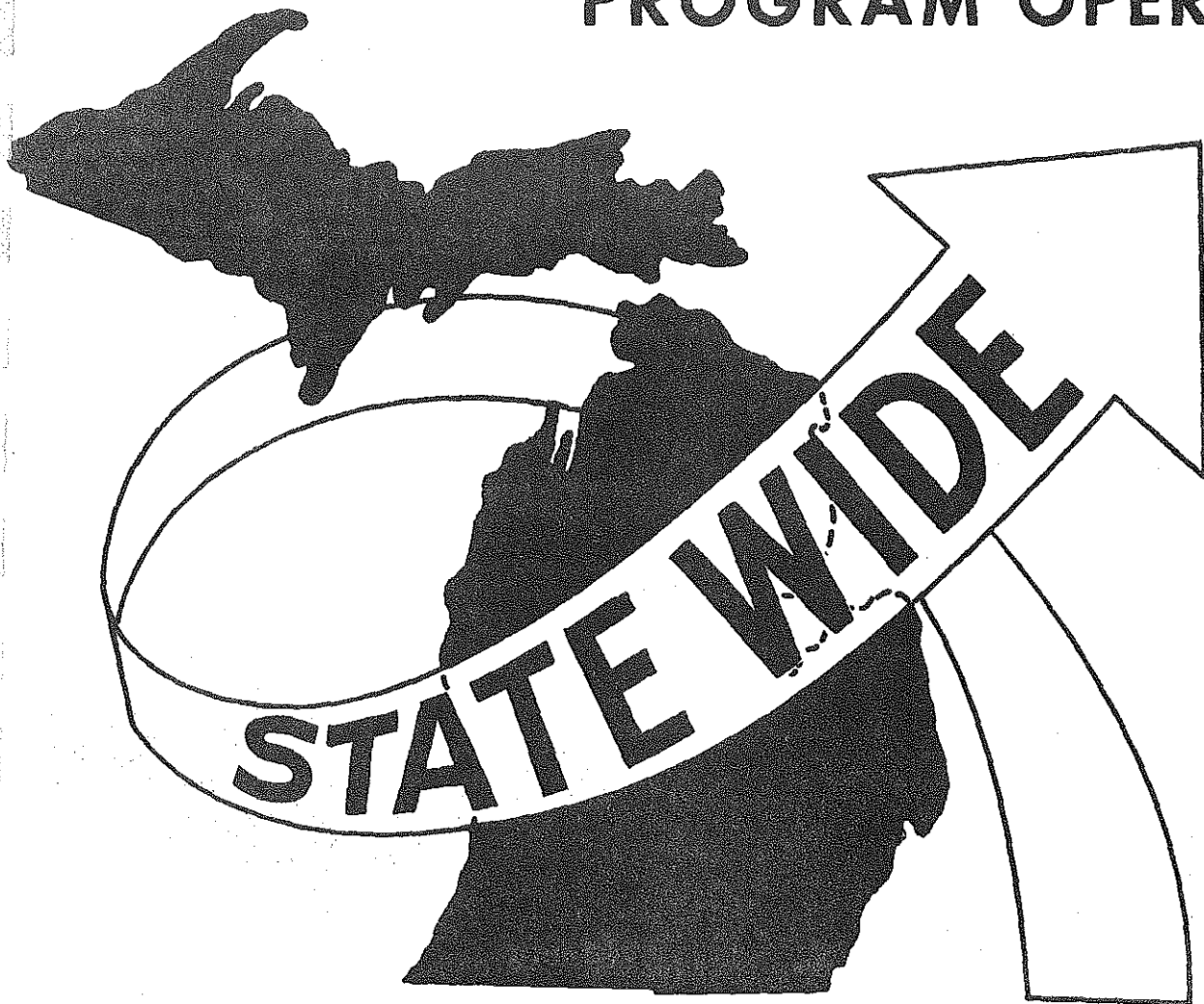
## AREA CHARACTERISTICS

LAKE FRONTAGE  
ASSESSED VALUATION  
WATER AREA

**FIGURE 3**

\*THOSE ITEMS LISTED HERE ARE SAMPLES TAKEN FROM THE COMPLETE  
FILE WHICH CONTAINS OVER 700 ITEMS.

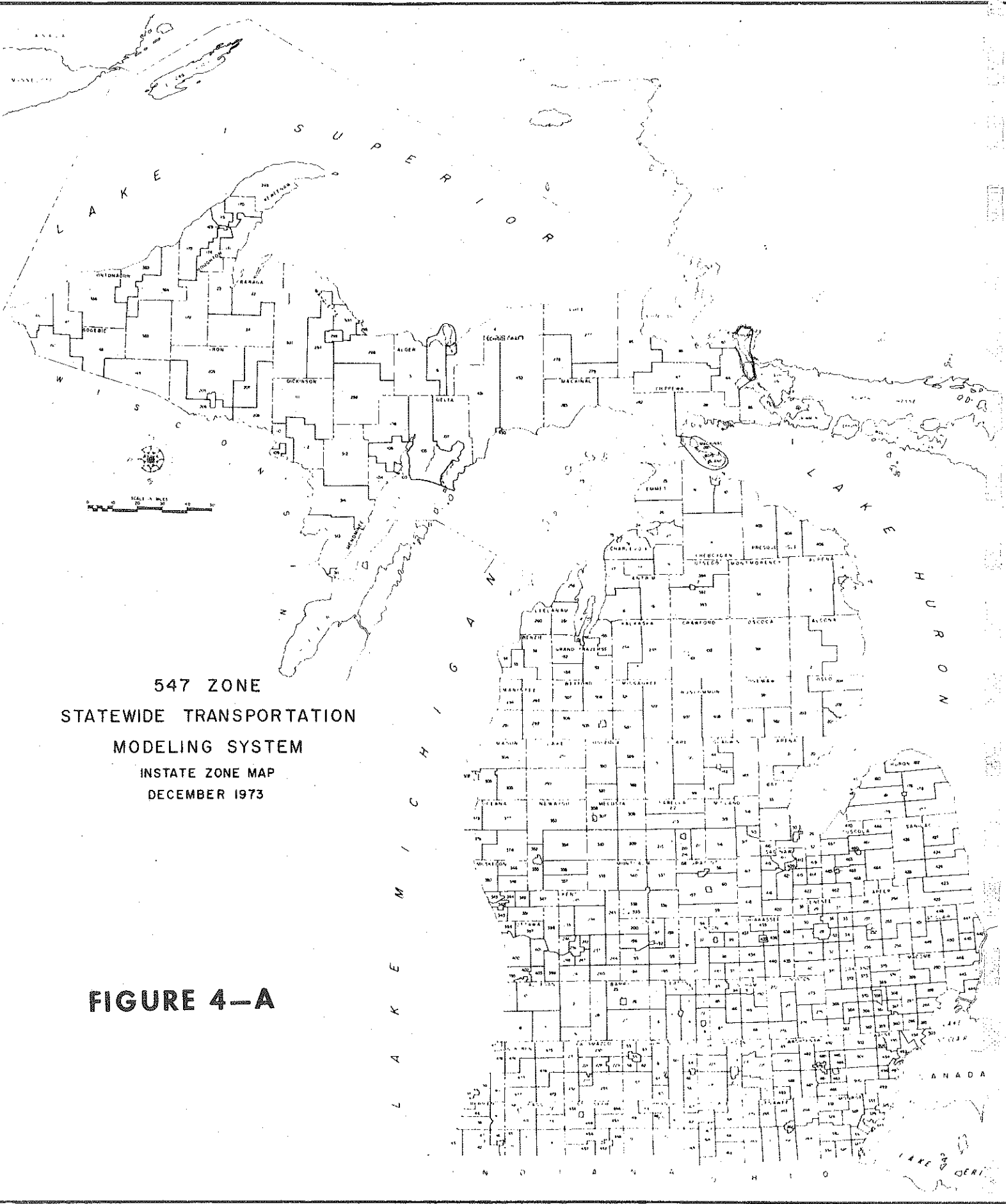
**PROGRAM OPERATION**



# PROGRAM OPERATION

The proximity analysis program has been operated on the 547-zone system (figures 4-A and 4-B), a county-level system produced by Segmental Model (figure 4-C) and experimentally on the 2300-zone system (figure 4-D). The reader is referred to report III of the Statewide series for details on Segmental Model. Note that the 547-zone system includes states other than Michigan, as indicated in figure 4-B; these same areas are also part of the county-level system and the 2300-zone system.

The user must specify how many bands he wishes to consider around each analysis zone. At the same time, he must stipulate the maximum value of time or distance or cost which is permitted to occur in each band. In the case of the existing definition of surrounding population, three time bands are involved, and their outer limits are 20, 30, and 40 minutes. One may place these bands around all zones or any designated subset of them.



547 ZONE  
 STATEWIDE TRANSPORTATION  
 MODELING SYSTEM  
 INSTATE ZONE MAP  
 DECEMBER 1973

FIGURE 4-A



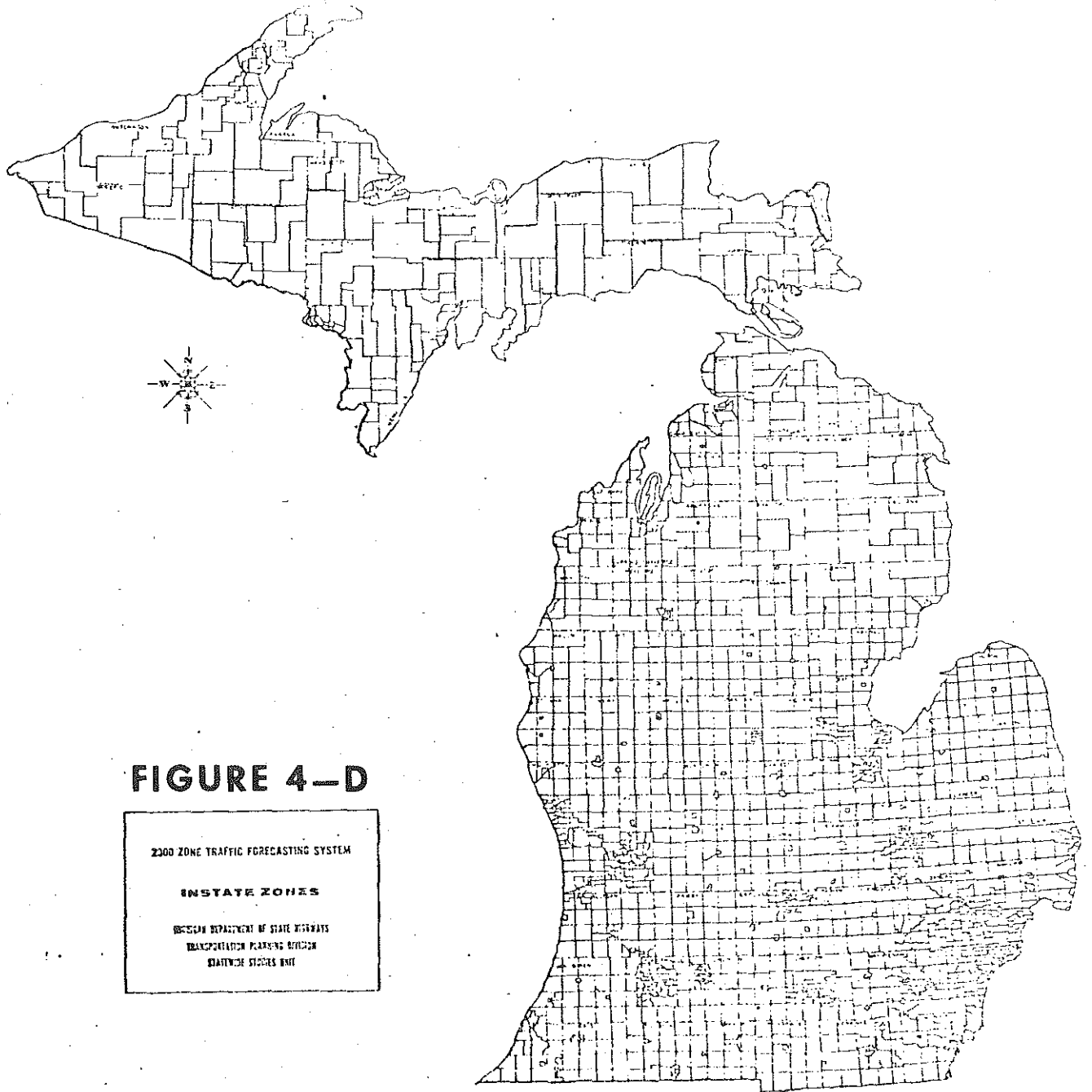


**FIGURE 4—B:**  
**OUTSTATE ZONES**

MICHIGAN DEPARTMENT OF STATE HIGHWAYS  
TRANSPORTATION PLANNING DIVISION  
STATEWIDE STUDIES UNIT

**FIGURE 4-C: COUNTY-LEVEL  
ZONE SYSTEM**





Skimmed trees have been mentioned before, but the concept is worth repeating, since it is central to the logic behind the proximity model. Once a network has been created, a computer program named TPTREE chooses the "path of least resistance" from each zone to every other zone; these trees are chosen so as to minimize a user-specified variable of separation (total travel time, total travel distance, total travel cost) between zones. If a user wished to build trees only for use with this program, it is possible for him to build selected trees only from his analysis zones to all other zones in the system. Next, a program named TPSKIM calculates the actual minimum of this separation variable for each zone to zone pair, in effect "skimming" the tree. For an example of a selected tree plot from zone 28 to all other zones, see figure 5. The numbers along each link denote the average time in hundredths of a minute necessary to go from the centroid of zone 28 to the end of the link; thus the times are cumulative for each zone-to-zone path. The speeds used to build the tree are average speeds derived from speed studies.

