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16. Abstract

An overall analysis of traffic data acquisition and distribution processes and techniques as performed by the Transportation Planning Division (D-10) of the State Department of Highways and Public Transportation is presented in this report. An assessment of needs for traffic information is developed through a series of interviews with district and division personnel of the Department. An analysis of data acquisition and distribution techniques for each of the four principal types of traffic data is presented.

Traffic volume data is found to be the most utilized and most needed type of traffic information. An analysis of automatic traffic recorder (ATR) data acquisition practices indicates that the number and location of ATR stations may be altered to facilitate more efficient volume data acquisition. Recommendations for changes in the ATR program are produced as the result of comprehensive statistical analysis of a five-year data base. Enhanced levels of activity in the automatic cumulative recorder (ACR) or coverage counting activities is recommended to meet increasing desires for traffic volume information at the district level.

The current speed monitoring program utilized by D-10 is based principally upon FHWA requirements to monitor the national 55 mph speed limit. Since speed data produced by D-10 is utilized by few agencies, and the program is currently at the minimum levels allowed by FHWA, no alteration of this program is recommended. No major changes are recommended in the program of vehicle classification data, while enhanced levels of effort in vehicle weight data acquisition are recommended.

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TEXAS TRAFFIC DATA ACQUISITION PROGRAM

by

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Clyde E. Lee
Randy Machemehl

Research Report Number 245-1F
[redacted]

Texas Traffic Data Acquisition Program
Research Project 3-10-78-245

conducted for

Texas State Department of Highways and Public Transportation
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by the

CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

February 1980

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. [redacted] This report does not constitute a standard, specification, or regulation.

There was no in[redacted]ceived or first actua[redacted]course of or under th[redacted] method, process, machine, manufacture, design or composition of matter, or any new and useful improvement thereof, or any variety of plant which is or may be patentable under the patent laws of the United States of America or any foreign country.

PREFACE

This is the final report on Research Project 3-10-78-245 "Traffic Survey Program Improvement." The authors wish to acknowledge and extend their appreciation to the many individuals who have contributed to this research. In particular, the study supervisors wish to acknowledge the contributions by C. S. Wu, Brian Roberts, Charlie Copeland, Colby Parkhouse, and Pam Stanford.

Special recognition is extended to Mr. T. H. McWherter of D-10 for his guidance and assistance during the project.

February 1980

ABSTRACT

An overall analysis of traffic data acquisition and distribution processes and techniques as performed by the Transportation Planning Division (D-10) of the State Department of Highways and Public Transportation is presented in this report. An assessment of needs for traffic information is developed through a series of interviews with district and division personnel of the Department. An analysis of data acquisition and distribution techniques for each of the four principal types of traffic data is presented.

Traffic volume data is found to be the most utilized and most needed type of traffic information. An analysis of automatic traffic recorder (ATR) data acquisition practices indicates that the number and location of ATR stations may be altered to facilitate more efficient volume data acquisition. Recommendations for changes in the ATR program are produced as the result of comprehensive statistical analysis of a five year data base. Enhanced levels of activity in the automatic cumulative recorder (ACR) or coverage counting activities is recommended to meet increasing desires for traffic volume information at the district level.

The current speed monitoring program utilized by D-10 is based principally upon FHWA requirements to monitor the national 55 mph speed limit. Since speed data produced by D-10 is utilized by few agencies, and the program is currently at the minimum levels allowed by FHWA, no alteration of this program is recommended. Vehicle classification data, collected at 284 classification stations, is heavily utilized by virtually all agencies for pavement design and other analyses. With the exception of minor modifications to computational procedures, no major revisions in this program are recommended. Vehicle weight information collected to the current D-10 program is utilized by virtually all departmental agencies and is, therefore, a key element in traffic data acquisition program. Enhanced levels of effort in vehicle weight data acquisition are recommended and these include obtaining vehicle weights for both directions at each station during survey periods.

SUMMARY

An investigation was initiated to determine uses and needs for traffic data within the state and to evaluate acquisition procedures. A survey of users and uses of traffic data consisting of traffic volume, speed, classification, and weight information indicated significant differences among various users. Needs for larger quantities of data updated more frequently were identified in urban and urbanizing areas. Traffic volume, vehicle weight, and, to a lesser extent, vehicle classification information were found to be the most vitally needed types of traffic data.

Acquisition procedures and sampling techniques utilized for collection of each type of traffic data were analyzed. A summary of findings and recommendations is included for each type of traffic data.

A significant portion of these research efforts were devoted to analysis of traffic volume data acquisition. Timewise variation of traffic volume and volume patterns at permanent volume recording stations were analyzed using a variety of statistical techniques. Significant similarity in magnitude and timewise variation was detected among many locations; however, differences in timewise variation were sufficiently significant to preclude abandonment of large numbers of permanent volume counting stations.

IMPLEMENTATION STATEMENT

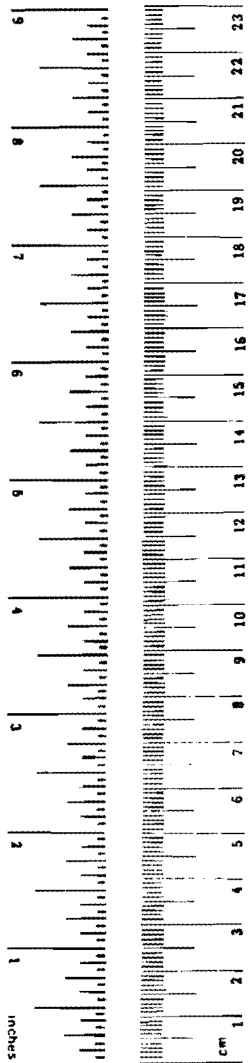
The efficiency, appropriateness, and reliability of many highway design and operational decisions is basically dependent upon traffic data. Traffic data is, however, only one part of the total information matrix required for highway engineering design and maintenance.

Traffic information must therefore be collected in exactly the right quantity, frequency, and type in order to facilitate operation of and not overburden the total design and maintenance system. This study represents an attempt to tune the supply of traffic data to the needs of that system. Additionally, attempts have been made to enhance the efficiency of data acquisition techniques. The benefits which should accrue from implementation of recommendations contained within this report include improved geographical correlation of data demand and supply.

METRIC CONVERSION FACTORS

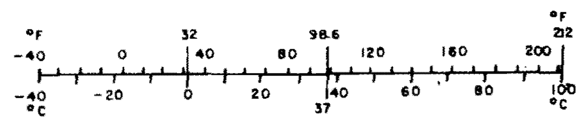
Approximate Conversions to Metric Measures

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



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CHAPTER 1. INTRODUCTION

Traffic data have been collected by the State Department of Highways and Public Transportation for many years through a comprehensive survey sampling program. These data have served as a primary basis for decision making regarding transportation issues at the local, state, and federal levels. Traffic volume and speed, along with vehicle class and weight, have comprised the basic data elements of the program.

Through several decades of operation, the traffic survey program has been highly effective; however, the efficiency of current survey techniques and hardware has not been evaluated in a comprehensive manner. As manpower, travel, and equipment costs have escalated over the years, efficiency, or cost-effectiveness, has become a growing concern.

The efficiency of the traffic survey program is at least partially dependent upon the degree to which data supply meets data demand. Program efficiency is also dependent upon the sampling methodology and hardware employed.

The overall objective of this study is to develop a more cost-effective traffic data survey program for the state. Inherent in this objective are a number of intermediate objectives which include the following:

(1) Performance of a comprehensive needs assessment to identify the present and future users and uses of traffic statistical data.

(2) Refinement of the scope of survey operations in response to the defined needs.

(3) Recommendation of applicable sampling methodologies which may reduce the magnitude of sampling operations while simultaneously retaining or improving the quality of traffic information.

(4) Identification, development, and evaluation of state-of-the-art hardware systems which offer potential improvements in efficiency, through reduced costs of hardware, manpower, maintenance, and operation. This objective was de-emphasized through the course of the study due to active equipment updating efforts undertaken by SDHPT.

CHAPTER 2. NEEDS ASSESSMENT

An assessment of the need for traffic information was conducted during the summer of 1978 and was updated through latter stages of this work. On-site interviews were conducted with personnel of the Department in both the divisions located in Austin and six randomly selected districts. Following the formalized person-to-person interviews of the summer of 1978, a series of informal discussions were conducted with other departmental personnel.

The overall objective of this assessment of needs was that of determining current usage patterns for traffic data and comparing this usage with the availability of data and contrasting availability with desires of principal users. Throughout the interviews, data were acquired in three principal areas which include generalized data usage, updating procedures, and collection techniques. Information acquired through interviews with district personnel is presented in the following section.

Reported Traffic Data Requirements in Districts

A tabular summary of questions and answers developed through interviews with district personnel in the Houston, Dallas-Ft. Worth, San Antonio, Lubbock, Brownwood, and Lufkin districts is included in Tables 2.1 - 2.3. These districts were selected for interviewing in concert with experienced personnel of D-10. The Houston, Dallas-Ft. Worth, and San Antonio districts were selected to represent developing urban areas and their particular problems and requirements. The Lubbock, Brownwood, and Lufkin districts were selected to represent less rapidly developing areas which would probably have differing requirements. The summary of results from these contrasting areas may represent a fairly exhaustive cross section of data needs and usage.

In virtually all cases, traffic volume data was reported as the most frequently utilized and most necessary item of information. Most respondents felt that district and county traffic volume maps were the most easily utilized presentation form for traffic volume information. Most reported that although ATR data was occasionally used, it was in general not directly used in design or maintenance operations. Personnel in the rapidly urbanizing

TABLE 2.1. DATA USAGE

	Houston	Dallas/ Fort Worth	San Antonio	Lubbock	Brownwood	Lufkin
Do you use speed data?	Yes	Yes	No	No	Yes	N/A
Do you use volume data?	Yes	Yes	Yes	Yes	Yes	Yes
Do you use classification data?	Yes	Yes	Yes	Yes	Yes	No
Do you use weight data?	Yes	Yes	Yes	Yes	Yes	Yes
Do you use lane distribution data?	Yes	No	No	No	No	No
Do you use flow maps?	No	Yes	Yes	Yes	Yes	Yes
Do you use ADT's?	Yes	Yes	Yes	Yes	Yes	Yes
Do you use ATR's?	Yes	Local only	Yes	No	No	Yes
How do you use speed data?	Level of service	Level of service, EPA	*	*	Geometrics, energy study	N/A
How do you use volume data?	Peak hour analysis, flow predictions	Peak volume trends	Public information	Public information	N/A	Predict flow

(continued)

TABLE 2.1. (Continued)

	Houston	Dallas/ Fort Worth	San Antonio	Lubbock	Brownwood	Lufkin
How do you use classification data?	Pavement design	Air quality, pavement design	Pavement design	Pavement design	Pavement design	Pavement design
How do you use weight data?	Pavement design	Pavement design	Pavement design	Pavement design	Pavement design	Pavement design
How do you use lane distribution data?	EPA road management	N/A	N/A	N/A	N/A	N/A
How do you use flow maps?	Public hearings	Public hearings	Public info.	Quick analysis, public info.	N/A	Public hearings

TABLE 2.2. COLLECTION TECHNIQUES

	Houston	Dallas/ Fort Worth	San Antonio	Lubbock	Brownwood	Lufkin
Is continuous data collection needed?	No	No	No	No	No	N/A
Are current station locations adequate?	No	Yes	Could be better	No	Yes	No
Who should determine survey station locations?	Locals	Locals	Locals to consult	Locals	N/A	Locals
How often should count locations be reviewed?	Yearly	Yearly	Yearly	Yearly	2-3 years	Yearly

TABLE 2.3. DATA UPDATE AND MISCELLANEOUS

<table>
<tr><th></th><th>Houston</th><th>Dallas/ Fort Worth</th><th>San Antonio</th><th>Lubbock</th><th>Brownwood</th><th>Lufkin</th></tr>
<tr><td>How often should speed data be updated?</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>How often should volume data be updated?</td><td>Yearly OK; monthly</td><td>Yearly</td><td>Yearly</td><td>Yearly</td><td>5 years</td><td>6 months-1 year</td></tr>
<tr><td>How often should classification data be updated?</td><td>Yearly OK; monthly</td><td>Yearly</td><td>Yearly</td><td>Yearly</td><td>Yearly</td><td>Yearly</td></tr>
<tr><td>How often should weight data be updated?</td><td colspan="4">← No opinion</td><td rowspan="3">As currently as possible</td><td>→</td></tr>
<tr><td>How often should lane distribution data be updated?</td><td colspan="4">← No opinion</td><td>→</td></tr>
<tr><td>How often should flow maps be updated?</td><td>1-3 years</td><td>1-3 years</td><td>2-4 years</td><td>3-5 years</td><td>1-4 years</td></tr>
<tr><td>Do you receive your data quickly enough?</td><td>No</td><td>No</td><td>Yes</td><td>No</td><td>Yes</td><td>No</td></tr>
<tr><td>Would you prefer to have data available at computer terminal or printed?</td><td>Computer</td><td>Printed</td><td>Computer</td><td>Pref.comp. Not imp.</td><td>Printed</td><td>Computer</td></tr>
<tr><td>Is current data adequate?</td><td>No</td><td>Yes</td><td>No</td><td>No</td><td>Yes</td><td>No</td></tr>
</table>

districts indicated that volume information should be updated at least annually, while a desire for monthly updating was indicated in Houston. Concurrent with these desires for frequent updating, personnel of the urbanized districts indicated that they felt that data were not delivered to them quickly enough. Several suggestions were made regarding possible publication of tabulated volume data on a more frequent basis or production of computer files which could be utilized by district personnel through their connection with Austin.

In summary, the urbanized districts indicated that traffic volume information currently available is generally inadequate for their needs and require more data produced on a more frequent basis. Rural districts, particularly Brownwood, indicated current data is adequate and, if anything, is produced too frequently. Results of these interviews may be further generalized to say that the requirements for traffic volume information are very definitely different for urban or urbanizing districts as compared with rural districts. The type, quantity, and update periods for traffic volume information should, therefore, probably be different for urban and rural areas.

Classification Data. In all districts, the predominant use for vehicle classification data was in pavement design. In this application, the basic statistic which is utilized is that of the percentage of a traffic stream which is composed of trucks. Thus, in this utilization mode, the categories into which a volume stream is placed could be much fewer than the 29 which are currently utilized. However, since the 29 are suggested by FHWA requirements, a reduction in the number of categories is not recommended.

Annual updating of classification data was desired as a minimum by all districts. The heavily urban districts, particularly Houston, expressed a strong desire for more frequent updating.

Several respondents indicated some marginal amount of classification data above that required for pavement design. Air quality analysis was particularly noted by the Dallas-Ft. Worth districts and was mentioned by the Houston district as another use and possibly growing need for vehicle classification data. Such usage was also noted by several central divisions and will be pointed out later.

In summary, vehicle classification information is currently heavily utilized by all districts for pavement design purposes. The update interval for this data is approximately adequate for those users contacted.

Speed Information. Although all respondents indicated some need for speed information, most indicated that data produced through the current monitoring program is of little value for their particular purposes. Since locations selected for speed monitoring under the current program are selected based on FHWA guidelines for monitoring the 55 mph speed limit, there is little reason to assume that this data would be appropriate for use by the districts. The respondents indicated needs for speed information to be primarily in the area of level of service and EPA analysis. Specific locations at which speed data are needed are therefore a matter of local concern and not really state or national concern.

The urban districts further indicated that the particular type of speed data that they need for level of service analysis must be updated at very short time intervals and at very particular locations. The consensus, therefore, was that collection of speed information should be primarily a district function and not a statewide function.

The current speed monitoring program as conducted by D-10 under FHWA guidelines was generally deemed appropriate for any requirements related to the nationally mandated 55 mph speed enforcement program. The districts did not request additional data or more frequent updating of currently produced speed information as developed by D-10. Based on these comments, it is recommended that the current or whatever updated program is required by FHWA be continued by D-10 and that specific speed information be collected by district on an as-needed basis.

Vehicle Weight Information. All respondents indicated that vehicle weight information is utilized on a regular basis for pavement design computations. General satisfaction with the type, quantity, and updating period for weight information was expressed by most respondents. However, since pavement design computations are frequently performed through departmental computer programs, the type, quantity, and update period for weight information is somewhat transparent to the user, and comments regarding these items should not be expected from district level respondents. Specific suggestions regarding collection of vehicle weight data and updating periods have been offered by central division respondents and will be noted later.

Responses regarding weight information from the districts may be summarized in the following manner. The district personnel are generally satisfied with currently available weight data and do not wish to have any additional published information. Weight information is, however, widely used by virtually all districts for pavement design purposes and to a limited extent for structural analysis.

Data Collected Through Austin Division Personnel

Comments offered by division personnel generally reinforced and expanded upon comments gathered from the districts. Several important points, however, were noted in interviews with division personnel, and these are included in the following paragraphs. Personnel of D-8 who are involved with air quality analysis and experimental source and diffusion modelling of automobile emissions indicated a continuing strong need for classification information. For emissions and air quality analysis, the numbers of categories into which traffic streams are classified should continue to be as numerous if not more numerous than that required by FHWA and currently utilized by D-10. Research in this area already completed and currently under way will produce modelling techniques which require detailed categorization of vehicles by types.

Those individuals directly concerned with pavement design within D-8 offered specific suggestions regarding acquisition of vehicle weight information. Currently active research efforts which quantify the amount of cracking in concrete pavements across the state have indicated predominant differences in the directional distribution of concrete pavement cracking. This phenomenon suggests a pronounced directionality of vehicle weights. It is therefore strongly suggested by these respondents that vehicle weighing include both directions at all weighing sites.

Summary

Interviews with district and division personnel who are in essence the consumers to whom the traffic data acquisition system is provided may be summarized with the following generalized comments.

(1) Requirements for traffic volume classification and speed information for urban districts are very different from those for rural districts. Urban and urbanizing areas generally require more data updated more frequently.

(2) The most conveniently utilized form for traffic volume information are the district and county traffic maps.

(3) The desirable update interval for traffic volume information in urban districts is one year or less, while 3-5 years is deemed adequate in rural districts.

(4) There continues to be little desire for statewide distribution of all ATR data or all weight data.

(5) Printed summaries of traffic volume data would be an acceptable means for updating district or county maps for those districts requiring more frequent updating.

(6) Vehicle classification information is used throughout the state for pavement design and is used marginally for other purposes. Therefore, production of this report on an annual basis should probably be continued for all districts.

(7) Production of vehicle weight information must be continued as a minimum at current levels with the addition of weighing at both directions at all count stations.

