ADVANCED SYSTEM IMPLEMENTATION WITH LIMITED RESOURCES

by

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SUMMARY

In an effort to alleviate congestion in urban areas, many agencies are considering the implementation of advanced transportation management technology. Most of these agencies are faced with the challenge of dealing with urban congestion with very limited resources. The implementation of these advanced systems raises issues of concern regarding the availability of funding, facility, personnel, and training resources.

This report represents the summarization and documentation of a review of selected advanced traffic management systems and their implementation in an environment of limited resources. The paper identifies critical funding, facility, personnel, and training issues related to the successful implementation of advanced systems, including freeway traffic management systems. A knowledge base acquisition approach was used to draw upon the experiences gained through the successful implementation of advanced traffic management systems in Chicago, Los Angeles, and Minneapolis. Finally, a critical review of the implementation plans for advanced systems, including freeway traffic management systems, in the Texas urban areas was performed and recommendations were provided for improvement of the transportation management strategy.

This report provides several recommendations which should streamline the traffic management implementation effort in Texas including the restructuring of some Division and District activities. Recommendations are also made for the procurement and attraction of funds, equipment, and personnel. Finally, recommendations are made concerning other related issues necessary for continued long-term success of the advanced system.

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INTRODUCTION

Background

The installation of a stop sign at a location where no prior traffic control has previously existed could be construed as a form of an advanced traffic management system. The stop sign would have the effect of metering the traffic input into the main stream of traffic, based on the driver in the secondary stream being required to stop and yield to the opposing traffic. The deceleration, stopped, and acceleration times incurred by the secondary vehicle could be considered as the metering rate at which these vehicles are allowed to enter the main traffic stream. By managing the secondary traffic stream, congestion incurred by the main stream traffic can be alleviated since right-of-way would be clearly defined and the frequency of incidents would then be reduced.

While the given example represents an unrealistic and very simplistic approach, the concept of traffic management is being considered in many urban areas to provide a more efficient transportation system. A recent performance review report on the Texas State Department of Highways and Public Transportation (SDHPT) offered the following comments (1):

> "SDHPT has come a long way from 1917 when a Department of Highways was created to 'get the farmer out of the mud.' Over the years, SDHPT has built an effective system of quality highways across the state--a system that is considered one of the best in the nation. However, an effective system is not necessarily an efficient one."
>
> "... the role of the SDHPT has changed from creating a statewide system to maintaining the quality of the existing highway system and providing greater mobility for commuters with minimum congestion and delay."

Clearly, the review suggests that the SDHPT should move toward the establishment of effective transportation management systems. Administrators in state highway agencies have commented that the future of their agencies rests in the ability to effectively manage the projected increases in traffic since the ability to build new roadways is becoming a less desirable option (2). Added capacity roadway improvements in urban areas are becoming considerably expensive with increasing right-of-way and construction costs. Therefore, the transportation engineer is faced with the task of finding new and innovative methods of maximizing the efficiency of the existing facilities.

Additional emphasis is being placed on the use of higher technology to provide more efficient and safer driving. The Highway/Vehicle Technology Committee of the Highway Users Federation offers the following comments from the national perspective (3):

"As a nation, we can be justly proud of building the finest system of highways the world has ever known. The 44,600 miles of Interstate Highway System has helped to secure the nation and fuel economic development. But this system is becoming obsolete and will be unable to handle changes in traffic coming its way."

"... new highways must be built in expanding areas and capacity must be increased in over burdened corridors. However, America must also make better use of the roads, streets, and highways we already have. The application of technology can add efficiency and capacity without adding pavement. At the same time it can reduce congestion, pollution, and accidents."

These comments coupled with the encouragement to develop intelligent vehicle highway systems (IVHS) have sparked a move to more effectively "manage the use of the highway network and increase its efficiency in much the same way as air traffic controllers manage the use of airway and airport terminal network" (4). Additionally, Congress is currently considering legislation to provide for funding and technological advancement in the area of IVHS along with a new federal highway bill (5,6).

Many agencies throughout the nation perceive the need to become more involved in transportation management and are looking toward the implementation of advanced systems as a means of reducing congestion. However, many of these agencies are experiencing a lack of available resources at their command as they embark upon the implementation of advanced traffic management systems. These limited resources take the form of funding, facility, personnel, and training constraints. The lack of available funding sources and revenues is considered to be limited resource. Another limited resource is the lack of sufficient facility requirements necessary to adequately provide for efficient and effective system operations. The lack of qualified personnel employed by the agency to adequately design, operate, and maintain such systems, along with the inability to maintain continuous long-term career opportunities for such a highly specialized staff is also perceived as a limited resource. Finally, the lack of existing training programs to keep abreast of new and changing technology is thought to be a limited resource. This report explores these and other issues that may either negate or encumber the implementation of advanced traffic management systems.

Problem Statement

In an effort to alleviate congestion in urban areas, many agencies are looking toward the implementation of advanced transportation management technology. While some agencies have undertaken extensive research and implementation programs, most are faced with meeting the challenge of dealing with urban congestion with very limited resources upon which they must rely. All agencies, regardless of size, must deal with problems associated with budgetary constraints and keeping abreast of ever changing new technology. Other associated problems include the attraction and retention of qualified employees and the challenge of implementing a useful and workable system.

The Texas SDHPT is certainly not immune from the budgetary constraints presently facing many states throughout the nation. In these times of economic hardship it is becoming increasingly difficult to attract and maintain a highly qualified work force. Additionally, governmental agencies, as a whole, are being held more accountable for their actions. Less costly innovative improvement programs are becoming more attractive as a result. Planning, design, and construction efforts for advanced traffic management systems are being initiated in most major urban cities in Texas by the SDHPT. It is believed that such systems will significantly reduce both recurrent and non-recurrent congestion with fewer associated costs than the traditional construction of additional freeway lanes.

Each advanced traffic management system must be tailored to meet the specific needs and provide the intended functions for the environment in which it is intended to serve. While most states have only one or two major urban cities, Texas presents the unique problem of having several major urban cities. Another state may be able to develop a system without regard for the interchangeability and compatibility of equipment or software, whereas, the Texas systems are bound by these constraints. Therefore, it is believed that a knowledge base of the experiences from various agencies who have undertaken such projects in the past would be beneficial when considering advanced system implementation.

Several questions need to be resolved at the onset of any advanced system project. The first major question that arises regards the availability of sufficient funds to provide for both the initial capital outlay and for adequate support and maintenance over the life of the project. The second major question focuses on the personnel issue. The agency must be able to attract, properly train, and provide incentives for retaining the highly specialized employees required to design, operate, and maintain advanced traffic management systems. Other questions that arise deal with facility requirements and the extent of systems required to meet the needs of the specific agency. This paper will focus on the funding, facility, personnel, and training requirements necessary for the successful implementation of an advanced freeway management system.

Objectives

This report represents the summarization and documentation of a review of selected advanced traffic management systems and their implementation in an environment of limited resources. The objectives of this paper are as follows:

1. Identify critical issues essential in the successful implementation of advanced systems, including freeway traffic management systems, as they relate to funding, facilities, personnel, and training.

2. Draw upon the experiences gained through the successful implementation of advanced traffic management systems in Chicago, Los Angeles, and Minneapolis create a knowledge base model (Survey Model) of freeway traffic management systems.

3. To review and provide recommendations for improvement of the proposed advanced traffic management systems in Texas using a model (Texas Model) developed from the proposed features of the systems in Fort Worth, San Antonio, and Houston.

Scope

The scope of this report was narrowed to deal specifically with advanced freeway traffic management systems due to the limited time available to complete the project. While this paper deals with only a small part of an overall advanced traffic management program, the issues being faced by the transportation engineer remain the same. Therefore, the issues identified herein could be applied to other advanced systems and critical reviews could be performed in a similar fashion.

In order to provide a comparison between other successful freeway traffic management systems from selected urban cities throughout the nation, a knowledge base was created. The systems in Chicago, Los Angeles, and Minneapolis were used to obtain a model system for the knowledge base. This knowledge base was then used to critique the proposed freeway traffic management systems planned for the major Texas urban cities. The planned systems in Fort Worth, San Antonio, and Houston were used for comparison. Recommendations for improvements to the plans for these Texas systems were then made based upon the conclusions drawn from this constructive review.