The user may request any of three type of summaries, each with a different point of view. One summary gives, for each analysis zone, its relationship to the zones around it. The second treats each zone in the system in turn and summarizes the impact of all the analysis zones on it. The third shows the relationship of the anaysis zones to one another. These options will be discussed more fully in the section on program definition. Run instructions and sample deck set-ups are given in Appendix A.

Any user must provide the following inputs at the level of detail of his own zone system:

- (a) A tape file of skimmed trees or selected skimmed trees.

- (b) A file giving one to five pieces of socio-economic data for each zone.
- (c) A list of zones for which computation is desired, the number of service facilities in each zone, and the service capacities (e.g., hospital beds, parking spaces, etc.) of each zone.
- (d) A list of options desired.
- (e) A zone-equivalence definition of summary areas (if regional summaries are desired).

See the data movement flow chart in Figure 6 for an overview of the process.

FIGURE 5

Portion of skimmed tree plot using zone 28 (\*) as zone of origin.  
Numbers on links are cumulative driving time from (\*) to end  
of link

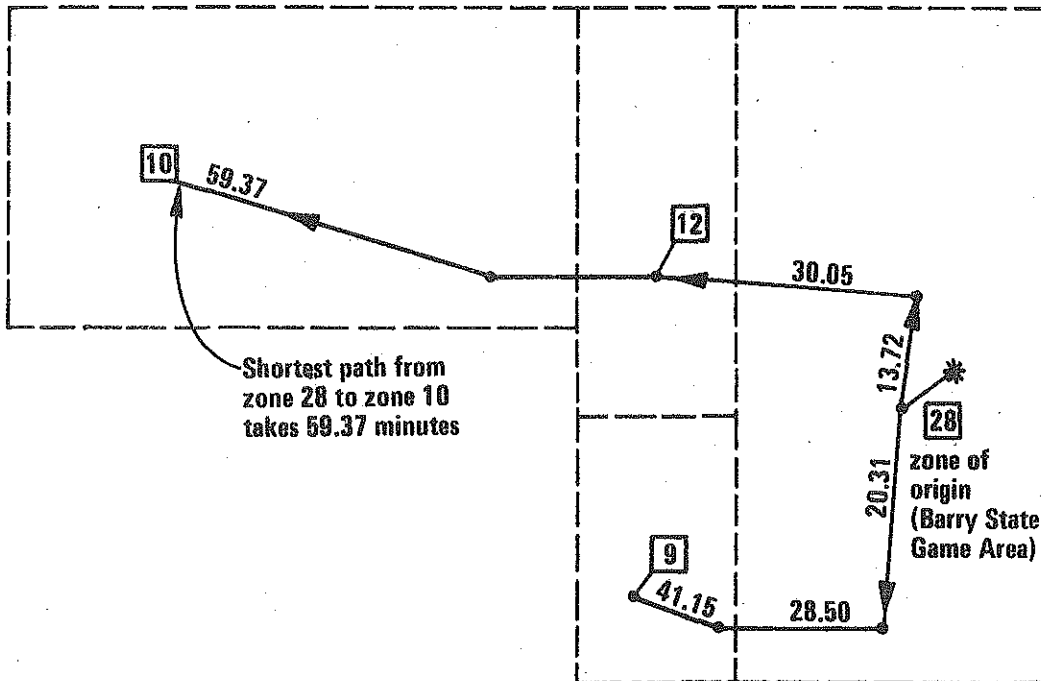
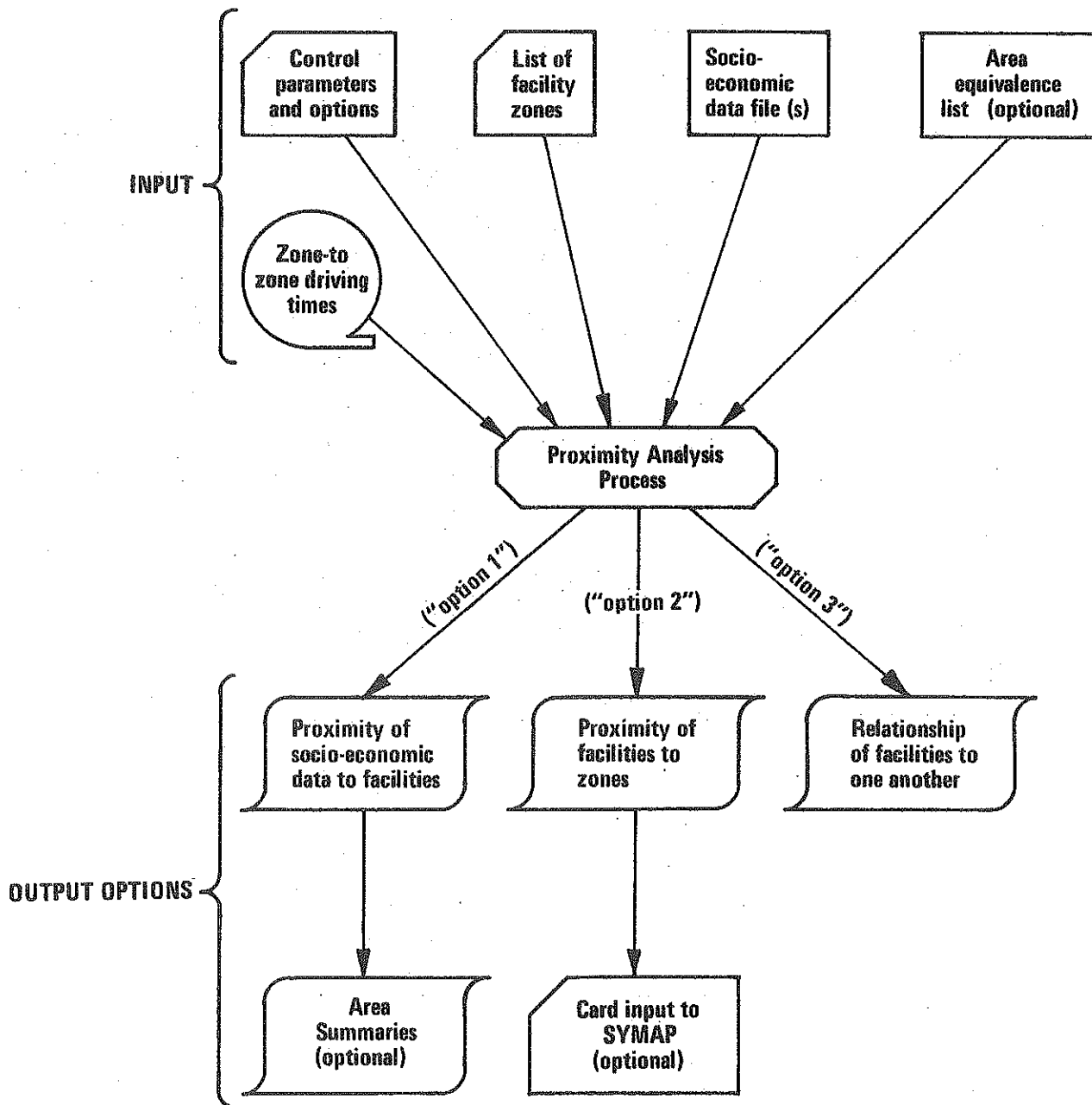
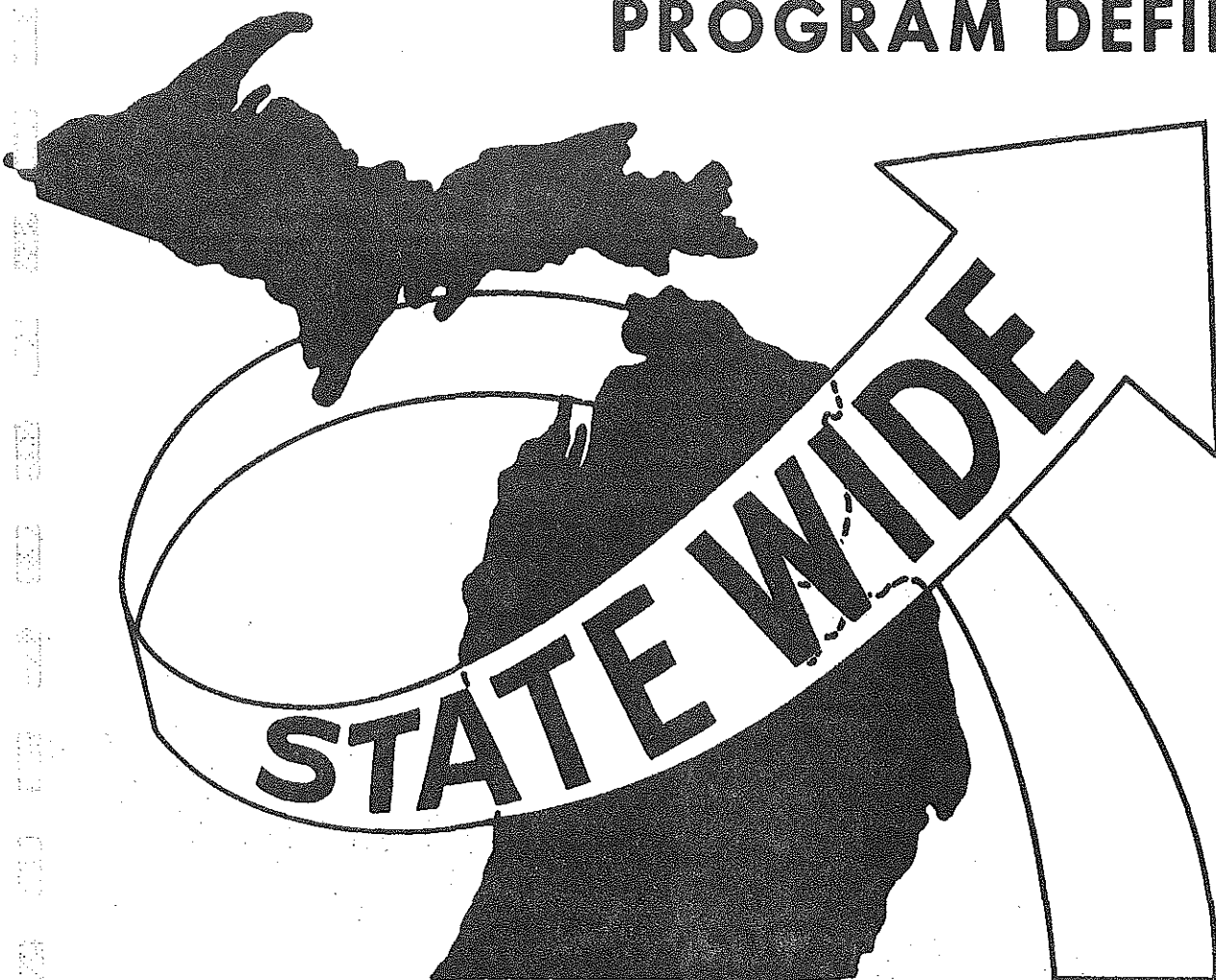


FIGURE 6  
DATA FLOW



# PROGRAM DEFINITION





# PROGRAM DEFINITION

The program treats each selected facility zone in turn, in ascending order. For each analysis zone, it searches the skimmed-tree file for the record or records corresponding to the zone. Having found the desired skimmed tree, it considers the time (or distance) to every other zone to see in which time band, if any, the zone falls. Finally, the socio-economic information desired by the user is added to the accumulation fields corresponding to the time band in which the zone lies. This process is repeated for each analysis zone until all have been treated.

(The reader should amplify the following discussion by referring to the flow chart of the program, Figure 7.)

The program begins by reading in the control parameters, list of facility zones and socio-economic data. If desired, a zone-equivalence table may be entered to produce regional summaries for up to fifty regions.