CHAPTER 3. TRAFFIC VOLUME SURVEYS

Traffic volume data collection was one of the original responsibilities of the Planning Survey Division when it was formed in 1936. These data have been collected through a network of continuous counting stations in combination with short duration or coverage counting activities. The following section presents a review of traffic volume counting activities, an assessment of needs, and a recommendation for future program scope. A generalized flow chart of volume counting activities is shown in Figure 3.1.

Historical Perspective

A basic element of the Traffic Volume Counting Program has been the continuous counting stations. A history of permanent counting station installations is included in Table 3.1. As indicated in the table, the program began shortly before World War II, was primarily suspended during the war years, and was resumed in 1946 with a complete update of system counts. The number of automatic traffic recorder (ATR) stations has increased from 19 in 1938 through 27 during 1941 to the current number of 167.

The first permanent traffic recorders employed photoelectric cell sensing devices that actuated magnetic counters which printed accumulated total volumes on paper tape. As these units were replaced, they were modified to photograph the accumulative counter reading hourly, replacing the need for paper tape printing.

The in-road sensing device utilized for volume counting has evolved through the years from the original photoelectric technique through the pneumatic road tube through a sonic detection system to present use of inductance loop detectors. Beginning in 1963, the recording and translating of volume data was gradually automated through purchase of Fisher-Porter punched paper tape recording and translating hardware. Currently, traffic volume data is recorded on punched paper tape and reduced or translated in the office using automated punched paper tape reading equipment. Today approximately 167 locations are continually monitored for hourly traffic volume information. These 167 stations represent the current network of ATR

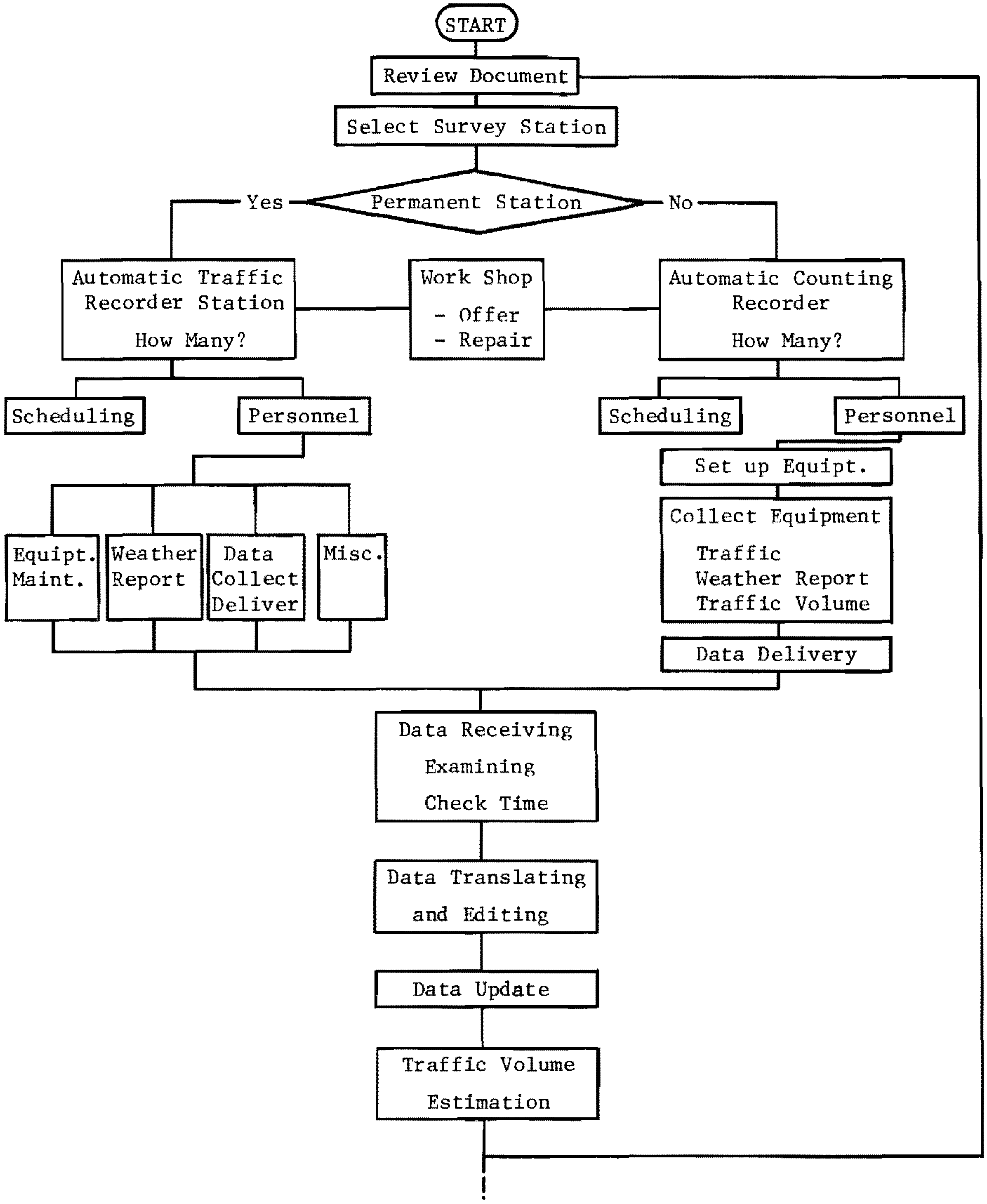

Figure 3.1. Schematic flow of traffic volume counting activities.

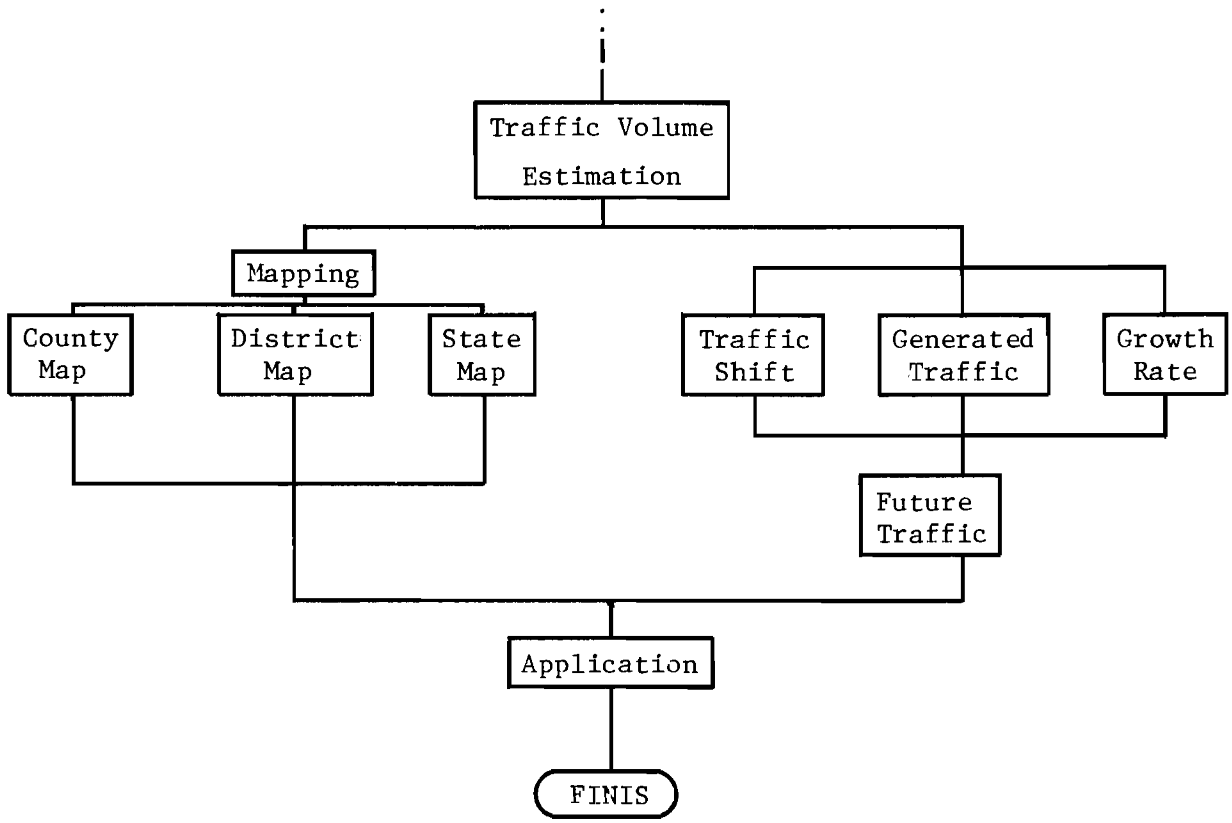

Figure 3.1. (Continued)

TABLE 3.1. HISTORY OF PERMANENT TRAFFIC RECORDER INSTALLATIONS

Year	Number Installed	Detector Type	Recorder Type	Record Type
Before 1938	19	Photo-Electric (through 1939)	Clock Driven Camera (through 1963)	Film Record (through 1963)
1939	5			
1940	8	Pneumatic Road Strip		
1941	3	Photo-Electric		
1942	24	Pneumatic Road Strip (through 1960)		
1943	11			
1944	1			
1945	1			
1946	10			
1947	6			
1948	5			
1949	17			
1950	3			
1951	4			
1952	5			
1953	0			
1954	2			

(Continued)

TABLE 3.1. (Continued)

Year	Number Installed	Detector Type	Recorder Type	Record Type
1955	5	Pneumatic Road Strip (through 1960)	Clock Driven Camera (through 1963)	Film Record (through 1963)
1956	5			
1957	0			
1958	3			
1959	4			
1960	0			
1961	1	Microphone; Pneumatic Road Strip (through 1965)		
1962	3			
1963	5			
1964	6		Fischer-Porter (to date)	Punch Tape Record (to date)
1965	10			
1966	2	Loop Detector (to date)		
1967	6			
1968	3			
1969	3			
1970	6			

(Continued)

TABLE 3.1. (Continued)

Year	Number Installed	Detector Type	Recorder Type	Record Type
1971	2	Loop Detector (to date)	Fischer-Porter (to date)	Punch Tape Record (to date)
1972	5			
1973	1			
1974	2			
1975	3			
1976	1			
1977	1			

or automatic traffic recording systems. Each station utilizes inductance loop detectors for vehicle in-road sensing and Fisher-Porter punched paper tape for recording.

Current ATR Section Activities

The ATR section of D-10 currently collects traffic veolume data at 167 permanent stations throughout the state which provide continuous traffic volume count information which is used directly in planning and design and most importantly for use in expansion of numerous shorter duration counts.

Administrative Structure. The section supervisor directs and coordinates the efforts of the field and office personnel. D-10 shop personnel consist of four field technicians, a shop foreman, and a shop technician.

The field technicians collect ATR data for the D-10 office monthly. During the first two weeks of each month, ATR data tapes are returned to Austin by mail where office personnel receive, check, and process ATR field data for further use. Office personnel include four analysts and an office supervisor.

Procedure. Local district personnel assigned the responsibility as caretakers prepare and forward to the D-10 office two reports for each station each week. One report documents the working conditions of each ATR while the second report provides daily weather information at each ATR station. If there is an ATR equipment malfunction and the caretaker is unable to make repairs, he notifies the D-10 office by phone as soon as possible so that a D-10 field technician can repair and put the recorder back into operation.

When ATR data arrives at the Austin office, it is first checked for recorder malfunction, and the beginning and ending time and date of the data are marked on the tape and recorded on the "F-P Tape Processing Form." Each tape is then translated by the Series 1550 Translator from binary form to computer cards in the appropriate format. When traffic volume data is missing, the analyst estimates the traffic volume from related physical, traffic, weather, and social conditions. For each missing traffic volume, the keypunch operator prepares a correction card for the estimated traffic volume. Once prepared, these cards are processed by computer, utilizing programs explained in the monthly traffic count processing bulletin. The output produced by the various programs depends somewhat on the clock dial utilized in the ATR, namely, whether these volume data are recorded on one hour, fifteen minute, or five minute intervals.

Publications. ATR data has historically been published and distributed on an annual basis to a large number of state departments. However, due to lack of use and great cost, the practice was discontinued in 1974. Data are currently stored permanently on magnetic tape and, when needed, are retrieved simply and efficiently. The traffic volume analysis section of D-10 incorporates and analyzes ATR data in preparation of traffic volume maps which constitute the most widely used form for volume data.

Costs. For the 1977-78 fiscal year, total cost allocated to ATR activities was approximately \$236,700. Since 4 of the 167 stations were inoperative leaving 163 locations, the cost per station was approximately \$1450.

Current ACR Section Activities

A very extensive system of short duration, volume count stations, is administered by the automatic cumulative recorder (ACR) section of D-10. Traffic volume counts obtained at these locations are normally for 24-hour duration and are expanded to ADT volumes using ATR data. A description of the activities of this section is contained in the following paragraphs.

Administrative Structure. The staff of the ACR section consists of a section supervisor, three field supervisors, and eleven field personnel. The section supervisor is responsible for planning, scheduling, and checking of required volume count data. The field supervisors are generally responsible for training and inspecting field personnel while the field personnel themselves actively set up ACR equipment and collect volume count data. A schematic flow chart of field activities is illustrated in Figure 3.2. Since 1974, ten of the 25 SDHPT districts have conducted their own counting operations. Field personnel in these districts are responsible directly to their respective district engineers but are funded, supplied, trained, and checked by the D-10 ACR section.

Procedure. Data collected through activities of the ACR section consist primarily of 24-hour weekday machine volume counts which serve the purpose of extending or providing coverage to the majority of highways and county roads within the state. Equipment utilized consists primarily of pneumatic road tubes as in-road sensing devices and non-recording accumulating counters. Until recently, a mechanical type recording device was utilized exclusively.

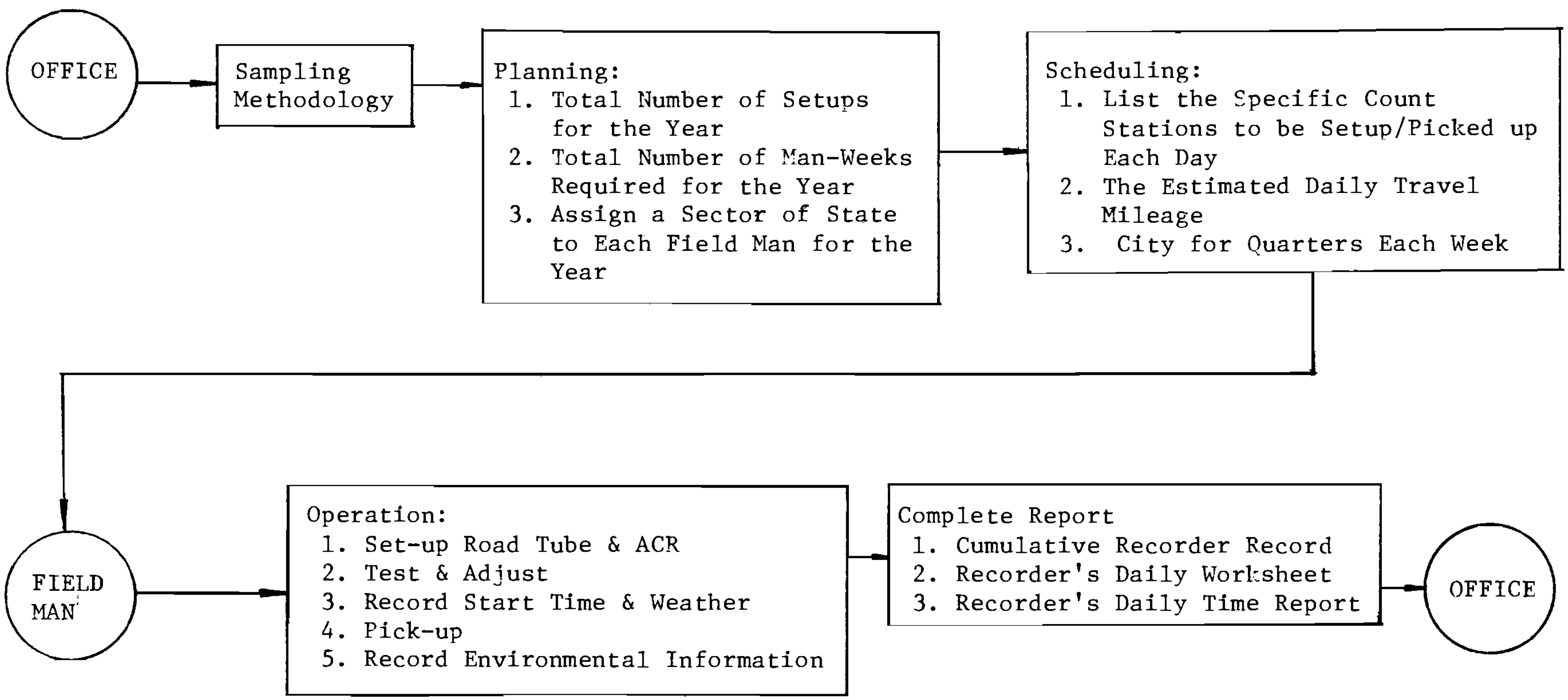

Figure 3.2. Schematic flow-chart of ACR field activities.

However, the department is currently purchasing several hundred solid state counting devices which offer much longer battery life and utilize an inexpensive 6-volt battery.

In each section of the state, volume counts are made at pre-selected sites on a rotating basis so that data on county roads are updated every five years while data on highways are updated annually, and urban counts are generally updated every seven years, with the exception of certain designated locations on highways withing cities which are updated on a five year repeating schedule. The frequency with which urban stations are updated is, however, variable and does require special scheduling each year.

Total number of person-weeks required is computed on the basis of a normal expectation of 90 setups per field person per week. The state is correspondingly divided into sectors that distribute the yearly workload evenly among field personnel. Field men who are assigned county road volume counts frequently do all their own scheduling, including highway volume counts in their sector. Districts conducting separate counting operations do some of their own scheduling except for urban studies while all other studies are scheduled by D-10. A detailed schedule of operations is normally prepared 6 weeks in advance for each field man. The schedule includes specific count station locations to be set up or picked up each day, the estimated daily travel mileage, and the city for quarters each week.

Upon completion of each 24-hour volume count, the field men will forward to D-10 the cumulative recorder record, and at the completion of each day's activities, the recorder's daily time report and the recorder's daily work sheet. When field reports are received in the ACR office, subtraction on the cumulative recorder record is checked, and a 50% factor is applied to obtain 24-hour vehicular volume counts, realizing that the recorder has obtained 24-hour axle counts. These computations are double checked, and the cumulative recorder records are filed by county for later use and analysis.

Publications. The ACR data received at the D-10 office is filed and used in raw form by D-10 analysis section along with ATR data for expansion purposes to prepare yearly traffic volume maps. Althought the ACR data are the primary basis for preparation of volume maps, the ACR information itself is not published in raw form. After each year's use, ACR data slips are filed and retained until those stations are counted again.

