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16. Abstract This report discusses the activities conducted for the Houston District on a variety of topics. High Occupancy Vehicle (HOV) Lane evaluations were conducted quarterly on five facilities and twenty-nine park and ride facilities were surveyed. Dynamic Lane Assignment Systems (DALAS) were evaluated, Automatic Vehicle Identification (AVI) Systems were designed for freeway traffic monitoring, and air quality impact analyses were conducted for a variety of traffic management applications. Urban planning studies involving roadway inventory, travel time, and vehicle classifications were conducted. General traffic data collections were conducted to maintain the District database and numerous roadway cost analyses were made. A Public Information Survey on Houston mobility and safety was conducted at the Houston Auto Show. The project staff provided technical assistance to the Department in the planning and design of the Central Control Facility for the Computerized Transportation Management System (CTMS). A system of above-pavement traffic detectors, using infrared light sensors, was successfully tested to measure speeds, classify vehicles and to initiate warning information to large trucks on freeway connectors.			
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**PLANNING, DESIGN, AND OPERATION  
OF TRANSPORTATION FACILITIES IN HOUSTON, TEXAS:  
A SUMMARY OF ACTIVITIES**

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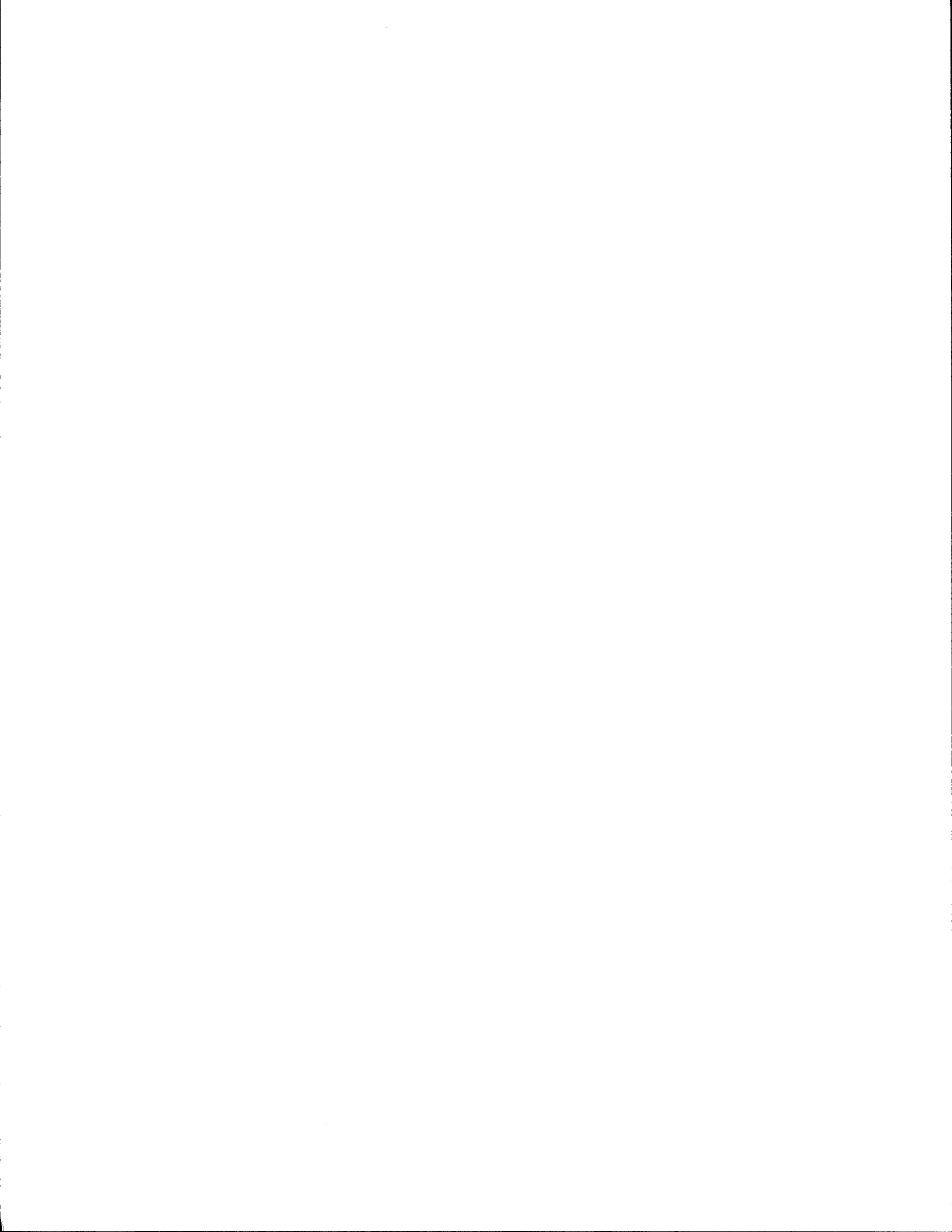
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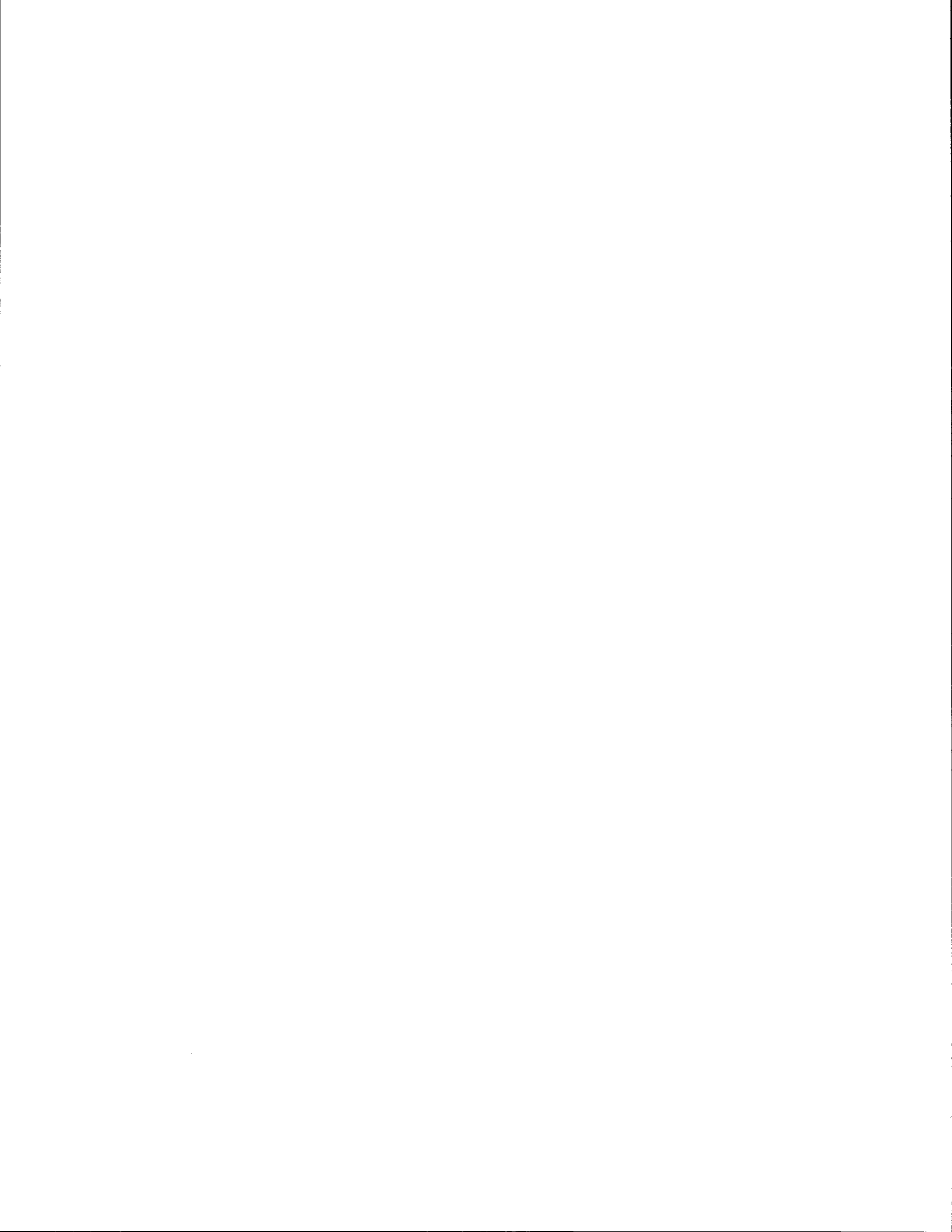
## **IMPLEMENTATION STATEMENT**

The Houston District office of the Texas Department of Transportation immediately utilized much of the work activity outlined and summarized in this report in order to make decisions regarding projects which were or are programmed to be funded and implemented. The Texas Transportation Institute conducted other historical and on-going work activity discussed herein which is continually being used in both planning and operational assessments of the transportation facilities in Houston.



