

1. Report No. FHWA/TX-94/1232-32F		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle URBAN HIGHWAY OPERATIONS AND IMPLEMENTATION PROGRAM OVERVIEW AND SUMMARY				5. Report Date October 1994	
				6. Performing Organization Code	
7. Author(s) Thomas Urbanik II				8. Performing Organization Report No. Research Report 1232-32F	
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. Study No. 0-1232	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080				13. Type of Report and Period Covered Final: September 1989 - August 1994	
				14. Sponsoring Agency Code	
15. Supplementary Notes Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. Research Study Title: Urban Highway Operations Research and Implementation Program					
16. Abstract  This report summarizes the main conclusions resulting from the research study. The study provided an effective implementation document, the <i>Texas Highway Operations Manual</i> , and a coordinated program of highway operations research that has advanced the practice traffic operations in Texas and the United States.					
17. Key Words Highway Operations, Freeway Operations, Planning, Design			18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161		
19. Security Classif.(of this report) Unclassified		20. Security Classif.(of this page) Unclassified		21. No. of Pages 32	22. Price



**URBAN HIGHWAY OPERATIONS AND IMPLEMENTATION  
PROGRAM OVERVIEW AND SUMMARY**

by

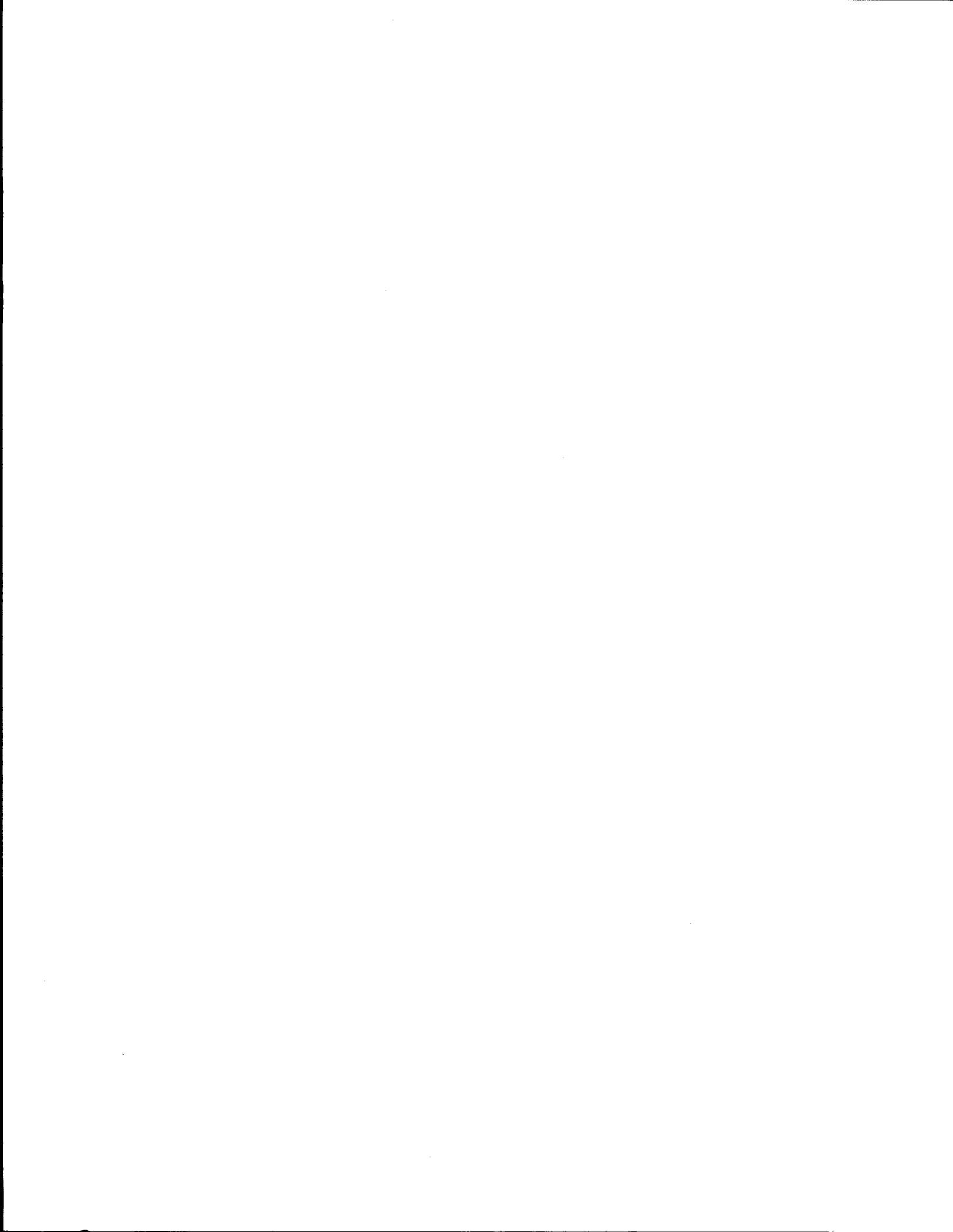
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Research Report 1232-32F  
Research Study Number 0-1232  
Research Study Title: Urban Highway Operations Research and Implementation Program