Costs. For the 1977-78 fiscal year, costs allocated to ACR activities were $393,700. These costs included 54,257 ACR "set-ups" for an average cost per set-up of $7.25.

Analysis of ACR Activities

Traffic volume counts made utilizing automatic cumulative recording systems appear to be a very cost effective way of gathering volume information. Resources required for information collection are closely related to the type and nature of in-road sensing device and recording device used. Major improvements in recording devices as noted earlier are being made through purchase of solid state electronic recording equipment. Pneumatic road tubes which are currently utilized as in-road sensing devices are the best presently available devices for counting vehicle passage at temporary locations.

An analysis of computational techniques utilized in ACR counting activities has created some interest concerning the conversion factor used to predict vehicle passage from axle counts. As noted earlier, a factor of 2.0 axles per vehicle is currently utilized to convert vehicles to axles. Manual classification count data from 257 randomly selected classification count sites were utilized to estimate the magnitude of this factor. Numbers of axles per vehicle in each of the 29 vehicle classes used for classification were multiplied by numbers of vehicles in each of the classes and summed for all 257 stations. The ratio of axles to vehicles which was thus produced utilizing 1977 data was a value of 2.29. The range of axles per vehicle ratios was 2.03 for station M1054 on FM50 to 3.04 at station M178A on IH20.

If counts made at these manual classification stations are representative of traffic on the highway system in general, a ratio significantly different from 2.0 is probably justified for use in ACR count activities.

A unique conversion ratio could be produced for specific areas from classification counts in the area on specific road systems. A mean statewide conversion ratio such as the one produced here could be used as an alternative. In either case, if classification count data are in any way representative of generalized traffic, the conversion ratio should be different from 2.0.

Analysis of ATR Activities

The following sections contain a description of a comprehensive analysis of activities related to continuous volume counting or ATR activities. Data collected through this program currently represent an extremely important part of D-10's overall activities and represent a significant share of the resources devoted to traffic data acquisition. Because of the importance and associated cost of ATR activities, this analysis has been conducted.

Data Base Development. ATR data is currently stored in a permanent form in D-10's magnetic tape library. All data from all 167 stations is stored for a six-month time period on each separate magnetic tape. Ten of these tapes, representing the years 1974-1978 were acquired for use in this analysis. Since the raw ATR data stored on tape consists of hourly totals for each of the 24 hours of each day, and the shortest analysis period to be considered in analysis of ATR data was 24 hours or one complete day, these data were summarized from hourly figures to produce daily totals.

Daily traffic volume totals for each ATR station for each direction (many stations have directional totals) were written on a new magnetic tape. This tape then contained all available daily traffic volume information produced by ATR stations for the most recent 5-year period. This data tape became the data base for the ATR analysis.

Urban vs. Rural Stations. Based upon the conclusions developed through the needs assessment that data requirements for urban and rural areas were different, the 167 ATR stations were categorized as being within the influence of an urban area or being basically rural. For purposes of this analysis, 7 areas were designated as being urban. These include the areas around the cities of Corpus Christi, Houston, Dallas-Ft. Worth, San Antonio, Austin, El Paso, and Beaumont. Stations designated as being within the influence area of each urban area are shown in Table 3.2. All stations not designated as being within an urban influence area were considered basically rural and were analyzed separately.

Analysis of Urban Stations. Although the term "urban station" cannot be used literally to denote all those stations listed in Table 3.2, the term will be used to refer to those stations which are in reasonably close proximity to the urban areas. The analysis process utilized consisted of analysis of variance followed by multiple range and non-parametric statistical testing. The test procedures were designed to identify those stations in each urban area which have similarity among themselves in timewise variation of traffic volume.

TABLE 3.2. STATIONS DESIGNATED AS BEING WITHIN THE INFLUENCE OF AN URBAN AREA

AREA	# Of stations	PERMANENT RECORDER NUMBERS
Austin	10	S004,S038,S053,S131,S132
Beaumont	6	S115,S117,S187
Corpus Christi	11	A029,S034,S054,S074,S091,S149,S161
Dallas	25	A001,S017,S041,S055,S109,S122,S126, S130,S147,,S148,S169,S170,S171
El Paso	9	A010,S070,S123,S162,S168
Houston	32	S089,S099,S124,S139,S140,S141,S142,S154, S155,S156,S157,S165,S166,S172,S176,S182
San Antonio	16	S094,S106,S108,S146,S184,S185,S186,S188

Daily traffic volumes were initially utilized as the test statistic. However, after the first repetition of the experiment, the ratio of daily traffic volume to average daily traffic volume was selected as being a more useful parameter for test purposes. Average daily traffic volume was computed for each station as the sum of the daily traffic volumes divided by 365. The data base of daily traffic volume for each station was then replaced by the ratios of each day's traffic volume to the ADT statistic. The testing process utilizing the ratio produces not only a means of identifying stations with similar timewise variations in traffic volume but also produces a means of quantitatively selecting an expansion ratio for converage counts in the same area.

Four-way analysis of variance was conducted for the stations in each urban group independently. The four treatment effects which were analyzed in each case included station, year, month, and day. Thus, the experiment attempted to quantify the statistical significance of differences among geographical placement through the station factor and timewise variation among years, months, and days with the other three factors. Results of this analysis are presented in Table 3.3.

Information presented in this table identifies those stations which were considered to be within the influence area of each city. The groupings of stations within each urban influence were developed using Duncan's Multiple Range Test with a confidence level of 95%.

Testing procedures, namely analysis of variance and multiple range testing, utilized to produce the groupings of Table 3.3 are parametric tests. These test procedures require certain assumptions about the parent population from which the data were taken. These assumptions include such things as normality of the parent population and independence. Tests performed on the parent populations indicate that these assumptions are not always met. A family of procedures called non-parametric statistical methods which do not require assumptions associated with parametric tests was utilized to verify and modify the grouping of Table 3.3.

Modified grouping of stations in each urban area is illustrated in Table 3.4. Two bases were utilized to form each of the groups shown in the table. The ADT expansion factors for all stations for all days of the most recent year contained within the data base were compared with each other.

TABLE 3.3. GROUPING OF ATR STATIONS UTILIZING ANALYSIS OF VARIANCE AND MULTIPLE RANGE TESTING

Area	Group Number	Station Number	Highway Designation
Austin	I	S144A	US290
		S053E	SH071
		S053W	SH071
	II	S004N	IH35
		S004S	IH35
		S132N	IH35
		S132S	IH35
	III	S131N	US183
		S131S	US183
		S038A	SH095
Corpus Christi	I	S161E	PR22
		S161W	PR22
	II	S034A	SH35
	III	S149E	IH37
	IV	S074A	US77
		S149W	IH37
	V	A029N	US181
		A029S	US181
		S091A	FM665

(Continued)

TABLE 3.3. (Continued)

Area	Group Number	Station Number	Highway Designation
Dallas	Ia	S126N	IH35E
	Ib	S126S	IH35E
	II	S170E	IH635
		S170W	IH635
	III	A001E	US80
		A001W	US80
		S055E	SH183
		S055W	SH183
		S109N	IH35W
		S109S	IH35W
	IVa	S147E	IH030
		S147W	IH30
		S148N	IH35E
		S148S	IH35E
		S017S	US175
		S041A	US81
	IVb	S130E	IH30
		S130W	IH30
		S171N	IH635
		S171S	IH635
		S017N	US175

(Continued)

TABLE 3.3. (Continued)

Area	Group Number	Station Number	Highway Designation
El Paso	I	S168E	LP375
		S168W	LP375
	IIa	S162E	IH10
		S162W	IH10
	IIb	A010N	SH20
		A010S	SH20
		S070A	FM258
		S123N	IH10
		S123S	IH10
San Antonio	I	S185S	IH37
	II	S185N	IH37
	III	S108W	IH35
		S108E	IH35
	IVa	S146N	IH410
		S184W	IH10
		S146S	IH410
		S186W	IH410
		S186E	IH410
	IVb	S094S	IH10
		S184E	IH10
		S094N	IH10
		S106N	IH35
		S106S	IH35

(Continued)

TABLE 3.3. (Continued)

Area	Group Number	Station Number	Highway Designation
Houston	I	S139E	US59
		S139W	US59
		S165W	IH10
		S165E	IH10
		S176E	IH10
		S176W	IH10
	II	S154E	IH10
		S154W	IH10
		S155E	IH10
		S155W	IH10
	IIIa	S140E	US59
		S140W	US59
		S142N	IH45
		S142S	IH45
		S156N	IH610
		S156S	IH610
		S166E	IH610
		S166W	IH610
		S172W	IH610
		S157E	IH610
	IIIb	S089N	IH45
		S089S	IH45
		S124N	US59
		S124S	US59

(Continued)

TABLE 3.3. (Continued)

Area	Group Number	Station Number	Highway Designation
Houston (continued)	IIIb	S141E	IH10
		S141W	IH10
		S157W	IH610
		S172E	IH610

TABLE 3.4. URBAN STATION GROUPING THROUGH NON-PARAMETRIC METHODS*

Area	Group Number	Station Number	Location	Highway Designation	Remarks
Austin	I	S004N	Austin	IH35	Over 95% of observations within 10% interval
		S004S		IH35	
		S053E		SH71	
		S053W		SH71	
		S144A		US290	
	II	S132N		IH35	99% of observations within 10% interval
		S132S		IH35	
	III	S038A	Bastrop	SH95	Over 95% of observations within 10% intervals
		S131N	Austin	US183	
		S131S		US183	
San Antonio	I	S094N	San Antonio	IH10	Over 95% observations within 5% interval
		S094S		IH10	
		S106N		IH35	
		S106S		IH35	
	II	S108E		IH35	Over 95% observations within 10% interval
		S108W		IH35	
		S146N		IH410	
		S146S		IH410	

(Continued)

TABLE 3.4. (Continued)

Area	Group Number	Station Number	Location	Highway Designation	Remarks
El Paso	I	A010N	El Paso	SH20	
		A010S		SH20	
		S070A	Ysleta	FM258	
		S123N	El Paso	IH10	
		S123S		IH10	
	II	S162E		IH10	100% observations within 10% interval
		S162W		IH10	
	III	S168E		LP375	99% observations within 10% interval
		S168W		LP375	

(Continued)

TABLE 3.4. (Continued)

Area	Group Number	Station Number	Location	Highway Designation	Remarks
Houston	I	S089N	Houston	IH45	Over 95% observations within 10% interval
		S089S		IH45	
		S124N		US59	
		S124S		US59	
		S140E		US59	
		S140W		US59	
		S141E		IH10	
		S141W		IH10	
		S142N		IH45	
		S142S		IH45	
	II	S154E		IH10	Over 95% observations within 10% interval
		S154W		IH10	
		S154E		IH10	
		S155E		IH10	
		S155W		IH10	
		S156N		IH610	
		S156S		IH610	
		S157E		IH610	
		S157W		IH610	
		S166E		IH610	
		S166W		IH610	
		S172E		IH610	

(Continued)

TABLE 3.4. (Continued)

Area	Number	Number	Location	Designation	Remarks
Houston (Cont.)	II	S172W	Houston	IH610	
	III	S139E		US59	Over 95% observations within 10% interval
		S139E		US59	
		S139W		US59	
		S165E		IH10	
		S165W		IH10	
		S176E		IH10	
		S176W		IH10	
Corpus Christi	I	A029N	Corpus Christi	US181	
		A029S		US181	
		S091A		FM665	
	II	S034A	Rockport	SH35	
	III	S074A	Sarita	US77	
	IV	S149E	Corpus Christi	IH37	100% observations within 10% interval
		S149W		IH37	
	V	S161E		PR223	
		S161W		PR223	

(Continued)

TABLE 3.4. (Continued)

Area	Group Number	Station Number	Location	Highway Designation	Remarks
Dallas	I	A001E	Arlington	US80	100% observations within 10% interval
		A001W		US80	
	II	S017N	Dallas	US175	
		S017S		US175	
		S041A	Ft. Worth	US81	
		S171N	Dallas	IH635	
		S171S		IH635	
	III	S055E		SH183	Over 95% observations within 10% interval
		S055W		SH183	
		S109N	Ft. Worth	IH35W	
		S109S		IH35W	
		S130E		IH20	
		S130W		IH20	
		S147E	Dallas	IH20	
		S147W		IH20	
		S148N		IH35W	
		S148S		IH35W	
	IV	S170E		IH635	Over 95% observations within 10% interval
		S170W		IH635	
		S126N		IH35E	
		S126S		IH35E	

* Criteria for grouping 10% variation for 90% of observation.

Those stations with expansion factors which varied no more than 10% from each other for 90% of the days observed were tentatively placed into the same group. Additionally, Spearman's Rank Correlation Coefficient was computed for each possible pair of stations. The expression for coefficient of rank correlation is given by:

$$R_{rank} = 1 - \frac{(6\Sigma d^2)}{N(N^2-1)}$$

where

d = differences between ranks of corresponding ADT expansion factors for a pair of stations

N = numbers of pairs of values in the data (number of days in the data base).

Formation of this test statistic required ranking the magnitudes of ADT expansion factors for each station for the entire data base. Resulting ranks of days for each station were then compared pairwise with each possible other station rather than comparing ADT values or volumes directly. Use of this test statistic as opposed to the parametric correlation coefficient solves problems related to assumptions about parent populations and their behavior.

Criteria for group formation within each urban area were then extended to include the fact that all stations within a group would have values for Spearman's Coefficient of Rank Correlation of 0.7 or more when compared with each other. As with the classical parametric coefficient of correlation, Spearman's coefficient is bounded by values of -1 and +1 where perfect correlation is defined by values of 1.

The remarks column of Table 3.4 identifies those groups in which the variation among group members was actually less than the maximum allowed by the grouping criteria. For example, in Group I for Austin, the variation among ADT expansion factors for the members of this group were within 10% for 95% of the observations as compared with 90% required for grouping. Many of the urban area groups do have less variation than that required for grouping. Correlation coefficients, although not shown, are, in most cases, much higher than 0.7.

Relationship among mean group expansion factors for each urban area are illustrated in Figs 3.3 through 3.8. Each line plotted in these figures is composed of mean expansion factors for all members of each respective group for each day of each month of the most recent year contained within the data base. Timewise variations of each group expansion factor and relative timewise variation among groups can be observed through these figures.

The grouping of Table 3.4 might be interpreted to mean that stations within the same group are essentially duplicates of each other and therefore might represent stations which could be dropped from the ATR network. Although variation among group members is very small and little additional data is currently gained through operation of more than one station in each group, abandoning urban stations is not recommended. The probability of dramatic changes in traffic volumes and volume patterns at the stations located adjacent to urban areas is very high. This probability of change, created by dynamic growth prospects of the State of Texas preclude sound recommendations for decreasing the number of continuous count stations adjacent to urban areas.

If, however, budgetary constraints dictate the need to decrease the number of ATR stations included in urban areas, the groupings of Table 3.4 provide a sound basis for accomplishing this task. The data base utilized in this analysis effort indicates that stations could be abolished within each group with the exception of groups containing only directional pairs. Abolition of a single member of a directional pair, such as stations S132N and S132S in Austin Group II, is not recommended.

Analysis of Rural ATR Stations

As noted previously, all ATR stations not designated as being within the influence of an urban area were designated as rural. This designation does not carry with it a connotation of rural land use or typically rural travel patterns in the vicinity of such a station. It only means that stations designated as being rural are separated from a major urban growth area to the extent that there is a significantly lower probability of dynamic changes in traffic volume and pattern due to immediately adjacent urban area growth.

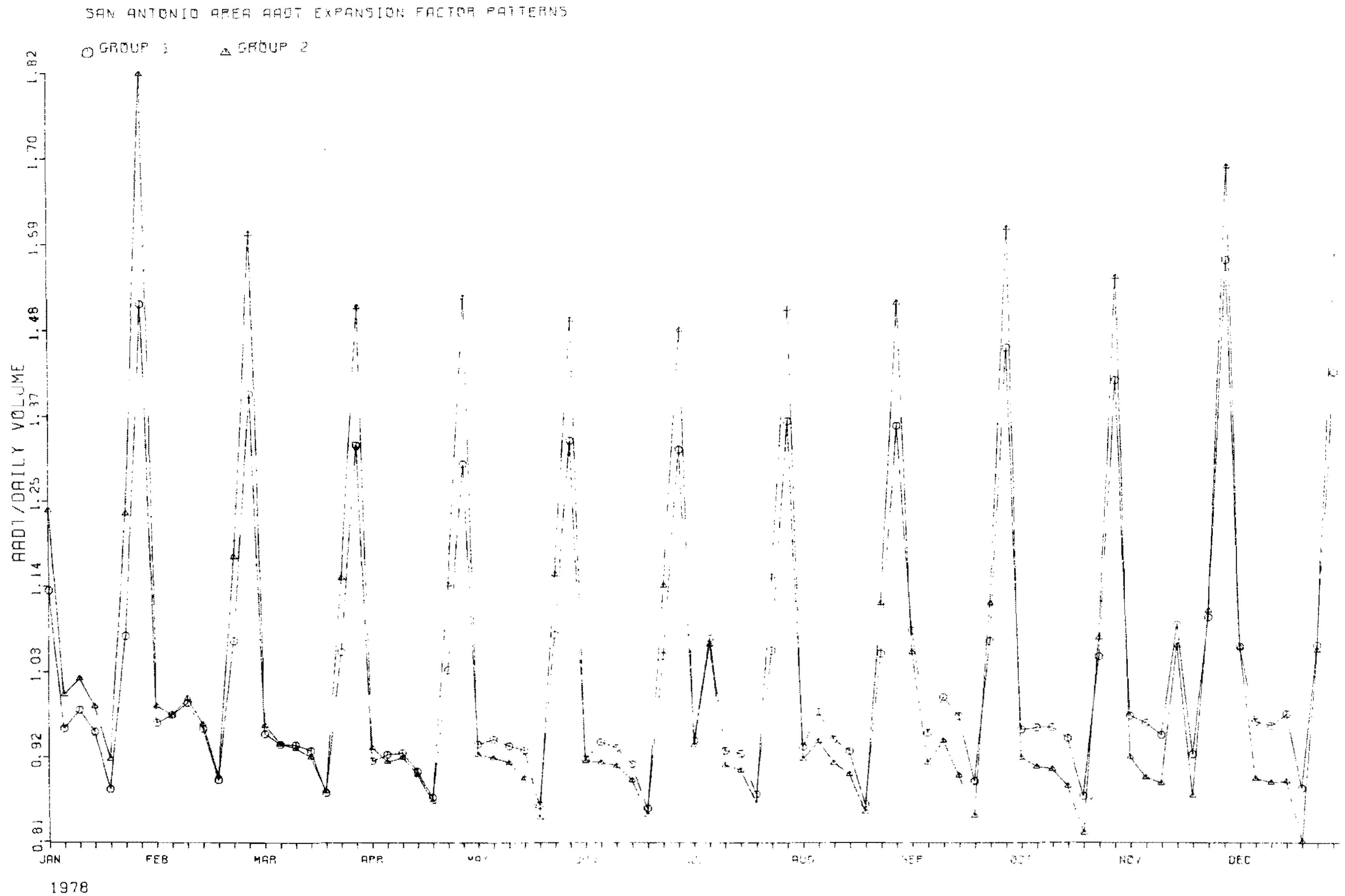

Figure 3.3. Timewise variation of AADT expansion factors by group by day of week and month of year for San Antonio groups.