The lowest-numbered facility zone is considered first. The file of skimmed trees, which has previously been sorted by zone of origin, is read until a match is found. At that point, the program knows the shortest time from the first analysis zone to every other zone in the system. It considers each of the other zones in turn to determine whether the zone falls into any of the specified time bands. In accumulator fields for that time band, it stores the zone number, time away from the analysis zone, and socio-economic data. If the zone does not fall into any of the specified time bands, its socio-economic information is accumulated in a special field.

At the same time, the program accumulates for future reference the impact that the analysis zone has on each of the other zones in the skimmed

tree. Suppose, for instance, that the time band limits are 15, 20, and 30 minutes, and assume zone 17 happens to be the analysis zone. Further assume that we happen to be analyzing the "service proximity" of hospitals, and zone 17 has 3 hospitals with a total of 100 beds. If zone 125 is 16 minutes away from zone 17, the program stores the information that zone 125 is served at a distance of 15-20 minutes by a facility zone consisting of 3 service units having a total service capacity of 100 beds. Now suppose that further on in the analysis, facility zone 19 is encountered at 17 minutes from zone 125; let us say that zone 19 has 2 hospitals with a total of 75 beds. It is now noted that zone 125 is being served at a distance of 15-20 minutes by 2 server zones having 5 service units with a total service capacity of 175 beds. If zone 19 happens to be 20 minutes from zone 140 and zone 140 is also a facility zone with 4 hospitals, the program notes that the efforts of zone 19 are being duplicated by 4 other facility units in the 0-15 minute band, because there is at least one zone which is less than 15 minutes away from both zone 19 and zone 140.

After all analysis zones have been treated, the program outputs any combination of the following three summary reports:

A. Concentrations of socio-economic data about each analysis ("facility") zone:

For each analysis zone, and for each time band,

- (1) Number of socio-economic units in the band (e.g., population)
- (2) Percent of the system total socio-economic information occurring in the band
- (3) A list of zones in the band and their time away from the analysis zone. (Optional; need not be listed)
- (4) Number of facilities (not facility zones) within the band
- (5) Ratio of the socio-economic data to number of facilities

(6) The number of socio-economic units within each time band away from at least one facility, without counting any unit twice.

(1), (2), (4), and (5) are also specified for cumulative bands.

For example, the user is supplied not only with population, number of hospital servers, and population per hospital for 0-20, 20-30, and 30-40 minutes, but also the same information for 0-20, 0-30, and 0-40 minute bands. In some applications, the latter approach may prove more useful.

B. Concentration of facilities around each zone of the system: For each zone in the system, and for each cumulative time band,

(1) Number of facility zones in the band

(2) Number of facilities in the band

(3) Total service capacity (e.g., number of hospital beds) in the band. Zones not served by any server zone are listed at the end of this option and then totaled.

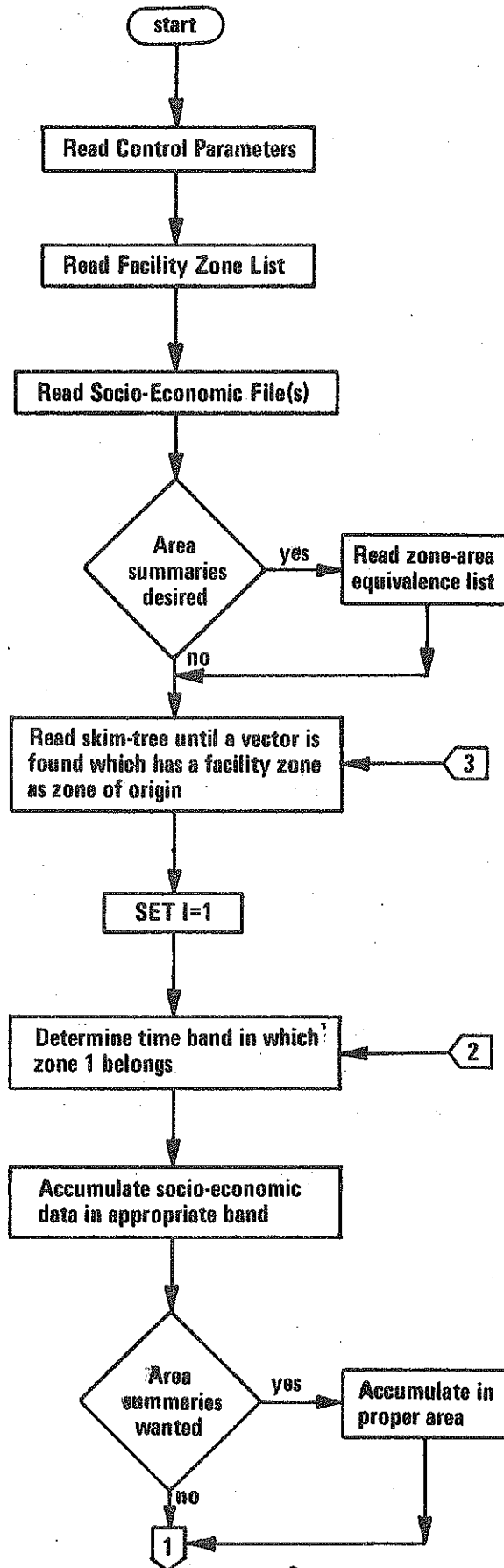
(4) A card deck of the number of facilities within the largest cumulative band around each zone. This deck may be input to the printer-plot routine SYMAP without further modification. (Optional)

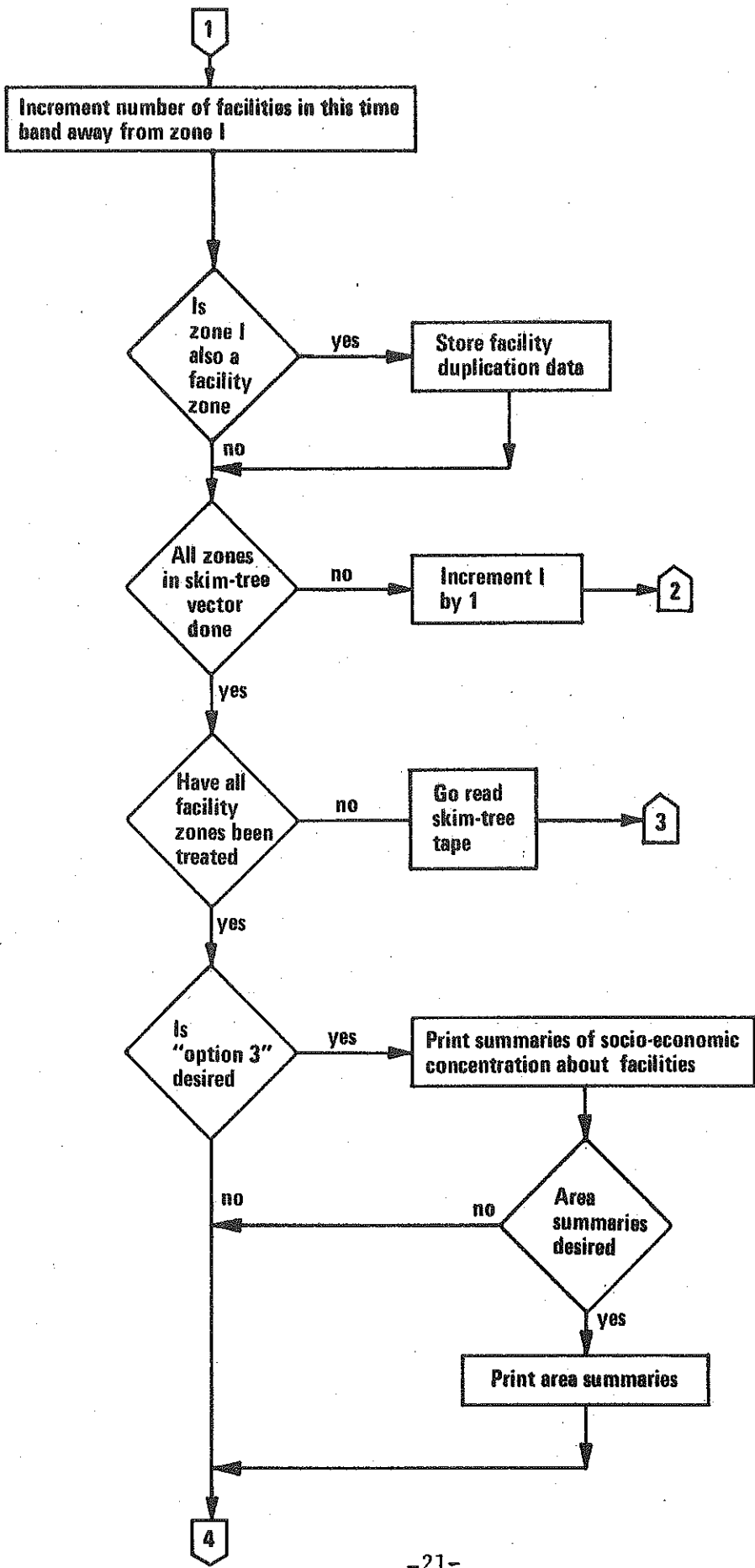
C. Facility duplication: For each facility zone, and for each time band, the number of facilities duplicating the efforts of the facility zone.

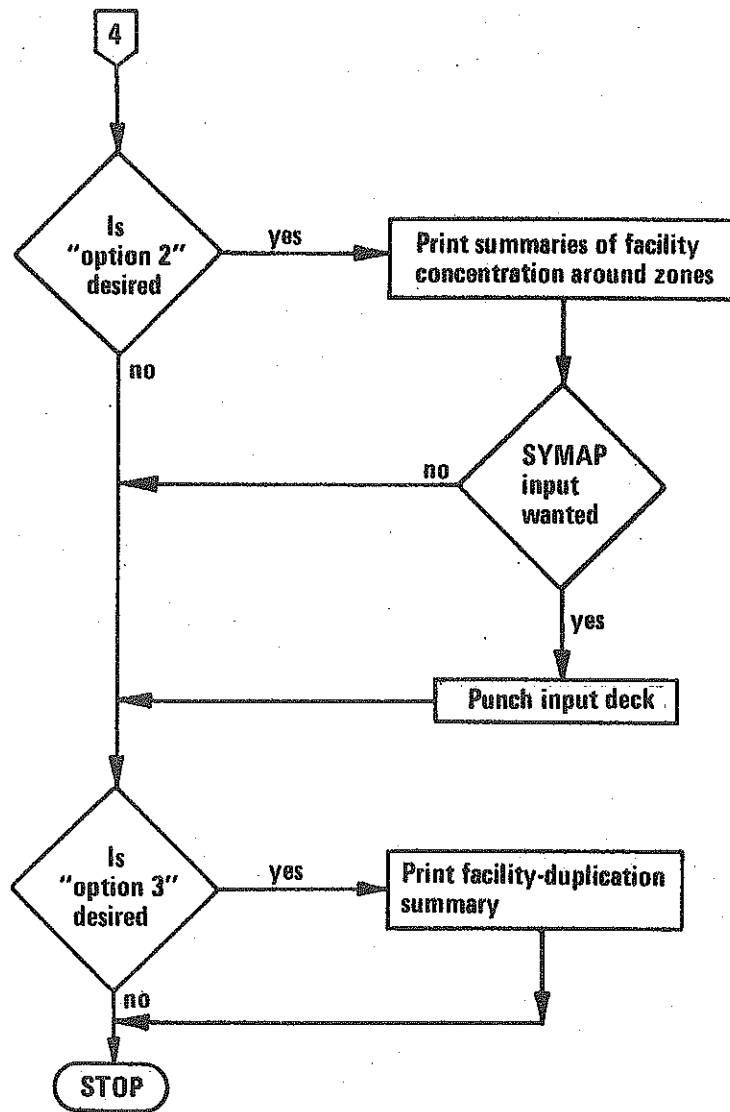
If desired, regional summaries may be produced for report (A).

The program is written in the FORTRAN-IV computer programming language. It was programmed to run on the Burroughs B-5500 computer. The skim-tree input is generated using the Transportation Planning package ("TP-package") of computer programs available for the B-5500 system. At present, most applications which have been run have used the 547-zone network of the Statewide Traffic Forecasting Model, either the full system or the compressed 122-zone system generated by Segmental Model. One test has been run with the 2300-zone network.