## **DISCLAIMER**

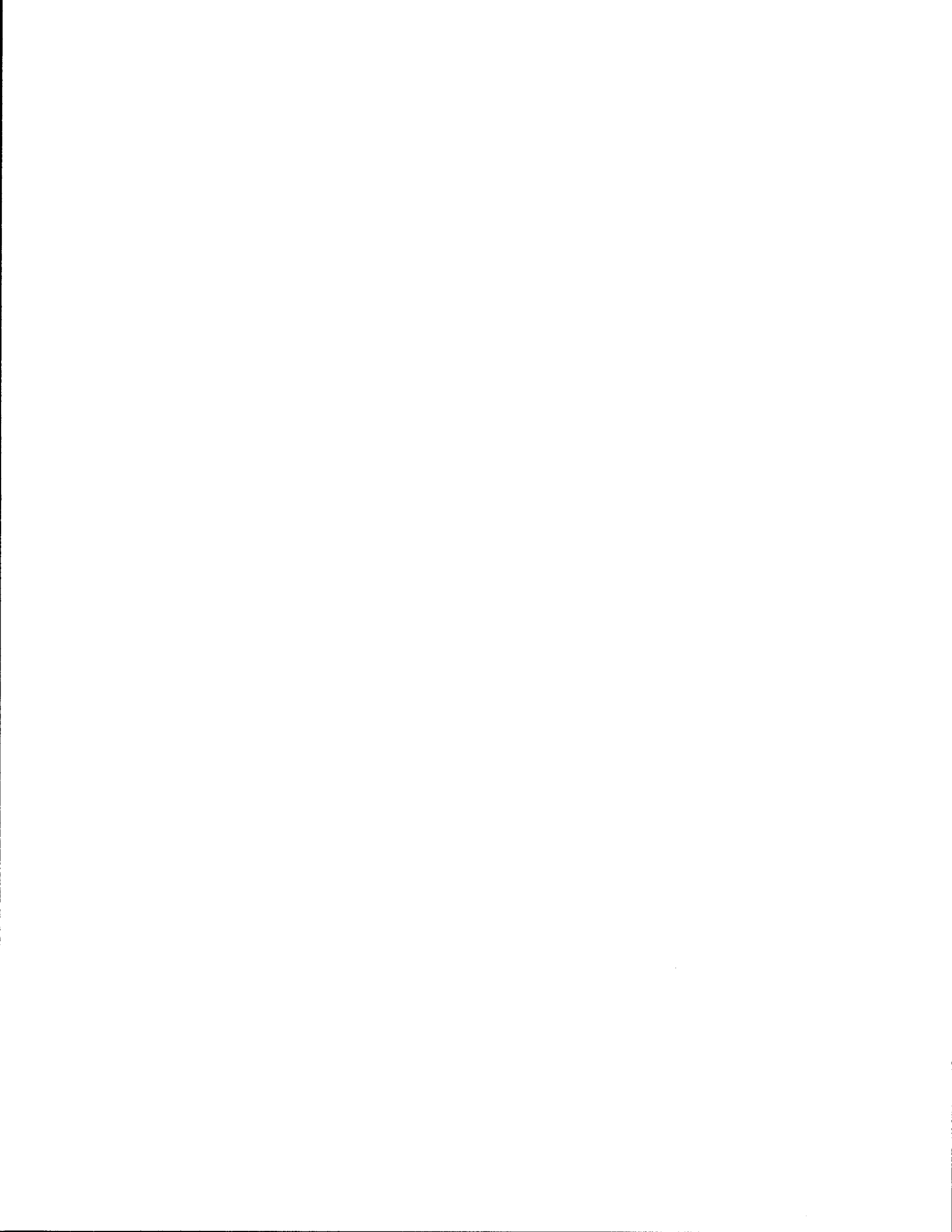
The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation and the Federal Highway Administration. This report does not constitute a standard specification or regulation and is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was William R. McCasland, P.E. #21746.





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## SUMMARY

This report summarizes the activities conducted on a variety of topics for the Texas Department of Transportation, Houston District. High Occupancy Vehicle (HOV) Lane evaluations were conducted quarterly on five facilities, measuring the vehicle occupancies, volumes, and travel times. Vehicle usage counts were also made at twenty-nine park and ride facilities. Dynamic Lane Assignment Systems (DALAS) were evaluated to determine if approach capacities on frontage roads could be adjusted to traffic demands. Automatic Vehicle Identification (AVI) Systems, Phases 1 and 2, were designed for freeway traffic monitoring. Air quality impact analyses were conducted for a variety of traffic management applications to determine if these applications qualified for Congestion Mitigation Air Quality Funding. A major activity was the development of the Priority Corridor Program for the Houston District. Urban System Planning studies were conducted with simulation models to study major geometric changes in the freeway network. Also low speed weaving on freeway frontage roads was investigated.

There were two major efforts in Freeway Incident Management: 1) the development of Geographical Information Systems (GIS) for traffic management applications; and 2) the monitoring and evaluation of the Motorist Assistance Program (MAP). Urban Planning studies were conducted on 150 roadways to measure travel time and speeds. Other surveys were conducted to develop roadway inventories and to collect vehicle classification data.

General traffic data collections were conducted to maintain the District database, and numerous road user cost analyses were made for specific areas. A Public Information Survey on Houston mobility and safety was conducted at the Houston Auto Show. The project staff provided technical assistance to the Department in the planning and design of the Central Control Facility for the Computerized Transportation Management System (CTMS). Several graphical modeling software development tools were evaluated and the DataViews package was acquired to begin the development of prototype software for the operator stations in the Central Control Facility.