SYSTEMS OVERVIEW

Intelligent Vehicle/Highway Systems

Intelligent Vehicle / Highway Systems (IVHS) covers a broad spectrum of topics in the transportation arena. The earliest intelligent vehicle consisted of a chinese chariot with a Budda figurine on top which pointed North, independent of the direction of travel. In modern terms research has been ongoing since the early 1950s to develop a vehicle which could maneuver itself on the roadway. In 1972, General Motors determined that such "smart cars" were cost prohibitive. Recently a great deal of research is being conducted in the area of IVHS by the United States, Japan, England, Germany, and many other European countries (7).

Envisioned benefits of IVHS include increased mobility and safety. To provide these benefits IVHS will concentrate on four specific areas:

1. Advanced Traffic Management Systems (ATMS),
2. Advanced Traveler Information Systems (ATIS),
3. Advanced Vehicle Control Systems (AVCS), and
4. Commercial Vehicle Operation Systems (CVO).

Advanced Traffic Management Systems will provide more efficient real-time motorist information. These systems will be designed to advise the motorist of both current and expected traffic conditions. They will also inform the motorist of the location, severity, and expected duration of incidents. The systems will also be used to provide recommended routes for the motorist to best reach his destination. Additionally, the system will used to develop and implement a variation of traffic control strategies.

Advanced Traveler Information Systems will provide the traveler with specific information on his particular mode of travel. This system is designed to provide the motorist with real-time traffic condition advisories and route guidance information. The equipment will use a combination of auditory and visual systems to provide information to the motorist (8).

Advanced Vehicle Control Systems will provide for control of on-board vehicle maneuvering systems. This system is designed to facilitate and augment the driver's performance. Through various levels of control (advisory, partial, and complete) the driver can be assisted in or relieved of vehicular control (8).

Commercial Vehicle Operation Systems will provide for commercial vehicle tracking to increase efficiency. This system is intended to reduce costs and increase efficiency for commercial vehicle operators. The system will include automatic vehicle identification and classification, weigh-in-motion, electronic placarding and bill of lading, and clearance sensing (8).

Freeway Traffic Management Systems

The purpose of advanced transportation management systems is to improve mobility on our transportation facilities. Benefits of such systems include increased speed, reduced travel time, and a lower accident rate. Transportation management systems will seek to establish good relations with the public and media, develop support among the various agencies involved, and develop a framework for control logic, operation procedures and communications (9).

Two types of congestion are common on our transportation facilities, recurring congestion and non-recurring congestion. Recurring congestion is that congestion which occurs at predictable times. Examples of recurring congestion occur during daily inbound and outbound work trips. Non-recurring congestion results from an unexpected occurrence. An example of non-recurring congestion is the congestion which results from an accident or other incident along a facility.

The management strategies used to deal with recurring congestion include the management of vehicular demand, design improvements, and management of travel demand. To manage vehicular demand we must look to the implementation of ramp controls, mainline controls, and priority controls. Geometric improvements such as the installation of HOV lanes, and projects to increase capacity can also reduce congestion. Management of travel demand can be accomplished through the use of other modes of transportation, such as public transit.

In order to deal effectively with non-recurring congestion a coordinated effort of cooperation and prompt incident service is required. Extensive use of surveillance is necessary to provide information to officials regarding real-time traffic conditions. Motorist information is also necessary so that traffic diversion may be considered to avoid an incident, thus reducing congestion on a facility.

Advanced control systems will look primarily at corridor control. By monitoring corridor routes, traffic may be diverted as necessary to manage congestion. Advanced technology will be used extensively in transportation management systems. Such technology includes the implementation of freeway management systems, HOV lanes, signal control, and the development of better models to predict traffic patterns.

Advanced motorists information systems are an essential part of an advanced transportation management system. These systems have numerous applications in the transportation systems of today and will play an important role in the transportation systems of the future. Such applications include traffic management and diversion, warning of road and weather conditions, control at crossings, special-use lane and roadway control, and control during construction and maintenance (10).

Real time motorists information displays can take the form of audio or visual communication or a combination of the two. Types of real time information displays include changeable message signs, highway advisory radio, and in-vehicle displays. Other types include telephone call-in, CB radio, commercial radio, television or teletext, and computer terminals and monitors.

Changeable message signs consist of a visual display where the displayed message may be changed at will. The messages are displayed through either a series of rotating disks or light emitting arrays. Changeable message signs are currently in use in the United States and Europe. In the United States, the signs are generally located in the metropolitan areas and are used primarily as a traffic management tool by the highway jurisdictions. In Europe, changeable message signs are primarily used in the rural areas by the police agencies to present safety and diversion information. New technology includes the use of fiberoptics, arrays of fixed messages, fixed disks with fiberoptic centers, and light emitting diodes. Research is currently being conducted in France, Germany, and Canada in these areas of new technology.

Highway advisory radio is a low power radio transmission of motorist information. Radio frequencies for such use are AM 530 and AM 1640. The messages are generally voice synthesized or taped messages broadcasted over a localized area to provide information relative to that specific area. Additionally, is some instances commercial type public radio stations are using highway advisory radio transmissions during peak periods and reverting to normal programming during off-peak periods.

Cellular telephones are becoming a more popular communications device in light of decreasing initial and operating costs. Programs have been established to provide motorist reporting services where the motorist can report traffic conditions or incidents to traffic control centers. In some cases the private sector is providing services whereby the motorist can call and receive traffic information reports and updates from either home or auto.

Future applications of motorists information systems will include in-vehicle displays. Research is currently being conducted in England, Germany, Japan, and the United States in this area. Systems being developed include the Autoguide in London, England, the LISP in Germany, where the destination is input, the computer is self reckoning, and motorist information is displayed through simple in-car audio and visual displays. The RACS and AMTICS systems are being developed in Japan and provides two-way communication, with the vehicle is a sensor in the traffic stream. In the United States work is being conducted in the cities of Los Angeles, Orlando, Houston, and San Antonio on advanced motorist information systems.

EXISTING FREEWAY TRAFFIC MANAGEMENT SYSTEM REVIEW

Overview

Ongoing freeway traffic management has been a reality in the United States for over thirty (30) years. Throughout the country there are notable examples of effective systems. Technology used by the systems range from being somewhat dated to current state-of-the-art. System design is also quite varied between the systems depending on the needs and intended purpose of the system. Furthermore, the varied experiences of those individuals who have the responsibility to design, operate, and maintain such systems is quite valuable to those agencies setting out to implement similar systems.

Notable freeway traffic management systems in the United States include those located in the cities of Chicago, Los Angeles, Minneapolis, Seattle, and Detroit. Also, the system located in Toronto, Canada should be noted as an example of an effective system. For the purpose of this paper only three (3) of the above systems were reviewed due to the limited time available to conduct the required data collection. The systems selected for review included Chicago, Los Angeles, and Minneapolis. The system review and data collection consisted of a review of available literature regarding each existing system and telephone interviews with the transportation officials responsible for their operation.

Chicago

Chicago began work in the area of freeway traffic management in 1961 as a means of "improving traffic flow on existing urban road systems by using automatic control and information techniques." The project began as a research project with a variety of funding sources and research interests. Today the responsibility for operation of the freeway traffic management program rests completely with the Illinois Department of Transportation. The system was designed to help alleviate congestion caused by numerous traffic incidents and excessive peak period traffic demand (11).

The Chicago freeway traffic management program is comprised of three major components: the Traffic Systems Center, the Communications Center, and the Emergency Traffic Patrol. The traffic systems center is "responsible for improving the efficiency and safety of traffic flow on expressways within the 6-county Chicago metropolitan area, by means of automatic traffic surveillance, control, and information systems." The Communications Center serves as a focal point for radio dispatching and other communications responsibilities. The center also coordinates all traffic and maintenance information and operations, including the communications for the departments emergency service patrol. The Emergency Service Patrol, dubbed "Minutemen," consists of a fleet of vehicles on continuous patrol to provide mobile surveillance and assistance for all incidents and potentially hazardous situations. Other activities include measures to "help maintain high capacities for the mix of traffic demands, geometrics and weather conditions prevailing in the Chicago area," including rail transit, safety lighting, truck lane restrictions, and control of freeway work zones (12).