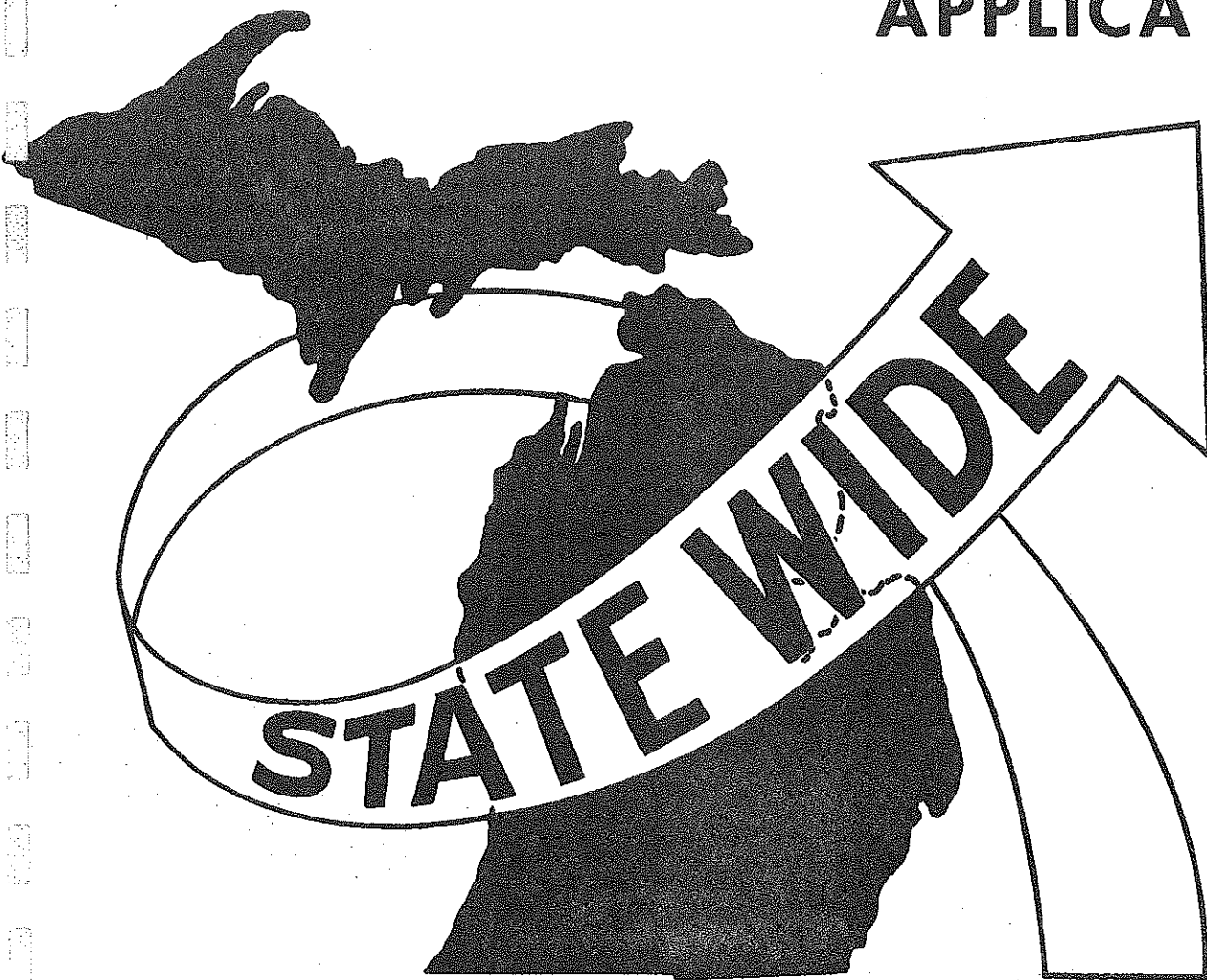
FIGURE 7  
PROGRAM OPERATION







# APPLICATIONS



# APPLICATIONS

## (A) Trip-generation and trip-distribution modeling

As has been explained in the introduction, the population-proximity option is presently being used to update the definition of "surrounding population" in the Statewide trip-generation equations. The server-proximity and server-duplication options may be utilized in the development of a recreational-travel model, especially in developing the form of the trip-distribution equations to be employed.

## (B) Recreation and resource planning

The population-proximity option has been used to analyze the recreational potential of certain selected areas. The program was run on a county-level network using ten selected counties as analysis zones. At that time, the other two options did not exist, but we are confident that the server-duplication option would be of great value in planning new recreational facilities. The information was requested by Mr. James Pearce of the Department of Park and Recreation Resources, Michigan State University. A part of the output is seen in Figure 8.

## (C) State Park Planning

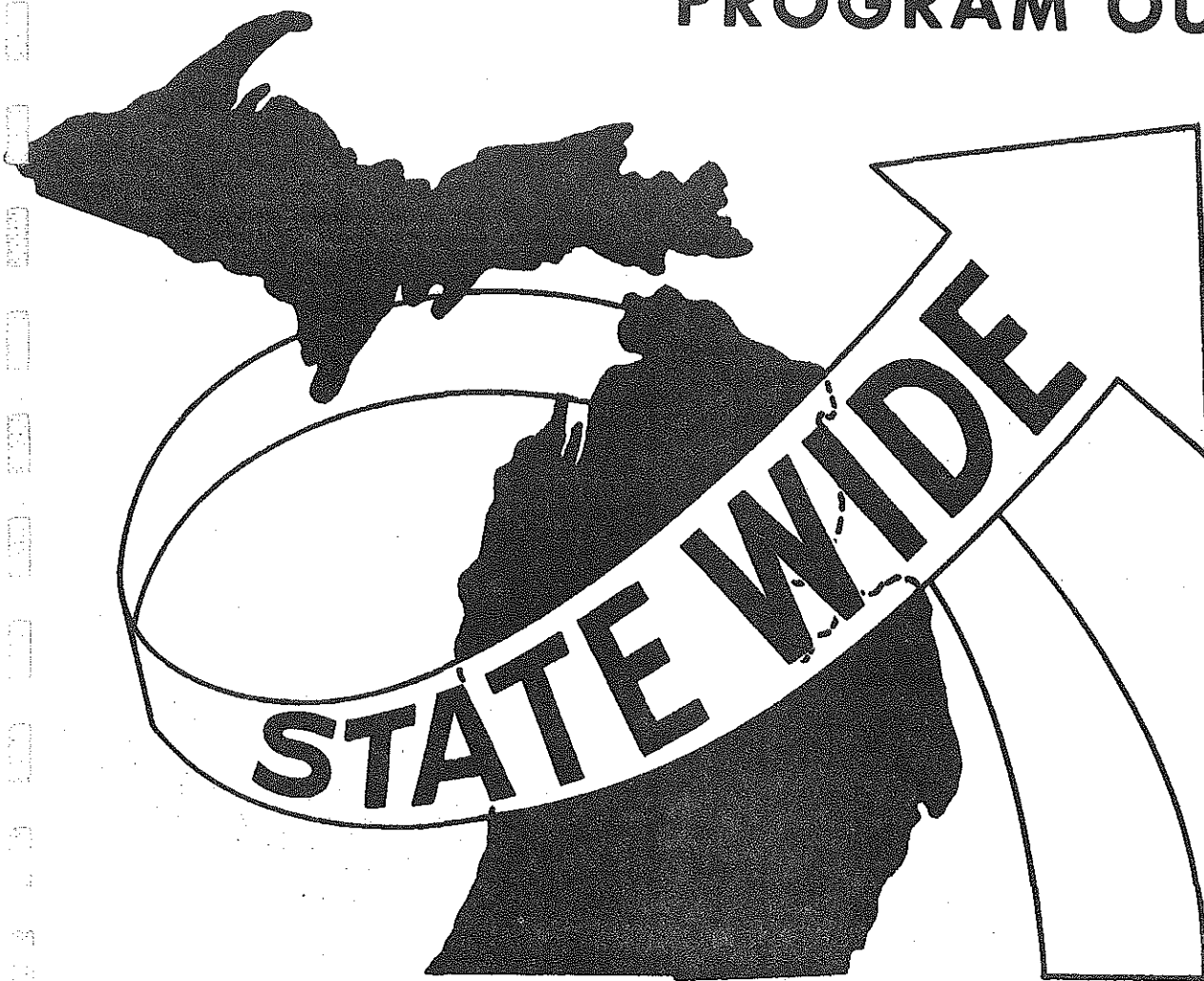
In the same vein, the population - proximity option was used by William Colburn of the Michigan Department of Natural Resources for use in state park planning. Again, the duplication option was not available at that time, but it would probably have been helpful.

## (D) Critical service planning

All three options could be extensively used in planning the locations of hospitals, ambulance services, fire stations, and other similar services.



**EXAMPLES OF  
PROGRAM OUTPUTS**



# EXAMPLES OF PROGRAM OUTPUTS

The term "proximity analysis" covers a rather broad range of different outputs; there are three basic optional reports involved. One takes the point of view of the facilities and computes the concentration of potential users around each facility. Another takes the position of the user and looks at the availability of facilities to each area of the state. Still a third attempts to give an indication of the degree to which facilities duplicate one another's efforts. Each of these report orientations should be considered separately.

## 1. From the Viewpoint of the Facility Set

Figure 10 shows the first type of report generated in this option. This particular analysis relates Michigan's twenty-two air-carrier airports to 1970 population. Zone 15 contains Phelps Collin Airport in Alpena County (see inset). The heading gives the data for this zone only: its 1970 population was 6,478; it contains only one airport; and its capacity, measured in number of passengers enplaned, is 12,922.

There are two columns of data on the remainder of the page. As labeled, the left-hand column provides data for "simple" time bands (0-15 minutes, 15-30 minutes), and the right-hand column contains figures for "cumulative" bands (0-15 minutes, 0-30 minutes). Obviously, for the first band limit, both columns contain the same information. As shown in Figure 11, zone 15 is large enough so that no other zone centroid may be reached within 15 minutes driving time; therefore, the data given for the first band belongs only to zone 15. The population within the driving radius is 6,487, which comprises 0.064% of the total population of Michigan. Only one airport is encountered within 15 minutes, so that the ratio of population to airports is  $6,478/1 =$

6478. The zone list confirms that only zone 15 lies within the driving radius.

For the second band, there are 27354 people within 15-30 minutes, making up 0.270% of Michigan's population. No additional airports are encountered, so the ratio of population to airports is set to zero by convention. The data for the cumulative (0-30 minute) band shows that 33832 people are encountered within 30 minutes' driving time of the airport zone, giving 0.333% of Michigan's population. The only airport encountered is still in zone 15, for a population/airports ratio of 33832. The optional zone list explains that only zones 13 and 14 can be reached within 15-30 minutes (see Figure 11).

In addition to treating each facility individually, the program also provides supplementary calculations showing the number of people within the designated driving times of at least one facility (Figure 12). The difference between this output and simply adding up the numbers from each of the individual facility reports is that there is no double counting here. If a person is found to be within 15 minutes of two airports, he is counted only once; if he is found to live 14 minutes from one airport and 28 minutes from another, he is counted only in the 0-15 minute band. As the output states, 28.195% of the population of Michigan lived within 0-15 minutes of at least one airport, and another 44.618% lived 15-30 minutes from at least one airport.

Finally, an area summary may be requested, relating the facilities of a region to only the socio-economic data of that region. In the example shown in Figure 13, a summary was done for only Alpena County, containing zones 13, 14, and 15. There is only the airport in zone 15 in the region, and its capacity is as before. The total population of the region is 33832. The output shows that 19.148% of Alpena County lives within 15 minutes of the airport, and the remaining 80.852% lives within 15-30 minutes of the airport. For an excellent application of the regional summary option, the reader is encouraged to look at the Statewide Transportation Model Multiple Applications report entitled Community College Service-Area Analysis (Part A).

DATA FOR COUNTY 33

TIME BAND	0-30 MINUTES	
POPULATION WITHIN BAND		117384
COUNTY	TIME AWAY	
19	30	
23	29	

[NOTE: COUNTY 33 POPULATION  
NOT INCLUDED

TIME BAND	30-60 MINUTES	
POPULATION WITHIN BAND		311164
COUNTY	TIME AWAY	
34	49	
38	52	
47	44	
76	43	

TIME BAND	60-90 MINUTES	
POPULATION WITHIN BAND		2294301
COUNTY	TIME AWAY	
8	67	
12	86	
13	65	
25	66	
29	75	
41	79	
59	82	
63	85	
81	76	

TIME BAND	90-120 MINUTES	
POPULATION WITHIN BAND		4403627
COUNTY	TIME AWAY	
9	109	
18	109	
30	101	
37	91	
39	95	
44	95	
46	95	
50	120	

FIGURE 8:  
COUNTY-LEVEL POPULATION  
PROXIMITY RUN FOR DEPARTMENT OF  
PARK & RECREATION RESOURCES, M.S.U.

(E) Budget Planning

Instead of building trees of minimum-time paths, it is also possible to build trees of ~~minimum-cost~~ paths whenever the cost of traversing each link in the system can be specified. The skimmed trees are then the minimum costs from each zone to every other zone, and proximity can be defined in terms of cost bands. Then the same type of analysis can be done.