A major study in the collection and processing of real time travel time information was conducted in the North Houston Corridor. A cellular telephone call-in system involving 200 volunteers was developed and operated on four separate roadways. This study was used to justify the development and implementation of the Automatic Vehicle Identification monitoring system.

A system of above-pavement traffic detectors, using infrared light sensors, was successfully tested to measure speeds, classify vehicles, and to initiate warning information to large trucks on freeway to freeway connectors.

In the development of the Houston Intelligent Transportation Systems (HITS), this project assisted the Houston District in the preparation of position papers and drafted a design and implementation program that resulted in the approval of a cooperative agreement between the Federal Highway Administration and the Texas Department of Transportation.

## INTRODUCTION

The Houston District of the Texas Department of Transportation (TxDOT) continues to reconstruct the urban freeway system to replace roadways that have reached their effective life, to expand the roadways to accommodate the increasing demand for mobility, and to incorporate special use facilities HOVLs to provide priority operations for high volumes of commuter traffic. However, the expansions must be further justified in terms of the effects on air quality since Houston has been designated as a non-attainment area. This designation presents opportunities to expand the applications of traffic management strategies and techniques to improve the efficiency and safety of the existing and new freeways and arterial streets, since Houston has been designated as a Priority Corridors Site. Finally, the development of advanced systems of traffic management in Houston through the Intelligent Vehicle/Highway System (IVHS) Program has progressed with the establishment of the first of many such projects in Houston in the *Smart Commuter Project* in 1993.

The Texas Transportation Institute (TTI), through its research program, has developed a staff that is uniquely qualified to assist the TxDOT in the planning, development, and operation of transportation facilities, in the management of traffic and traffic operations on the Houston HOVL and freeway system, and in the development of proposals for the award of contracts in the IVHS and Priority Corridors Programs. The Houston-based staff of TTI has the support of the headquarters office at College Station, but is available for daily consultations with the TxDOT, Houston District staff. It is through these continuing and personal contacts that the statements of work to be performed are developed under the direction of the Houston District staff.

This report summarizes the activities of the many projects undertaken as part of this contract, which is the seventh 2-year contract between TTI and the Houston District office. Many of these activities, such as roadway inventory, network travel time analyses, and traffic data collection, are continuing efforts that support several departments of the District Office. Many other projects involve short term studies with specific time dependent schedules for the analysis and determination of solutions. Recent activities have involved the formation of projects in the Federal IVHS Program and the development of documentation for other demonstration programs supported by the Federal Highway Administration. The significance of these issues

is the ability of the Houston District office to respond through the TTI agreement to rapidly changing requirements in areas of air quality, traffic management and information systems.

Therefore, the objective of the study is to provide the Houston District office of the TxDOT with staff support to conduct planning, engineering, and technical services in the development and management of urban transportation facilities.

## **STATEMENT OF TASK ACTIVITIES**

### **TASK I. HOVL SYSTEM IMPLEMENTATION AND EVALUATION**

This task provides planning and engineering services to TxDOT in support as needed for the implementation and evaluation of the High Occupancy Vehicle Lane (HOVL) System. This task provides for the monitoring of operations on all active HOVL's, the conduct of necessary studies and analyses to expedite implementation of HOVL's in planning and design, and the documentation and reporting of evaluative results and decisive recommendations relating to the Houston HOVL System. TTI also assists TxDOT with coordination between cooperative agencies and serves with representation at all requested technical meetings.

Occupancy and vehicle volume counts were conducted monthly on all Houston HOVL's at two or more locations on each facility. Vehicle counts were also made at all associated park-and-ride lots and park-and-pool lots (twenty-nine lots in total) in the major freeway corridors. Travel time surveys were conducted on each HOVL during each quarter. Quarterly reports of this data were prepared and distributed (1). A 90-day evaluation of HOVL operations on the Southwest Freeway (U.S. 59S) was conducted (2).

### **TASK II. TRAFFIC MANAGEMENT, OPERATIONS, AND CONTROL ANALYSES**

This task provides engineering and technical assistance to TxDOT for the analyses of traffic management, operations, and control problems on the Houston freeway system and the adjacent arterial network. Studies were conducted to optimize capacity, level of service, and motorist information within physical and fiscal constraints. The areas of study included construction and maintenance work zones, major interchange and intersection connections, ramp metering and reconfiguration, freeway and frontage road interface, transportation system management improvements, and accident location evaluation. Studies were conducted on automated signs and signals on frontage roads to adjust approach capacities to traffic demands to reduce congestion and energy consumption. TTI also coordinated and provided participative support to traffic management meetings and conducted workshop training in specific areas of technical need as defined by TxDOT.