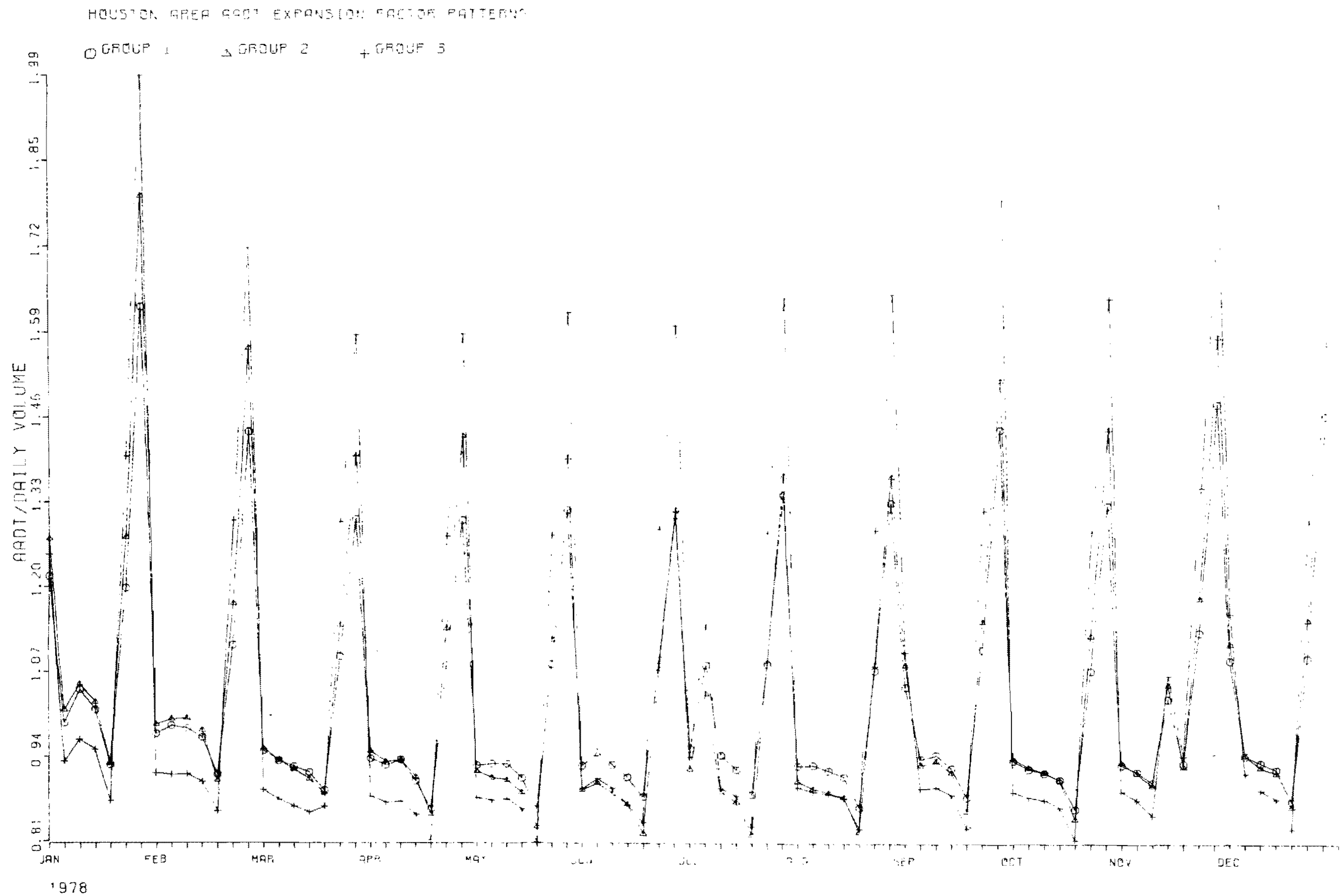

Figure 3.4. Timewise variation of AADT expansion factors by group by day of week and month of year for Houston groups.

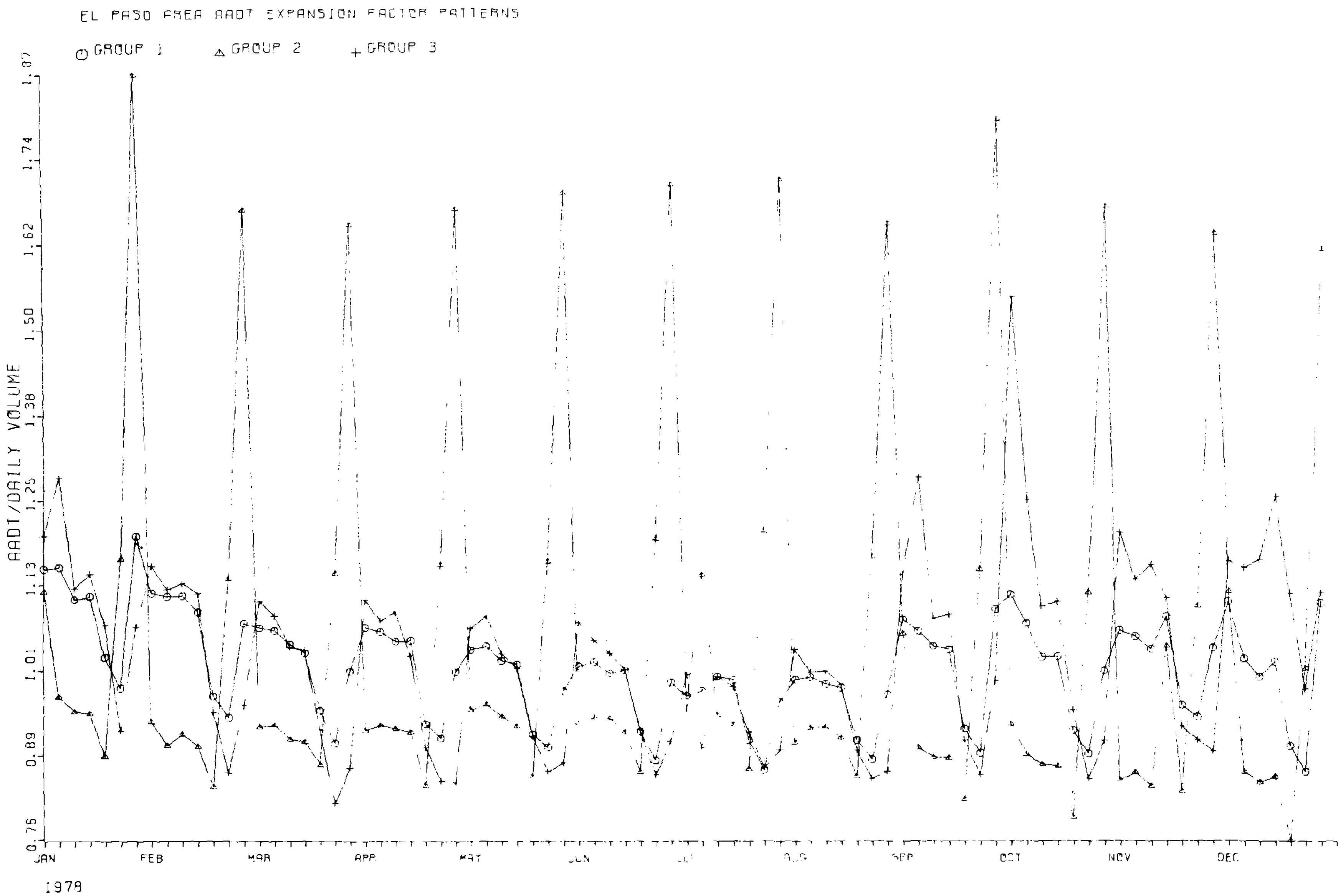

Figure 3.5. Timewise variation of AADT expansion factors by group by day of week and month of year for El Paso groups.

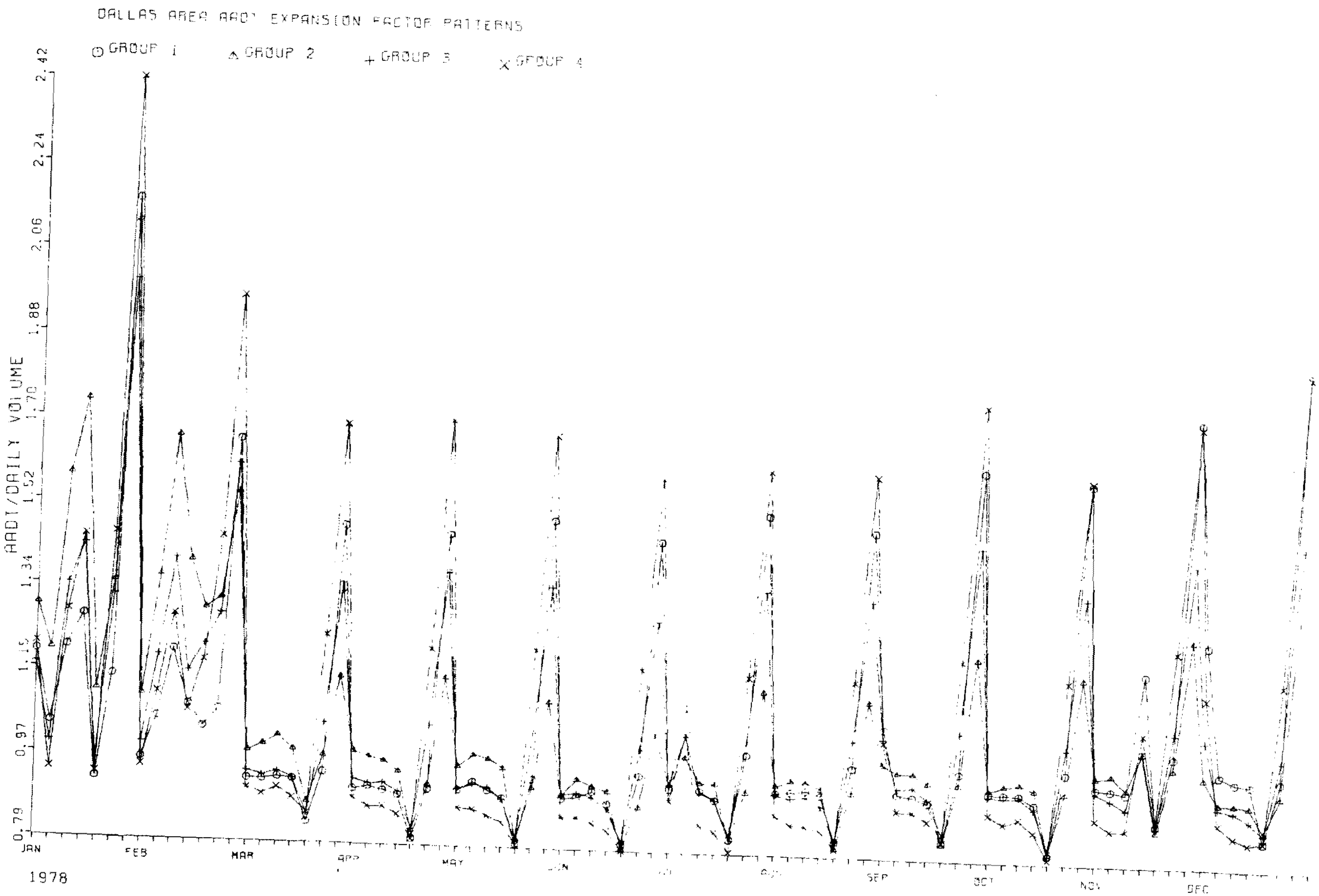

Figure 3.6. Timewise variation of AADT expansion factors by group by day of week and month of year for Dallas groups.

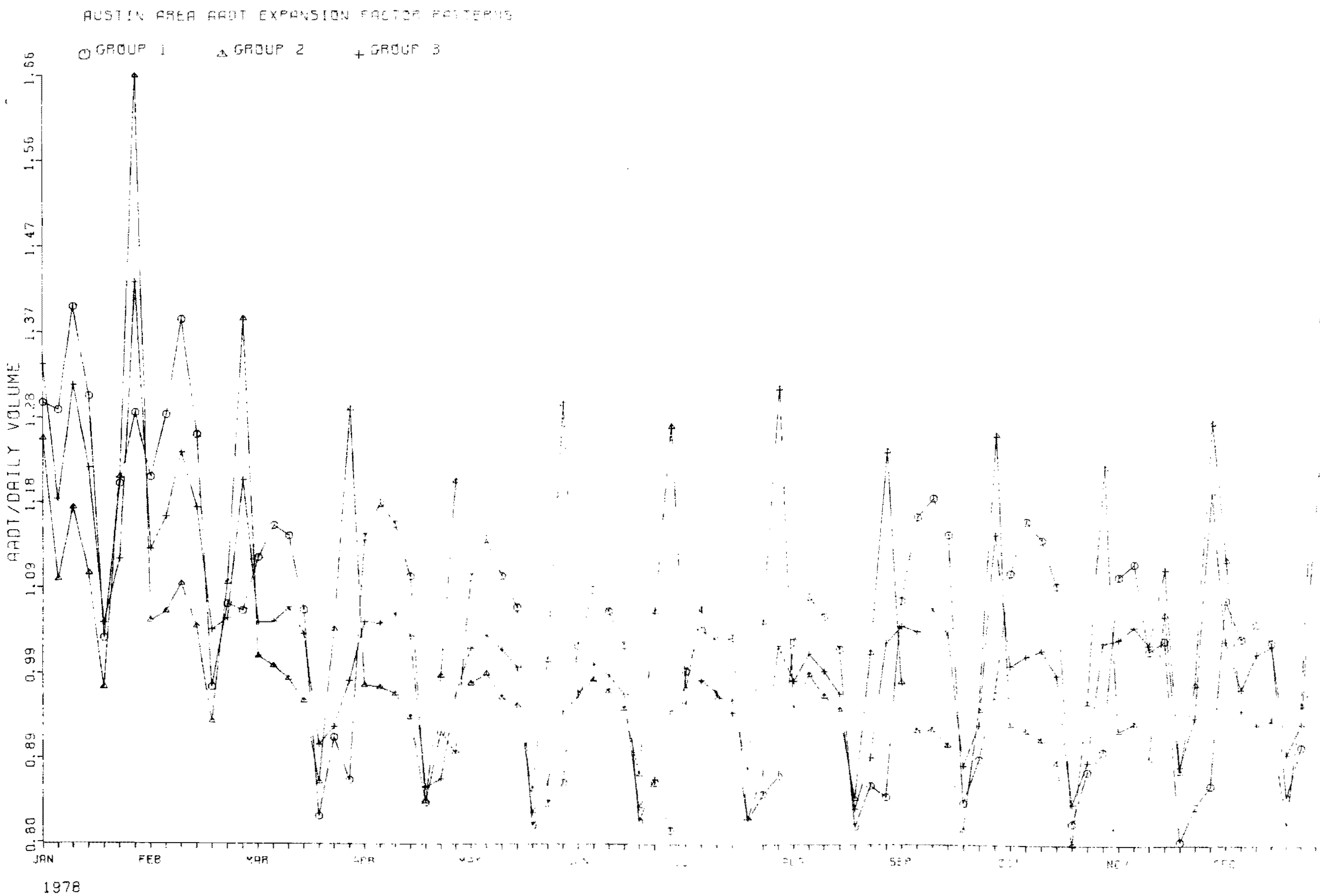

Figure 3.7. Timewise variation of AADT expansion factors by group by day of week and month of year for Austin groups.

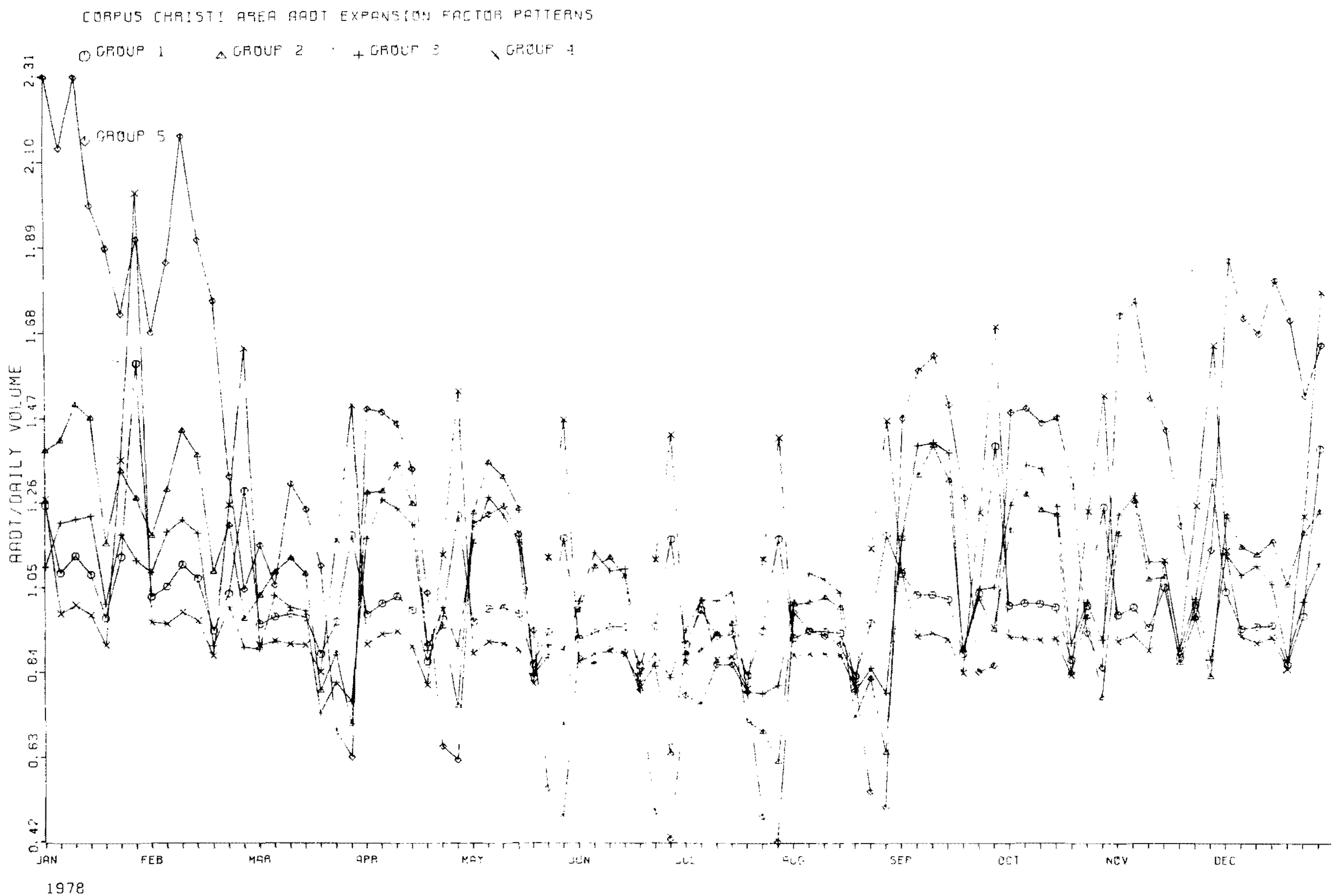

Figure 3.8. Timewise variation of AADT expansion factors by group by day of week and month of year for Corpus Christi groups.