(F) Location of recreational facilities

The DNR has used the program to check on how well its rifle ranges serve the needs of the state. The skimmed tree in figure 5 was plotted in conjunction with this study.

(G) Location of government facilities

All three options, used together, could be used to plan the locations of new state colleges, maintenance installations, state police headquarters, and the like.

(H) Graphic display

Using the Transportation Planning battery of computer programs available for the B-5500 computer, one can plot the actual tree itself for any selected zone and the cumulative time from the zone of origin along each link of the tree. As an illustration, refer again to Figure 5.

Also, any output from the program can be printer-plotted using a routine called SYMAP available at Michigan State University. As has been stated, input is direct in one special case. This program prints a shaded map of Michigan and would ascribe to each zone a level of proximity (the type of proximity would be determined by the option exercised).

A bibliography of applications of the proximity process which have been made to date is given in Appendix B. The list of these sample analysis efforts appears in Figure 9.

DEPARTMENT OF NATURAL RESOURCES

-STATE PARK PLANNING

-RIFLE RANGE STUDY

AERONAUTICS

-AIRPORT PLANNING

DEPARTMENT OF COMMERCE

-INDUSTRIAL SITE ANALYSIS

-RECREATION INDUSTRY ANALYSIS

DEPARTMENT OF STATE

-REGIONAL OFFICE PLANNING

DEPARTMENT OF PUBLIC HEALTH

-HOSPITAL PLANNING

-ACCIDENT LOCATION ANALYSIS

DEPARTMENT OF TREASURY

-DATA COLLECTION CENTER ANALYSIS

EXECUTIVE OFFICE

-LEGISLATIVE PLANNING - AMBULANCE SERVICE

DEPARTMENT OF EDUCATION

-COMMUNITY COLLEGE SERVICE AREA ANALYSIS

MSU

-ECONOMIC DEVELOPMENT - RECREATION

-RECREATION DEMAND STUDY

**INTER-  
DEPARTMENTAL  
TEST  
PROJECTS**

**FIGURE 9**

DATA FOR ZONE 15  
 POPULATION 6478  
 NUMBER OF AIRPORTS 1  
 TOTAL CAPACITY = 12922

POPULATION	0-15	0-15
PERCENT OF TOTAL POPULATION	6478	6478
AIRPORTS	0.064	0.064
POPULATION/AIRPORTS	1	1
	6478.00	6478.00

ZONE	TIME AWAY
15	0

] NO ZONE EXCEPT ZONE 15 CAN BE REACHED  
 WITHIN 15 MINUTES

	15-30	0-30
POPULATION	27354	33832
PERCENT OF TOTAL POPULATION	0.270	0.333
AIRPORTS	0	1
POPULATION/AIRPORTS	0.00	33832.00

ZONE	TIME AWAY
13	22
14	26

] ZONE 13 IS 22 MINUTES AWAY;  
 ] ZONE 14 IS 26 MINUTES AWAY;

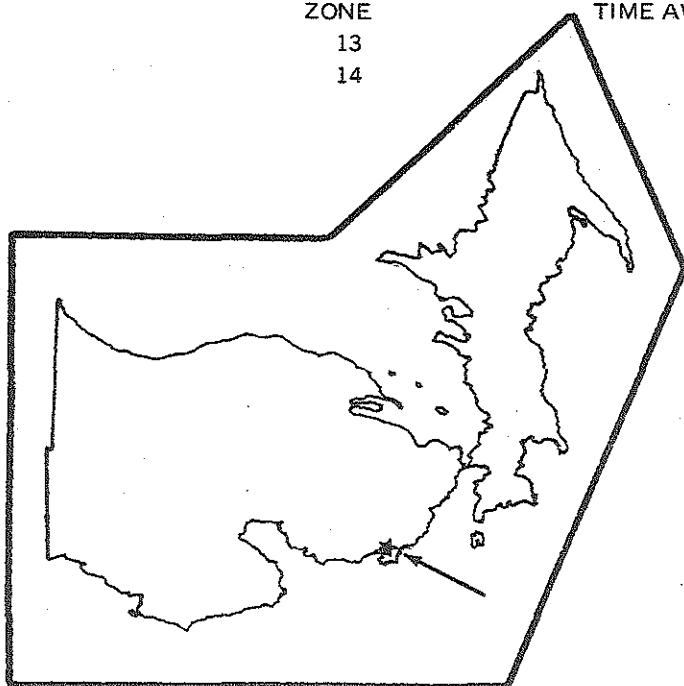
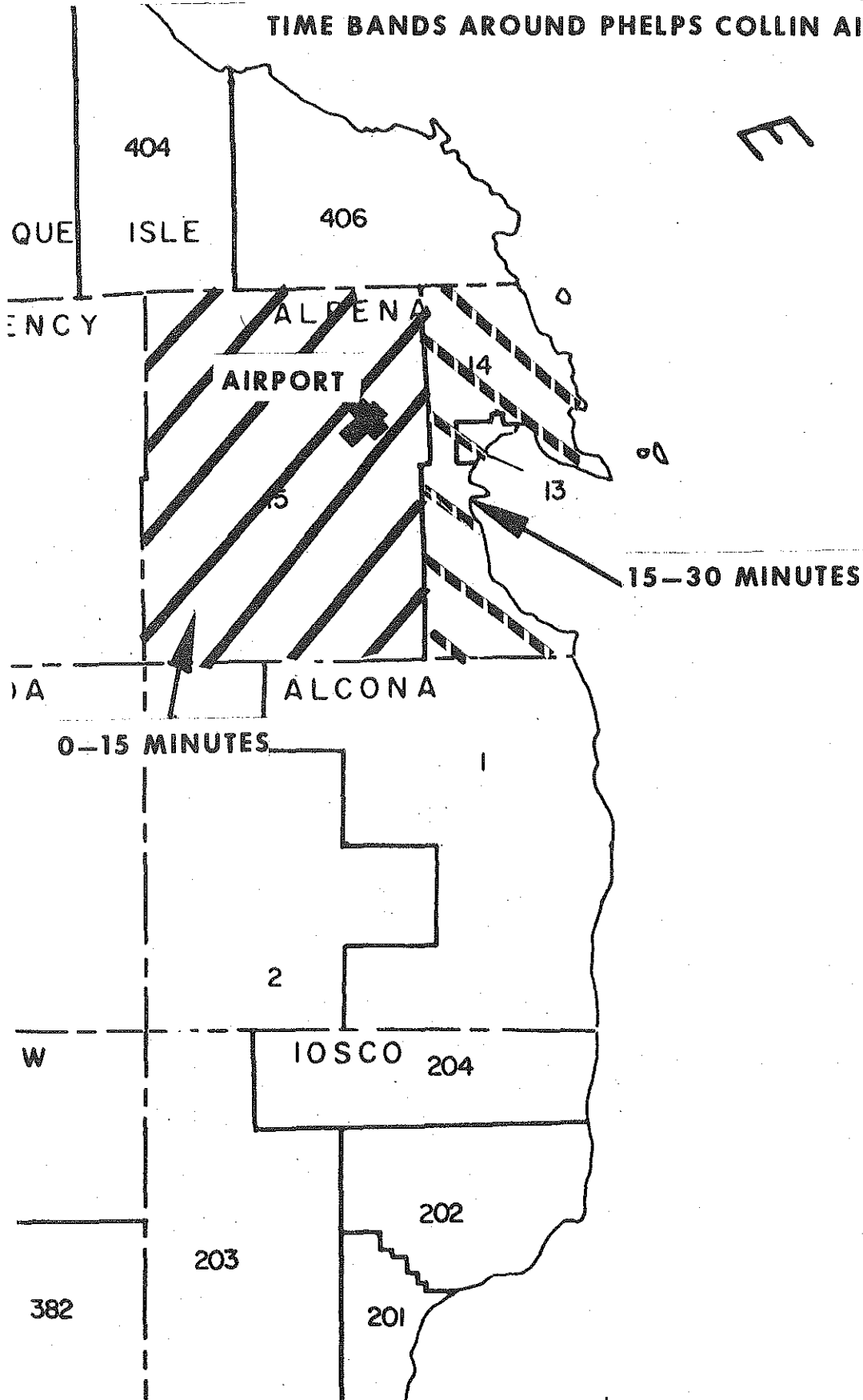


FIGURE 10:  
 ANALYSIS FOR A  
 SINGLE AIRPORT

FIGURE 11

TIME BANDS AROUND PHELPS COLLIN AIRPORT



H  
U  
R  
O  
N



**FIGURE 12:  
SYSTEM-WIDE SUMMARY  
(NO DOUBLE COUNTING)**

TIME BAND	POPULATION	PERCENT OF TOTAL POPULATION
0-15	2861272	28.195
15-30	4527969	44.618

**FIGURE 13:  
AREA SUMMARY**

**SPECIAL AREA SUMMARY  
ALPENA COUNTY SUMMARY**

ZONES INCLUDED IN AREA 1 ARE . . .

	13	14	15
AIRPORTS IN AREA 1	=	1	
TOTAL CAPACITY #	=	12922	
POPULATION IN AREA 1	=		33832

TIME BAND	POPULATION	PERCENT OF TOTAL POPULATION IN AREA 1
0-15	6478	19.148
15-30	27354	80.852

ZONE	(1) SERVICE ZONES	(2) AIRPORTS	(3) CAPACITY	(4) POPULATION / AIRPORTS	(5) POPULATION / CAPACITY
59 0- 15MIN.	0	0	0	0.00	0.00
59 0- 30MIN.	1	1	57464	12229.00	0.21
60 0- 15MIN.	0	0	0	0.00	0.00
60 0- 30MIN.	1	1	57464	7163.00	0.12
61 0- 15MIN.	0	0	0	0.00	0.00
61 0- 30MIN.	1	1	57464	5870.00	0.10
62 0- 15MIN.	1	1	57464	11862.00	0.21
62 0- 30MIN.	1	1	57464	11862.00	0.21
63 0- 15MIN.	1	1	57464	9131.00	0.16
63 0- 30MIN.	1	1	57464	9131.00	0.16
64 0- 15MIN.	0	0	0	0.00	0.00
64 0- 30MIN.	2	2	68218	1347.00	0.04
65 0- 15MIN.	0	0	0	0.00	0.00
65 0- 30MIN.	0	0	0	0.00	0.00
66 0- 15MIN.	0	0	0	0.00	0.00
66 0- 30MIN.	1	1	10754	13148.00	1.22
67 0- 15MIN.	0	0	0	0.00	0.00
67 0- 30MIN.	1	1	57464	7360.00	0.13
68 0- 15MIN.	0	0	0	0.00	0.00
68 0- 30MIN.	0	0	0	0.00	0.00
69 0- 15MIN.	0	0	0	0.00	0.00

FIGURE 14:  
 AVAILABILITY OF FACILITIES  
 TO AREAS OF THE STATE

## 2. From the Viewpoint of Potential Users

For each zone in the state, the program computes for each cumulative time band:

- (1) The number of service facility zones encountered,
- (2) The number of facilities they hold, and
- (3) Their combined capacity (refer to Figure 14).

It then divides the socio-economic variable for the zone first by the number of facilities and then by the capacity to yield a "population/airports" ratio (4) and a "population/capacity" ratio (5).

If the user wishes, he may elect to produce a card deck containing the number of facilities in the broadest driving-time band; in Figure 14, this would be the number of airports within 0-30 minutes for each zone. This card deck is in a format which can be input without further modifications to SYMAP, a printer-plot routine developed by Harvard Graduate School and modified by Michigan State University. The output of the program is thus a shaded map of the number of facilities which can be accessed by each zone, such as that shown in Figure 15. Using a map such as this, a decision-maker could instantly spot areas of the state which are under-served. Furthermore, this type of output could be taken a second step by using a second-generation program called SYMVU, which produces three-dimensional output such as that shown in Figure 16. Finally, at the end of the option 2 output, a list is printed out of those zones whose residents can reach no facility within the broadest driving time band, along with their populations (Figure 17).