The Chicago freeway traffic management system includes over one hundred freeway miles of expressway surveillance and an extensive monitoring and motorist information system. The various components that comprise the Chicago system are included in Table 1. The system is designed as a central processing system and does a remarkable job utilizing some of the older technology. The trend is to maintain the older system because of its demonstrated reliability in performing the job required. There is also a reluctance to venture out into the higher technology systems and as one official noted, "it is better to be on the leading edge of technology rather than the cutting edge."

Los Angeles

The California Department of Transportation (Caltrans) is involved with a host of freeway traffic management strategies in the Los Angeles area. Operational projects include the Los Angeles Metropolitan Area Management System, the Artesia Freeway HOV Commuter Lane System, and the El Monte Busway. Planned projects include the Pathfinder and Santa Monica Freeway Smart Corridor Demonstration Projects (13). All of these projects are aimed at the reduction of both recurrent and nonrecurrent congestion. Caltrans began work in the area of freeway traffic management as a result of a legislative mandate after a series of incidents caused serious congestion. A task force on traffic management recommended that the agency be reorganized, conduct research, and begin implementation of traffic management projects.

The various traffic management systems were successfully demonstrated during the 1984 Summer Olympic Games. The Olympics was a 16 day major special event contained entirely within the urbanized area of Los Angeles. The experience showed that with good planning, proper equipment, and extensive coordination between the various agencies involved, congestion could be held to a minimum.

For the purpose of this paper the Los Angeles Area Management System project will be used for comparison studies. The system consists of an extensive traffic monitoring, surveillance, and motorist information system that covers a 3 county area surrounding the City of Los Angeles. The initial 42 mile project began in the early 1970s and has been expanded to include approximately 700 centerline freeway miles. Table 1 reflects the significant system components with the Los Angeles system.

Minneapolis

The Twin City Traffic Management System in the Minneapolis and St. Paul area has been in operation for approximately 22 years. The program was implemented as a result of the combination of recurrent congestion and incidents producing average speeds below 30 miles per hour on freeway facilities. The project began as a 17 mile freeway ramp metering project and has since grown to include extensive traffic control, expressway surveillance, and motorist information systems. The various components of the Minneapolis freeway traffic management system are shown in Table 1.

Table 1. System Components for Selected Existing Freeway Traffic Management Systems

System Components	Chicago	Los Angeles	Minneapolis
Expressway Surveillance	X	X	X
Loop Detectors	X	X	X
Closed Circuit Television		X	X
Ramp Metering	X	X	X
Traffic Reports	X		X
Media Communications	X		X
Changeable Message Signing	X	X	X
Central Computer Monitoring System	X	X	X
Highway Advisory Radio (Roadside)	X	X	
Highway Advisory Radio (Commercial)			X
Incident Management Teams	X	X	X
Motorist Assistance Patrols	X	X	X
High Occupancy Vehicle Facilities	X	X	X
Traffic Management Team Coordination	X		X
Lane Control Signals	X		
Cellular Communications Program	X	*	
Emergency Call Boxes		X	
Accident Investigation Sites	X		X
In-Vehicle Guidance	X	?	X
Years of Operation	varies to 30+	varies to 20+	varies to 22+

LEGEND:
X - Existing Component
* - Private sector activity
? - Questionable at this time

The motorist information aspects of the Minneapolis system show innovative combinations of typical highway advisory radio transmissions on commercial type public radio stations producing an areawide broadcast system. Motorist information is also being broadcast over a local cable television channel. Other motorist information dissemination sources include the extensive use of changeable message signs.

PROPOSED TEXAS FREEWAY TRAFFIC MANAGEMENT SYSTEM REVIEW

Overview

The Texas plan for overall traffic management consists the development of four distinct programs in the major urban cities in Texas. The programs are listed below:

1. Arterial Traffic Management (ATM),
2. Freeway Traffic Management (FTM),
3. High Occupancy Vehicle (HOV), and
4. Signal Coordination System (SCS).

Each of these components are designed to operate independently. However, efforts are underway to develop an overall corridor or areawide traffic management system by combining the FTM, HOV, and SCS systems into a single package. The programs will primarily impact the six largest cities in Texas. However, not all programs will be immediately implemented in each urban area. Each traffic management systems will be tailored to the specific transportation needs of the area. Also, smaller urban cities will be able to take advantage of selected programs as the need for such systems arise. In addition to these active programs, all areas are urged to develop and participate in Traffic Management Teams in order to identify transportation deficiencies and bridge gaps in communication with other local agencies (14).

The Arterial Traffic Management (ATM) program is intended to provide for overall traffic management along major arterial facilities. The basic component of this system will involve the use of closed loop type traffic signal systems. The existing arterial signal control system is currently being upgraded and a prototype is being planned for installation in Houston.

The Freeway Traffic Management (FTM) program will provide for overall traffic management along freeway facilities. This system will consist of expressway surveillance and traffic condition monitoring, motorist information, and other traffic management components. Presently, work is being conducted at local levels to install the basic communications networks and other various appurtenances. Various prototypes are expected to be installed in El Paso, Fort Worth, and Houston upon development.

The High Occupancy Vehicle (HOV) program is intended to provide for implementation of HOV facilities with monitoring and management capabilities. Currently, the only functional HOV facilities in the state are located in Houston. Future plans include the upgrading of an existing facility in Houston to include the prototype advanced system.

The Signal Coordination System (SCS) program will consist of traffic signal control and coordination along frontage road systems. The program is planned for eventual expansion beyond the frontage roads. A prototype system is planned for implementation in Houston.

The transportation management effort is very active in the state of Texas. While the effort is progressing at a varied pace throughout the state, 3 urban areas seem to be taking the lead. The freeway traffic management systems in Fort Worth, San Antonio, and Houston are proceeding at a much faster pace than those systems being planned in Dallas, El Paso, and Austin. The remainder of this chapter will deal specifically with the 3 lead systems. The proposed system review and data collection consisted of both telephone and personal interviews with the traffic engineers responsible for systems design, implementation, and operation. Additionally, personal interviews were conducted with transportation engineers involved in the overall system planning process in order to gain a statewide perspective.

Fort Worth

Fort Worth is currently in the process of establishing a firm foundation for its proposed freeway traffic management system. A massive ongoing roadway reconstruction effort in the area is being used to the benefit of the proposed traffic management system with the inclusion of communications conduit and various other appurtenances being added to the larger reconstruction projects. The placement of underground facilities are less costly and much easier to construct as reconstruction proceeds, as opposed to returning upon project completion and performing considerable excavation. Therefore, plans were made to proceed with the proposed system even though congestion had not reached problem proportions. Recurrent congestion in the area is not a major factor, however, non-recurrent congestion that results from incidents is of primary concern. The proposed freeway traffic management program is planned as an extension of existing incident management and motorist information activities (15).

Upon completion, the Fort Worth freeway traffic management system will provide traffic monitoring and expressway surveillance for approximately 300 freeway miles. Table 2 indicates the various system components being planned for the system. The project is planned to be constructed in stages over the next 13 years. The system will include approximately 80 miles of closed circuit television surveillance along with capability to perform corrective actions when problems arise. The system will use a distributed architecture to eliminate the need for a vast amount of central processing.

San Antonio

The plan in San Antonio was to be "ahead of the game" when considering advanced traffic management. While neither congestion nor the frequency of incidents presents any immediate problems, the growth rate is considered to be somewhat high. Given the increasing traffic demands, the fact that the city is highly tourist oriented, and growth trends and congestion problems be faced by other major urban areas of similar size, plans were made to proceed with the proposed freeway traffic management system (16).

Planning has begun on a freeway traffic management system that will cover approximately 138 freeway miles. The various system components are also shown in Table 2. The San Antonio system differs considerably from the Fort Worth system in that this system is based on a central control strategy rather than a distributed system. This will

Table 2. System Components for Proposed Freeway Traffic Management Systems in Selected Texas Urban Areas.