Some specific activities conducted under this task are:

1. Developed specifications for the Automatic Vehicle Identification (AVI) system (3, 4).
2. Conducted analyses of air quality impacts (5) for:
  - automatic barrier gate operations;
  - fire fighting water system on IH 610 Ship Channel Bridge;
  - intelligent vehicle highway system projects;
  - motorist assistance program; and
  - computerized transportation management system.
3. Prepared proposal with TxDOT for development of the priority corridors program (6).
4. Conducted analyses of detection systems to be utilized on elevated roadways (7).
5. Completed an evaluation of reflectorized fencing on U.S. 59 Eastex Freeway (8).
6. Completed analysis of proposed modifications to IH 610 West Loop Freeway at U.S. 59.
7. Prepared HOVL demand estimates for a proposed IH 610 West Loop HOVL (9).

### **TASK III. URBAN SYSTEM CONCEPTUAL PLANNING AND DESIGN**

This task provides conceptual planning and engineering design services for TxDOT to establish long-range reconfiguration of the Houston urban system. Capacity and level-of-service model projections were made to identify operational and safety constraints, and alternative interim and future improvements were evaluated in terms of mobility benefits accrued versus construction and delay costs incurred. Recommended designs were prepared in both schematic and report form.

Some of the specific analyses that were conducted under this task are:

1. Prepared a complete model of the IH 610 Loop and radial freeways to downtown using the freeflow simulation model. The Houston freeway system model was demonstrated with a report documentation submittal (10).
2. Conducted analysis and evaluation of North Shepherd strategic arterial improvements with development of a conceptual design submitted to the Houston District.



3. Evaluated low speed weaving sections characteristic of collector-distributor roadways. Results were summarized in a submitted technical memorandum (11).
4. Assessments were made of alternative possible uses for sections of abandoned railroad rights-of-way with the Houston District. Traffic (rail/highway) characteristics were analyzed relative to existing and modified alignments. Overlay index maps were prepared.

#### **TASK IV. FREEWAY INCIDENT MANAGEMENT**

This task provides technical support to TxDOT for documentation and analysis of all major and minor freeway incidents and associated responses. This technical support was focused on assistance in the evaluation of the Motorist Assistance Program (MAP) and the development of an incident response plan that provides for management of real-time data, alternative diversion routes, and coordination of incident response agencies.

Coordination of field data collected by MAP personnel was summarized and evaluated for preparation of monthly and quarterly (12) activity reports assessing the effectiveness of MAP. A specific report was prepared analyzing the effectiveness of MAP during reconstruction of the Southwest Freeway (13).

Architecture of an automated incident management (AIM) plan has been developed using geographic information systems technology. The proposed automated incident management (AIM) plan utilizes several maps and databases, which are manipulated by application programs, that have been written for use in traffic management centers, such as the Interim Central Control Facility (ICCF). A report documented the use of GIS for implementing an Incident Management Plan (14).

The following activities were performed towards the AIM plan:

1. Developed a set of digital computer maps, using TxDOT quad maps, representing freeway and major and minor arterials in the Houston metropolitan area.
2. Designed a set of databases associated with the digital maps. The databases include roadway inventory, 24-hour hourly volumes, and latitude and longitude referencing using data from Census Bureaus TIGER files and incident management resource contacts.

3. Additional databases have been designed for incident management resources such as police, fire, and hospitals.
4. Developed applications to operate on the maps and databases stated above. The applications may be classified into one of the following two types. The first are those that address real-time incident management issues. The second are those that address incident management planning and analysis issues.

#### **TASK V. URBAN PLANNING STUDIES AND TECHNICAL ASSISTANCE**

This task provides for the collection, reduction, and analysis of transportation and related socio-economic data in support of TxDOT studies relevant to urban planning. The data collected under this task include traffic movements, vehicle volumes, types of vehicles, passenger volumes and distributions, operational speeds and travel times, roadway physical features, and other areas of special interest (such as environment) that are required for urban planning studies. These data are processed and maintained by computer files for summary tabulation, statistical analysis, and/or simulation modeling as directed by TxDOT. TTI also provided technical assistance as directed by TxDOT with any other computer databases or programming.

The following activities were conducted under this contract:

1. Travel time and speed surveys were conducted on 150 separate roadway facilities. Data was collected for the AM, OFF, and PM peak periods and were published in two reports (15, 16).
2. The 24-hour vehicle classification studies were conducted at 16 locations, with vehicles being counted in both directions at 15-minute intervals and classified into nine categories (17).
3. Roadway inventory studies were conducted covering the Houston-Galveston Regional Transportation Study (H-GRTS) area (18).
4. Travel time and speed studies were conducted with special emphasis on the activity centers (19) in and around the Houston central business district. Data was collected during the AM, OFF, and PM peak periods and reported in a technical memorandum.
5. Coordinated the distribution of data collected to the Houston District's Planning Department as the needs were identified.