## 3. Oriented from Facilities to Other Facilities

The program also relates facilities to other facilities in the same set in order to measure the extent to which facilities duplicate one another's

MICHIGAN DEPT. OF STATE HIGHWAYS  
 STATEWIDE STUDIES UNIT  
 EMERGENCY AMBULANCE SERVICE DATA  
 NUMBER OF EMERGENCY AMBULANCE FACILITIES  
 WITHIN 20 MINUTES

**FIGURE 15:  
 SYMAP OUTPUT EXAMPLE**

DATA VALUE EXTREMES ARE 0.00 27.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL  
 (MAY INCLUDE OR EXCLUDE ZERO LEVEL ONLY)

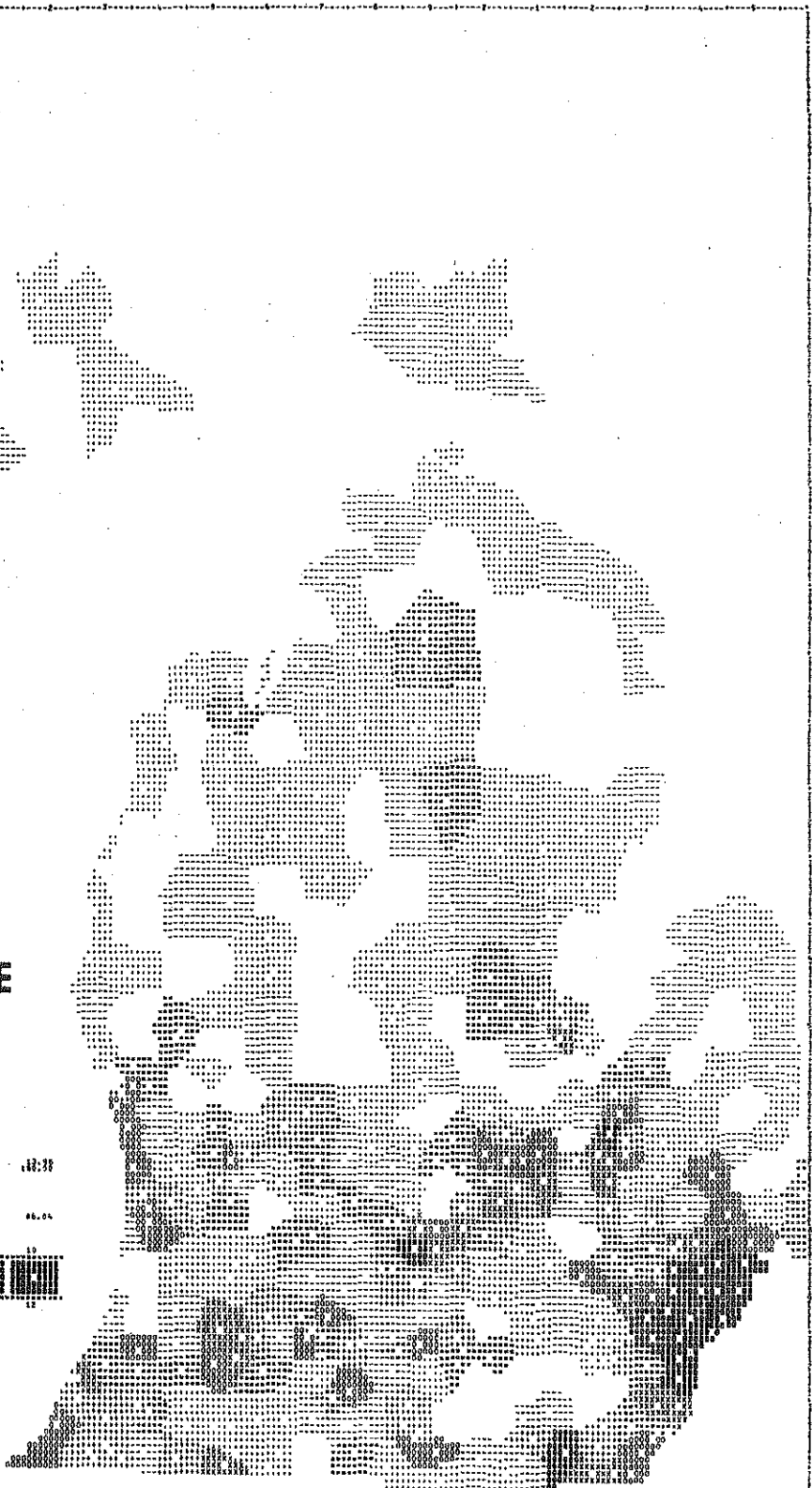
MINIMUM 0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00 9.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

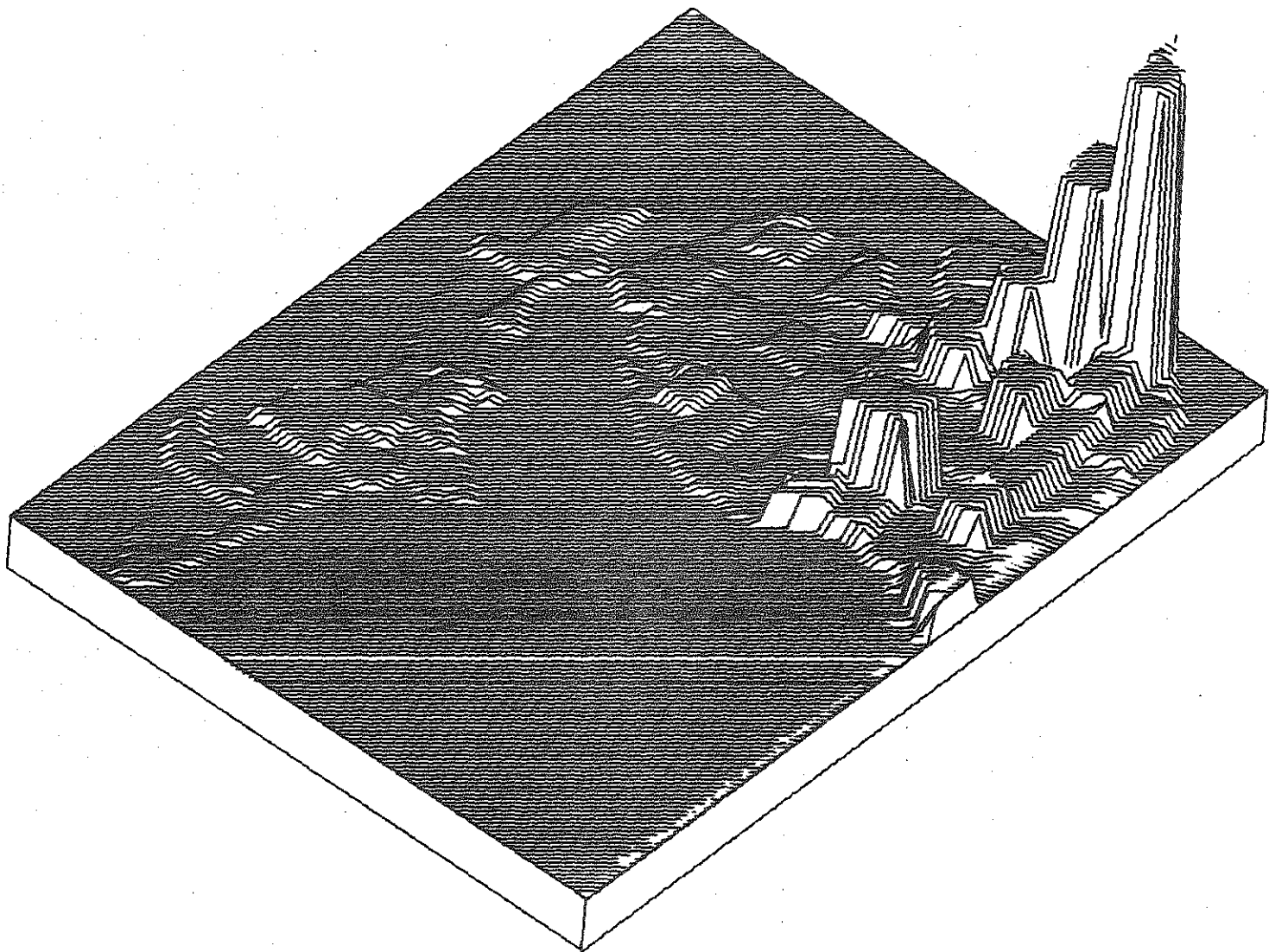
.28 .69 .49 .19 .99 .90 1.00 2.00 3.00 86.04

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

SYMBOLS  
 FREQ. 98 139 98 59 48 31 22 9 9 12  
 TIME .09.17.01.



TIME .09.22.01.



2.12	7620223.10
2.00	7184415.24
1.50	5388311.43
1.00	3592207.62
0.50	1796103.81
0.00	0.00

C RETAIL SALES TAX BY COUNTY

SYMVU OUTPUT EXAMPLE

FIGURE 16:

**FIGURE 17:  
LIST OF  
UNSERVED ZONES**

STATEWIDE PROXIMITY ANALYSIS

ZONES NOT SERVED

ZONE	POPULATION
1	6151
2	1130
3	3552
4	2032
5	2017
6	572
7	11646
8	9019
9	15806
10	14636
11	5901
12	15990
16	3370
17	3784
18	5753

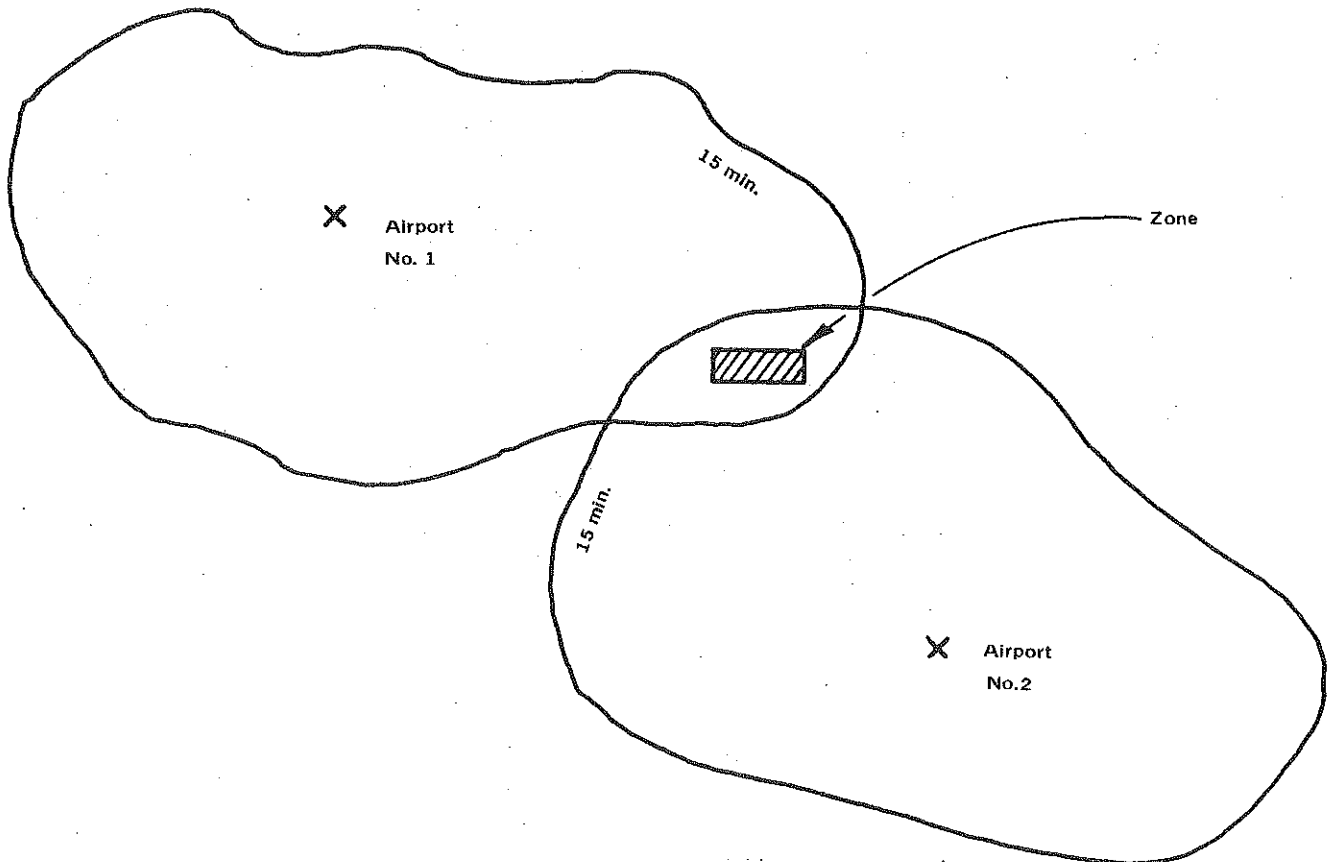
STATEWIDE PROXIMITY ANALYSIS

460	3981
461	4707
462	6785
463	5260
464	4623
465	5073
466	4743
467	3020
468	6889
469	3060
470	4598
471	7233
472	11217
473	10638
474	8004
475	5026
477	3917
479	137993
482	11904
487	9351
488	3595
489	3390
491	4772
492	9053
505	10336
506	5503
507	1884
508	2708

POPULATION NOT SERVED BY ANY AIRPORTS = 2759053

efforts. It looks to see whether, for instance, there is at least one zone within 15 minutes of one airport which is also within 15 minutes of another airport; the two airports are thus dualing efforts on the center zone.