System Components	Fort Worth	San Antonio	Houston
Expressway Surveillance	X	X	X
Loop Detectors	X	X	X
Closed Circuit Television	X	X	X
Ramp Metering	X	I	X
Traffic Reports	X	X	X
Media Communications	X	X	X
Changeable Message Signing	X	X	X
Central Computer Monitoring System	X	X	X
Highway Advisory Radio (Roadside)	X	NP	X
Highway Advisory Radio (Commercial)	NP	NP	X
Incident Management Teams	X	X	X
Motorist Assistance Patrols	X	X	X
High Occupancy Vehicle Facilities	?	?	X
Traffic Management Team Coordination	X	X	X
Lane Control Signals	X	X	X
Cellular Communications Program	*	X	X
Emergency Call Boxes	?	I	NP
Accident Investigation Sites	X	NP	X
In-Vehicle Guidance	?	X	?
Extent of System (miles)**	300	138	420

LEGEND:

X - Planned component
? - Questionable at this time
* - Private sector activity
** - Values reflect completion of total program
NP - Not planned
I - In isolated locations

require increased computing capabilities and communications network; however, the "built-in" redundancy of the design offers San Antonio a more desirable design. Again, the system will be implemented in stages as roadway reconstruction in the area proceeds.

Houston

The Houston freeway traffic management system is probably the most elaborate system planned for the state and it is largely due to the visions of Mr. Dexter Jones, formally with the SDHPT Houston District--now retired, and Mr. Herman Haenel, formally with SDHPT--Maintenance & Traffic Operations Division, Freeway Operations Section. Houston has been involved in portions of freeway traffic management for many years. The Houston Surveillance Center located on the Gulf Freeway was an early "test-bed" of traffic management activities. Early work covered a wide range of activities including ramp metering and exclusive high occupancy vehicle lanes. Many activities were expanded to other freeways in the Houston area. Budgetary constraints forced the closing of the Surveillance Center in 1975. Since those early days of freeway traffic management, congestion has increased to severe conditions. Therefore, the implementation of a freeway traffic management system is perceived to be the most economical means of creating additional vehicular throughput and maintaining existing capacity on the existing facilities (17,18).

The Houston freeway traffic management system will cover approximately 420 freeway miles upon completion. The planned system components are also shown in Table 2. The system is now the only system in the state being designed to incorporate all of the advanced traffic management program components. The system will utilize a distributed architecture and is being constructed in stages similar to the previous projects.

STUDY PROCEDURE

Phase One of this project consisted of a survey of selected existing freeway traffic management systems. The survey included the development of a questionnaire which was used as a guide for either a telephone or personal interview with those persons responsible for the systems being surveyed. To aid in the survey design and identification of relevant issues, interviews were conducted with Mr. R. G. Biggs, formally with the SDHPT Houston District and Lufkin District--now retired, and Mr. Richard McCasland, with the Texas Transportation Institute--Houston Office, who were instrumental in the operation of the Gulf Freeway traffic management system in Houston, Texas in the late 1960s and early 1970s. Upon development of the questionnaire 3 existing freeway traffic management systems were selected for survey. Each of the 3 systems surveyed were selected based on the existence of unique components which were intended to produce a well rounded model. Those surveyed included Mr. Joseph McDermott with the Chicago, Illinois system, Mr. David Roper with the Los Angeles, California system, and Mr. Glen Carlson with the Minneapolis, Minnesota system. Also, an interview was conducted with Mr. Herman Haenel with Advanced Traffic Engineering and formally with the SDHPT Maintenance & Operations Division--Freeway Operations Section, due to his active involvement with the Transportation Research Board Committee on Freeway Operations, to gain a national perspective of the issues and gather some historical information surrounding the early development of the proposed Texas systems. The information obtained in the survey of the existing freeway traffic management systems was used to create a knowledge base from which a model system (Survey Model) was later produced.

Phase Two of the project consisted of a survey of the proposed freeway traffic management systems in various phases of planning, design, and construction in Texas. The questionnaire developed for Phase One of this project was modified to obtain information on the proposed systems. Interviews similar to those in Phase One were first conducted with Mr. Gary Trietsch with the SDHPT Maintenance & Operations Division, Mr. Ray Derr, and Ms. Joni Brookes with the SDHPT Maintenance & Operations Division--Traffic Management Section in order to gain a statewide perspective on the directions of the proposed systems. Four systems were selected to obtain the local perspective of the issues surrounding the freeway traffic management system implementation. Telephone interviews and personal visits were then conducted with Mr. Wallace Ewell with the SDHPT in Fort Worth, Mr. Pat Irwin and Mr. Pat McGowan with the SDHPT in San Antonio, Mr. John Hemme and Mr. Mark Conway with the SDHPT in Houston, and Mr. Harold Watters with the SDHPT in Dallas. Informal conversations were also held with other employees of the SDHPT to gain additional information as needed. The information obtained in the survey of the proposed Texas freeway traffic management systems was used to create a knowledge base from which a model (Texas Model) of these proposed systems was later produced.

Phase Three of this project consisted of a critical review of the proposed freeway traffic management systems in Texas. Models of the existing freeway traffic management systems (Survey Model) and the proposed Texas freeway traffic management systems (Texas Model) were created from the knowledge base obtained in phases one and two of this project. The existing model system was then compared to the model Texas system to identify key strengths and weaknesses in the proposed plans. Conclusions were then drawn from the analysis and recommendations for improvements in the overall plan were made.

DISCUSSION AND RESULTS

The discussion and results presented in this chapter summarize the data collected as part of phases one and two of this project which dealt with interviews and visits with several leading transportation professionals active in the areas of advanced systems and freeway traffic management systems. The **APPENDIX** contains the questions asked of the professionals and their responses. In order to maintain their anonymity, no locations, names, or order schemes are associated with the professionals comments.

Upon completion of the Phase One and Phase Two data collection processes, the knowledge base was used to create a model of both the existing freeway traffic management systems and the proposed Texas systems. The results of these model systems are shown in Table 3, Table 4, Table 5, and Table 6. Table 7 reflects the issues deemed most important to those individuals surveyed.

Table 3 indicates that the funding issues are quite similar between agencies. This is as expected since most states compete for funding in much the same manner. However, the model Texas system proposes somewhat lower annual maintenance and operations costs than the model existing system. It is believed that this is due, in part, to the use of new state-of-the-art technology and somewhat optimistic planning estimates.

Table 4 shows the comparison of facility aspects between the model existing and the model Texas systems. These results are quite varied due to the various system designs being compared. It is the judgement of this author that this issue is important in the planning process, but comparisons between actual numbers cannot be made due to system variations.

Table 5 deals with the personnel issue. Again, the model Texas system and the model existing system are very similar. It should be noted that the model existing system employs student workers which not only lowers the operating costs, but also provides for much needed training at the college level.

Table 6 presents a comparison of training considerations between the system models. The indicated results are identical between the two systems. A wide range of training opportunities are being utilized by all those agencies surveyed.

Table 7 shows the major issues, as rated by the interviewer, based on the remarks

Table 3. Funding Comparison Between Existing and Proposed Freeway Traffic Management System Models.

Funding Issue	Survey Model	Texas Model
Source for Initial System Implementation	State/Federal	State/Federal
Source for Operations & Maintenance	State	State
Source for Research & Development	State/Federal	State/Federal
Cost of Initial System	varies	varies
Annual Cost of Operations & Maintenance	10% to 20% of initial cost	5% to 10% of initial cost
Annual Cost of Research & Development	1% +/- of initial cost	unknown

Table 4. Facility Comparison Between Existing and Proposed Freeway Traffic Management System Models.

Facility Issue	Survey Model	Texas Model
Size of Control Center (1000 sq. ft.)	10 - 16	7.5 - 30
Computing Capability of Central Computer	varies	varies
Service Patrol Fleet	6 - 51	3 - 4

Table 5. Personnel Comparison Between Existing and Proposed Freeway Traffic Management System Models.

Personnel Issue	Survey Model	Texas Model
Operations Center	2 - 4 shifts w/ varied lengths 2 - 4 per/shift Engr. Tech. & Students w/ little experience	2 - 3 shifts w/ normal lengths 3 - 8 per/shift Engr. Tech. w/ Traffic experience
System Maintenance	1 shift w/ normal length 3 - 7 persons Tech. & Students w/ varied experience	1 shift w/ normal length 3 - 4 persons Tech. w/ Elect. training
Service Patrol	2 - 3 shifts w/ varied lengths 6 - 18 per/shift Maint. Tech w/ varied experience	up to 3 shifts w/ varied lengths 6 - 8 per/shift Maint. Tech. w/ varied experience
Research & Development	1 shift w/ normal length 1 - 5 persons varied exper. & education	1 shift w/ normal length 1 person Engr. & Engr. Tech.
Planning & Design	1 shift w/ normal length 1 - 7 persons varied exper. & education	1 shift w/ normal length 3 - 10 persons Engr. & Engr. Tech.
Communications Center	3 shifts w/ varied length 2 - 4 per/shift varied exper. & education	N/A

Table 6. Training Comparison Between Existing and Proposed Freeway Traffic Management System Models.