Sponsored by the  
Texas Department of Transportation  
In Cooperation with  
U.S. Department of Transportation  
Federal Highway Administration

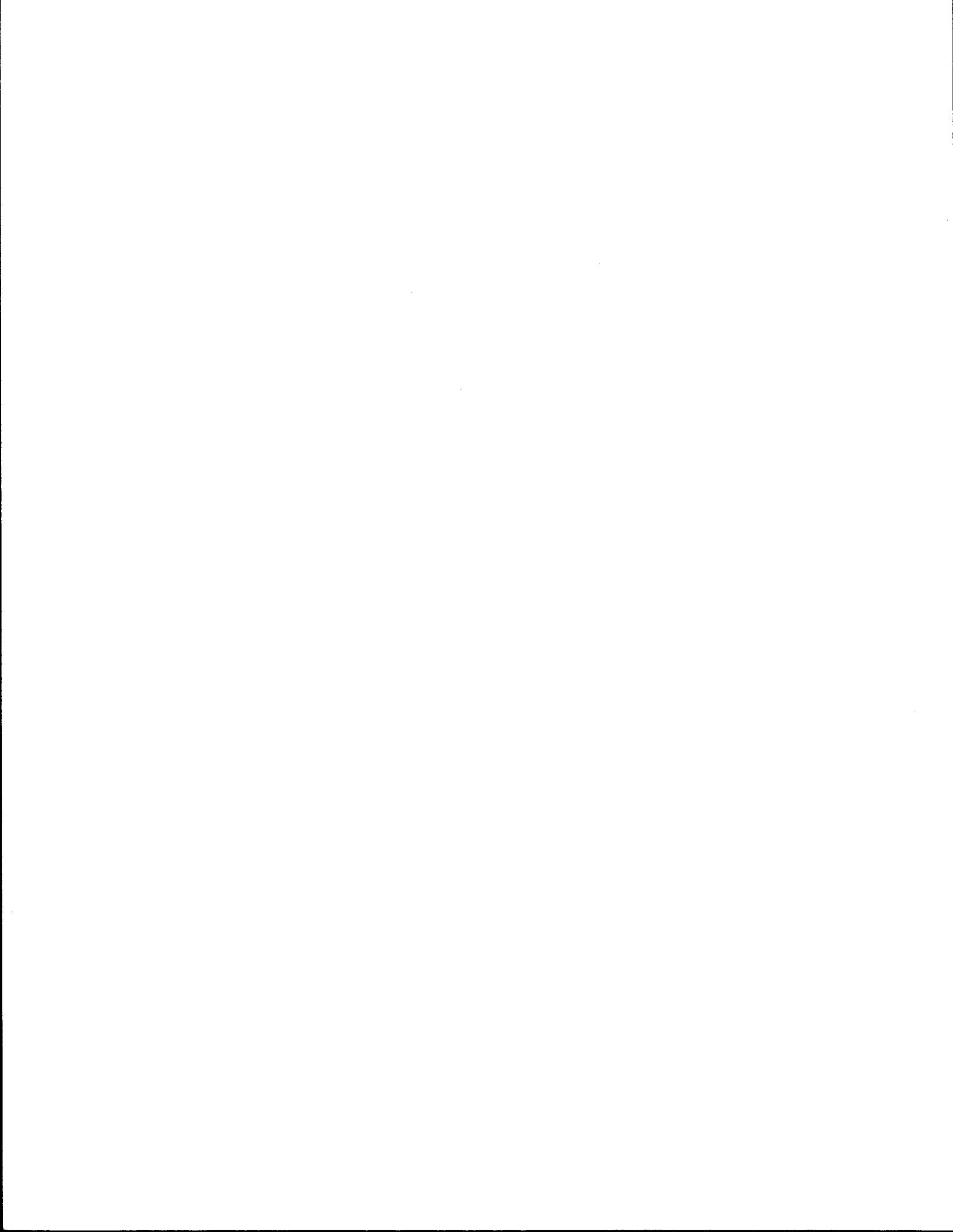
October 1994

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## IMPLEMENTATION STATEMENT

This study had its own unique implementation document, the *Texas Highway Operations Manual*. The Manual presents the many research findings in a format useful to field personnel. The research results are being implemented.