## **TASK VI. TRAFFIC DATA COLLECTION, DATABASE, AND COMPUTER MANAGEMENT**

This task provides technical services necessary for the continuation of the freeway traffic database model for TxDOT. This task includes the field acquisition of freeway, ramp, frontage road, and major intersection vehicular volumes and movements. Computer assimilation of this data was conducted with analysis and outputs as directed by TxDOT. Under this task TTI also developed a database for intersection control to include inventory of traffic signal equipment, timing patterns, scheduled and performed maintenance, and citizen complaints. TTI was also responsible for developing and testing bar code technology with GRiDPad computers for signal maintenance records.

A summary of the many studies, data collection activities, and reports prepared at the request of the TxDOT Houston District staff is presented as follows:

1. For the two-year period from September 1, 1991 to August 31, 1993, TTI completed 2,583 traffic volume studies at 1,457 separate locations. Manual turning movement or freeway mainlane volume counts were also completed as needed. All data was provided to the TxDOT contact person requesting the specific counts upon completion of the effort. A summary of all counts and 24-hour totals is submitted to several Houston District departments (traffic operations, right-of-way, construction, advanced project development, advanced transportation planning, design) each month (20).
2. Travel time studies, ramp and frontage road volume studies, and mainlane vehicle volume and occupancy studies are completed in IH 610 West Loop on a quarterly basis. This is the continuation of an ongoing monitoring effort that began in October 1990 (21).
3. Major traffic studies were conducted at six-month intervals near two shopping malls in the Southwest Freeway area to assess the impact of the reconstruction project on traffic patterns (22). Additional studies were conducted for similar construction projects on the IH 45 North Freeway and S.H. 249 began in 1993.
4. Freeway mainlane and HOV lane traffic counts were completed to supplement yearly ramp counts completed by D-10 (23).

5. Routine and signal statistical evaluations of District traffic signal maintenance records were completed as requested.
6. Field studies were completed to address special problems as requested by the Houston District staff. Separate detailed reports were prepared for "Operation Big Switch" (24), the NASA Road 1 corridor (25), and a noise study on IH North (26).
7. Road user cost estimates were completed to assist TxDOT in assessing liquidated damages in construction contracts. TTI collected the necessary traffic data and prepared cost estimates for construction projects on U.S. 59 Southwest (27), IH 45 North (28, 29), IH 10 Katy (30), and S.H. 249 (31, 32).

This task has been one of the primary sources of information on traffic characteristics on freeways and frontage roads in the Houston area for several years. This information is used by the Planning, Construction, Design, Maintenance, and Operation Department of TxDOT and others.

#### **TASK VII. PUBLIC SURVEYS AND INFORMATION**

This task provides technical services to TxDOT for the conduct of public opinion surveys to obtain data relevant to the presentation of public information. This includes the production of pamphlets, brochures, and videos. Survey questionnaires were designed for response utility and statistical analysis. Public information documents were prepared from survey results to optimize communication and understanding of TxDOT activities. TTI also provided both artistic and graphical (computer) support as requested by TxDOT for the production of public information material.

Some of the activities and accomplishments of this task are listed:

1. Prepared and evaluated the Texas Transportation Information Program ("TIP") brochures and assisted in the distribution to the public at the 1992 Houston Auto Show (33).
2. Prepared and evaluated a public information survey distributed at the 1992 Houston Auto Show relative to mobility in Houston and transportation information (34).

3. Prepared and evaluated a public information survey distributed at the 1992 Houston Auto Show concerning traffic safety issues (35).
4. Developed and evaluated a survey of motorist comprehension and response to changeable message sign display information, which was distributed at the 1992 Houston Auto Show (36).
5. Prepared and evaluated a public information survey concerning traffic congestion, which was distributed at the 1993 Houston Auto Show (37).
6. Prepared and evaluated a public information survey relative to traffic safety which was distributed at the 1993 Houston Auto Show (38).

### **TASK VIII. CENTRAL CONTROL SYSTEM DESIGN AND SOFTWARE DEVELOPMENT**

This task provides technical assistance in the development of specifications for the surveillance, communication, control, and computer hardware to be installed in the Central Control Facility for the Computer Traffic Management System (CTMS).

Some of the activities conducted under this task are:

1. TTI conducted a review of the computing hardware specifications with various other agencies.
2. TTI assisted TxDOT in the review of the equipment proposed by contractors (39).
3. TTI obtained and evaluated different graphical modeling software development tools for Central Control utilization. DataViews was selected and the following programs and documentation manuals were obtained: DV-Draw Version 9.1, DV-Tools Version 9.1, DV-Play Version 9.1, and DataViews Demo Version 9.1.
4. TTI has initiated development of prototype software for use by the Central Facility (40).
5. TTI is assisting in the determination of communications design for the Central Facility. The proposed design is outlined in a technical memorandum on CTMS Operations Theory (41). Modifications to this design may be made when detail design efforts on the Central Facility begins.
6. Administrative control of the DECstation was given to TTI to be utilized in the development of the central applications software package, DataViews.