Training Issue	Survey Model	Texas Model
On-the-Job Training	yes	yes
Specialized Training (in-house and outside)	yes	yes
Participation in Professional Activities	yes	yes
Technology Transfer	yes	yes
Information Gathering Visits to Other Systems	yes	yes

Table 7. View of Most Important Issue Comparison Between Proposed Freeway Traffic Management System Models.

Most Important Issue	Survey Model Priority	Texas Model Priority
Funding	1	1
Facilities	4	4
Personnel	2	2
Training	3	3
Other	5	5

1 = highest rank 5 = lowest rank

obtained during the interview. Funding was the prevailing issue of concern in all cases. The next most important issue was that of personnel. Training issues ranked third and facility issues ranked fourth. All of the other issues of concern were placed in the last category even though some were considered extremely important to some individuals.

Dudek and Ullman, in a revised draft of a report on Freeway Corridor Management, identified several major points that must be considered when implementing advanced systems. In the process of data collection for this project, many of the same issues were echoed in the interviews on freeway traffic management systems. Therefore, the inclusion of a synopsis of a portion of that said report identifying the various "lessons learned" is deemed appropriate and included below (19):

1. A distinct need must exist for the freeway traffic management system. Experience has shown the establishment of systems to alleviate future problems have been rather unsuccessful. However, in areas where immediate needs exist for such systems valuable financial and administrative support have been received.

2. Administrative support at the highest levels is essential for the success of traffic management projects. When placed in competition with projects of a more traditional nature, traffic management projects must be perceived as economical methods of achieving similar results rather than as luxury items.

3. Local and state political support provides assistance in the implementation and funding efforts of traffic management projects. If support is not automatic, consideration should be given to the selling of traffic management projects to the political establishment as a means of opening new avenues of funding and implementation support.

4. Actual and expected benefits must be demonstrated to maintain integrity and support for the traffic management system. Demonstration of operational, safety, and economic benefits will aid in gaining administrative, public, and political support.

5. Long-term success is linked to the ability to maintain continuity of key personnel in a traffic management program. Many successful systems contribute the success of their system to the long-term retention of key personnel involved with the project.

6. Continuing operations and maintenance costs and funding sources must be identified and considered at the onset of the traffic management project. Without the consideration of continued operations and maintenance costs traffic management projects may be doomed to failure during times of economic hardship.

Additional issues identified in the data collection process of this project include the following "lessons learned."

7. Effective communication and coordination between the various agencies involved in the traffic management effort is essential. Without a forum to ease the communication and enhance coordination processes, precious time may be lost when immediate and critical decisions are required.

8. There is no reason to "re-invent the wheel." If existing system components are commercially available and can be economically tailored to the traffic management system then consideration should be given to the inclusion of such components (example: software graphics packages).

9. An effective and ongoing training program must be initiated so that personnel can keep abreast of ever changing technology. All sources of training are essential. Examples include professional activities, specific training seminars, visits to other traffic management systems, technology transfer, and group training at the local level.

10. Specifications must be written in such a manner that quality, expandable, and interchangeable products are obtained. Consideration must be given to the manner in which specifications are written and contracts awarded to insure that products are both useable and effective.

Upon review of the data collected for this project it became apparent that these issues need to be addressed in the early stages of the planning process of any advanced system, including a freeway traffic management system, otherwise, implementation will be difficult or impossible.

In a report on congestion in major urbanized areas, Hanks and Lomax (20) have identified the congestion index for the areas targeted in this report. These roadway congestion values represent the computed relative mobility index for freeways and expressways in each of the selected urban areas, and are shown in Table 8. The report also indicates the ranking of each of the urban areas based on the annual cost due to congestion.

The report indicates only the largest Texas urban areas are experiencing the severe urban congestion that areas with existing freeway traffic management system are facing. These results would indicate a need for an established warranting procedure for advanced system implementation. Additionally, it is believed that the existence of a freeway traffic management system would have an impact on the roadway congestion index. The index is expected to be lower in areas where an advanced system has been installed and is operational than in those areas without such systems. While the referenced roadway congestion index is for an entire metropolitan area, it is believed that any reduction in congestion on specific highly congested roadways will bring about some reduction in areawide congestion.

Table 8. Roadway Congestion Index for Selected Urban Areas.

Urbanized Area	Congestion Index (1985)	(1986)	(1987)	(1988)	Rank (1988)
Chicago	1.08	1.15	1.15	1.18	4
Los Angeles	1.36	1.42	1.47	1.52	1
Minneapolis	0.83	0.87	0.87	0.88	20
Fort Worth	0.82	0.87	0.87	0.87	19
San Antonio	0.87	0.90	0.85	0.86	25
Houston	1.23	1.21	1.19	1.15	8
Dallas	0.98	1.04	1.02	1.02	11
Austin	0.91	0.98	0.96	0.96	27
El Paso	0.70	0.75	0.71	0.74	38

FINDINGS AND CONCLUSIONS

Funding

The results of the data collection phase of this project indicated that the most significant concern in the implementation of an advanced freeway traffic management system is that of funding. Without adequate funding all other associated issues are irrelevant. As budgets become more strained the level of competition between traffic management projects and traditionally higher priority roadway improvement projects will be increased. In many cases the advanced system will fall victim to the process since it will be considered a "luxury that cannot be afforded." Total administrative support for traffic management systems is essential to insure that such systems are recognized as economical solutions to traffic congestion problems and compete equally with more traditional projects.

Funding considerations need to consider both short-term and long-term requirements. Funding for initial project construction costs appears to be a lesser problem than funding for continued system support and operation. Currently, funds are available for initial construction costs from various federal sources, including FHWA and UMTA. However, federal funding for annual operations and maintenance costs are not available at this time. These costs must be absorbed by the operating budgets of the various agencies. The annual operation and maintenance costs in some cases can be shared with other partners in the local traffic management program and supplemented through the privatization of some activities.

The most effective way to gain support and funding is generally linked to the successful demonstration of program benefits. This requires the education and selling of traffic management concepts to and the education of various administrators, local lobbying groups, and political officials. In some cases local urban mobility groups are becoming quite effective in assisting with this effort. These groups can also be a source of revenues coming from private contributions.

Upon implementation of a traffic management program or other advanced freeway traffic management system, the agency should not become complacent and expect funding support to continue. Eventually all agencies experience budget deficits and such programs are subject to elimination. Therefore, it is essential that public awareness campaigns be implemented to inform the public of the advantages of the advanced systems and to continue to demonstrate the benefits derived from such a system.

Facilities

The study results indicate that facility issues are rather insignificant when compared to other issues. Facility requirements for advanced systems and specifically freeway traffic management systems are quite varied. Each advanced system design will dictate the size of control center required, and the necessary computing and communication capabilities. Also, the purpose of the system and the functions the system is intended to perform will play an important role when considering this issue.

The most important aspect of this issue centers around proper preliminary planning. Preliminary planning should consider the immediate facility requirements along with future expansions to the system. Preliminary planning should identify the necessary system components required to adequately perform the intended functions of the system. If a service patrol fleet is needed then consideration should be given to where and how the fleet will be parked and maintained when not in operation. The required computing and communication capabilities should also be examined. If satellite control buildings are necessary then their size and placement will have a direct impact on other construction which may be planned in the area. Additionally, the size and placement of required structures and appurtenances should also be explored. With proper preliminary planning both time and money can be saved over the duration of the project.

Another facility issue concerns the establishment of a permanent and separate control center facility. Some individuals suggest that it is important to be able to identify a physical center of traffic management activity that is distinctly separate from any other agency activity. While it is believed that this concept would be a useful tool in promotional programs, the main point to this issue reverts to the ability to successfully demonstrate program benefits.