## **DISCLAIMER**

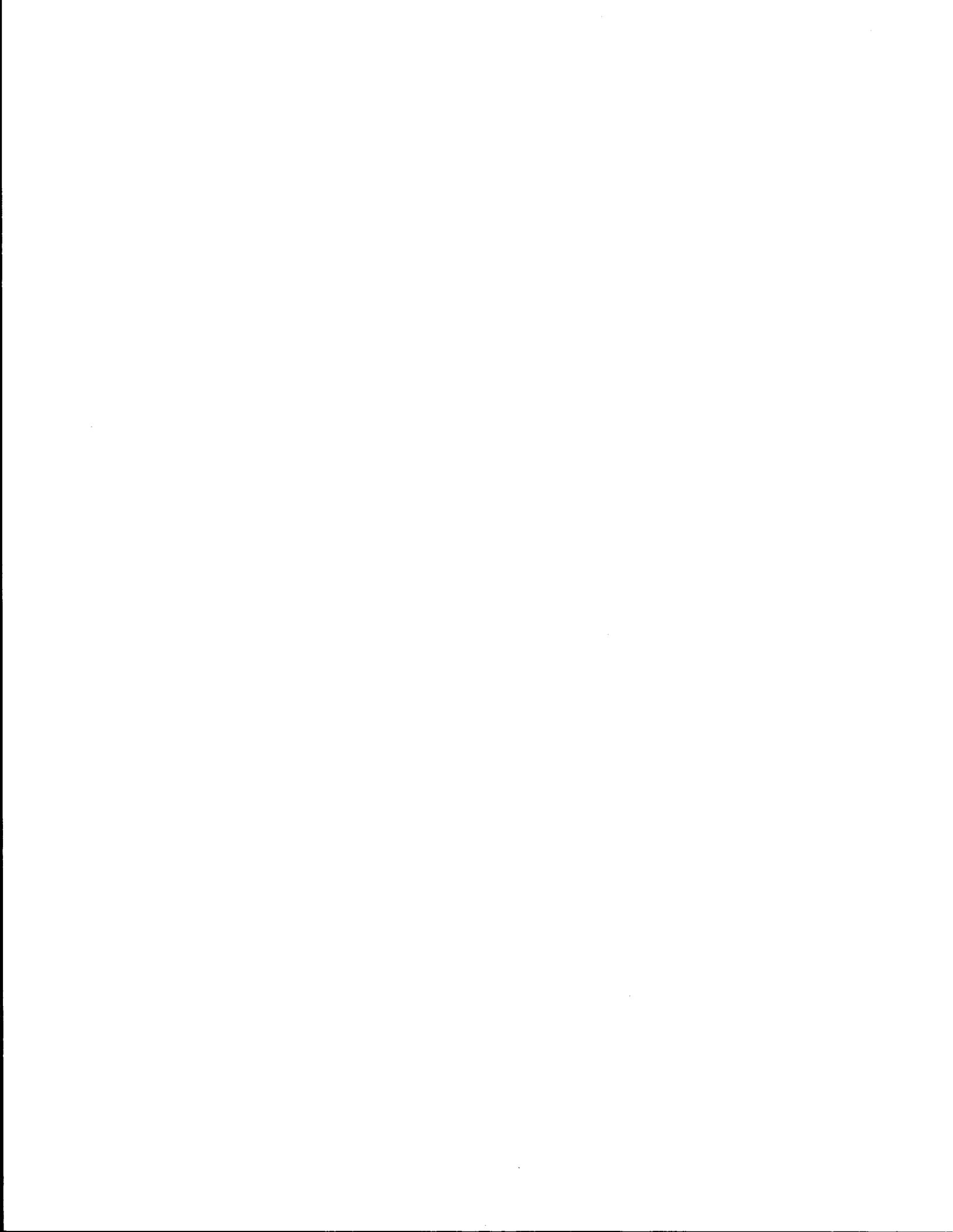
The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation.

## ACKNOWLEDGMENT

The study was made possible by the understanding and support of Bob Hodge (retired) and Gary K. Trietsch (project director). Without their vision and leadership, the study would not have been possible.

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## **SUMMARY**

This report is a summary of the five-year research project and the major study findings.



## **BACKGROUND**

Study 1232 was the result of a problem statement (See Appendix A) developed in 1988 to address the need for a coordinated program of highway operations research and the need for improved implementation of operational strategies. The proposed study was not intended to replace the traditional approach to research which has helped to make Texas a leader in highway transportation. Instead, it was aimed at enhancing the existing research program. The approach proposed included the following:

- A strategic identification of long term needs;
- Coordination with related research projects;
- An implementation format readily available to field personnel; and
- A long term commitment to advance highway operations.

## **CONCEPT**

The basic study concept was to develop a five-year work program focusing on improved highway operations. The work program focused on seven technical areas and a Highway Operations Manual. The Highway Operations Manual was the implementation vehicle for the study and contained the results of all previous related research as well as the results of the current study. It is also the implementation document for future highway operations related research.

Researchers selected seven technical areas to provide a broad program covering all areas of highway operations. The seven were:

- Operational Effects of Geometrics;
- Surveillance Systems;
- Incident and Special Event Management;
- Control Systems;

- Motorist Information Systems;
- System Management; and
- Operational Evaluation and Analysis.

## **MANAGEMENT**

In 1988, the TxDOT R&D Committee approved Study 1232. Study 1232 was a five-year undertaking with an annual budget of \$500,000. The study was started under the direction of Gary Trietsch of the Maintenance and Operations Division. In 1993, Traffic Operations became a separate division. An advisory committee comprised of Division Heads and District Engineers provided broad policy oversight. A separate technical committee provided input on individual tasks. An individual from the Traffic Operations Division was assigned as technical contact on each individual task.

## **STUDY BEGINNING**

The project was begun by convening a national panel of traffic operations experts. The panel was composed of public and private sector individuals with national expertise in the area of highway operations. The workshop format allowed for the presentation of the proposed research plan and refinement of the study concept. The workshop confirmed the need for the study and provided input into both the research and the proposed Highway Operations Manual.