## **TASK IX. INTELLIGENT VEHICLE/HIGHWAY SYSTEMS (IVHS) DEVELOPMENT**

This task is designed to develop proposals for implementation and evaluation of IVHS demonstration projects. The first project selected under this task was to establish and operate a Traveler Information Center as part of a demonstration project in the North Houston Corridor. A study employing 200 volunteers to report travel times and roadway conditions on their commute trips by cellular telephone was conducted over an 18-month period (42). The results of this study were presented in a technical report (43).

## **TASK X. DEVELOPMENT OF THE HOUSTON INTELLIGENT TRANSPORTATION SYSTEM (HITS) PLAN**

This task was initiated to develop the framework for an organization to manage the various projects that will make up the Houston Intelligent Transportation System (HITS) (44). These projects include, but are not limited to, the CTMS, the Smart Commuter, the Motorist Assistance Program (MAP), and the Automated Incident Management System. A plan was developed for the implementation of these various systems with emphasis on the institutional issues for providing coordination and integration of resources between various governmental and private agencies.

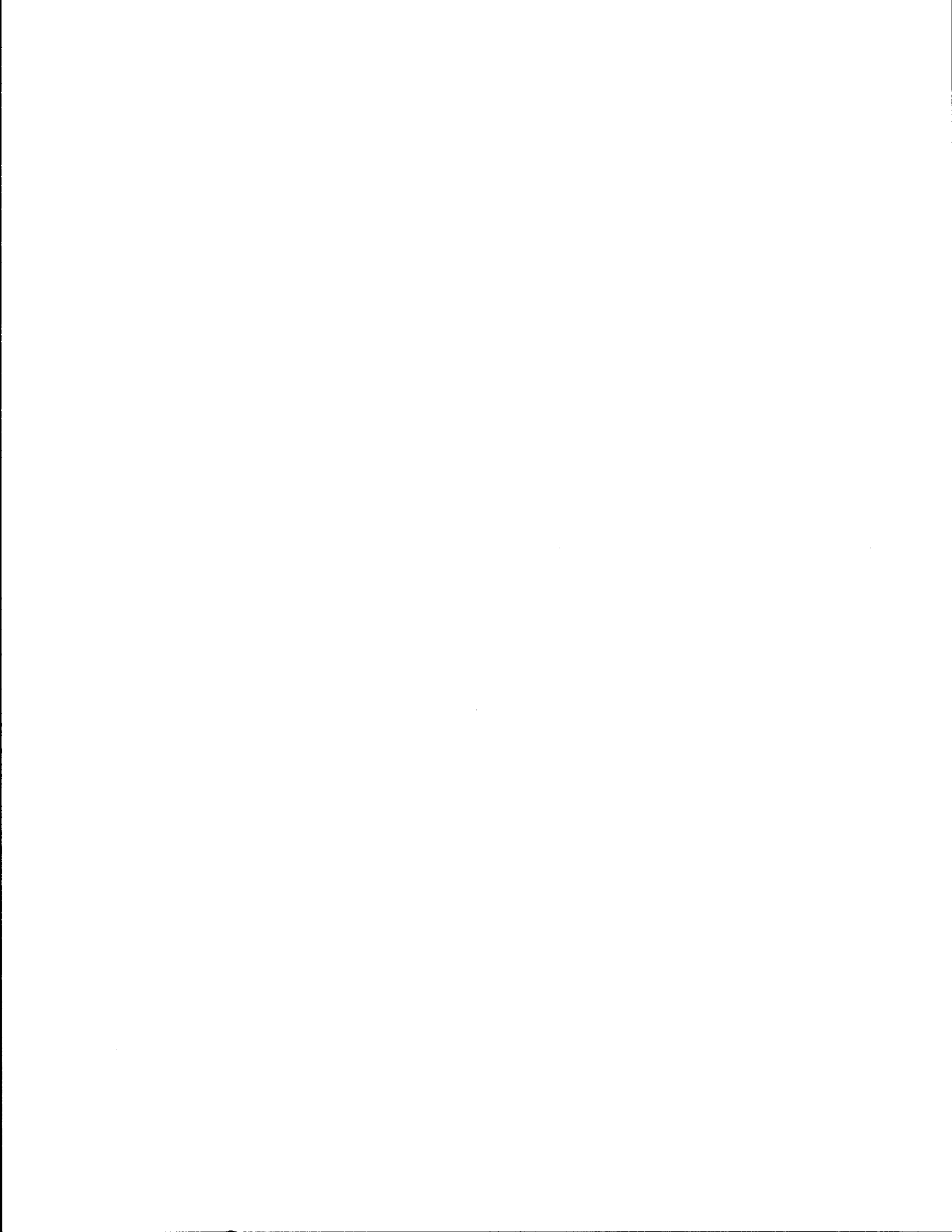
A position paper was prepared for the Houston District that outlined the requirements for an institutional structure for the implementation of an integrated transportation management system (45).

A conceptual design and implementation program for the Houston Smart Commuter IVHS project, which was drafted in May 1991, resulted in the approval of a cooperative agreement between FHWA and TxDOT in October 1992 (46).