Pictorially:



**FIGURE 18: SCHEMATIC OF DUPLICATION**

In the picture, airport #2 would be considered to be duplicating the efforts of airport #1, because their fifteen-minute service areas have a zone in common. The output is shown in Figure 19.



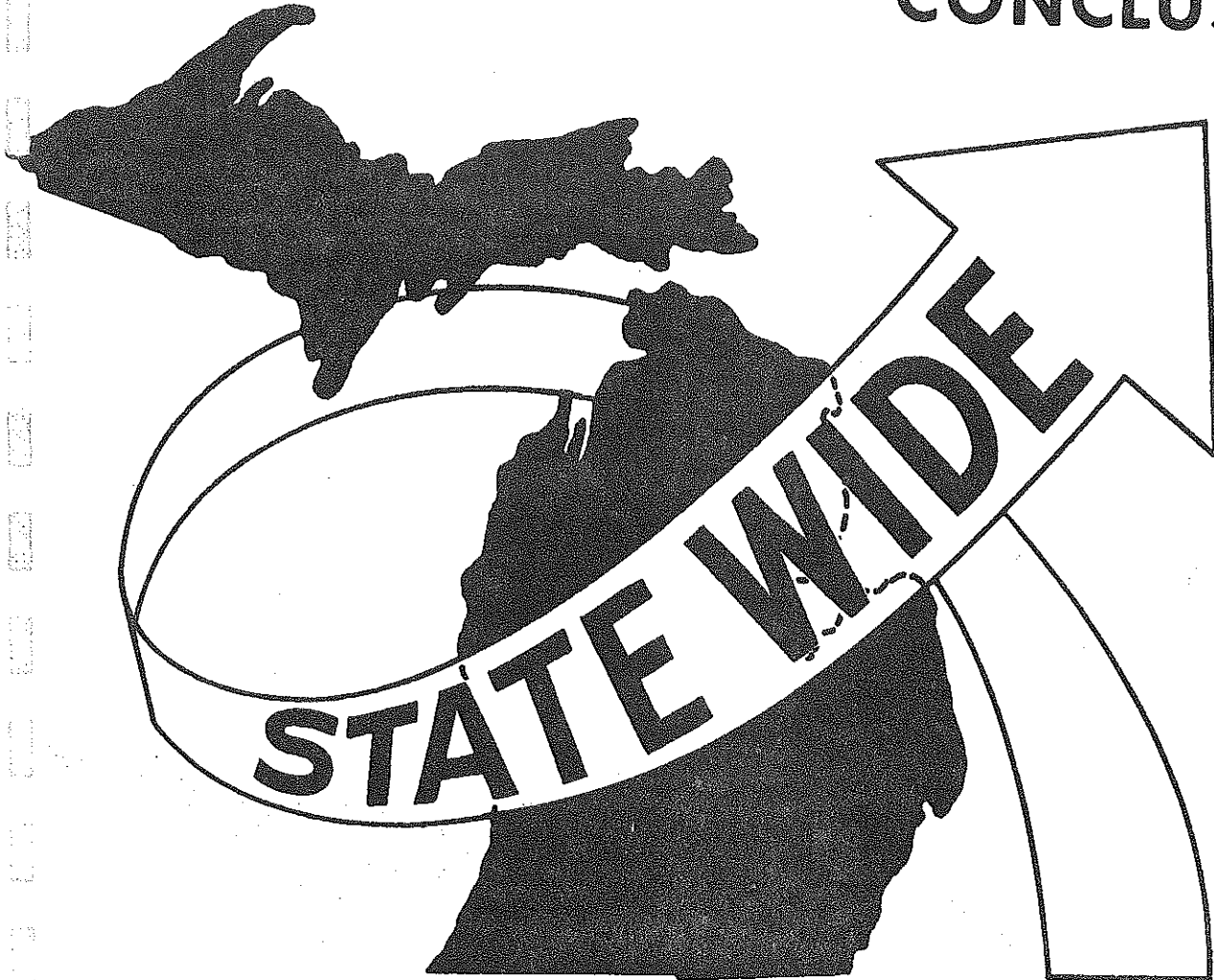
**FIGURE 19:  
SERVER-DUPLICATION  
OUTPUT**

**SERVER ZONES DUPLICATING AT LEAST ONE OTHER SERVER BY TIME BAND**

<b>ZONE</b>	<b>0- 15MIN.</b>	<b>15- 30MIN.</b>
37	0	1
58	1	2
219	0	1
227	1	2
237	0	1
345	0	1
496	0	1
500	0	1

**NOTE-----(SERVERS DUPLICATED)=NUMBER OF  
SERVERS HAVING AT LEAST ONE ZONE IN THEIR  
OWN TIME BAND WHICH ALSO LIES IN THAT BAND  
RELATIVE TO THE ANALYSIS ZONE.**

**CONCLUSION**



# CONCLUSION

The Proximity Analysis routine has been integrated with the Statewide Information System, which is the combination of the Statewide Travel Data Bank, the Statewide Socio-Economic Data File, and the Statewide Public and Private Facility File. Therefore, it is possible to do proximity analysis on any data characteristic catalogued in the Michigan portion of the U.S. Census, in addition to the uses suggested in the previous section.

Although the concept behind this analysis package is quite simple, a literature search reveals no system-level computerized routine which offers the versatility of analysis opportunities incorporated in Proximity Analysis. It promises to save a great deal of time and effort: in the aforementioned M.S.U. project, a data file for which two to three man-months had been allotted was produced in minutes. If this had been an in-house project, this would have meant a savings of about \$2,000, conservatively speaking, as well as freeing a man to do more constructive work. Moreover, this was accomplished with the most rudimentary form of the program, which is now in its fifth generation.

Obviously, the applications of the process are not limited to those described here. Facilities may be related to other facilities; for example, in one analysis, the proximity of airports to certified industrial parks was studied. Or, using census data, facilities may be related to age or educational level (as in the community college study) or any other socio-economic characteristic. Finally, one socio-economic variable may be related to another by initially looking at the geographical concentration of the first variable. We hope that this report will stimulate fresh

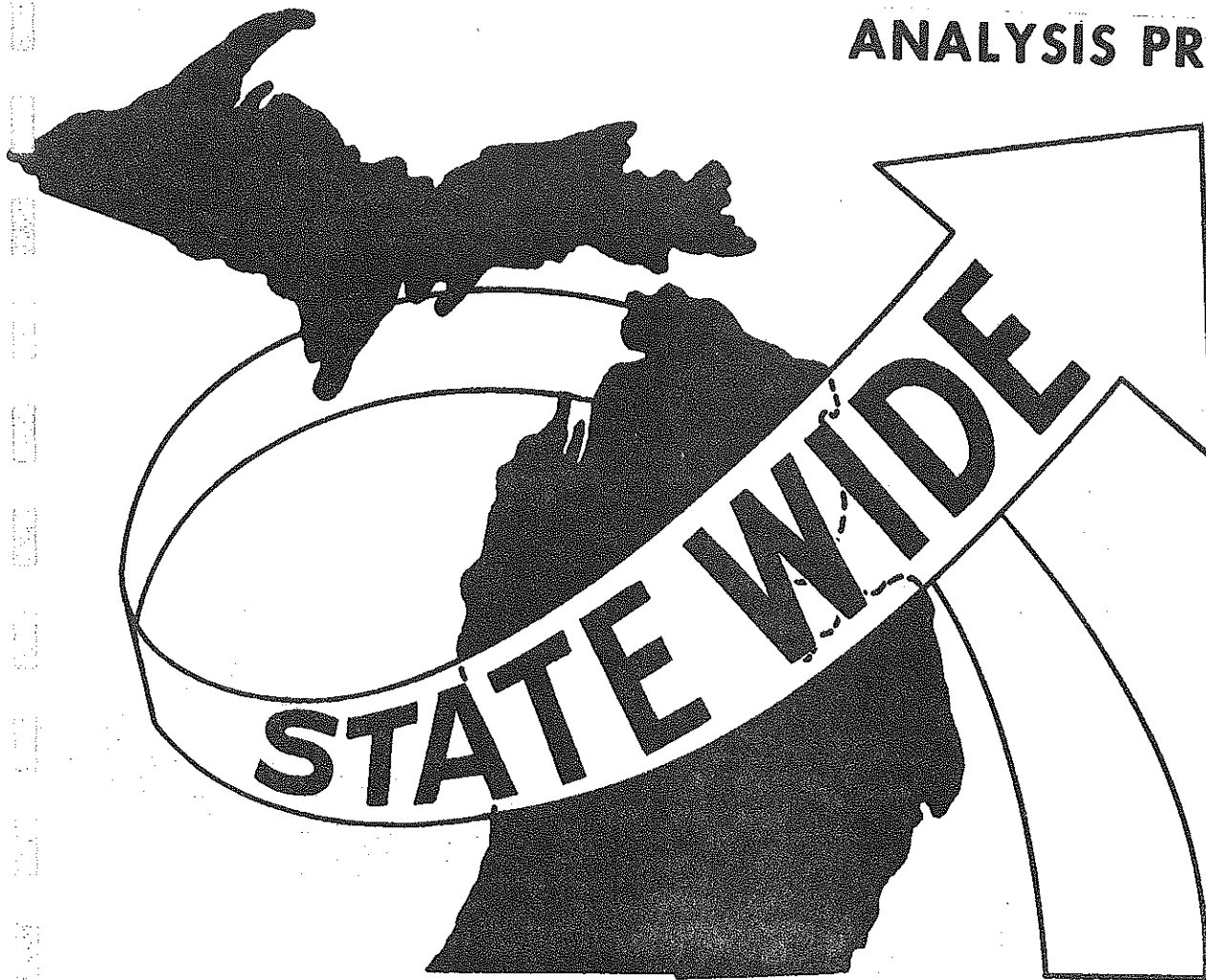
ideas concerning new applications of proximity analysis, and we would be most grateful for any dicussion on the subject.

Any questions or comments connected with this report or the Proximity Analysis process in general should be directed to;

Richard E. Esch, Manager  
Statewide Interagency Procedures Research and  
Development Section  
Highway Planning Division  
Bureau of Transportation Planning  
Michigan Department of State Highways and Transportation  
P.O. Drawer K  
Lansing, Michigan 48904

He may be reached by telephone at (517) - 373-2663.

**APPENDIX A:**  
**RUNNING THE PROXIMITY**  
**ANALYSIS PROGRAM**



# RUNNING THE PROXIMITY ANALYSIS PROGRAM

## A. Control parameters:

At the time of running, the user must provide the program with the following information, all input from cards:

- (1) Number of socio-economic variables used
- (2) Names of socio-economic variables
- (3) Name of facility set
- (4) Number of time bands used
- (5) Cutoff values for the bands
- (6) Report option indicators (detailed descriptions follow)
- (7) Input medium for socio-economic data (CARD, DISK, or TAPE)
- (8) Number of zones in user's modeling system
- (9) Number of facility zones; i.e., number of records in facility file
- (10) Logical indicator of whether or not user wishes to input summary areas; if this is set equal to T (true), it must be followed by the (2-digit) number of areas to be specified.

[This control record follows the socio-economic and facility sets in a card deck]

- (11) Titles for summary areas

## B. Socio-economic data:

Up to five sets of socio-economic data may be processed on each pass. The sets are input back-to-back, each set being in zone sort. Tape, disk, or card may be selected as the input medium.

C. Facility set:

One and only one record is input for each zone containing at least one facility. Each such record gives the zone number, the number of facilities in that zone, and their aggregated capacity. Input is from cards.

D. Summary areas (optional):

The user has the option of relating the socio-economic data of a particular region to the facilities lying in that region. He may specify up to fifty disjoint summary areas. For each region, he must provide a list of the zones comprising that region. Although the zones of a region need follow no particular order, a blank field must follow the last zone in each region, even if another record must be used. The input medium is the same as that selected for the socio-economic data.

E. Matrix of zone-to-zone travel times (or distances or costs):

The program is set up to read a "skimmed-tree" tape written in full words as output from the Transportation Planning ("TP") program TPSKIM. The tape is unblocked, each vector being 300 words long plus a linkword which cannot be accessed in FORTRAN. As many consecutive vectors are read for each zone as it takes to complete the number of zones in the user's system. The first word of each vector group is a packed word which has no relevance to this application; that word is read and forgotten. Likewise, an empty-list unformatted read statement skips the first record of the tape, which is a type of header record.