## **RESEARCH APPROACH**

The research was oriented around tasks within each of the seven research areas. Each research area had a technical expert assigned to the subject area. The study supervisor coordinated between the research areas and with other research projects not explicitly within the study. This provided one of several key benefits of the project. The study supervisor, because of the responsibility to provide implementation of all operations related research into the Highway

Operations Manual, needed to be knowledgeable in all on-going highway operations related research. This activity provided the impetus for on-going communication between current highway operations research efforts.

The study also had some flexibility to change direction and priorities as the result of either changing needs or as the result of the research findings. Each year the study was modified as necessary to reflect changing on-going research results or more urgent priorities. These changes were more of a fine-tuning of the research than major changes in direction. Also, with the concurrence of the panel and following normal modification procedures, a few special studies were added during the course of the projects. These minor efforts were generally of an urgent need and would not have been addressed in the normal cycle of the research program.

## **RESULTS**

The study resulted in more than 30 technical reports (See Appendix B). Technical reports are the documentation of the research. They include methods, data, successes, failures, and results. Reports varied in content; some were very technical and others more application oriented. Some are more useful to future research efforts, others are more appropriate for general use. Unfortunately, it is not readily apparent to the engineer in the field what reports or parts of reports are of immediate usefulness. Furthermore, training and technical bulletins do not always have lasting value, especially if there is not a suitable reference document.

Study 1232 included the development and implementation of a *Texas Highway Operations Manual*. This document takes only information that is necessary for practical use and puts it in an organized document that is entirely implementation oriented. An entire research report may only warrant a sentence or a paragraph in the operations manual. Other user oriented reports are referenced (not repeated) in the *Texas Highway Operations Manual*.

The success of the *Texas Highway Operations Manual* can be seen in several ways. First, the Federal Highway Administration published the document as a technology sharing reprint (DOT-T-93-09). The Federal Highway Administration also used the document in their own internal training program. Several other states, including California, New York, and North Carolina, have asked for copies of the Manual for the development of similar documents in their state.

The Study also resulted in more communications among researchers and between researchers and the Department. This is an important activity to maximize the effectiveness of available resources and to assure practical application of the results.

## **LESSONS LEARNED**

The fact that the study was a large, multi-year effort made it different. The normal practice in the research program is to keep studies as small as possible with the shortest practical time for completion. This made the study an item for intense scrutiny. Therefore, a TTI administrative structure was established to provide maximum accountability and oversight. Later in the study, it was determined that a less extensive structure was appropriate. TTI area leaders were eliminated. Each task was assigned a responsible researcher, but the additional layer of area leader was eliminated.

The advisory committees provided a formal mechanism for monitoring the research. However, because of their size, they were not as effective as desired. Future efforts should focus on an advisory structure that involves small teams. A policy advisory committee should have four or five members to review the activities from a big picture perspective. Each task should have a small group of technical experts to review and advise on the research.

## **PERFORMANCE**

The biggest concern with a large research project is one of accountability. The reality is that a larger project forces continual scrutiny due to its size. Larger research projects also provide the necessary critical mass to sustain a high quality effort. A team of researchers working on a common goal can achieve a higher quality product due to the collective exchange of ideas.