## **TASK XI. DEVELOPMENT OF A WARNING SYSTEM FOR HIGH, FAST VEHICLES ON CURVED FREEWAY RAMPS**

This task is directed to supporting the development of detection and instrumentation to measure speeds and classify vehicles that travel the urban interchange ramps with high degree of curves in order to provide warning devices when speeds exceed certain limits.

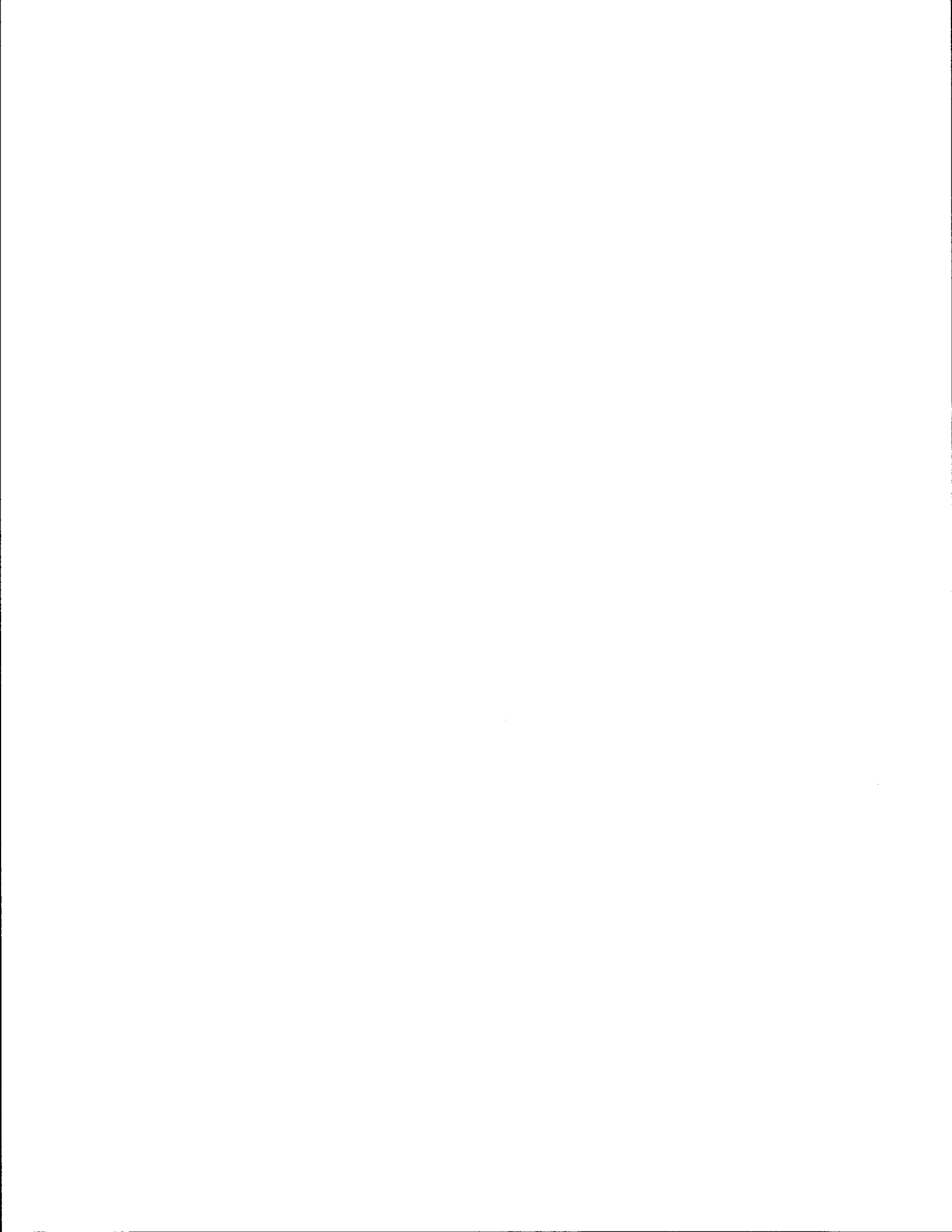
On-pavement systems were deployed to measure speeds and classify vehicles using induction loops and piezo electric axle sensors (47). An above-pavement system, using infrared light sensors, was used to detect the speeds of high vehicles (48). These systems were used to warn trucks entering a freeway connection that speeds were too high for the ramp alignment. Different types of warning systems will be tested at this study site.





## **CLOSURE**

The activities listed in this report represent only a part of the accomplishments of the partnership of the Houston District office and TTI. TTI staff attend and participate in numerous meetings with TxDOT and other transportation agencies. TTI staff are often asked to meet with visitors to TxDOT from other states and countries. Prebid conferences, planning and management meetings, plan reviews, and traffic control conferences are some of the activities in which TTI staff are asked to participate.



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