Personnel

Personnel issues continue to be at the forefront of any discussion of advanced system implementation. The ability to maintain long-term continuity of key project personnel has been linked to the success of many advanced systems. Efforts to attract and maintain a highly qualified and motivated work force should begin at the onset of any advanced system project. During the preliminary planning phase such personnel issues should be addressed and steps taken to alleviate any institutional barriers that may exist.

The most important concern in dealing with the personnel issue is the ability to provide a long-term career track for the highly specialized employees required in the implementation of advanced systems. Such employees are not only required to be highly skilled in their field of expertise but also must become proficient in all of the other closely associated fields required by the system. An example of this concern is an electrical engineering assistant at the local level who must become proficient in both computer science and traffic engineering in order to properly perform the functions of his position. This person will most likely report to a civil engineer, in many highway agencies, and concerns also arise when he applies for professional registration as an electrical engineer. Furthermore, many agencies isolate the various disciplines and the possibility for long-term advancement does not exist.

The attraction of a highly qualified work force does not appear to be an issue for some administrators. Many believe that, through successful demonstration of the advanced system, the system itself will attract highly qualified people who want to be a part of such work. The biggest problem is the ability to maintain the long-term employment of that person. There will most likely be tremendous temptation for that person to move to another equally or more exciting system if advancement possibilities and incentives are not recognized.

The staff levels for the various system activities is quite varied. The personnel requirements are largely dependent on the extent and design of the system. Also, the various services provided by the system plays an important role in the number of people required. Preliminary planning should identify the number of employees and the experience and education requirements for each of the major branches of the system, which include; the operations center, systems maintenance, service patrol, and planning and design.

Training

As stated previously, personnel must become proficient in a broad spectrum of fields which are brought together to form these advanced systems. While most employees will gain considerable expertise in a single field while attending a college or university, his horizons must be broadened considerably when working with an advanced system such as a freeway traffic management system. An employee must look to alternate means of training in order to expand his knowledge base.

Many agencies have active and ongoing employee training activities, and Texas is no exception. The most basic form of training is obtained from on-the-job experience. Many agencies have specialized training seminars conducted by both in-house personnel and consultants. Participation in professional activities at all levels is an extremely important method of obtaining additional training. Additionally, the technology transfer systems between agencies, universities, and others are valuable resources and provide an effective method of obtaining much needed information. Finally, information gathering visits to other advanced systems has proven to be a great help in learning about advanced system technology.

Probably the most overlooked form of training comes from the documentation of local system design and operations. Thorough documentation of the local system implementation, foundations can be provided from which future employees can be trained. System documentation can also serve as a reference for other agencies planning their own advanced system. These materials can also be used as a tool to aid in soliciting support for the system from administration and political officials.

RECOMMENDATIONS

Based on the results presented in Chapter VI and the conclusions drawn in Chapter VII of this report, the following recommendations are made regarding the proposed implementation of freeway traffic management systems in Texas:

1. In order to provide total administrative support for traffic management projects and eliminate the immediate conflicts between routine maintenance programs and traffic management programs, it is recommended that a Traffic Engineering and Operations Division of the Texas State Department of Highways and Public Transportation be created. This recommendation is based on the current organization of the Department without regard to proposed legislative mandated organizational changes. It is further recommended that the all existing functions, personnel, and budgetary allocations for traffic engineering and operations in the current Maintenance & Operations Division be transferred to the new Division. This action will facilitate an avenue for direct administrative support for traffic management programs and separate budgetary allocations so that long-range planning and project development can occur more efficiently.

2. In order to provide direct lines of communication and support at the local level it is recommended that a Traffic Engineering Residency, along with a subordinate Traffic Maintenance Section, be established in each SDHPT District Office. It is further recommended that all existing functions, personnel, and budgetary allocations for traffic engineering planning, design, and maintenance activities be transferred to the new Residency. The Residency should operate on a District-wide basis and be responsible for all traffic engineering, operations, and maintenance activities. This includes traffic signal maintenance, traffic management system operation and maintenance, and District-wide signing and pavement marking functions; however, it does not include routine sign repair and maintenance currently conducted by individual Maintenance Sections. This will allow for increased training activity and personnel allocation as employees will have the opportunity to rotate between the various activities and gain valuable experience and create a work environment that allows for an exchange of ideas that will improve the end products of all activities.

3. External funding sources for advanced system projects need to be identified and considered. Proposed federal legislation should open additional avenues for funding. Also, the solicitation of funds or in-kind contributions from local partnership agencies should be encouraged. Additionally, more innovative funding sources need to be explored, such as privatization of some portions of the traffic management program, and possible contributions from private mobility groups. Increased funding specifically for traffic management projects will result in such projects having advantages over more traditional reconstruction projects and will encourage their implementation.

4. Whenever possible it is recommended that staged construction of advanced systems occur. Staged construction should first target the most highly congested roadways and then utilize ongoing reconstruction projects as a vehicle for installing various portions of the proposed advanced system. Staged construction results in decreased initial costs and provides more efficient implementation of underground appurtenances. It is further recommended that small portions of the planned project be implemented and made operational first so that benefits from such systems can be immediately demonstrated. This will also provide the transportation engineer an ongoing critical assessment for future designs.

5. Long before the planning phase of any advanced system it is imperative that a Traffic Management Team consisting of the various agencies impacted by area traffic operations be formed. This will help to bridge any gaps in communication and coordination between the various agencies. The effective use of such teams will provide much needed input on specific operational deficiencies and minimize any institutional barriers that may exist.

6. Preliminary planning must occur prior to any advanced system implementation. Continued maintenance and operations costs associated with the implementation of advanced systems should be addressed at the forefront of the process. Initial costs are generally considered to be minimal compared to the long-term annual costs associated with these projects. It is useless to implement an advanced system and have budget deficits cause the project to be abandoned a few years later. This leads to the misconception that such systems are "luxury" items rather than economical methods of alleviating traffic congestion. Preliminary planning should also include a statewide perspective and direction for the entire program. Care should be taken to create harmonious designs between urban areas so that compatible and interchangeable equipment can be acquired. The planning process should also include a warranting process so that a clear and present need for advanced system implementation can be identified.

7. Probably the most important aspect of an advanced system deals with continued operation and support. The ability to maintain long-term commitments for system operation are essential. Systems will eventually be doomed to failure without such commitments. Commitments should include adequate staffing allocations, sufficient maintenance and operations funding, and an appropriate means of maintaining system integrity.

8. It is recommended that the current specification and procurement process be reviewed with respect to equipment and software requirements for advanced systems. In many cases the most effective and high quality equipment is considered proprietary and problems occur when current "low-bid" purchasing practices are employed. Equipment with a lesser initial cost should not be implemented if future replacement and maintenance costs are considerably more than the higher quality equipment. Also, specifications and requirements should be written in such a manner so as to insure system compatibility and allow for future upgrades. The use of national communication standards and military software standards should be

employed whenever possible. Additionally, the writing of specifications for advanced system software development presents a frustrating problem. In some cases the end product may conform to the specifications, yet not perform the actual function intended and modifications may be nearly impossible to obtain. Finally, stringent enforcement of specifications and requirements is essential to insure an effective and high quality end product.

9. It is recommended that existing software packages be incorporated into the software design whenever possible. There is no need to develop a program which is very similar to existing program. An example of this is to design the system software to utilize an existing graphics package. In such a case the existing package will be more economical and flexible than a package developed only for the intended application. Certainly, considerations should be given to the tailoring of existing packages to meet the needs of the system users.

10. Whenever possible it is recommended that the communications and computing components of the system be over designed to allow for future expansion. This will produce a minor increase in initial costs when compared to future reconstruction costs. The computing capabilities of the system should be expandable and compatible with other systems in the state. With increasing traffic demand and increasing congestion system expansion will no doubt be inevitable.

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This report represents a the summary of information gathered from interviews and visits with leading national transportation officials working in the area of advanced systems, including freeway traffic management systems. It has been a very meaningful learning experience working with the various professionals during the preparation of this report. As a member of the Texas State Department of Highways and Public Transportation (SDHPT) Master of Science in Civil Engineering Program, this research effort will be very beneficial as I become more involved in the Department's freeway traffic management program through the course of future assignments.