## **ALTERNATIVE APPROACHES**

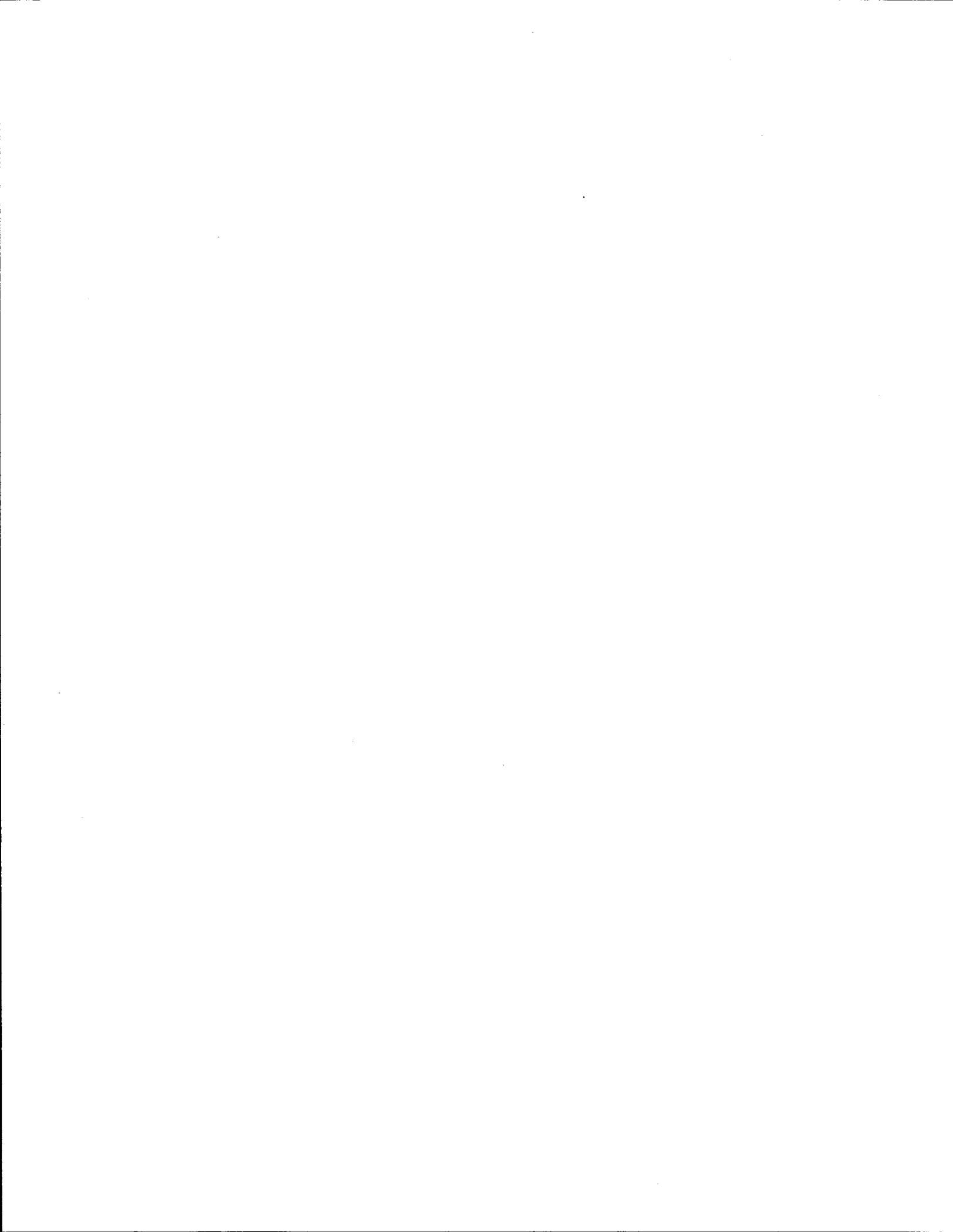
As a result of TxDOT 's Continuous Improvement Program, TxDOT is looking at developing a strategic plan to guide the program for several research areas. This is an appropriate step to give a long term direction to the research program. However, it is not the complete answer to needs based on the experience of this study. Coordination is a continuous process that cannot be provided in a strategic plan. Coordination is an ongoing activity which goes beyond a plan which provides the overall direction to a program. Although the Department used a variety of technology transfer mechanisms to deliver new research to the field, the reality is those activities are volatile. As staff change or new employees are hired, the previous newsletters or training are not available. The *Texas Highway Operations Manual* provides a permanent record of research findings, but it must be maintained to be useful.

## **CONCLUSION AND RECOMMENDATION**

The study met its objectives of providing a coordinated program of highway operations research and the development of an effective implementation mechanism, the *Texas Highway Operations Manual*. The *Texas Highway Operations Manual* was updated at the end of the project and should be revised periodically to keep it current. Coordination is an activity that requires resources in order for it to be accomplished. When resources are committed to an effort, as they were in this study, significant progress can be made in a research area. In addition, when resources

are dedicated to effective implementation, a practical means of transferring research findings to the field can be maintained.

**APPENDIX A:**  
**PROBLEM STATEMENT**



**FIRST STAGE**

**RESEARCH PROBLEM STATEMENT**

FOR D-10R USE ONLY		
Area No.	Program Year	Statement Number

- I. **PROBLEM TITLE:** Urban Highway Operations Research and Implementation Program
  
- II. **PROBLEM STATEMENT:** A need exists for a coordinated program of highway operations research in order to assist districts in implementing operational improvements. Furthermore, freeway and arterial street operations have not been studied or evaluated sufficiently to allow the establishment of effective analysis procedures, strategies for operation, and guidelines for implementation. Many traffic operational "problems" are now being addressed on a crisis-decision basis at the district level without sufficient documentation or evaluation due to limited resources. Also, the technical transfer of viable solutions of common traffic problems among the districts is limited by the time and resources available to the districts' staffs. Most important, improved implementation of operational strategies to safely and efficiently accommodate traffic on urban highways is required.
  
- III. **RESEARCH PROPOSED:** A five-year program of coordinated highway operations research is proposed in support of the State's development of traffic management plans in urban areas throughout the state. The program will include the development of the Urban Highway Operations Research Program; the definition of the implementation and institutional issues; and the conduct of selected highway operations research studies as follows:
  - 1. **Develop Scope of Research** - The study will work with an Advisory Committee of district engineers and division heads to establish and define goals, objectives, and scope of work. The Committee will establish research priorities for the first year and a schedule of proposed areas of research for the remaining four years of the program.
  - 2. **Develop a Texas Highway Operations Manual** - Collect documents and information on research and field experiences in Texas and selected national projects. Prepare a document in "loose leaf" format and update the material throughout the research program.
  - 3. **Recommend Policy Statements and Guidelines for Implementation of Solutions to Operational Problems** - Study implementation requirements, institutional issues, and agency policies identified in Highway Operations workshops to be conducted in the Summer of 1989 that will help the State address its highway operations problems as related to planning, design, and traffic operations.
  - 4. **Conduct research studies of topics identified by program's Advisory Committee** related to five major areas of urban highway operations: Design, Operations, Traffic Management, Analysis and Evaluation Tools, and Institutional Issues.

