

**FINAL/SUMMARY REPORT ON THE TRAFFIC ASSIGNMENT STUDY**

by

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**Research Report 60-14 (Final)**

**Traffic Assignment**

**Research Study Number 2-8-63-60**

**Sponsored by**

**The Texas Highway Department**

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The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the Bureau of Public Roads.

### SCOPE OF THE FINAL/SUMMARY REPORT

The final/summary report on Study Number 2-8-63-60 is intended to cover the "highlights of the four-year study. The several objectives of the study are listed together with a summary as to how each was met.

The various research reports and technical memoranda which evolved from the project are also listed herein. The major contributions to the state-of-the-art of traffic assignment are briefly outlined to provide an overview of the project.

The final/summary report does not attempt to summarize the technical findings reported in each of the research reports or technical memoranda. Rather it attempts to outline how the project funds were spent and to identify the output from the research.

## AN OVERVIEW OF THE PROJECT

### Objectives and Accomplishments

The objectives for each of the fiscal years dealt with the specific research tasks undertaken. These objectives together with a summary as to how each objective is satisfied are reviewed for each of the four years. In any review of the individual proposals for renewal of Study Number 2-8-63-60, (or for that matter any research proposal), it should be realized that there is a distinct difference between the statement of the objectives and the outline of the plan of study by which the objective was expected to be accomplished at the time the proposal was written.

All research has (or should have) the flexibility to accomplish the objective by alternative means that might become apparent in the conduct of the research. Indeed, it is possible that in view of subsequent research findings, work on an objective ought to be terminated because it was improperly defined. Also, alternative opportunities exposed or evolving over the term of a project might offer more promise for useful results.

Relative to Study 2-8-63-60, these comments are relevant to Objective 3 of the trip generation phase for the 1965-66 fiscal year. In this instance, the objective was met but not in the manner outlined in the plan of study incorporated into the renewal proposal for that year.

## REVIEW OF THE 1963-64 FISCAL YEAR

### Objectives

1. Improve sensitivity characteristics of traffic assignments through program revisions and testing of networks under consideration in various Texas cities.
2. Conduct a critical study to improve techniques of diverting traffic in traffic assignment studies.
3. Begin to study and incorporate techniques to assign traffic effectively to systems where traffic desire service would overload proposed facilities.
4. Begin to study and incorporate methods of computing and presenting pertinent program output visually to reduce costs and drudgery associated with effective use and presentation of results.

### Accomplishments

1. A study of the effect of zone size (geographical area) on traffic assignment was conducted. This work involved the assignments only; a draft of the report was prepared in 1964-65 and completed in 1966-67.
2. This objective was met by "in-house" work by T.H.D.
3. This objective eventually led to the incremental loading - volume/capacity restraint procedure developed in the latter phases of this study and identified for testing and evaluation under a new project.
4. Work was initiated on the development of programs for the IBM 1401 and IBM 709/90/94 to provide the following plot capability on the CAL-COMP 565.
  - (a) plot network description  
options: directional or non-directional street "type" (freeway, arterial, local) by color.
  - (b) plot loaded network  
options: directional or non-directional, street type by color, volume of flow range by color.
  - (c) plot trees

5. Study techniques of assigning traffic to very large systems.
  6. Study techniques of forecasting interzonal movements in metropolitan areas and incorporate necessary improvements into the existing programs.
  7. Prepare a guide manual for planning and design engineers using the traffic assignment programs.
  8. Complete minor needed programs and operating revisions and prepare a machine operator's manual.
  9. Review available computer programs prepared by others for other computing systems, incorporate necessary changes in existing programs, and write new programs to make effective use of the IBM 1401 computing system.
5. A procedure for traffic assignment on very large networks was developed and outlined by C.W. Blumentritt. (This work provided the basis for the TEXAS-Large Systems Traffic Assignment Programs.)
  6. The Fratar procedure was revised.
  7. A draft of a "guide to traffic assignment" was prepared. (This draft was completely abandoned; see objective #5, 1965-66 and #2 1966-67.)
  8. Texas Control programs were modified to incorporate a non-directional volume as well as turns.  
  
A new control program (Revised Texas Control) was written and the traffic assignment programs most frequently used were modified to operate under it.
  9. The following IBM 1401 programs were written and write-ups prepared.
    - (a) edit link data - Research Report 60-1
    - (b) edit and block trip volumes - Research Report 60-2.

## REVIEW OF THE 1964-65 FISCAL YEAR

### Objectives

### Accomplishments

1. Prepare new programs and adopt existing programs for inclusion in the traffic assignment package as they are needed by the Texas Highway Department.
2. Complete and implement developed plotting techniques for the traffic assignment computer program.
3. Test existing Bureau of Public Roads capacity restraint programs and evaluate their usefulness in improving traffic assignment techniques.