SAMPLE RUN SET-UP

?ØEXECUTE	Q01480/HYA.	___	begins execution of proximity analysis program
?ØDATA	QR1480	___	Card input follows
02		___	2 socio-economic variables
PØP.ØOVERØ65			Socio-economic characteristics to be input
PØP.UNDERØ35			
HØSPITALS			Facility set name
02		___	2 time bands are to be considered
030,060		___	User wishes to scan 0-30 and 30-60 minutes around each facility zone
T,T,F,T,F		___	User wants reports showing (1) Proximity of socio-economic data to facilities and (2) Proximity of facilities to zones. He does not want (3) Facility duplication report. He asks for (4) Lists of zones in each time band around each facility zone, but does not request (5) Card deck as input to SYMAP.
CARD		___	Socio-economic and summary-area inputs are from cards
0508		___	There are 508 instate zones in the modeling system
0132		___	There are 132 "hospital zones" in the state
[SØCIØ -			
ECØNØMIC			
DATA			
			DECK #1]*



[SØCIØ -  
ECØNØMIC  
DATA

DECK #2]\*

[FACILITY  
FILE]

T,02

\_\_\_\_\_ User wishes to specify 2 summary  
areas

SUMMARY	REGION ONE	}	titles of
SUMMARY	REGION TWO		summary areas
ØØØØ1ØØ203ØØ196ØØØØØØ			*} descriptions
ØØØØ2ØØØ13ØØØ14ØØØ15ØØØ37ØØØØØ*			} of summary areas

?ØEND

Note: If the socio-economic input medium (record 8 after DATA statement) is given as TAPE or DISK, records marked with an asterisk (\*) will input from that medium in the order shown instead of being a part of the card file.

The disk-file is labeled QD1480; the tape file is QT01480/PØPDCK. File-equate cards may be used to change the file name in either case.

Detail--Report Options--Control Record 6

The report options are chosen by inputting a string of five logical parameters separated by commas or blanks. Such a string might appear as:

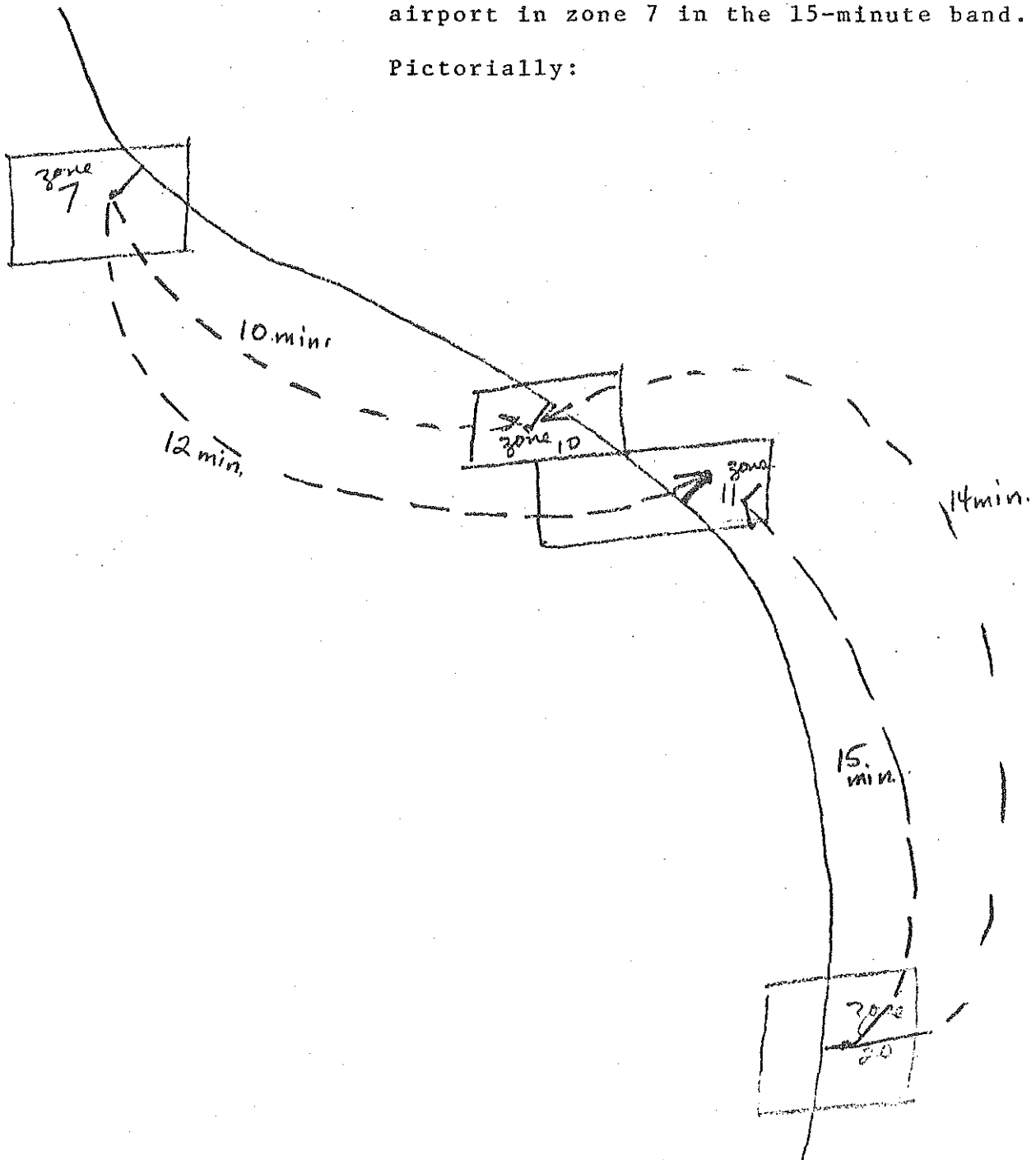
T,T,F,F,T.

Parameter

Result if = T

1. Produces a report of the proximity of each socio-economic variable to each facility; for example, the number of people within 15, 30, 45, and 60 minutes' driving time of each airport.
2. Produces a report of the proximity of facilities to each zone in the system; for example, the number of airports which can be reached in 15, 30, 45, and 60 minutes' driving time of each zone.
3. Produces a facility-duplication report; that is, for each facility zone "Z", the report notes how many other facilities in the set serve areas already served by zone Z. A little more explanation is probably in order here. Suppose zone 7 has an airport, and that it lies within 15 minutes

from zones 10 and 11. Suppose further that airport zone 20 also lies 15 minutes from zones 10 and 11. Then the airport in zone 20 would, in a sense, be "duplicating" the efforts of the airport in zone 7 in the 15-minute band. Pictorially:



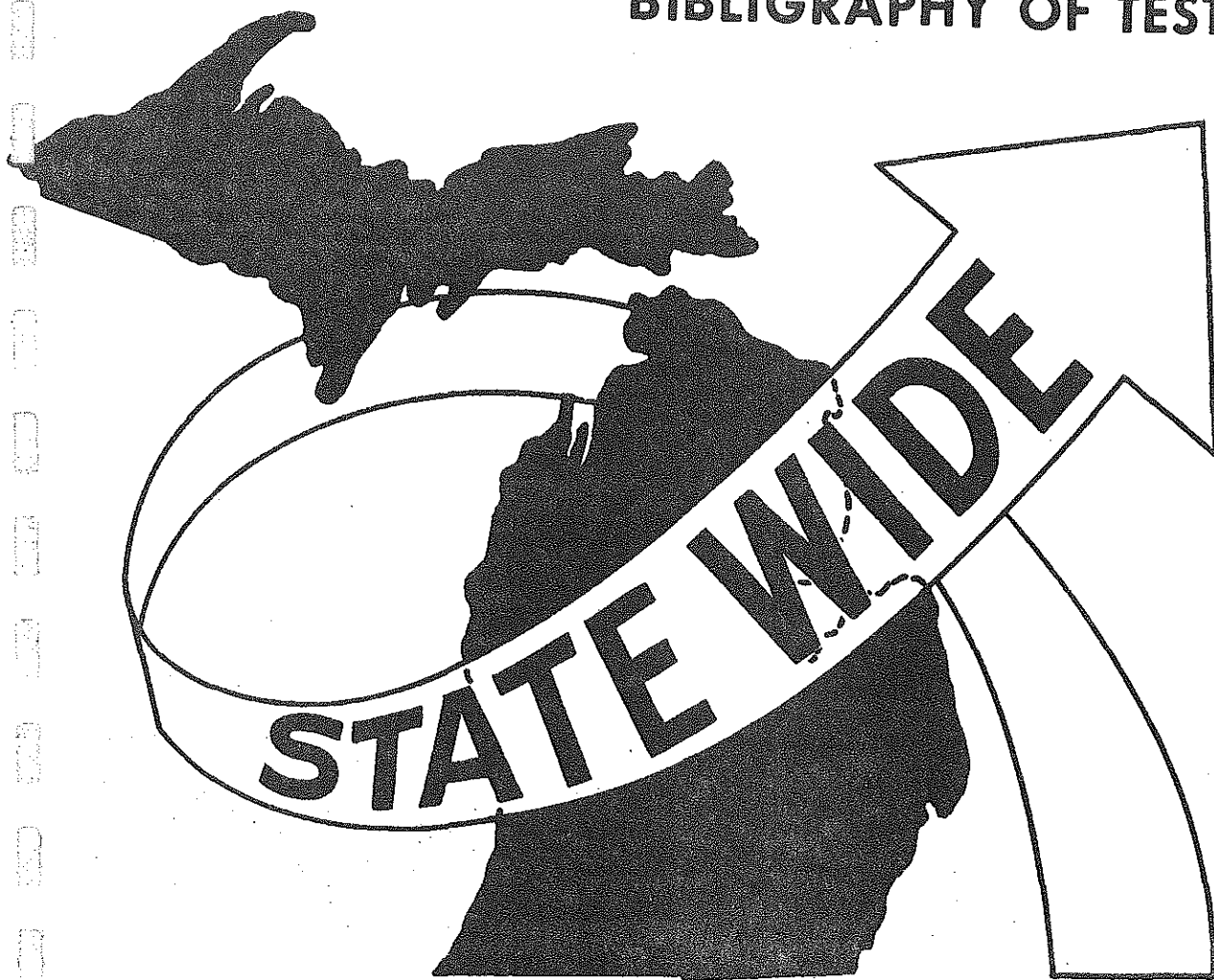
4. If parameter 1 is also = T, this produces a list, for each facility zone, of the zones lying in each time band and their distance from the facility. If parameter 1 is set to F, parameter 4 has no effect.
5. If parameter 2 is also = T, a punched-card deck of the number of facilities within the largest time band of each zone in the state. For instance, if the cutoffs were 15, 30, 45, and 60 minutes, the deck would contain the number of facilities within 60 minutes of each zone. This deck can be input without modification to the printer-plot routine SYMAP. If parameter 2 is set to F, parameter 4 has no effect.

RECORD FORMATS

Record type	FORTRAN format	Example
1. Number of socio-economic variables	12	02
2. Names of socio-economic variables	2A6	POPULATION <del>12</del> 12 digits
3. Name of facility set	2A6	HOSPITALS <del>12</del> 12 digits
4. Number of time bands	12	04
5. Band limits (cutoff values)	10 (13, IX) (can have up to 10 values specified)	015,030,045,060 <u>Or</u> 015 <del>030</del> 045 <del>060</del>
6. Report option indicators	4(L1, IX), L1	T,T,F,F,T <u>Or</u> T <del>T</del> F <del>F</del> T
7. Input medium for socio-economic data (and optional area specifiers)	AL <u>1</u>	CARD <u>Or</u> C TAPE <u>Or</u> T DISK <u>Or</u> D
8. Number of zones in system	14	0508
9. Number of facility zones	14	0022
10. Socio-economic data	(T17, 17)	0003264 Col. 17 Col. 23
11. Facility set	T1, 14, T6, 14, T11, 110)	(zone) (no. of (total facilities) capacity) 0007 <del>0001</del> <del>00000010150</del> Col.1 Col.6 Col.11
12. Logical area-sum option indicator and no of areas	L1, IX, 12	T,02 <u>Or</u> T <del>02</del>
13. Titles for summary areas	12A6	any 72-character Alphameric description
14. Area-equivalence records	15 1315 area no. zones included in area	<del>1</del> <del>203</del> <del>196</del> <del>1</del> Area #1 2 zones are mandator included in field of 5 area #1-- blanks-- zones 203 says area and 196 #1 is not completely spec.

**APPENDIX B:**

**BIBLIOGRAPHY OF TEST REPORTS**



# **BIBLIOGRAPHY OF TEST PROJECT REPORTS**

1. Rifle-Range Proximity Analysis
2. Regional Park Proximity Analysis
3. Proximity of Airports with Regularly-Scheduled Service to Population
4. Proximity of People to General-Purpose Hospitals
5. Industrial Park Proximity Analysis
6. Proximity of Automobile Injury Accidents to Hospitals
7. Community College Service-Area Analysis