IV. POTENTIAL IMPLEMENTATION: The goals of this research program are to provide highway operations solutions to urban mobility problems and to provide support for the implementation of those solutions. Many of the studies proposed in this research program will aid the districts in developing and implementing traffic management plans.

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C.L. Dudek	Texas Transportation Institute	Operations Division
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# **URBAN HIGHWAY OPERATIONS RESEARCH AND IMPLEMENTATION PROGRAM**

Prepared by  
Texas Transportation Institute  
The Texas A&M University

## **Problem Statement**

Highway Operations Research in Texas is currently fragmented. A need exists for a coordinated program of highway operations research in order to assist the districts in implementing operational improvements. The employment of improved and sometimes technically sophisticated operational strategies to safely and efficiently accommodate traffic movement in urban areas is required. Many aspects of highway operations are of concern and have not been studied or evaluated sufficiently to allow the establishment of effective analysis procedures, strategies for operation, and guidelines for implementation. Many highway operational "problems" are now being addressed on a crisis-decision basis at the district level with limited possibility for adequate documentation or sufficient evaluation due to available funding or resources. In addition, there currently exists little technical transfer between the urban districts as to viable solutions to common operational issues. Improved research coordination and implementation are required.

## **Research Proposed**

The goal of the research is to provide the mechanism to aid district in all aspects of urban highway operations including implementation. The Study of Urban Highway Operations can be divided into five major areas: Design, Operations, Traffic Management, Analysis and Evaluation Tools and Institutional Issues.

A number of potential topics for research are listed for each of these areas of study. To determine the priorities for the establishment of projects, the following steps are proposed.

- o First, an advisory committee comprised of representatives of urban districts, D-8, D-10 and D-18 would convene to monitor and provide study direction. This committee would meet at least annually with the researchers to identify and prioritize individual studies for inclusion in the State's HPR Program.
- o Secondly, a work task would be established to develop a Texas Highway Operations Manual. This document would identify all research and field experience related to urban highway operations in Texas, and selected studies and projects on a national and international basis. This activity would be more extensive than a literature review of published research reports.
- o Subsequent study tasks would be formulated to address those "problem" areas designated by the advisory committee. In the design and operations areas, safety and operational evaluations would be made to qualify and quantify existing conditions as well as to analyze alternative treatment effects. These evaluations would include both computer simulations and

accident data analyses as necessary. In the traffic management and institutional issues, all factors that can be identified that relate to the implementation and operation of proposed solutions would be studied. In the analysis and evaluation tools area, necessary analytical tools such as computer simulation models would be evaluated, improved, and generally made usable for design and operations engineers. Where applicable, guidelines and criteria would be determined and recommended for inclusion as updates in the *Texas Highway Operations Manual*.

### **Design**

The design of urban freeways to accommodate higher traffic demands within limited rights-of-way is underway in most urban areas of Texas. These future designs include: roadway crosssections of twelve and fourteen lanes; major expansions of freeway-to-freeway interchanges; dual roadways to provide express lanes and reconfiguration of ramps and frontage roads. Several potential areas of research are:

1. Establishment of a methodology for the analysis of weaving sections;
2. Formulation of guidelines for lane balance at freeway to freeway interchanges;
3. Assessment of design and operational requirements for freeway to freeway connections between mainlanes and express lanes; and
4. Formulation of guidelines for the design of interchange intersections.

### **Operations**

Urban motorists are trying to compensate for delays caused by congestion by increasing speed and reducing headways. Traffic volumes in excess of 2200 vph on main lanes and ramps have been observed. Large trucks that normally avoid the commuter hours are now encountering high volumes during the off peak hours of the day. Several potential areas of research are:

1. Development of Planning and Capacity Values in Large Texas Cities for Urban Freeways (Project 11968 - now underway);
2. Evaluation of effects of reduced speed limits and lane restrictions for trucks on urban freeways;
3. Evaluation of alternative operational strategies to improve motorists compliance to speed limits on freeway to freeway connectors;
4. Analysis of operational and safety problems associated with freeway ramp connections to frontage roads; and
5. Evaluation of improved signing and driver information techniques.

## **Traffic Management**

SDHPT (State Department of Highways and Public Transportation) is presently involved in the planning, design, implementation, and operation of Traffic Management Systems and Procedures that improve the efficiency, quality, and safety of urban travel. One of the more important systems being developed is freeway surveillance, communications, and control (SC&C). It has been over 15 years since the last SC&C system was installed in Dallas and over 10 years since major research efforts have been a part of the State's HPR Program. The renewed interest in SC&C has also generated the need for improved facilities for responding to major incidents, both planned and unscheduled, that cause serious impacts to freeway operations. Some of the proposed areas of research are:

1. Development of enhanced ramp metering software (continuation of study by Dr. Messer);
2. Development of control strategies for freeway-freeway connectors and freeway main lanes to balance travel demands;
3. Investigation and establishment of cost-effective traffic management strategies for special events;
4. Preparation of a manual for response to major incidents to include: agency cooperation, diversion routing, equipment and personnel requirements;
5. Development of motorists information systems to include: changeable message signs, highway advisory radio, and computer bulletin boards; and
6. Integration of commercial radio systems into the driver information system.