1. A user's manual for the Revised Texas Control written in 1963-64 was prepared - Research Report 60-5.
2. The plot programs, initiated in 1963-64 (Obj. #4), were completed and incorporated under Revised Texas Control. A user's operating manual (Research Report 60-3) and a manual on the utilization of computer plotting (Research Report 60-4) were prepared.
3. Accomplished by THD.

4. Continue the programming of a new traffic assignment system for handling large networks.

4. Basic programs for the TEXAS-Large Systems Traffic Assignment Package were written and tested using partitioned and non-partitioned network of Corpus Christi. The following major programs were developed:

- Main control and Input-Output
- Attached Initialization
- Build-Network Description
- Output Network Description
- Build Trees
- Build Trip Volumes
- Output Trip Volumes
- Sum Trip Ends
- Load Network
- Output Loaded Network
- Convert Binary Trip Volumes

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5. Analyze measurable parameters such as population, income, car ownership, land use, socio-economic aspects, etc., in order to determine their correlation and effect on trip generation and distribution in urban areas.

5. Carried forward to 1965-66 Fiscal Year.



## REVIEW OF THE 1965-66 FISCAL YEAR

### Objectives

### Accomplishments

#### Traffic Assignment Phase

1. To provide additional tabular display of individual intersection for the respective intersections as provided by the tabular output of the traffic assignment package.
  2. To increase the capacity of the program to handle a maximum of 1600 four-way intersection turning movements.
  3. To incorporate an effective turn prohibitor in the program initially to be at least one prohibited turn per intersection.
  4. To investigate means of obtaining more realistic traffic assignments.
  5. To draft a manual on basic traffic assignment procedures.
1. "Intersection stringing" program (actually a print selected nodes program) was written in 1966-67; the operating write-ups are included in Research Report 60-6.
  2. This objective was dropped since the considerable effort required to increase the number of turning movements was considered not to be justified in view of the impending conversion to the IBM 360 System.
  3. A new Search Minimum Paths program was written and tested which incorporated an effective turn prohibitor.
  4. Research involving the effect of zone size and the degree-of-detail in the coded network was initiated. This research was carried over into 1966-67. Existing (1964) trips were made to three different coded networks for Waco. Results are reported in Research Reports 60-8, 60-10, 60-11, and a Technical Memorandum dated January 10, 1968.
  5. This objective was moved to the 1966-67 fiscal year by the Project Advisory Committee in March 1966.

6. To perform programming changes, additions, and testing necessary to support production usage of the system.

6. The Large Systems programs were tested on a 4 subnet system (Dallas-Ft.Worth). Basic revisions were made as a result of the continuous testing.

Special purpose programs were written and tested to support usage of the Large Systems programs, programs include:

binary trip tape to BCD and converter  
block and unblock trip data (2 programs)  
magnetic tape inventory.

Modifications were made in the Output Network Descriptions program to provide improved format.

The Prepare Network Description program was revised too as a result (a complete revision in the method of handling link parameters was necessary).

The Fratar forecast program was optimized to reduce execution times by a factor of 5 to 10 depending upon the size of the trip table. The effect of the location of the partition lanes was critically reviewed.

7. To investigate the incorporation of certain plotting programs in the traffic assignment package.

7. Several improvements were made in the plot programs for the Revised Texas Control System. Certain program functions were combined so as to require a smaller number of programs. Modifications were also made to adopt the plot programs to the CALCOMP 760.

The problems in converting the plot programs to the Large Systems Package were identified.

## Trip Generation Phase

### 1. Multiple Regression Model of Trip Generation

- a. To analyze measurable parameters such as population, income, car ownership, land use, socio-economic factors, etc., and to determine their correlations with respect to generation of traffic.
- b. To develop a comprehensive model to determine the major factors affecting the motivation of people which will be composed of the most significant measurable parameters as the basis for the prediction of future trip production.

Dwelling unit data were edited. Responsibility for processing the space use data was assumed by TII. (Work was carried over to the 1966-67 FY.)

### 2. Trip Generation Rate Analysis

- a. To develop trip generation rates by land area for each classification of trip purpose.
- b. To evaluate the variation of the generation rate for each classification of land use, particularly as related to the variability introduced through sampling.
- c. To determine the spacial limits within which the generation rate can statistically be assumed to be constant and to evaluate the magnitude of the errors involved in using this average rate to estimate trips at the zonal level.

(Work was carried over to the 1966-67 FY.)

### 3. A comparison of the Texas Procedure of Zonal Trip Generation Projection With the Multi-Regression and Trip Rate Analysis Models.