The analysis process used for stations designated rural was analogous to that used for urban stations with one exception. Rural stations were not grouped geographically prior to analysis. In the first stage of analysis where parametric statistical procedures of analysis of variance and multiple range testing were utilized, these stations were studied in randomly composed groups of 30. The group size of 30 was selected based upon computer software constraints.

Four-way analysis of variance was again utilized and factors of station, year, month, and day were primary treatment effects. Duncan's Multiple Range Test was again employed to produce groups of stations having characteristics which were not significantly different at the 95% confidence level. Groups produced through this analysis are shown in Table 3.5. As shown in the Table, from the 129 analyzed, eight groups were produced. As with analysis procedures for urban stations, data utilized in this analysis consisted of ADT expansion factors developed by forming the ratios of daily volume and annual average daily traffic.

As with rural stations, statistical testing indicated that all assumptions required for use of parametric analysis of variance and multiple range testing were not met by the rural stations data base. Therefore, non-parametric techniques were once again utilized to modify grouping produced in Table 3.5. New groups were formed utilizing as criteria for grouping the difference between expansion factors of group members could be no more than 20% for 90% of the observations. Additionally, Spearman's Rank Correlation Coefficient could be no less than 0.7 for all possible pairs of stations within a group. That is, criteria for group formation was the same as that used for urban stations with the exception that 20% variation was allowed among group members as opposed to 10% variation allowed for urban stations.

Groups along with station number, location, highway designation, and district number are shown in Table 3.6. Nine groups have been formed without any geographic structure. Illustrations of timewise variation among group means of these nine groups are provided in Figures 3.9 and 3.10.

If the same criteria for grouping that was utilized for urban stations were applied to rural stations, the larger magnitude of timewise variation would preclude development of any large groups. Evidence of this fact is provided in Table 3.7 which illustrates results of grouping procedures with criteria of 10% variation in 90% of all observations. From all 129 stations,

TABLE 3.5. GROUPING OF RURAL ATR STATIONS UTILIZING PARAMETRIC STATISTICAL PROCEDURES

Group Number	Station Number	Highway Designation	Location
IA	S113A	SH332	Freeport
IB	S078A	FM1936	Odessa
	S164W	IH10	Schulenburg
	S164E	IH10	
II	S001E	IH40	Shamrock
	S001W	IH40	
	S145W	IH20	Terrell
	S180A	SH123	Seguin
III	S145E	IH20	Terrell
	S040N	IH45	Corsicana
	S120W	US287	Amarillo
	S181A	FM1792	Brownsville
	S110A	US277	Del Rio
	S120E	US287	Amarillo
	S013W	IH30	Sulphur Springs
	S013E	IH30	
	S040S	IH45	Corsicana
	S015A	SH159	La Grange
IV	S014E	IH10	Sonora
	S014W	IH10	
	S003E	US290	Hearne
	S016S	US281	Jacksborough
	A008S	IH35	Laredo

(Continued)

TABLE 3.5. (Continued)

Group Number	Station Number	Highway Designation	Location
IV	S003W	US290	Cypress (Houston)
	S006A	US67	San Angelo
	A025E	IH20	Colorado City
	S016N	US281	Jacksborough
	A020A	IH20	Colorado City
	S016N	US281	Jacksborough
	A020A	SH34	Italy
	S044A	US82	Henrietta
	S052A	US87	Mason
	S059A	FM156	Denton
	S043A	US59	Linden
	S060A	SH207	Claude
	S068A	SH163	Ozona
	S083A	FM47	Wills Point
	S118N	IH35	Waco
	S103W	US90	Del Rio
	S118S	IH35	Waco
	S116W	US59	Victoria
	S133E	US80	Terrell
	S150W	IH20	Marshall
	S134A	US82	Archer City
	S135A	SH158	Ballinger
	S158N	US87	Amarillo
	S158S	US87	

(Continued)

TABLE 3.5. (Continued)

Group Number	Station Number	Highway Designation	Location
V	A017E	IH45	Galveston
	A017W	IH45	
	A025W	IH20	Colorado City
	S010A	US79	Hearne
	S024A	US70	Matador
	S027A	FM428	Denton
	S033A	US77	Cuero
	S047A	SH351	Albany
	S057A	FM207	Breckenridge
	S071A	SH16	Tilden
	S076A	FM747	Jacksonville
	S087A	FM562	Anahuac
	S096W	US67	Brownwood
	S084A	FM271	Bonham
	S111A	US90	Uvalde
	S116E	US59	Victoria
	S119A	SH16	Fredericksburg
	S113W	US80	Terrell
	S136A	SH15	Perryton
	S151A	SH43	Marshall
	S175N	US59	Nacogdoches
	S160S	US181	San Antonio
	S153E	IH20	Abilene

(Continued)

TABLE 3.5. (Continued)

Number	Number	Designation	Location
V	S178A	US82	Paris
	S174N	US59	Nacogdoches
VI	A008N	IH35	Laredo
	A015A	SH159	La Grange
	A028A	US70	Vernon
	S007A	US90	Marfa
	A016N	IH45	Houston
	S026A	SH5	McKinney
	S023S	US277	Haskell
	S025A	US83	Shamrock
	S023N	US277	Haskell
	S020A	US69	Woodville
	S036A	SH90	Anderson
	S049A	SH86	Tulia
	S058A	FM386	Mason
	S062A	FM142	Stanford
	S077A	FM372	Gainsville
	S063A	FM535	Smithville
	S090A	FM240	Yorktown
	S081A	FM644	Loraine
	S088A	FM218	Hamilton
	S097A	US281	Falfurrias
	S096E	US67	Brownwood
	S112A	FM268	Childress

(Continued)

TABLE 3.5. (Continued)

Group Number	Station Number	Highway Designation	Location
VI	S107N	SH146	Baytown
	S121N	US75	McKinney
	S121S	US75	
	S137A	SH31	Tyler
	S143W	US83	Pharr
	S143E	US83	
	S175S	US59	Nacogdoches
	S167S	US287	Wichita Falls
	S153W	IH20	Abilene
	S167N	US287	Wichita Falls
	S179A	SH154	Sulphur Springs
VII	S018S	US83	Abilene
	A005W	US80	Marshall
	S018N	US83	Abilene
	A005S	US80	Marshall
	A016S	IH45	Houston
	A027E	LP374	Pharr
	A027W	LP374	
	S028A	SH359	Laredo
	S022A	SH60	Wharton
	S029A	US277	Eagle Pass
	S046A	US183	Breckenridge
	S039A	SH6	Waco
	S051A	US277	San Angelo

(Continued)

TABLE 3.5. (Continued)

Group Number	Station Number	Highway Designation	Location
VII	S065A	FM147	Marlin
	S072A	US285	Ft. Stockton
	S085A	FM557	Pittsburg
	S086A	FM92	Silsbee
	S107S	SH146	Baytown
	S125E	IH10	Houston
	S128E	US84	Lubbock
	S128W	US84	
	S174S	US59	Humble
	S159E	US83	Mission

TABLE 3.6. GROUPING OF RURAL ATR STATIONS USING NON-PARAMETRIC TECHNIQUES*

Group Number	Station Number	Location	Highway Designation	District Number
I	A005E	Marshall	US80	19
	A005W		US80	19
	A016N	Houston	IH45	12
	A016S		IH45	
	A018A	Nacogdoches	SH21	11
	A028A	Vernon	US70	3
	S018N	Abilene	US83	8
	S018S		US83	
	S022A	Wharton	SH60	13
	S025A	Shamrock	US83	25
	S039A	Waco	SH6	9
	S051A	San Angelo	US277	7
	S057A	Breckenridge	FM207	23
	S058A	Mason	FM386	14
	S059A	Denton	FM156	18
	S078A	Odessa	FM1936	6
	S081A	Loraine	FM644	8
	S085A	Pittsburg	FM557	19
	S096W	Brownwood	US67	23
	S107N	Baytown	SH146	12
	S107S		SH146	
	S112A	Childress	FM 268	25
	S128E	Lubbock	US84	5

(Continued)

TABLE 3.6. (Continued)

Group Number	Station Number	Location	Highway Designation	District Number
I	S112A	Childress	FM268	25
	S128E	Lubbock	US84	5
	S128W		US84	
	S136A	Perryton	SH15	4
	S137A	Tyler	Sh31	10
	S164E	Schulenburg	IH10	13
	S167N	Wichita Falls	US287	3
	S167S		US287	
	S174N	Humble	US59	12
	S181A	Brownsville	FM1792	21
II	A008S	Laredo	IH35	21
	A015A	La Grange	SH159	13
	A025E	Colorado City	IH20	8
	S003E	Cypress	US290	12
	S003W		US290	12
	S010A	Hearne	US79	17
	S014A	Sonora	IH10	7
	S014W		IH10	7
	S015A	Lampasas	US281	23
	S020A	Woodville	US69	20
	S023N	Haskell	US277	8
	S023S		US277	
	S033A	Cuero	US77A	13
	S036A	Crockett	US287	11

(Continued)

TABLE 3.6. (Continued)

Group Number	Station Number	Location	Highway Designation	District Number
II	S063A	Smithville	FM535	14
	S065A	Marlin	FM147	9
	S072A	Ft. Stockton	US285	6
	S086A	Silsbee	FM92	20
	S088A	Hamilton	FM218	9
	S096E	Brownwood	US67	23
	S116W	Victoria	US59	13
	S119A	Fredericksburg	SH16	14
	S125E	Houston	IH10	12
	S125E		IH10	
	S153E	Abilene	IH20	8
	S153W		IH20	8
	S160S	San Antonio	US181	15
	S173A	Pharr	US281	21
	S175N	Nacogdoches	US59	11
III	S013W	Sulphur Springs	IH30	1
	S037A	Anderson	SH90	17
	S040N	Corsicana	IH45	18
	S040S		IH45	
	S043A	Linden	US59	19
	S052A	Mason	US87	14
	S113A	Freeport	SH332	12
	S118N	Waco	IH35	9
	S118S		IH35	

(Continued)

TABLF 3.6. (Continued)

Group Number	Station Number	Location	Highway Designation	District Number
III	S134A	Archer City	US82	3
	S135A	Ballinger	SH158	7
	S145E	Terrell	IH20	18
	S145W		IH20	
	S150E	Marshall	IH20	19
	S150W		IH20	
	S151A		SH43	
	S164W	Schulenburg	IH10	13
	S180A	Seguin	SH123	15
IV	A020A	Italy	SH34	20
	S024A	Matador	SH70	25
	S026A	McKinney	SH5	8
	S027A	Denton	FM428	18
	S046A	Breckenridge	US183	23
	S047A	Albany	SH351	8
	S049A	Tulia	SH86	5
	S060A	Claude	SH207	4
	S077A	Gainsville	FM372	3
	S083A	Wills Point	FM47	10
	S084A	Bonham	FM271	1
	S121N	McKinney	US75	18
	S121S		US75	
	S133E	Terrell	US80	

(Continued)

TABLE 3.6. (Continued)

Group Number	Station Number	Location	Highway Designation	District Number
IV	S178A	Paris	US82	1
	S179A	Sulphur Springs	SH154	
V	A027E	Pharr	LP374	21
	A027W		LP374	
	S029A	Eagle Pass	US277	22
	S068A	Ozona	SH163	7
	S090A	Yorktown	FM240	13
	S143E	Pharr	US83	21
	S143W		US83	
	S159E	Mission	US83	
	S159W		US83	
VI	S001E	Shamrock	IH40	25
	S001W		IH40	
	S120E	Amarillo	US287	4
	S120W		US287	
	S150N		US87	
	S150S		US87	
VII	A017E	Galveston	IH45	12
	A017W		IH45	
	S006A	San Angelo	US67	7
	S076A	Jacksonville	FM747	10
VIII	A008N	Laredo	IH35	21
	A025W	Colorado City	IH20	8
	S007A	Marfa	US90	24

(Continued)

TABLE 3.6. (Continued)

Group Number	Station Number	Location	Highway Designation	District Number
VIII	S028A	Laredo	SH359	21
	S062A	Stamford	FM142	8
	S071A	Tilden	SH16	15
	S087A	Anahuac	FM562	20
	S097A	Falfurrias	US281	21
	S103A	Del Rio	US90	22
	S110A		US277	
	S11A	Uvalde	US90	
	S116E	Victoria	US59	13
	S160N	San Antonio	US181	15
	S174S	Humble	US59	12
	S175S	Nacogdoches	US59	11
IX	S013E	Sulphur Springs	IH30	1
	S016N	Jacksboro	US281	2
	S016S		US281	
	S044A	Henrietta	US82	3
	S133W	Terrell	US80	18

* Criteria for classification less than 20% variation among group members for 90% or more of all observations.

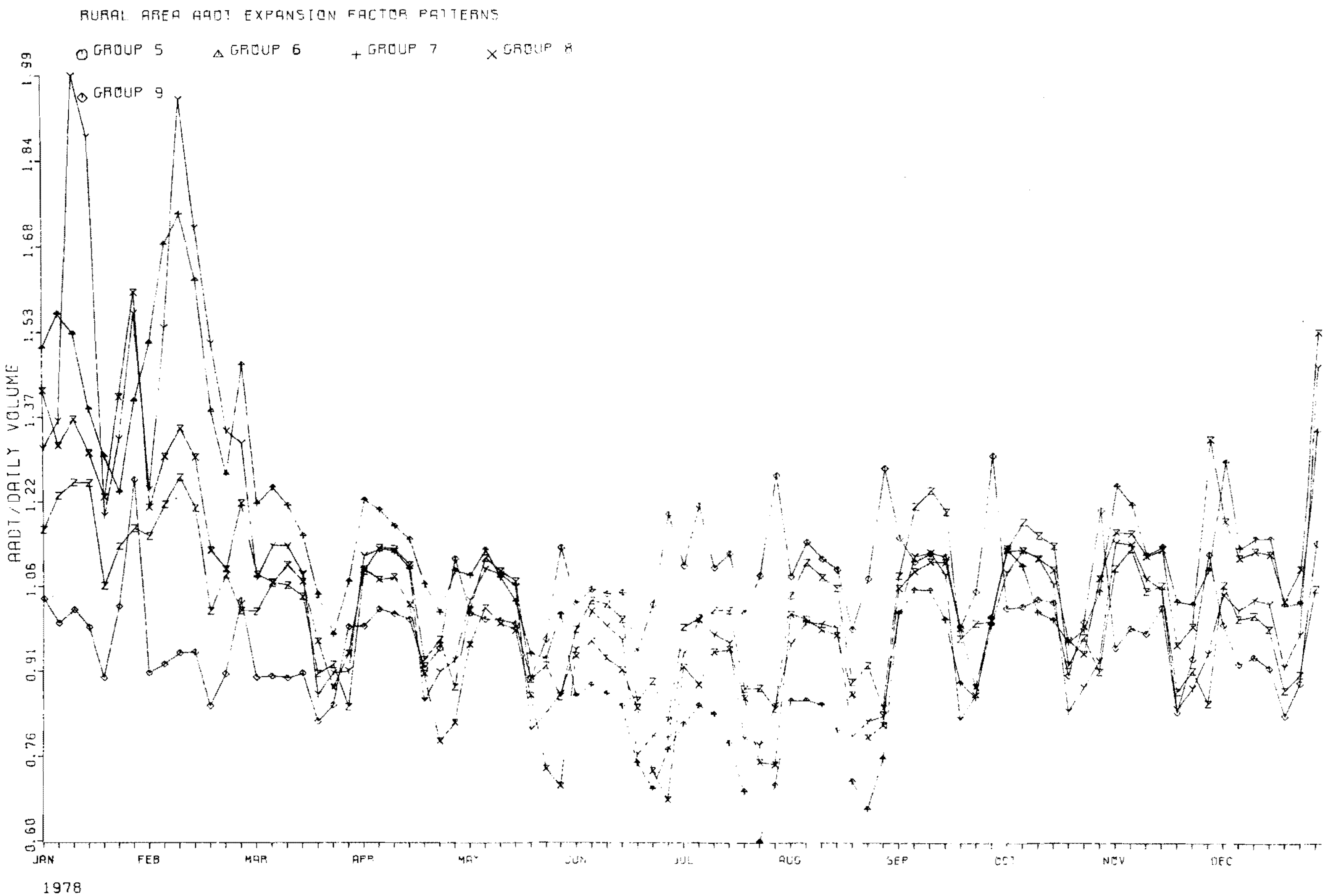

Figure 3.9. Timewise variation of AADT expansion factors by group by day of week and month of year for rural groups.