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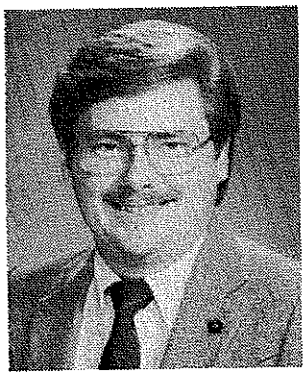

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APPENDIX

Survey Results of Selected Existing Systems

The survey results of selected existing freeway traffic management systems are documented in the following sections. The responses were obtained as a result of telephone interviews with leading national transportation engineers who have the responsibility to design, operate, and maintain such systems. This portion of the APPENDIX represents the knowledge base used to create the model existing freeway traffic management system (Survey Model).

Introduction

Were the freeway traffic management system components listed below implemented in stages or as a complete project?

1. The system was implemented in stages.

2. The system was implemented in stages consisting of an extensive program for ramp metering and surveillance, with an operations center being staffed since the early 1970s.

3. The system was implemented in stages.

4. Staged construction is probably the most economical approach.

5. The system was implemented in stages as a research demonstration project.

Was the advanced system technology research planning and preliminary system design conducted in-house or through consultant contacts?

1. Most of the work was performed in-house except for the first "Feasibility Report."

2. Design was accomplished by consultants as research projects.

3. All work was performed in-house.

4. Most states are faced with only one major urban area when implementing freeway management systems. Probably the best means of system development is to use a combined approach utilizing a combination of both in-house and consultant contracts. With the implementation of a single system the agency should rely more on a consultant approach, otherwise, if implementing several systems the agency should rely more on an in-house approach. For successful maintenance and system improvement the agency

will be more familiar with the system if it is developed in-house. Care should be taken not to "re-invent the wheel." If a consultant has a software package that can be incorporated into your system or enhances your system then it should be considered. An example of this would be a graphics package developed by a consultant that could be tailored to your package that will eliminate the need for an in-house programmer to develop same.

5. The work was performed in-house and in cooperation with the Texas Transportation Institute.

How does the primary agency promote coordination of multi-jurisdictional improvements?

1. Coordination is accomplished by Traffic Task Forces that deal mostly with incident management and some parts of major projects that will affect incident management.

2. There is a great need for cooperation between all agencies involved. A close working relationship exists between engineering and enforcement agencies. Incident management teams play a vital role in encouraging multi-jurisdictional cooperation and coordination.

3. Coordination is accomplished through a wide range of communication efforts with other agencies.

4. Traffic Management Teams are essential in order to create the good working environment between engineering and enforcement areas of the various agencies involved. These teams should be kept small and members must be able to make binding decisions for the agency represented. When teams become too large there will be a need to consider multiple teams (example adjacent cities may have individual teams rather than a single team). The traffic management team should be considered as being more regional than an incident management team which should deal with specific situations at specific locations. Membership may be identical between the traffic management team and the incident management team, however, the incident management team should consist of staff closer to those who are actually performing the work involved.

5. Experience has shown that cooperation between agencies is essential. Partnership agencies should buy into the concept early and provide as much support as possible.

At what point should an agency consider the implementation of an advanced freeway traffic management system?

1. Implementation should occur when there is total and long-term organizational support commitments along with sufficient resources to follow through.

2. Implementation should occur when a roadway is approaching the point of being congested.

3. Implementation should occur when there is serious congestion and accident problems.

4. An agency should consider their goals and needs before embarking on such a system. The most important criteria would be the elimination of congestion, both recurrent and non-recurrent.

5. Our system was implemented primarily to perform research activities and demonstrate the success of such systems.

On what basis did your agency choose to implement such a system?

1. An early decision was made to actively manage congestion on major roadways.

2. Congestion and a couple of major accidents led to a legislative directive to create a task force on traffic management and as a result the Department was reorganized, research was begun, and systems were implemented.

3. Recurrent congestion and accidents caused speeds to drop below 30 mph on some major freeways.

4. Implementation was as a result of an agency and Texas Transportation Institute demonstration project.

Briefly comment on the organizational structure for your freeway traffic management operations.

1. Program grew from three separate efforts and now involves three District Bureaus linked by computer for coordination.

2. A freeway management staff consisting of design, operations, research, and computer technology in a metro district.

3. Traditionally traffic operations have been a part of maintenance. Consideration should be given to the separation of the two functions with separate budgets and with dedicated funding for the latter.

Briefly describe the freeway traffic management system your agency operates.

System Components	Chicago	Los Angeles	Minneapolis
Expressway Surveillance	X	X	X
Loop Detectors	X	X	X
Closed Circuit Television		X	X
Ramp Metering	X	X	X
Traffic Reports	X		X
Media Communications	X		X
Changeable Message Signing	X	X	X
Central Computer Monitoring System	X	X	X
Highway Advisory Radio (Roadside)	X	X	
Highway Advisory Radio (Commercial)			X
Incident Management Teams	X	X	X
Motorist Assistance Patrols	X	X	X
High Occupancy Vehicle Facilities	X	X	X
Traffic Management Team Coordination	X		X
Lane Control Signals	X		
Cellular Communications Program	X	*	
Emergency Call Boxes		X	
Accident Investigation Sites	X		X
In-Vehicle Guidance	X	?	X
Years of Operation	varies to 30+	varies to 20+	varies to 22+

LEGEND:
X - Existing Component
* - Private sector activity
? - Questionable at this time

Funding

How can political support be obtained for that funding in a climate of financial competition between other more traditional programs?

1. Current programs must address congestion relief and have total support.

2. Support is difficult to obtain and competition is tough. However, in urban areas we cannot simply build more highways, and with more emphasis being placed on air quality, community and environmental impacts, and the need to reduce congestion the only viable solution is to effectively manage the traffic.

3. Funding has not been a problem especially with the high priority being placed on congestion reduction techniques and IVHS.

4. This is a difficult issue. Traditionally, most agencies place higher priorities on construction rather than traffic operations. Operational improvement programs are difficult to sell because it is difficult to demonstrate accomplishments since improvements are not physical and are often negated by diversion or other impacts.

5. Each project must stand on its own merit and should compete equally with other more traditional projects.

Please identify costs and funding sources for the following areas of system operation.

Chicago

Area of System	Cost	Funding Source
Initial System	$25+ Million	IDOT/FHWA
Operations (Annual)	$5 Million	IDOT Operating Budget
Maintenance (Annual)		
Research and Development (Annual)	insignificant *	IDOT
Future Improvements	$20+ Million	Op. Green Light

*Does not include $40 million over 5 years for "Advance" IVHS Project w/ Private/IDOT/FHWA funds

Los Angeles

Area of System	Cost	Funding Source
Initial System		Research
Operations (Annual)	data	Caltrans Oper.
Maintenance (Annual)	not	Caltrans Maint.
Research and Development (Annual)	available	varies *
Future Improvements		Caltrans Const.

* Funding sources include Caltrans/FHWA/Private partnerships

Minneapolis

Area of System	Cost	Funding Source
Initial System	$2 Million	Mn DOT/FHWA
Operations (Annual)	$600,000	Mn DOT
Maintenance (Annual)	$250,000	Mn DOT
Research and Development (Annual)	$100,000	Mn DOT
Future Improvements	$30 - 40 Million	MnDOT/FHWA

Facilities

Briefly describe the type and location of facilities being utilized by your system.

Chicago

Facility	Response
Central Control Center Area (sq. ft.)	16,000
Size of Central Computer (computing capability)	32 mb
Number of Fleet Vehicles in Service Patrol (vehicles)	51
Other (describe)	-

Los Angeles

Facility	Response
Central Control Center Area (sq. ft.)	data
Size of Central Computer (computing capability)	not
Number of Fleet Vehicles in Service Patrol (vehicles)	available
Other (describe)	

Minneapolis

Facility	Response
Central Control Center Area (sq. ft.)	10,000
Size of Central Computer (computing capability)	Honeywell 2mb(ram) .4mips
Number of Fleet Vehicles in Service Patrol (vehicles)	6
Other (describe)	-

Personnel

Please identify staff allocations, approximate turn-over rates, and minimum experience or education levels for the following areas of system operation on a per shift basis.