- a. To evaluate the variation in the zonal trip ends as determined by the trip generation projection procedure now in use in Texas with that of the multi-regression and trip rate analysis model.

(Work was carried over to the 1966-67 FY.) A Technical Memorandum dated March 28, 1968 and an earlier one dated October 23, 1967 demonstrate that useful results beyond those included in Research Reports 60-12 and 60-13 could be accomplished only with a very substantial cost. Therefore, it was concluded that the comparisons suggested in the plan of study for 1965-66 should not be made.

REVIEW OF THE 1966-67 FISCAL YEAR

Objectives

1. To prepare an Operating System (User's) manual for the large systems assignment package.
2. To prepare a modern manual of the traffic assignment process as practiced in Texas. Such a manual is to include a chapter or chapters explaining the output data and its use in planning and design.
3. To investigate and program a basic capacity restraint feature for the large systems assignment package.
4. To provide a Spider network assignment capability for the large systems assignment package.
5. To continue an investigation of the factors relating to residential and non-residential trip generation.

Accomplishments

1. A User's Manual for the TEXAS-Large Systems Traffic Assignment System (TEXAS-BIGSYS) was prepared - Research Report 60-6.
2. A manual on Texas traffic assignment practice and the use of data in planning and design was prepared. Research Report 60-9.
3. A basic capacity restraint program was written as a stand-alone program for the IBM 360 Model 50. The program utilizes an incremental loading (percent of zone-to-zone trip interchanges) process. Testing, further development, and evaluation were identified as an objective of Study No. 2-10-68-119.
4. A series of Spider programs were incorporated under TEXAS-BIGSYS and program write-ups in the User's Manual. The programs originally had a capacity of 3,500 nodes; this was later increased to 3,600. Program write-ups were included in Research Report 60-6.
5. Trip generation rates for residential land use were calculated and analyzed using the Waco data; rates analyzed were: trips/person, trips/person 5 years and older, trips/dwelling unit, and trips/net residential area.

6. To provide additional miscellaneous utility programming support for the large systems package.

Multiple regression techniques were also used to analyze trip generation. Models were evolved for origins and destinations as well as for productions and attractions. Models for origins and destinations were directional (i.e. separate models were evolved for home-to-work and work-to-home, etc.). For productions and attractions the purposes used were home based work, home based non-work, non-home based, and total.

These analyses are reported in Research Report 60-12. Further research on trip generation was also incorporated into Study No. 2-10-68-119.

6. A utility program to convert binary trip to BCD was developed. Plot programs were incorporated under TEXAS-BIGSYS control; these are:
  - (a) plot network description
  - (b) plot loaded network (with or without volumes)
  - (c) plot trees

Trip conversion programs were written to handle incompatibility (both directions) between the Revised Texas trip format and the TEXAS-BIGSYS format.

A partition line edit routine was written and tested; this routine was incorporated in the Prepare Network Description program. Corrections were made to the Output Loaded Network program.

The build trees program was modified to provide additional off-line information.

Changes were made in the Load Network program to skip a redundant record and printout the origin and subnet of the tree lost.

A program to build a trip table for selected zonal interchanges from a complete trip table was written and tested.

A selected link program was also written. The zone pairs between which the minimum path includes the selected link(s) are printed off-line; loading the selected link(s) is optional - if exercised, assigned volumes are also printed off-line.

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7. To investigate means of combining the most desirable properties of the Fratar Forecast procedure and the Pattern Trip procedure, so that a more flexible forecast model is available for general application.
  8. To investigate and recommend procedures to be followed in reprogramming the large systems package for third generation computing equipment.
  9. To investigate the availability and adequacy of sources of information, such as employment and retail sales data, that affect trip generation, and recommend methods of obtaining these data on a small area (Survey Zone) basis.
7. A computer programmable procedure was formulated and outlined in a Technical Memorandum dated September 1967. This procedure would incorporate certain aspects of the gravity model, pattern trip procedure, and Fratar procedure. Programming, testing, and evaluation were written into Study No. 2-10-68-119.
  8. A summary of expected program availability and recommendations for THD use was prepared and revised: A Technical Memorandum dated October 13, 1967 was the final revision of these recommendations.
  9. State and Federal sources of employment and retail sales information were reviewed and summarized - Research Report 60-7.

10. To compare a three purpose and a six purpose gravity model with the Texas procedure.

11. To complete all phases of the research proposed on the Study and prepare a final report.

10. Gravity models were calibrated for one purpose, (total) three purpose (HBW, HBNW, NHB), and seven purpose (HBW, HB Shop, HB School, HB Business, HB Social-Recreation, HB Other and NHB) for existing (1964) interval auto driver trips. The total trip tables thus obtained were compared to each of them and to the O-D trip table. These trip tables were also loaded on the E-2 (1964 study network). The analyses are reported in Research Report 60-13.