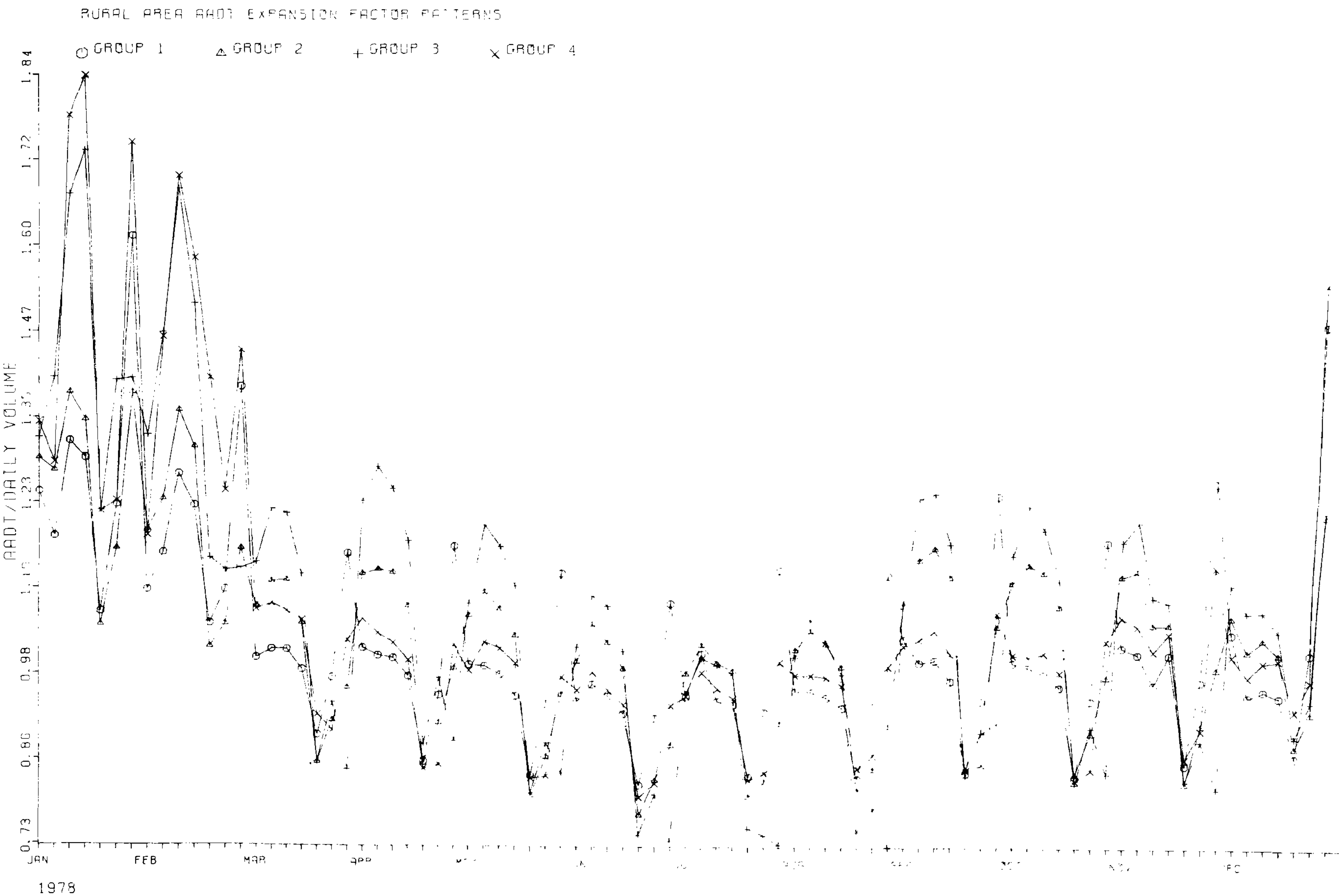

Figure 3.10. Timewise variation of AADT expansion factors by group by day of week and month of year for rural groups.

TABLE 3.7. GROUPING OF RURAL ATR STATIONS UTILIZING NON-PARAMETRIC METHODS AND TEN PERCENT VARIATION*

Group Number	Station Number	Location	Highway Designation
I	A005E	Marshall	US80
	A005W		US80
	A016N	Houston	IH45
II	A016N		IH45
	S174N	Humble	US59
III	A016S	Houston	IH45
	S174S	Humble	US59
IV	A025E	Colorado City	IH20
	S153E	Abilene	IH20
V	A027E	Pharr	LP374
	A027W		LP374
VI	S016N	Jacksboro	US281
	S016S		US281
VII	S018N	Abilene	US83
	S018S	Abilene	US83
VII	S020A	Woodville	US69
	S086A	Silsbee	FM92
IX	S143E	Pharr	US83
	S143W		US83

(Continued)

TABLE 3.7. (Continued)

Number	Number	Location	Designation
X	S159E	Mission	US83
	S159W		US83
XI	S167N	Wichita Falls	US287
	S167S		US287

* Criteria for grouping 10% variation among group members for 90% of all observations.

only eleven groups could be formed and all of these consist of only two members with the exception of Group I which contains three. If preservation of both members of all directional pairs is considered mandatory, only Groups I, II, III, and VIII could be considered to contain duplicates. One member of each of these four groups of two might be considered duplicates and could be considered for elimination.

The striking phenomenon observed in analysis of rural stations is the magnitude of timewise variation among virtually all members of the rural stations class. With a grouping criterion of 10% variation, very few stations could be grouped, and with a 5% grouping criterion, only 2 stations which are a directional pair could be grouped.

Methodology for Expansion Factor Selection

If the groups of Table 3.6 are related to geographic areas such as SDHPT districts and additionally related to highway systems, a technique for selection of expansion factors can be derived. An illustration of the relationship between ATR groups of Table 3.6 and districts and highway systems designations is provided in Table 3.8. This table indicates, for example, that the expansion factor to be utilized for production of an AADT volume from a 24-hour ACR count in District 2 on a US designated highway could be chosen from expansion factors of ATR stations in Group IX. Another representation of this relationship is provided in Table 3.9. This table indicates which districts contain stations belonging to each of the ATR groups of Table 3.6.

Conclusions and Recommendations

Separate analyses of ATR stations designated urban and designated rural have indicated significant timewise correlation among ATR stations. Parametric as well as non-parametric statistical testing procedures have been utilized to develop groups of ATR stations which have statistically significant similarities among group members. The analyses procedures indicate a significantly higher degree of similarity among urban stations than among rural stations.

Based upon the analyses of the preceding sections, the following recommendations are made.

TABLE 3.8. RELATIONSHIP OF RURAL STATION GROUPS TO SDHPT DISTRICTS AND HIGHWAY DESIGNATION

District Number	Highway Designation				
	IH	US	SH	LP	FM
1		G4	G4		G4
2		G9			
3		G1,G9		G4	
4	G6	G1			
5		G1	G4		
6	-	-	-	-	-
7		G1,G7	G5		
8	G2,G8	G1	G4		G1
9			G1		G2
10			G1		G7
11		G2,G8	G1		
12	G1	G2,G8	G1		
13		G2,G8	G1		
14		G3	G2		G1
15		G2,G3	G8		
16	-	-	-	-	-
17	G2	G3			
18	G3	G4,G9		G1	
19	G3	G1			G1

(Continued)

TABLE 3.8. (Continued)

District Number	Highway Designation				
	IH	US	SH	LP	FM
20		G2	G4		G2,G8
21	G8,G2	G5,G8	G8	G5	
22		G5			
23		G1,G2,G4			G1
24		G8			
25		G1	G4		

TABLE 3.9. RELATIONSHIP OF SDHPT DISTRICTS TO RURAL STATION GROUPS AND HIGHWAY DESIGNATION

Group	Highway Designation				
	IH	US	SH	LP	FM
G1	12	19,3,5 7,8,4 23,25	11,13,9 12,10	18	8,14 19,23
G2	8,17,21	11,12,13 15,23,20	14		9,20
G3	19,18	14,15, 17			
G4		1,18,23	1,5,8 20,25	3	1
G5		21,22	7	21	
G6	4				
G7		7			10
G8	8,21	11,12,13 21,24	21,15		20
G9		2,3,18			

(1) Although analyses of urban stations indicate high degrees of correlation among members of the groups created, no reduction in the number of urban stations is recommended. Probabilities of volume magnitude and pattern changes in the vicinity of urban areas is too large to allow a decrease in the level of effort in urban station activities.

(2) Should budgetary, new construction, or other constraints preclude continuation of those stations currently designated urban, the groups provided in Table 3.4 may be used to select stations for abandonment. At least one station in each group must be retained, and those groups having the smallest error ratio for the largest percentage of time would provide the best candidates for abandonment. The most reasonable grouping of rural ATR stations was obtained with a criterion of 20% variation among group members in 95% of the observations. This criterion is deemed sufficient for grouping but likely not sufficient for designating stations for exclusion from the system. A grouping criterion of 10% variation in 90% of the observations produced only 11 groups containing 23 stations. If no single member of a directional pair of stations is considered for elimination, this grouping would allow elimination of only four stations.

(3) Relationships between groups and geographic entities such as districts and highway systems may be utilized to choose AADT expansion factors for use in ACR counting. Such relationships have been derived and are presented in Table 3.8 and 3.9.

CHAPTER 4. VEHICLE CLASSIFICATION SURVEYS

Vehicle classification surveys are conducted by D-10 on a continuing basis to develop information regarding density of classes of vehicles for use in highway design and for use by the Environmental Protection Agency. These surveys have been conducted at 284 vehicle classification stations located in all 25 districts. A generalized flow chart of vehicle classification data acquisition is shown in Figure 4.1.

Procedures

The network of 284 vehicle classification stations represent primarily permanent locations which are designed to provide representative classification samples for all portions of highways within the state. The network is composed of control stations and coverage stations which have sampling durations of different lengths. For both types of stations, however, field personnel follow the same procedures which are described in detail in the Instructions for Manual Recorder.

As noted previously, all classification counts are currently made manually and 29 vehicle classifications are utilized with two minor exceptions. These 29 classes are exactly those suggested by the Federal Highway Administration in their manual entitled "Guide for Truck Weight Study Manual"(Transmittal 107, Appendix 51).

Control Stations. A comprehensive study of all districts led to the designation of stations in Districts 8, 11, 14, 16, 18, and 22 as control stations. Classification surveys are conducted at each control station once each season for a 24-hour period. Since one technician in each control district is normally involved in the classification surveys, the 24-hour sampling period may be scheduled as follows:

Monday	Midnight to 8:00 a.m.
Monday	4:00 p.m. to Midnight
Tuesday	8:00 a.m. to 4:00 p.m.

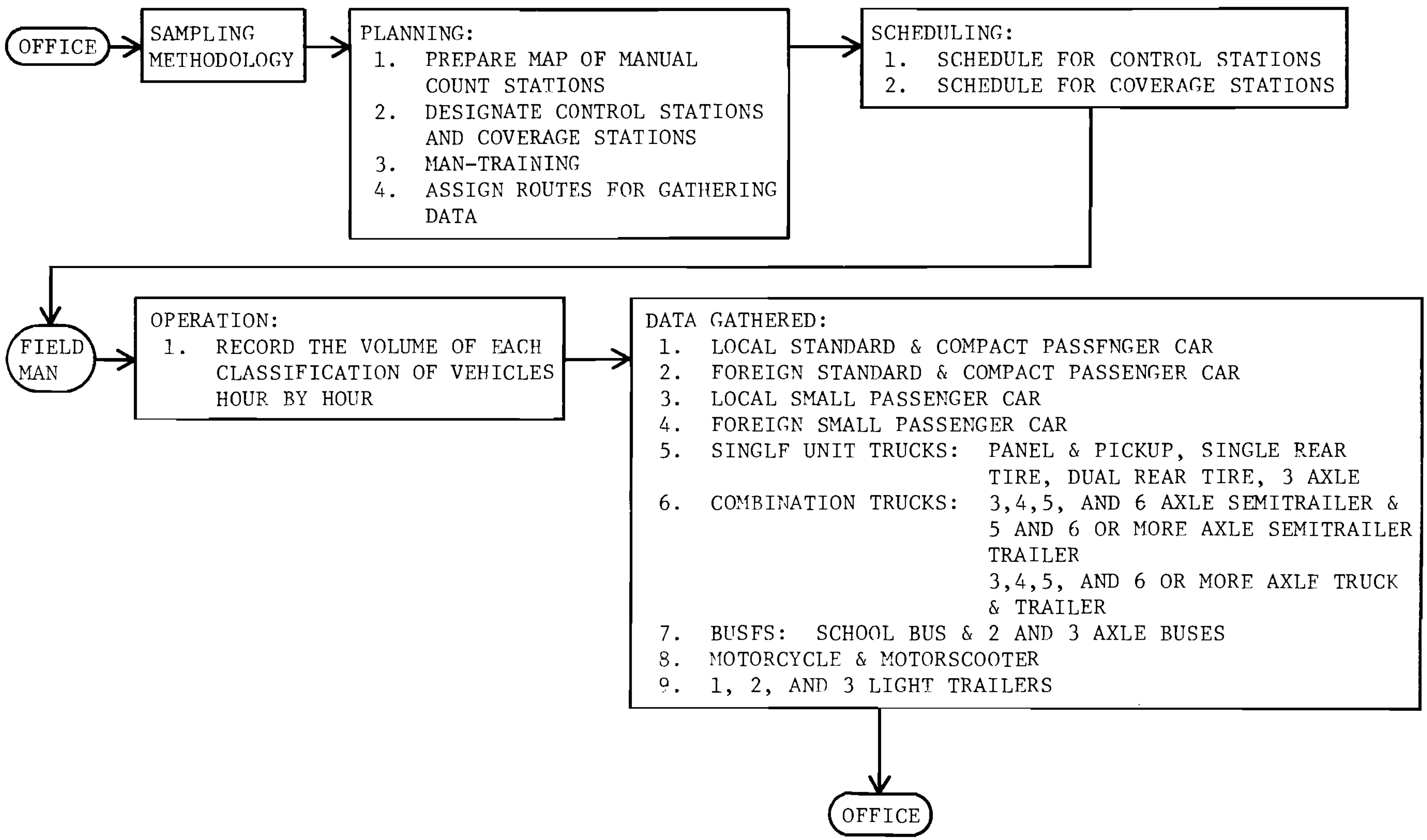

Figure 4.1. Flow-chart of vehicle classification data acquisition program.

After completion of the 24-hour surveys, the district technician sends the worksheet to D-10 for processing. A D-10 technician compiles a yearly summary of quarterly classification totals for each station. Utilizing the quarterly survey data and an annual average daily traffic volume figure (obtained from D-10's volume count section), an annual average volume is computed for each class of vehicles at each station. This value is later used to factor coverage count data and is the value reported for each respective station for each vehicle class. The annual average is computed as follows:

$$AA = WK\left(\frac{AADT}{\Sigma WK}\right)$$

where

AA = Annual Average

WK = $ave_{12m-8am} + ave_{8am-4pm} + ave_{4pm-12am}$

$AADT$ = Annual Average Daily Traffic (obtained from D-10 volume count section)

$\frac{AADT}{\Sigma WK}$ = Adjusting Factor

Computation of this annual average figure may be exemplified using the numbers from Figure 4.2 or local passenger cars as follows:

$$\begin{aligned} AA &= WK\left(\frac{AADT}{\Sigma WK}\right) \\ &= (109 + 222 + 310)\left(\frac{1220}{1108}\right) \\ &= 706 \end{aligned}$$

<u>Coverage Stations</u>. Classification survey stations in districts other than 8, 11, 14, 16, 18, and 22 are designated coverage stations and are operated for shorter time durations than control stations. While control

stations are operated for a complete 24-hour cycle each quarter of each year, coverage stations are operated for 16-hour periods during only one season of every other year. A team of 12 temporary summer employees is hired every other summer to conduct classification surveys at the coverage stations. The 12 work in teams of 2 employees each and a different path of coverage stations is assigned by D-10 to each of the 6 teams. Each 2-person team is assigned two contiguous 8-hour shifts to provide 16 hours of data at each station. The first shift runs from 6:00 a.m. until 2:00 p.m., while the second begins at 2:00 p.m. and ends at 10:00 p.m. Surveys are normally conducted during 4 weekdays and each team is allowed a three day rest period following these 4 working days. Each team normally requires 20 working days to conduct the assigned surveys for its coverage station.

After completion of the surveys, worksheets are sent to D-10 for processing. The D-10 technician expands 16-hour survey data into 24-hour data which is basically comparable to that from the control stations by dividing the 16-hour totals for each class by 0.9. The factor of 0.9 is utilized based on empirical studies which show that 90% of daily traffic volume passes the average control station during the hours of 6:00 a.m. and 10:00 p.m. The technician chooses a control station with similar physical and traffic characteristics as that of the coverage station under consideration and uses that station's adjusting factor to produce annual average volume totals for each class for each coverage station.

Publications. Two documents are generated as basic reporting items for classification information. The primary reporting document is a computer printed report which is exemplified in Figure 4.3. This report includes a list and explanation of locations for all counting stations and a station-by-station summary of annual average counts by each class of vehicle for each station. This document is printed annually for all count stations including control and coverage stations. A large scale map is also available for identifying station locations on the ground. The complete computer printout of numbers of vehicles by classification type by station is used by D-10 future traffic section as well as other departmental users, FHWA, and the Environmental Protection Agency as required.

Costs for the fiscal year September 1, 1977 - August 31, 1978, vehicle classification surveys were allocated $179,936. A large portion of this cost was that of field data acquisition which includes salaries, equipment

YEAR 1977 DATE	DAY	PASSENGER CARS LOCAL	PASSENGER CARS FOREIGN	SINGLE UNIT PANEL AND PICKUP	OTHER 2 AXLE SINGLE REAR	OTHER 2 AXLE DUAL REAR	3 AXLE	TRACTOR TRUCK SEMI-TRAILER 3 AXLE	4 AXLE 2S2	4 AXLE 3S1	5 AXLE	6 AXLE	SEMI-TRAILER TRAILER 5 AXLE	SEMI-TRAILER TRAILER 6 AXLE	TRUCK & TRAILER 3 AXLE	TRUCK & TRAILER 4 AXLE	TRUCK & TRAILER 5 AXLE	TRUCK & TRAILER 6 AXLE	BUSES SCHOOL	BUSES OTHER 2 AXLE	BUSES OTHER 3 AXLE	MOTORCYCLES - MOTORSCOOTERS	TOTAL	LIGHT TRAILERS 1 AXLE PASS.	1 AXLE P-P	2 AXLE PASS.	2 AXLE P-P	3 AXLE PASS.	3 AXLE P-P
12M. — 8AM: 2-9	W	224	7	83	—	11	2	1	3	—	60	—	—	—	—	1	—	—	1	—	1	—	394	—	—	—	—	—	2
[illegible]	W	338	4	156	—	30	—	—	—	—	100	—	—	—	—	—	—	—	—	—	—	2	630	—	—	—	—	—	—
[illegible]	W	289	19	143	—	21	1	4	9	—	88	—	—	—	—	—	—	—	—	—	2	4	580	—	2	2	2	—	—
[illegible]	W	283	11	153	2	21	4	2	5	—	71	—	—	—	—	—	1	—	1	1	1	1	559	2	2	—	3	—	—
TOTAL		1124	41	535	2	83	7	7	17	—	319	—	—	—	—	1	1	—	2	1	4	7	2161	2	4	2	5	—	2
AVERAGE		283	10	134	1	21	2	2	4	—	79	—	—	—	—	—	—	—	1	—	1	2	540	1	1	1	1	—	1
8AM — 4PM: 2-11	Th	942	9	266	2	69	17	3	19	—	103	3	1	—	2	5	—	—	—	1	2	—	1566	3	6	2	11	—	—
4-12	W	1127	54	211	16	86	27	6	19	1	88	3	—	—	—	4	4	—	2	—	8	6	1926	9	12	2	20	—	—
5-3	Th	1252	77	348	7	72	46	11	19	—	143	—	1	1	1	—	—	—	—	—	6	14	2048	11	10	4	18	—	—
10-11	Tu	1143	64	459	9	96	36	9	22	—	91	3	1	—	1	2	2	1	2	—	9	4	1741	13	7	4	24	—	1
TOTAL		4516	244	1614	27	303	126	29	79	1	431	9	3	1	4	11	6	1	4	1	23	24	7481	36	35	13	73	—	1
AVERAGE		1129	61	403	7	76	31	7	20	1	108	2	1	1	1	2	2	1	1	—	6	6	1870	9	9	3	18	—	—
4PM — 12M: [illegible]	F	1641	42	[illegible]	—	43	4	5	3	—	67	—	3	—	1	1	—	—	3	—	5	2	2234	13	6	3	7	—	
[illegible]	Th	976	40	[illegible]	5	25	6	4	4	—	77	—	—	—	—	2	1	—	—	1	5	11	1519	5	5	2	25	—	—
[illegible]	Tu	1172	[illegible]	[illegible]	3	32	5	2	4	—	93	2	—	—	2	2	—	—	—	—	6	14	1748	21	18	—	17	—	—
[illegible]	F	2252	74	629	2	50	5	2	12	—	71	2	1	—	—	4	—	—	1	1	5	11	3122	13	29	3	25	—	—
TOTAL		5974	223	1817	10	160	20	11	32	—	300	4	4	—	3	11	1	—	3	2	21	38	8644	51	58	8	72	—	—
AVERAGE		1493	58	454	3	40	5	3	8	—	75	1	1	—	1	3	—	—	1	1	5	9	2161	13	15	2	18	—	—
24 HR. WK. DAY		2964	134	991	11	139	72	12	32	1	262	3	2	1	2	5	2	1	2	1	12	19	4571	23	25	6	37	—	1
24 HR. SAT.																													
24 HR. SUN.																													
ANNUAL AVE.		2199	139	1023	12	140	39	12	33	1	271	3	2	1	2	6	2	1	3	1	12	18	4720	24	26	6	38	—	1

(14)

FILE 10.126

4770

Figure 4.2. Example of typical field sheet.