## **Analysis and Evaluation Tools**

Texas highways operate as a system which includes the entire corridor of frontage roads and adjacent arterials. The ability to analyze this complex system is dependent on good analytical tools. The currently used simulation model for freeways, FREQ9, has limited system capabilities. It can not handle freeway to freeway connectors, double deck freeways (in a single model), frontage roads (in any detail), or alternative routes. The TRAF model is currently used for some interagency work, but its general applicability to freeway operations needs further investigation. TRAF can analyze highway systems, and its appropriateness for implementation in Texas should be evaluated. Some proposed areas of research are:

1. Determine appropriate highway corridor simulation models for use in Texas and necessary data requirements;
2. Enhance computer simulation capabilities to evaluate alternative traffic management strategies;
3. Enhance computer simulation capabilities to include operational research findings; and
4. Provide any additional traffic analysis and evaluation tools needed to assess proposed traffic management strategies.

## **Institutional Issues**

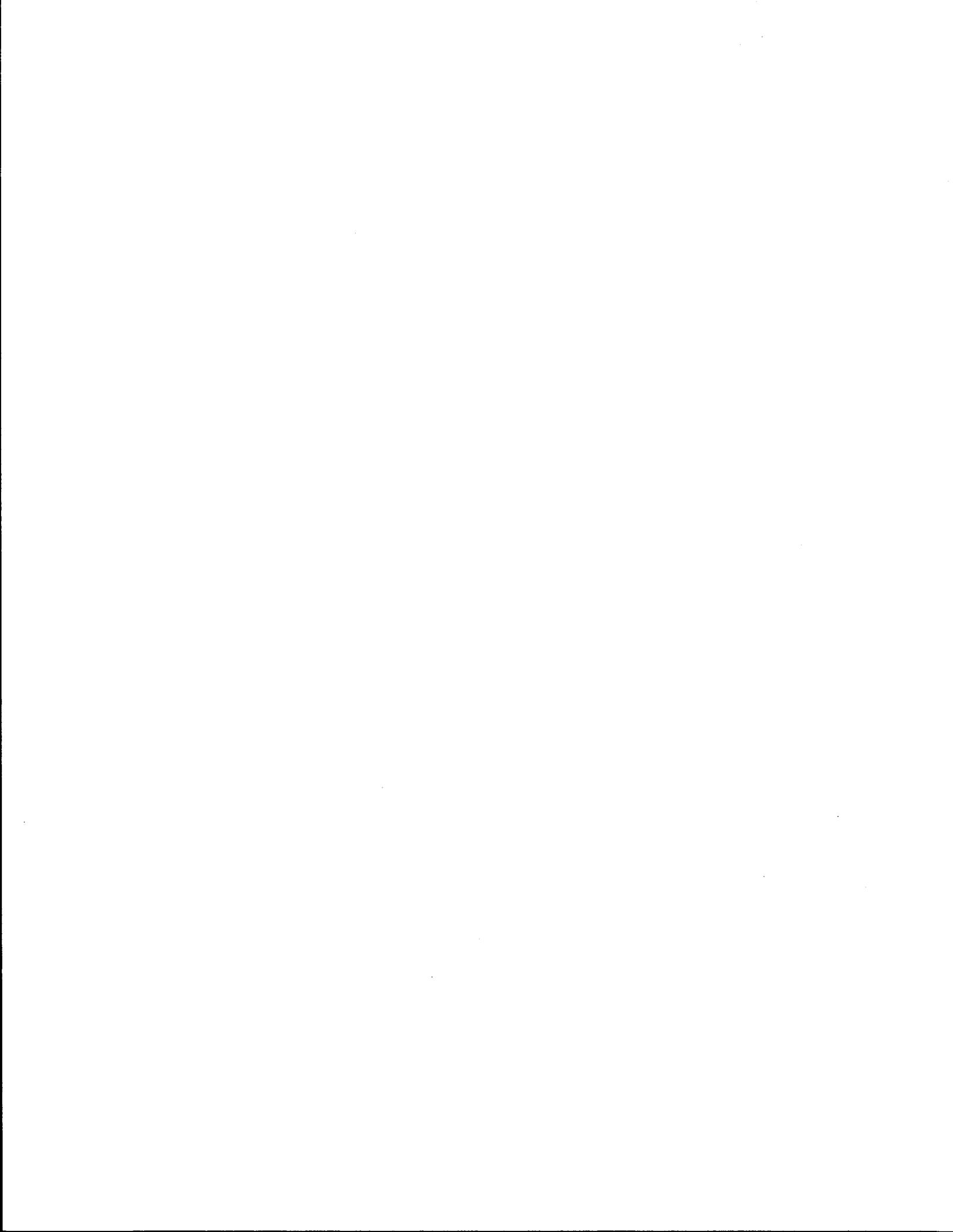
There are delays on implementing research results in Highway Operations. The solutions usually involve several organizations; the area of concern usually crosses jurisdictional boundaries. Traffic management is a full time activity, requiring 24-hour participation, seven days a week. The funding requirements can include capital, operating, and maintenance costs shared by several agencies. Finally, the benefit of Highway Traffic Management are directed outward to the public not inward to the operating agencies. Some of the proposed areas of research are:

1. Review and evaluate current policies for SC&C design and implementation.
2. Determine the technical expertise and manpower requirements to design, implement, and operate traffic management systems.
3. Identify Interagency Agreements that are required to operate an Urban Traffic Management Center and an Incident Management System.