### Summary of Major Accomplishments

The several research reports and technical memoranda produced in the course of the research are listed in Tables 1 and 2 respectively.

The research throughout the four-year period of the project might be divided into two general categories; these are:

- (1) computer program development
- (2) analysis and evaluation

Although there were numerous smaller tasks and accomplishments under each of these, there are a few major elements which merit mention in this final/summary report.



### Computer Program Development

The principal accomplishments in the area of computer program development include:

- (1) Revised Texas Control Package
- (2) Texas-Large System Traffic Assignment Package (Texas-Bigsys)
- (3) Plot programs

All the computer programs involved in the above were written for the IBM 7094, 32K computer. The change-over to the IBM 360 system - with a 512K model 50 at the Highway Department in Austin and a 512K model 65 at Texas A&M - of course, made the individual programs obsolete. However, "short life" utilization is to be expected and unavoidable in a rapidly changing technology.

Nevertheless, significant use was made of the programs developed. The TEXAS-BIGSYS programs made it possible to analyze large traffic systems as a single network. This capability was effectively utilized in the Dallas-Fort Worth Urban Transportation Study.

The concept used in TEXAS-BIGSYS continues to have potential application in the analysis of extremely large networks such as the entire U.S. highway system where the cone capacity of the newest and largest computers is not sufficient. The capability developed under Project 60 research also has application in making it possible to make traffic assignment to larger networks than would otherwise be possible with small cone size computers. This can provide highway departments having a small computer with the capability of making traffic assignments to networks of a much larger size than that possible with their "in-house" computer.

The concepts developed under this research are also being utilized as the basis for additional computer program development under Study Number 2-10-68-119.

## Analysis and Evaluation

The research relative to analysis and evaluation of the various data processing phases involved in urban transportation planning studies might be summarized in the following principal findings for the purpose of this final/summary report.

- (1) Zone sizes of up to one-half square mile can be used in areas such as Waco without adverse effect on the traffic assignment results,
- (2) The degree of detail currently used in the coding of urban networks is most suitable with the all-or-nothing assignment. Added detail does not improve the results but substantially increases the cost and effort involved.
- (3) With the level-of-service of speed concept, turn penalties are not needed to avoid "stair-stepping". Further, their use does not improve the logic of the minimum path; more often than not, the path without a turn penalty is as logical or more logical than the one with the penalty.
- (4) The gravity model does not reproduce the O-D trip table or yield an acceptable one for smaller study areas. It grossly over-estimates the number of zone to zone interchanges of low frequency. Nor does it reproduce the zone-to-zone interchanges of the largest frequency; the gravity model trip pattern appears to be run down and not related to the real world observations.
- (5) Multiple regression is superior to rates for the estimation of home end trips. However, rates or growth factors calculated directly from land use and land use activity information are probably appropriate for non-home trip ends.

TABLE 1

## LIST OF REPORTS ON STUDY NO. 2-8-63-60

<u>No.</u>	<u>Title</u>
60-1	Texas A&M Traffic Assignment Link Data Editor for IBM 1401 Data Processing System
60-2	Texas A&M Traffic Assignment Edit Print Trip Volumes for IBM 1401 Data Processing System
60-3	Traffic Assignment Plot Systems for IBM 1401 and 709-90-94 Data Processing System
60-4	Utilization of Computer Plotting in Traffic Assignment Analysis
60-5	Operating System Manual for Revised Texas Traffic Assignment System
60-6	User's Manual for Texas Large Systems Traffic Assignment Programs
60-7	Availability of Secondary Data for Determining Employment and Sales by Traffic Zones
60-8	Effect of Zone Size on Traffic Assignment Results
60-9	Manual of Texas Traffic Assignment Practice
60-10	The Effect of Turn Penalties on Traffic Assignment Results
60-11	The Effect of Network Detail on Traffic Assignment Results
60-12	A Partial Analysis of Trip Generation
60-13	An Evaluation of the Gravity Model Trip Distribution
60-14	Final/Summary Report on the Traffic Assignment Study

TABLE 2

LIST OF TECHNICAL MEMORANDA ON STUDY NO. 2-8-63-60

1. Recommendations for IBM 360 Traffic Assignment
2. Outline of a Proposed T.H.D. Trip Distribution Procedure
3. Partial Analysis of Turn Movements
4. 1970 Trip End Estimation for Waco

Project Cost

The total estimated cost of the study had been estimated at \$254,000. The actual costs for each fiscal year as recorded in the records of the Texas A&M University Fiscal Office are:

1963-64	\$ 59,810.18
1964-65	42,980.29
1965-66	67,262.41
1966-67	74,364.80
Total	<u>\$ 224,417.68</u>