LOCATION OF MANUAL COUNT STATIONS FOR 1977

RURAL STATIONS

M-1062	SHELBY	US 84 - AT LOUISANA STATE LINE *
M-1063	PANOLA	US 79 - NORTHEAST OF DEBERRY
M-1064	CASS	US 59 - NORTH OF ATLANTA
M-1065	BOWIE	IH 30 - WEST OF TEXARKANA
M-1066	BOWIE	SH 8 - NORTH OF NEW BOSTON
M-1067	BOWIE	US 259 - NORTHWEST OF DEKALB
M-1068	LAMAR	US 271 - NORTH OF PARIS
M-1069	FANNIN	SH 78 - NORTH OF BONHAM
M-1070	GRAYSON	US 69 & 75 - NORTH OF DENISON
M-1071	GRAYSON	US 377 - NORTH OF WHITESBORO
M-1072	COOKE	IH 35 - NORTH OF GAINSVILLE
M-1073	MONTAGUE	US 81 - NORTH OF RINGGOLD
M-1074	CLAY	SH 79 - NORTHEAST OF BYERS
M-1075	WICHITA	US 277 & 281 - NE OF BURKBURNETT
M-1076	WILBARGER	US 283 - NORTH OF VERNON
M-1077-A	CHILDRESS	US 62 - NORTHEAST OF CHILDRESS
M-1078	LIPSCOMB	US 60 - NORTHEAST OF HIGGINS
M-1079	OCHILTREE	US 83 - NORTH OF PERRYTON
M-1080	SHERMAN	US 54 - NORTEAST OF STRATFORD
M-1081	DALLAM	US 287 - NORTHWEST OF STRATFORD
M-1082	DALLAM	US 87 - NORTHWEST OF DALHART
M-1083	OLDHAM	IH 40 - WEST OF ADRIAN
M-1084	PARMER	US 60 - NORTHEAST OF FARWELL
M-1085	BAILEY	US 84 - NORTHWEST OF MULESHOE
M-1086	ANDREWS	SH 115 & 176 - SOUTHWEST OF ANDREWS
M-1087	HUNT	US 69 & FM 2194 - NW OF GREENVILLE
M-1088	RED RIVER	US 271 & FM 410 - NORTHWEST OF BOGATA
M-1089	WISE	US 287 & FM 407 - SE OF DECATUR
M-1090	HOOD	US 377 & FM 208 - SOUTHEAST OF ACTON
M-1091	PALO PINTO	SH 16 & 254 - WEST OF GRAFORD
M-1092	JACK	US 281 & SH 199 - NW OF JACKSBORO
M-1093	OCHILTREE	US 83 & SH 70 - SOUTH OF PERRYTON
M-1094	DEAF SMITH	US 385, FM 1057 & 1062 - SOUTH OF VEGA
M-1095	PARMER	SH 86 & 214 - SOUTH OF FRIONA
M-1096	HALE	US 70 & FM 789 - EAST OF PLAINVIEW
M-1097	LUBBOCK	US 87 & FM 41 - SOUTH OF LUBBOCK
M-1098	MIDLAND	SH 349 & FM 1213 - SOUTH OF MIDLAND
M-1099	MIDLAND	US 80 - SOUTHWEST OF MIDLAND
M-1100	ECTOR	SH 302, SH 158 & FM 181 - NW OF ODESSA
M-1101	WARD	SH 18 & FM 1776 - SOUTH OF MONAHANS
M-1102	UPTON	US 67 & SH 349 - SOUTHWEST OF RANKIN
M-1103	GLASSCOCK	SH 158 & 137 - WEST OF GARDEN CITY
M-1104	COKE	SH 208 & FM 2034 - SOUTH OF ROBERT LEE
M-1105	HOWARD	SH 350 & FM 820 - NE OF BIG SPRING *
M-1106	NOLAN	US 84 & FM 1982 - NW OF ROSCOE *
M-1107	JONES	US 83 & FM 540 - NORTH OF HAMLIN *
M-1108	SHACKELFORD	US 180 & SH 6 - EAST OF ANSON *
M-1109	CORYELL	US 84 & FM 1996 - WEST OF MCGREGOR
M-1110	BELL	US 190 - NOLAN CREEK, E OF NOLANVILLE
M-1111	MCLENNAN	US 77 & FM 2643 - NORTH OF CHILTON

* Control Manual Count Station

Figure 4.3. Example of computer-produced classification report.

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
1977 ANNUAL AVERAGE DAILY NUMBER OF VEHICLES FOR EACH TYPE OF VEHICLE AT SPECIFIED STATIONS
RURAL STATIONS

* STATION NUMBER * & * HIGHWAY * TYPE OF VEHICLE *	M-1139				M-1140			M-1141				M-1142		
	FM-390	SH-36	FM-390	SH-36	US-290	CO.RD.	US-290	FM-1774	SH-105	FM-1774	SH-105	US-190	FM-2296	US-190
	NE	SE	SW	NW	E	S	W	N	E	SE	W	E	S	W
PASSENGER CARS														
TEXAS	173	2276	176	2448	3397	130	3371	274	935	760	1099	1909	368	1846
OUT OF STATE	1	65	2	68	57	1	55	1	25	2	26	39	2	41
TOTAL PASSENGER CARS	174	2341	178	2516	3454	131	3426	275	960	762	1125	1948	370	1887
TRUCKS														
SINGLE UNIT														
PANEL AND PICKUP	138	1096	142	1092	1307	108	1280	251	456	650	567	1037	298	943
OTHER 2-AXLE	18	164	9	175	188	23	206	34	95	88	106	159	96	149
3-AXLE	1	12	2	15	54	-	52	-	7	2	8	37	3	44
TOTAL SINGLE UNIT	157	1279	153	1282	1549	131	1539	285	558	740	681	1233	397	1136
COMBINATIONS														
SEMI-TRAILER														
3-AXLE	16	35	-	19	43	-	41	3	12	2	17	17	-	18
4-AXLE (2S2)	-	27	-	27	66	-	63	-	22	3	24	35	21	16
4-AXLE (3S1)	-	-	-	-	1	-	1	-	-	-	-	-	-	-
5-AXLE	16	587	12	616	842	4	811	5	110	14	124	154	55	107
6-AXLE	-	-	-	-	7	-	7	-	-	-	-	6	-	6
SUB-TOTAL	32	649	12	662	959	4	923	9	144	19	165	212	76	147
SEMI-TRAILER - TRAILER														
5-AXLE	-	1	-	1	6	-	5	-	-	-	-	-	-	-
6-AXLE OR MORE	-	1	-	1	-	-	-	-	-	-	-	-	-	-
SUB-TOTAL	-	2	-	2	6	-	5	-	-	-	-	-	-	-
TRUCK & TRAILER														
3-AXLE	-	8	-	8	5	1	5	1	3	5	6	11	3	9
4-AXLE	1	6	3	4	11	-	11	2	6	5	5	6	-	6
5-AXLE	2	9	1	8	6	-	5	3	-	9	5	7	-	7
6-AXLE OR MORE	-	-	-	-	1	-	1	-	-	-	-	-	-	-
SUB-TOTAL	3	23	4	20	23	1	22	6	9	19	16	24	3	22
TOTAL COMBINATIONS	35	674	16	684	988	5	950	15	153	38	181	236	79	169
TOTAL TRUCKS	192	1952	169	1966	2537	136	2488	300	711	778	862	1469	476	1305
BUSSES														
2-AXLE	4	14	3	15	18	4	22	3	3	7	7	4	3	7
3-AXLE	-	1	-	1	17	7	9	-	-	-	-	1	-	1
TOTAL BUSSES	4	15	3	16	35	11	31	3	3	7	7	5	3	8
MOTORCYCLES & MOTORSCOOTERS	-	12	-	12	14	2	15	2	6	3	6	9	1	10
TOTAL 24-HOUR AADT	370	4320	350	4510	6040	280	5960	580	1680	1550	2000	3430	850	3210

Figure 4.3. (Continued)

rental, mileage, and per diem for field personnel which normally averages $90 per day.

Conclusions and Recommendations

The Federal Highway Administration Highway Planning Program Manual, Volume 4, Chapter 2, dated 23 September 1971, provides a suggested set of guidelines for determining a minimum number of classification stations for an average state. These guidelines are as follows:

Rural

Interstate	- 1 Station per 50 miles
FA Primary	- 1 Station per 200 miles
FA Secondary	- 1 Station per 500 miles

Urban

Interstate	- (including FA Primary) 1 Station per 25 miles
FA Secondary	- 1 Station per 25 miles

If this general guideline is applied to the state of Texas, the number of suggested classification stations would significantly exceed the 284 now used. With this fact in mind and the fact that the state is undergoing dramatic growth and dramatic increases in commercial vehicle traffic, a reduction in the number of stations from the current 284 does not seem wise. On these bases, continued operation of the current network of classification count stations is recommended.

The currently utilized assumption that 90% of the daily traffic at classification stations passes between the hours of 6:00 a.m. and 10:00 p.m. was verified through analysis of ATR data. Hourly traffic volumes for all ATR stations for the last six months of 1978 were analyzed to determine the overall percentage of daily traffic arriving during the sixteen hour period. During this six month time span, over 817 million vehicles were counted at the ATR stations and, of this number, 89.24% passed during the hours of 6:00 a.m. and 10:00 p.m. Therefore, it is additionally recommended that use of a .90 factor for converting sixteen hour classification counts to twenty-four hour classification counts be continued.

CHAPTER 5. SPEED MONITORING

Concerted speed monitoring efforts began during World War II with the advent of federally mandated restrictions. In 1945, 24 permanent count locations were selected for speed surveys which were to be conducted once each year. This basic sampling scheme was maintained through 1975 when 29 survey locations were monitored, although through the 30 year period, minor location changes were brought about by re-routing and/or construction.

Federal legislation which mandated the 55 mph speed limit in 1975 also carried with it requirements for a monitoring procedure to check compliance with the new speed limit. Beginning with the month of March 1975, 8 locations were monitored each month as well as the regular 29 locations during the summer of 1975. Beginning in 1976, a monitoring system consisting of 10 control stations and 22 randomly selected stations was implemented. Under this scheme, each of the 32 locations is monitored during each of the 4 quarters of each year. Although this program continues at the present time, implementation of the highway performance monitoring system by FHWA and revised legislation regarding national monitoring of the 55 mph speed limit may alter this program.

Collection Locations

The sampling procedures currently used for the speed monitoring program reuqire that all highway miles within the state be categorized into 5 different groups and that links of highway in each group be specified in lengths as required by the FHWA Procedural Guide. Categories, links, and numbers of stations are shown in Table 5.1. Under this scheme, speed surveys are conducted at the same 10 control stations every quarter. However, a random selection technique is utilized to select the location of 22 non-control stations for each quarter's efforts. Standard mileposts are utilized wherever possible to specify ground positions of count stations.

Procedures

One D-10 supervisor schedules and generally coordinates speed survey activities. A conceptual activity flow chart is included as Figure 5.1. As

TABLE 5.1. SPEED MONITORING SURVEY STATIONS

Highway Category	Length	Control Stations	Non-Control Stations
Interstate Urban	25	2	3
Interstate Rural	25	2	3
Multi-lane, Non-Interstate	100	2	4
Multi-lane (Divided) Non-Interstate	25	1	4
2-lane (Undivided) Rural	150	3	8
Total		10	22

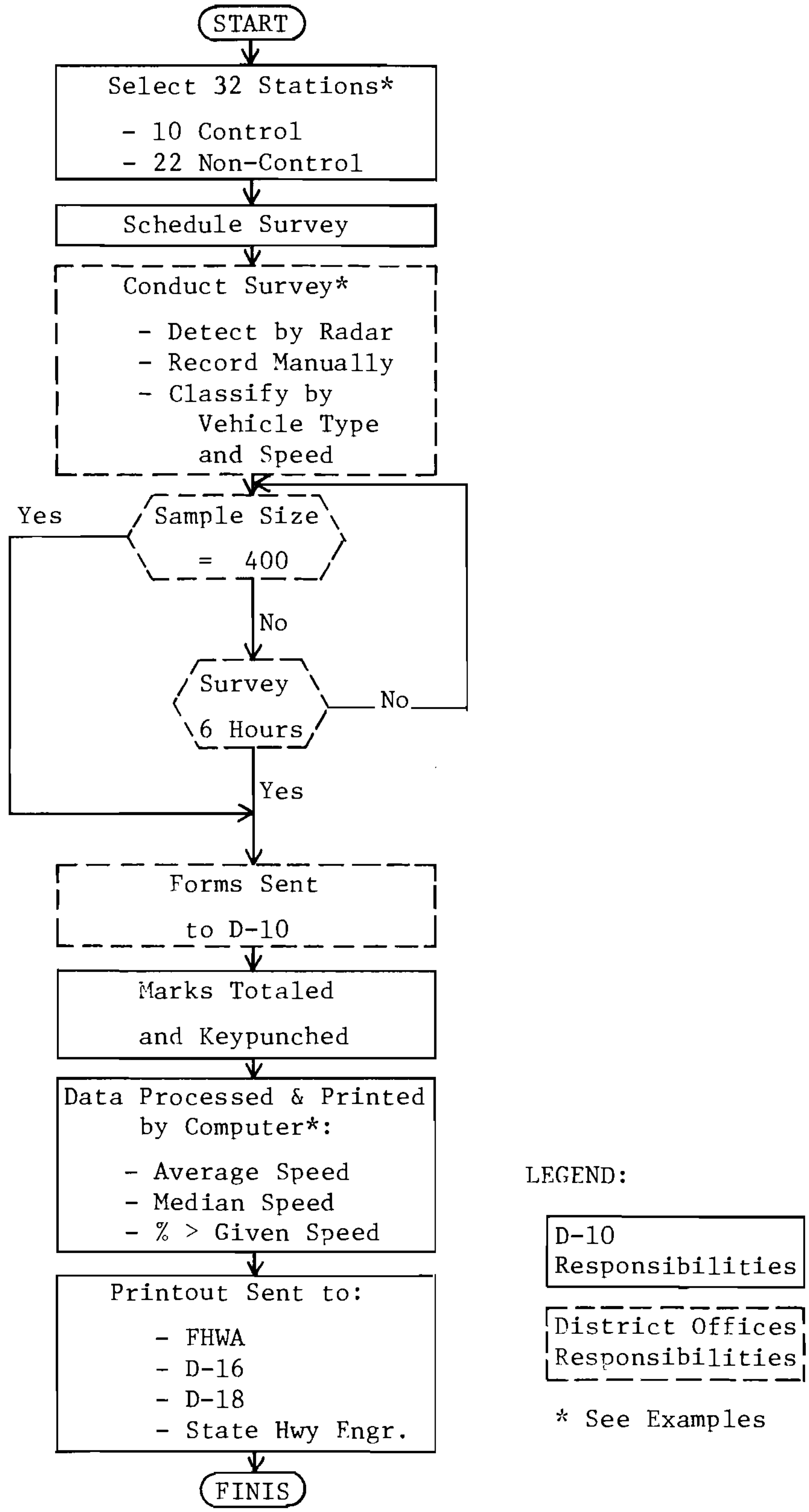

Figure 5.1. Conceptual flow of speed data acquisition process.

shown in the flow chart the D-10 technician sends letters and maps to the district responsible for the chosen stations requesting that the districts conduct the speed surveys on specified highway segments. The district then schedules one technician to gather speed data at each required station. The technician utilizes a district-owned radar speed meter to detect speed and then manually tallies each vehicle by speed and classification (see Figure 5.2).

The technician attempts to gather speed data for all free-flowing vehicles passing the station until he has collected data for 400 vehicles or until 6 hours have elapsed. The technician totals the tallies and sends the speed data collected to D-10. After checking the totals, the data is keypunched and processed by computer. A summary is produced for each station and for all stations monitored during the quarter, examples of which are shown in Figure 5.3.

Publications

In addition to the quarterly reports, an annual report is prepared for the state's certification of the 55 mph speed limit enforcement, which includes a map of all locations monitored, and speed data summaries of data collected during a twelve-month period. The quarterly and annual reports are transmitted to FHWA, the administration, and other departmental divisions.

Costs

For the fiscal year September 1, 1977 - August 31, 1978, a total of $20,575 was allocated to speed monitoring efforts. These costs include time for the D-10 technicians and time, mileage, and per diem charged to the D-10 operation by district personnel. The D-10 technician normally spends about 5 to 10 workdays per month scheduling, coordinating, and reporting on speed monitoring activities.