## **Duration and Budget**

The proposed study effort is estimated at \$500,000 per year for five years.

**APPENDIX B:**  
**LISTING OF RESEARCH REPORTS**



- 1232-1 "VISION Brochure"
- 1232-2 "Compendium of Papers for Southwest Texas Regional Transportation Center," Beasley, P.S.; Timm, R.J.
- 1232-3 "*Texas Highway Operations Manual*"
- 1232-4 "Operational Evaluation of Effects Resulting from Freeway-Freeway Interchange Geometrics," Hanks, James W.; Gisler, W.; Taylor, S.; Mounce, John M.
- 1232-5 "A Review of Automated Enforcement," Fitzpatrick, Kay
- 1232-6 "Development of Fiberoptic Sign Displays for Dynamic Lane Assignment," Gisler, W.; Rowan, N.
- 1232-7 "Computational Realizations of the Entropy Condition In Modeling Congested Traffic Flow," Nelson, Paul; Bui, D., Narasimhan
- 1232-8 "Advanced Technologies for Communicating With Motorists: A Synthesis of Human Factors and Traffic Management Issues," Balke, Kevin N.; Ullman, Gerald L.
- 1232-9 "Guidelines on the Use and Operation of Changeable Message Signs," Dudek, Conrad L.
- 1232-10 "Guidelines on the Selection and Design of Messages for Changeable Message Signs," Dudek, Conrad L.
- 1232-11 "Considerations in the Application of Freeway Computer Simulation Models to Project Evaluation," Barnes, Kirk E.
- 1232-12 "Method for Selecting Among Alternative Incident Detection Strategies," Balke, Kevin N.; Ullman, Gerald L.
- 1232-13 "Effect of Freeway Corridor Attributes Upon Motorist Diversion Responses to Real-Time Travel Time Information," Ullman, Gerald L.; Dudek, Conrad L.; Balke, Kevin N.
- 1232-14 "Evaluation of Express Lane Effectiveness in Freeway to Freeway Interchanges," Hanks, James W.; Barnes, Kirk E.; Mounce, John M.
- 1232-15 "Incident Response and Clearance in the State of Texas: Case Studies of Four Motorist Assistance Patrols," Wohlschlaeger, S.D. ; Balke, Kevin N.

- 1232-16 "Considerations in the Application of Collector-Distributor Designs for Improving Mainlane Freeway Operations," Barnes, Kirk E.; Hanks, James W.; Mounce, John M.
- 1232-17 "Methodology for Assessing Feasibility of Bottleneck Removal," Walters, Carol H.; Poe, Christopher M.; Skowronek, D.
- 1232-18 "Space Management: An Application of Dynamic Lane Assignment," Jella, Rohini K.; Sunkari, Srinivasa; Gisler, W.; Rowan, N.; Messer, Carroll J.
- 1232-19 "Alternative Method of Analyzing Merge/Diverge and Weaving Areas on Freeways with Four or More Directional Lanes," Barnes, Kirk E.
- 1232-20 "An Evaluation of Existing Incident Detection Algorithms," Balke, Kevin N.
- 1232-21 "Evaluation of Sensors for Monitoring Truck Speeds," Middleton, Dan R.
- 1232-22 "Detector Accuracy and Reliability Testing for Elevated Roadways," Woods, Donald L.; Hamm, Robert A.
- 1232-23 "Advanced Freeway System Ramp Metering Strategies for Texas," Messer, Carroll J.
- 1232-24 "Advanced Real-Time Ramp Metering Systems (ARMS): The System Concept," Liu, Jyh-Charn S.; Kim, Junguk L.; Chen, Yilong; Hao, Ying; Lee, Soojung; Kim, Taeyoung
- 1232-25 "Interim Program Documentation on System Ramp Control Optimization Algorithms," Chang, Edmond C.P.; Messer, Carroll J.; Wang, Su-Hua; Huang, Wei; Li, Allen
- 1232-26 "Hardware/Software Compatibility for Traffic Management/IVHS Systems," Carvell, James D.; Seymour, Edward J.
- 1232-27 "Improved Communication of a Left Exit Lane Drop Using Pavement Markings," Fitzpatrick, Kay; Lance, M.; Urbanik II, Thomas
- 1232-28 "A Study of Selected Warning Devices for Reducing Truck Speeds," Middleton, Dan
- 1232-29 "Corridor Analysis Guidelines for Incident Management," Lee, Sibok ; Krammes, Raymond A.;
- 1232-30 "An Evaluation Guide Signing at Multilane Freeway Exits," Summers, Richard A.; Hawkins, Jr. H. Gene; Urbanik II, Thomas

1232-31 "Real-Time Adaptive Metering Bottleneck Optimization (RAMBO) Users Manual,"  
Tyer, Kevin D.; Charara, Hassan A.

1232-32F "Urban Highway Operations and Implementation Program Overview and Summary,"  
Thomas Urbanik II