Recommendations

The needs assessment discussed earlier indicates that very little use of speed survey data is made within the department. Based on those identified needs, it would appear that the speed monitoring effort should be kept to the minimum level required by federal statutes. The existing program is

Tally Sheet

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION
TRANSPORTATION PLANNING DIVISION
SPEED SURVEY

File 10.99

Station #2 Date 8-15-78

0 0 2 7 8
1 2 3 4 5

County Travis Highway IH35 Location 12 miles south of Austin

Time: From 9:00 To 10:15 Weather Clear Surface Type [illegible] Surface ~~(Wet)~~ (Dry) and (Smooth) ~~(Rough)~~

MILES PER HOUR	Passenger Cars	Single Unit Trucks: Panel Pickup	Single Unit Trucks: Other	Combinations: 3-Axle	Combinations: 4-Axle or more	Buses
Over 80						
80	1				1	
78	2	2			1	
76	1	2			1	
74	4	–			1	
72	7	1			1	
70	13	2			1	
68	16	4			5	1
66	22	7		1	3	
64	23	9	2	–	8	
62	42	10	3	1	12	
60	33	12	2	–	6	
58	45	12	3	1	4	
56	21	7	4	–	2	
54	13	8	–	–	1	
52	7	2	1	1		
50	6	–				
48	2	–				
46	3	1				
44						
42						
40						
38						
36						
34						
32						
30						
28	Category — 02	Axle —	06			
26						
24	Duration — 1.3	Date —	081578			
22						
20						
Under 20	(361)	(77)	(15)	(4)	(47)	(1)

Remarks: Checked radar with Tuning fork before & after set up

Recorder: [illegible]

407

Figure 5.2. Example speed tally sheet.

TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
TRANSPORTATION PLANNING DIVISION

MONITORING OF SPEED

(STATISTICAL SUMMARY)
(FREE FLOW)

QUARTERLY REPORT--CALENDAR QUARTER ENDING - DEC 31, 1979

	*MILES	NUMBER OF MONITOR LOCATIONS	NUMBER OF VEHICLES MEASURED	DURATION OF MEASUREMENT SESSION (HOURS)	AVERAGE SPEED (MPH)	MEDIAN SPEED (MPH)	85TH PERCENTILE SPEED (MPH)	PERCENT OF MOTORISTS EXCEEDING 55 MPH	60 MPH	65 MPH
INTERSTATE URBAN	690	8	3988	7.5	56.7	57.8	63.7	62	22	6
INTERSTATE RURAL	2,250	5	2422	14.9	59.2	60.2	66.1	75	40	13
MULTI-LANE, NON-INTERSTATE										
DIVIDED	3,460	7	3013	13.5	58.3	59.7	65.7	70	35	12
UNDIVIDED	1,800	6	2334	20.3	58.9	59.7	67.8	71	35	19
2-LANE RURAL	51,800	11	3777	52.8	56.7	58.1	65.0	63	27	11
STATE TOTALS	60,000	37	15534	109.0	57.7	58.8	65.5	67	31	12

* Estimated mileage in each highway category zoned at 55 MPH

Figure 5.3. Example of quarterly statistical summary of observed speeds.

TEXAS STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
TRANSPORTATION PLANNING DIVISION

SPEED MONITORING STATION SUMMARY   DATA QUARTER ENDING - DEC 31, 1979

HIGHWAY CATEGORY - INTERSTATE RURAL

STATION NUMBER - 422   LOCATION - IH-37 4 MILES SOUTH OF MATHIS IN SAN PATRICIO CO.

NUMBER OF SESSIONS - 1 DATE - 12/12/79   VEHICLES MEASURED - 513

AVERAGE SPEED (MPH) - 60.9   STANDARD DEVIATION (MPH) - 6.4

MEDIAN SPEED (MPH) - 61.6   85TH PERCENTILE SPEED (MPH) - 67.9

PERCENTAGE OF VEHICLES EXCEEDING □

55 MPH - 85   60 MPH - 46   65 MPH - 22

HIGHWAY CATEGORY - INTERSTATE RURAL

STATION NUMBER - 423   LOCATION - IH-45 1 MILE NORTH OF FM-1097 IN MONTGOMERY CO.

NUMBER OF SESSIONS - 1 DATE - 12/06/79   VEHICLES MEASURED - 411

AVERAGE SPEED (MPH) - 57.5   STANDARD DEVIATION (MPH) - 4.7

MEDIAN SPEED (MPH) - 58.3   85TH PERCENTILE SPEED (MPH) - 62.9

PERCENTAGE OF VEHICLES EXCEEDING □

55 MPH - 63   60 MPH - 24   65 MPH - 6

Figure 5.3. (Continued)

basically the minimum which would be allowed under federal statutes and so represents a proper level of effort.

As HPMS and/or other federal requirements necessitate modification of the existing program, the low level of needs for speed data within the department must continue to be considered. All efforts should be made to minimize the type and quantity of speed data collected unless new needs for data are identified.

CHAPTER 6. TRUCK WEIGHT SURVEY PROGRAM

For nearly four decades, directional truck weight surveys were made at 21 carefully selected roadside sites in Texas by systematically stopping trucks and weighing all the wheels on the right-hand side of each truck with a portable wheel-load weigher. After 1967, however, the survey schedule was reduced to sampling for a total of 24 hours each year during three summer months at each station. Then in 1972, primarily because of cost and personnel considerations, sampling was discontinued at 11 of the stations. Annual sampling during June, July, and August continued at the remaining 10 stations until 1975.

A comprehensive study of truck weight characteristics made in 1974-75 by Machemehl, Lee, and Walton (Ref 4) indicated that the 21 original stations could be arranged into six groups in such a way that no statistically significant difference would be expected between weight data from any two stations in the same group. Thus, it was possible to sample at only six stations and obtain truck weight data of at least equal quality to that which had been obtained previously from 21 stations.

Also by 1975, new in-motion weighing equipment had been developed through research sponsored by the Department to a stage that it could be used to replace the wheel-load weighers, and static weighing was no longer necessary. With the new equipment, it was feasible to weigh each wheel of a truck as it traveled at normal speed in an instrumented highway lane, measure vehicle speed, calculate axle spacing, and record these and other associated data on computer-compatible magnetic tape. Around-the-clock measurements were possible with only one operator at a time required at the site. The instrument system was mounted in a vehicle and, thus, could be conveniently moved from site to site.

Recommendations in the report by Machemehl, et. al. (Ref 4) were that the in-motion weighing system by used for continuous 7-day surveys in each direction during each season at each of six sites during the first year of operation to define any timewise or directional variability in vehicle weight patterns at a particular location. Only a limited amount of seasonal data had been obtained since 1967, and there was a need to determine the significance of this variable. Analysis of these data would then allow proper scheduling of future surveys at each site.

Six sites were discretionarily chosen, one from each group, in 1975, and a sampling program using in-motion weighing was begun. Installations were made at five sites over the state immediately, but road construction near Lubbock has delayed the sixth installation until now. Manpower, availability and budget considerations made it necessary to limit the operational schedule to one week per month; thus, each station could be occupied twice per year for one week at a time. Travel time and overtime restrictions on personnel dictated that sampling should begin on Monday morning and continue until Friday afternoon if necessary to obtain a minimum of 500 vehicle weight records. Because the in-motion weighing system was capable of handling data from only one lane at a time, sampling was restricted to one direction only. Data have been obtained on this basis at five sites for the past five years.

During this time. significant improvements have been made in the weigh-in-motion (WIM) instrumentation, and the Department's present system that first became operable in 1969 has reached advanced obsolescence. Recently completed action has been taken to replace the old WIM system--it was, incidentally, the first of its kind in the world--with a modern version. The new system features improvements such as microprocessor computation, cathode ray tube display of the two most recently observed truck records, on-site analog-to-digital conversion, immediate computation of wheel weight, axle weight, gross weight, axle spacing, vehicle length, vehicle type, and speed, and perhaps most important, the ability to handle data from two lanes simultaneously. Data are recorded on floppy discs in digital format in such a way that all records can be transmitted directly from the instrument van to the Department's computer in Austin over telephone lines. The new system is expected to provide simpler and more reliable operation, more efficient data handling, and extended capability for directional sampling of truck weight and dimension data.

Weight and Size Data Needs

New highway facilities must be planned and designed to accommodate the vehicles which will use them in future years, and existing facilities must be maintained so that continuous, efficient, safe service is provided. Factual information concerning the weight and size of the vehicles serves as the primary basis for making many legal, policy, financial, and technical decisions related thereto. The Transportation Planning Division, D-10, has responsibility for conducting surveys, analyzing the data, keeping traffic records, and forecasting future traffic on all highways in Texas; vehicle weight and size information is an important part of this responsibility.

The present truck weight survey program in Texas serves the needs of the Federal Highway Administration for reporting annual statistical data as part of the cooperative engineering and economics investigations which have been ongoing for many years at the State and National levels. Survey data are processed locally into a standard format and forwarded on digital magnetic tapes to FHWA for summary and analysis.

The primary use that is made in Texas of truck weight and size data is in the structural design of pavements. It is not possible to design an efficient, safe, economical pavement structure without first having a good estimate of the loading to which it will be subjected. The loading needs to be defined in terms of the magnitude of wheel or axle loads, the number of repetitions of various magnitudes of load with respect to time, and the placement of the load--at least by direction, and preferably by the highway lane. Texas has been a national leader in pavement research. Full benefits from the improved pavement design and management techniques which have been developed over the years cannot be realized unless very good forecasts of expected traffic loading can be made readily available to the design engineers. The traffic survey program of D-10 must be structured to provide such information.

Pavement and bridge maintenance management requires not only a forecast of future traffic at the time of design, but also a current record of the traffic loading which has already been imposed on each particular section of roadway. Remaining structural life can be estimated from these and other parameters, and timely arrangements can be made for maintenance, repair, or rehabilitation. D-10 must, therefore, keep adequate records of sampled truck weight and size information on a continuing section-by-section basis. These historical records also serve as a basis for assessing the potential effects of changes in weight and size regulations in Texas.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

An analysis of current D-10 traffic data acquisition procedures as well as an assessment of user needs for traffic data has been conducted. These study efforts justify the following conclusions:

(1) Needs for traffic data are significantly different in urban or urbanizing districts as compared with rural districts. The quantity of traffic volume data that is obtained currently for rural districts is generally adequate; however, larger quantities are needed in urban areas. Update periods for traffic volume data should, likewise, be more frequent in urban than in rural portions of the state.

(2) The current speed monitoring program is the minimum effort suggested by Federal guidelines. This level of effort is appropriate for current applications.

(3) The current level of effort devoted to manual classification counting in terms of numbers of stations is appropriate. Classification data in terms of percentage of trucks is widely used in pavement design and analyses. Environmental analyses, particularly vehicular emissions studies, require traffic stream classification into a larger number of classes. The currently used number of categories and criteria for classification are consistent with FHWA guidelines.

(4) A new weigh-in-motion instrument system with multi-lane capabilities, simpler and more reliable operation, and on-site data processing is urgently needed to bring the truck weight survey program up to par. A modified sampling schedule is needed for at least one year to define any significant daily or seasonal variations in truck weight patterns that might exist at each survey site. Truck traffic in both directions must be surveyed at each site,

Truck weight and size affect a number of geometric highway design features such as climbing lanes, speed-change lanes, and grades as well as operational features such as capacity and signal timing. Size is particularly important, but weight as it influences maneuverability must also be considered. Design engineers and traffic engineers need data on the number of trucks of various types and their respective weight and size characteristics.

There are numerous needs for the truck weight and size data which D-10 obtains on a statewide sampling basis. It must be as accurate and as complete as feasible if good legal, policy, financial, and technical decisions are to be made regarding highway planning, design, construction, operation, maintenance, and regulation.

Evaluation of the Current Program

The current truck weight survey program was begun in 1975 to take advantage of in-motion weighing technology and statistical sampling theory. The basic objective was to produce truck weight and dimension data of at least equal quality to that which had been obtained over previous years at significantly greater cost, manpower effort, and hazard to traffic. In devising the new data sampling program, no attempt was made to assess the overall adequacy of the previous programs to meet the needs of the data users. Rather, it was assumed that since the requirements of the Federal Highway Administration were satisfied and no serious problems had been encountered in responding to the needs of the Department, the quality and quantity of data were sufficient.

This study has revealed three deviations in the current program from the program recommended in 1975 (Ref 4) that would yield data comparable to the historical data evaluated.

(1) Stations selected for occupancy came from only five of the six groups. Two stations were chosen from Group 2 and none from Group 6 (see p. 34, Ref 4). One of the selected stations has not yet been occupied (Lubbock) due to construction.

(2) Sampling periods have been limited to weekdays only (Monday-Friday); thus, weekend traffic is not included. Each station is occupied only twice per year which is not adequate for detecting seasonal variations.

(3) Sampling has been in one direction only.

The first deviation is a matter of choice, and recognition is made of many years of experience which entered into the decision. The other two items are of concern, however. Experience has shown that there are significant timewise variations in traffic at certain locations. It is important that the magnitude of these variations be understood before an adequate statistical sampling program can be devised and before data can be evaluated with confidence. Timewise variations in truck weight and size need to be evaluated at each sampling station over a period of at least one year. This requires 7-day samples four times in the year. After that, the importance of the variations can be studied and a sound statistical basis for scheduling sampling can be defined.

The importance of directional distribution of truck traffic has recently been emphasized again by the data shown in Table 7.1. Field surveys of distress as evidenced by cracking, spalling, punch-outs, and patching in continuously reinforced concrete pavements in Texas have shown that considerably more distress exists in one direction than in the other. This can, in all probability, be attributed almost entirely to heavier traffic loading as all other conditions at the sites were virtually identical. Directional weighing is very important and should be undertaken as soon as feasible at all sites surveyed. Limitations on the old in-motion weighing equipment to one-lane weighing will be overcome when the new equipment becomes available later this year.

Some attention needs to be devoted to determining whether the current truck weight sampling program is adequate to characterize truck weight patterns at the important locations in Texas. The present program does not address this point; it simply assumes that historical experience has been adequate.

Recommendations

In recognition of the importance of the truck weight survey program in Texas, the following recommendations are offered as a basis for improving the program with a reasonable effort.

(1) The 1969 vintage in-motion weighing instrument system that is now in use should be replaced with a new model which incorporates the features mentioned earlier in this chapter. It is particularly important that the new system be capable of handling force transducers and vehicle detectors in at least two lanes so that directional weighing can be accomplished economically. Provisions should also be made for hourly recording of traffic volume in each of up to

TABLE 7.1. DIRECTIONAL DISTRIBUTION OF OBSERVED DISTRESS ON CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS, 1979.

Location	Length	Direction	Percent of Total Observed Distress	
			NB* or EB	SB or WB
Interstate 10 (from Luling to US Highway 11)	39.9	E-W	30	70
Interstate 10 (from US Highway 77 to US Highway 71)	22.6	E-W	30	70
Interstate 10 (US Highway 71 to end of research sections)	14.7	E-W	31	69
Interstate 10 (Winnie to Port Arthur)	17.4	N-S	31	69
Interstate 10 (Van Horn to Reeves County)	48.2	E-W	34	66
Interstate 20 (Kaufman County to SH 19)	10	E-W	55	45
Interstate 20 (SH 19 to SH 69)	33	E-W	57	43
Interstate 20 (SH 69 to US 271)	15.2	E-W	61	39
Interstate 20 (US 271 to SH 135)	13	E-W	76	24
Interstate 20 (SH 135 to Longview)	12.2	E-W	35	65
Interstate 35 East (CFHR Sections 906, 903)	9.6	N-S	32	68
Interstate 35 (CFHR Sections 910, 909, 908, 907, 905, 904)	6.9	N-S	43	57

* Northbound direction of traffic, etc.

eight lanes during weighing operations. This is an inexpensive feature which will automatically yield valuable information about timewise variations in percent trucks (approximation) as well as directional and lane distribution patterns of traffic if desired.

(2) As soon as the new equipment is available, a program should be undertaken to utilize it at least 70 percent of the time. The present system is used only about 25 percent of the time. In the first year, each of the six selected weigh stations should be occupied four times, once in each season, for a 7-day period each time. A loop detector should be installed in each lane of the highway for volume counting, and weighing should be in both directions simultaneously. After the first year, a specific sampling schedule for each site should be devised to recognize any important timewise variations in truck weight and size at that location. The site near Lubbock should be occupied as soon as possible to bring the number of sites up to six.

(3) In order to improve the adequacy of the truck weight survey program in giving quality coverage of all roads in the State, it is recommended that each year two sites which have not been previously occupied be selected, perhaps on the basis of manual vehicle classification counts where unusual patterns of truck traffic exist, and occupied with the WIM system for one week each. These sites might be near or in metropolitan areas where it was impossible to weigh previously with static equipment. Over a period of time, important new weight survey sites can be identified and incorporated into the program.

and consideration should be given to identifying new sites where truck weight and size characteristics are unique.

Recommendations

Analyses, findings, and conclusions developed through this study effort justify the following recommendations:

(1) The approximate level of effort currently devoted to ATR volume counting activities should be continued.

(2) If rural stations are to be abandoned, one member of each of the rural groups numbered II, III, and VIII shown in Table 3.7 would be the best choices. However, no single members of directional pairs of ATR stations are recommended for abandonment.

(3) Although compact groups of urban ATR stations were developed, abandonment of urban stations must be done very carefully. Probabilities of changes in volumes and volume patterns at these stations, due to urban land development, is very high. If error quantities and frequencies of occurrence shown in Table 3.4 are deemed sufficiently small, all members of each urban group except one directional pair could be deleted.

(4) Uniform use of a factor of 2.0 to convert ACR axle counts into vehicle counts should be modified. A ratio of axles per vehicle should be computed from manual classification counts performed at locations selected because of similarity in traffic composition with ACR sites.

(5) Future requirements for additional traffic volume data, particularly in urban areas should be accommodated wherever possible by enhanced ACR counting. Statistics for 1977-78 indicate that operating costs per location for ACR counting was less than $8 as compared with a per location cost of over $1400 for ATR counts. The economy of ACR usage is obvious and will provide perfectly adequate data except in those rare instances where timewise volume patterns are actually required.

(6) The current level of effort devoted to manual classification counting should be continued. Numbers of classes currently utilized

for classification should be retained. Use of a 0.90 factor for converting 16 hour counts into 24 hour counts should, likewise, be continued.

(7) Speed monitoring activities should be continued at the minimum level of effort required to be in conformance with FHWA guidelines.

(8) New in-motion weighing equipment should be procured as soon as feasible. Directional truck weight surveys should be incorporated into the program at each of the six sites previously selected as soon as the new equipment is available. Timewise variations in truck weight characteristics should be evaluated and new sites should be considered. The new equipment should be utilized up to approximately 70 percent of the time so that reliable statistical data can be made available concerning truck operations on the vast network of highways in Texas.

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