Chicago

Area Of System Operation	Number of Shifts	Number of Required Staff Per Shift	Turn Over Rate	Experience or Education Level
Operations Center	2	2 - 3	low *	none to 2
System Maintenance	1	3 - 5	low *	yrs college
Service Patrol	3	18	low	10 years OJ
Research and Development	1	1	-	-
Planning and Design	1	1	-	-
Other (Identify) Comm. Center	3	2 - 4	high *	none

* Co-op engineering students working with technicians. Graduation accounts for high turn-over rates

Los Angeles

Area Of System Operation	Number of Shifts	Number of Required Staff Per Shift	Turn Over Rate	Experience or Education Level *
Operations Center				
System Maintenance		data		
Service Patrol			not	
Research and Development				available
Planning and Design				
Other (Identify)				

Minneapolis

Area Of System Operation	Number of Shifts	Number of Required Staff Per Shift	Turn Over Rate	Experience or Education Level *
Operations Center	4 - 3hr	2 - 4	low	Engr. Tech.
System Maintenance	1	7	low	Elect. Tech.
Service Patrol	2 - 3hr	6	low	Maint. Worker
Research and Development	1	5	low	Engr. & Students
Planning and Design	1	7	low	Engr. & Tech.
Other (Identify)	-	-	-	-

Training

Briefly describe your recruiting and training programs for each of the personnel categories previously mentioned.

1. On-the-job training along with special training as needed. Additionally, consideration is being given to computer based training. Also, the agency must grow with its people since most will be highly specialized. Systems operations should be separate from maintenance. Explore the use of federal funds and the possibility of dedicated state funds.

2. An active recruitment program exists for professionals and training includes both on-the-job and in-house. Training for technical personnel is obtained from both on-the-job and in-house program sources.

3. Recruitment and training efforts are provided in-house.

4. The training effort was minimal.

How does your agency keep pace with ever changing technology?

1. Agencies need to be able to effectively operate and maintain the high technology equipment, otherwise, it should be avoided. It is generally better to be on the "leading-edge" of technology rather than the "cutting-edge" and some older technology may be dated, "but it works."

2. Through technology tracking and relying on consultants for design and training.

3. The TRB Freeway Operations Committee is the main source of new technology, along with a resource between agency personnel and other agencies. Also, new technology can be transmitted through NCHRP and ITE publications and meetings, and other literature.

Is training provided in-house or through consultants (universities, etc.)?

1. Training is mostly provided in-house.

2. Training is provided in-house and through consultants.

3. Training is provided in-house.

Miscellaneous

In your opinion, what should be the major areas of concern for agencies planning to implement a freeway traffic management program?

1. The scope of the project must be kept within the agencies capability to effectively operate, staff, and maintain the system over many years. And, the people part of the project is of prime importance.

2. An agency must have plenty of experience and technology to draw upon. Interagency coordination and cooperation is essential from the beginning. There is no need in installing a great system if there is not a willingness to operate it. Develop and understanding of the intended accomplishments and obtain public support.

3. Projects must be cost effective. Start small and demonstrate success before embarking on more elaborate systems.

Cite and describe any positive experiences that may be beneficial to others.

1. Success and survival over 30 years is definitely a positive experience.

2. Effective traffic management during major special events was accomplished through prior organization, coordination, and experience of working as a team.

3. Ramp metering and improved geometric designs have led to better traffic operations.
4. The effect of ramp metering and accident investigation sites proved to be very successful.

Cite and describe any negative experiences that may be beneficial to others.

1. Budgetary constraints often dictate the removal of equipment deemed to be "luxury items that cannot be afforded."

2. Support from the agency must include the ability to staff and fund the project.

3. Call boxes provides for motorist assistance, however, they do no provide for any congestion relief.

4. The lack of funding to continue the effort during times of budgetary deficits can negate any improvements brought by the implementation of an freeway traffic management system.

Additional comments.

1. When dealing with consultant contracts it is often difficult to write a specification to obtain a software product that is usable and effective.

Survey Results of Selected Proposed Systems

The results of the survey of proposed freeway traffic management systems in Texas are documented in the following sections. The responses were obtained as a result of telephone interviews and personal visits with SDHPT traffic engineers responsible for systems planning, design, implementation and operation. Both statewide and local perspectives on the relative issues are included. This portion of the APPENDIX represents the knowledge base used to create the model proposed Texas freeway traffic management system (Texas Model).

Introduction

Will the freeway traffic management system components listed below be implemented in stages or as a complete project?

1. The freeway management system will be implemented in stages by freeway utilizing staged construction on the project.

2. A lack of total support and funding create a situation where the installation of a comprehensive freeway traffic management system is questionable, at this time.

3. Most districts will implement the system in stages.

4. The system will be implemented in stages with staged construction as part of roadway reconstruction projects where available.

5. The system will be implemented in stages.

Will the advanced system technology research planning and preliminary system design conducted in-house or through consultant contacts?

1. Early preliminary work was performed by a consultant, however, since that time most work has been accomplished in-house with some input from the Texas Transportation Institute.

2. All work in design and planning will be conducted in-house.

3. The work will primarily be done in-house.

4. The work will primarily be done in-house.

5. All work will be performed in-house.

How will the primary agency promote coordination of multi-jurisdictional improvements?

1. Coordination is accomplished through meetings and interagency project reviews. A series of agreements define the scope of involvement by each agency.

2. Coordination is accomplished through the Traffic Management Team.

3. Traffic Management Teams would be the most appropriate method.

4. The Traffic Management Team is being used as the vehicle for coordination. The system design will be done in-house with other agencies invited into the project as partners in the operations area.

5. The Traffic Management Team is where coordination will occur.

At what point should an agency consider the implementation of an advanced freeway traffic management system?

1. A freeway traffic management system should be considered when other alternatives have been exhausted. In comparison, this is the only economical method of "increasing capacity" (actually, this would be increasing vehicular throughput and maintaining existing capacity). This should also be considered as an option to rebuilding a freeway. Additionally, administration support is essential.

2. An agency must first have the political support to embark upon such a project, then the choice is between the construction of more roads or less costly traffic operation improvements.

3. With the decreasing availability of construction funding the Districts should look toward traffic management to reduce congestion.

4. First, administration support is essential. Then freeway traffic management should be considered as traffic congestion increases above tolerable levels.

5. A freeway traffic management system should be considered in anticipation of congestion. Also, the frequency of accidents or incidents is another important factor.

On what basis did your agency choose to implement such a system?

1. We ran out of alternatives to effectively deal with congestion and this was the most cost effective alternative.
2. The decision was made to implement such a system in order to be prepared for future traffic growth. Although congestion may not be on the order of some larger cities, we want to be ahead of the game.

3. An ongoing massive reconstruction effort afforded the opportunity to easily install some underground portions of the system. Also, we were experiencing some congestion and somewhat of a problem with incidents.

Briefly comment on the organizational structure for your proposed freeway traffic management operations.

1. The SDHPT is the lead agency, yet, other agencies will make essential contributions. In the District the design and construction sections are separated from the maintenance and operations sections.

2. It is inevitable that the traditional maintenance and traffic operations areas must be separated in order to meet the challenges of the future.

3. The organizational structure combines planning, design, operations, and maintenance. However, now the incident response group is separate (such a group needs a strong coordinator in order to be effective).

4. The organizational structure should focus on combining the design, operations, and maintenance activities under one section. The traffic operations activities should be separate from general roadway maintenance activities.

5. Presently all functions will be under the Traffic Section. Later, it is expected that the freeway traffic management design, operations, and maintenance will break away into its own section, as the system grows.

6. Presently, the related maintenance activities are not a part of the Traffic Engineering Section. The operations and design areas are under the authority of the Traffic Engineer. In the future we would expect to take on the responsibility of maintenance to the freeway traffic management system.

Briefly describe the proposed freeway traffic management system.

System Components	Fort Worth	San Antonio	Houston
Expressway Surveillance	X	X	X
Loop Detectors	X	X	X
Closed Circuit Television	X	X	X
Ramp Metering	X	I	X
Traffic Reports	X	X	X
Media Communications	X	X	X
Changeable Message Signing	X	X	X
Central Computer Monitoring System	X	X	X
Highway Advisory Radio (Roadside)	X	NP	X
Highway Advisory Radio (Commercial)	NP	NP	X
Incident Management Teams	X	X	X
Motorist Assistance Patrols	X	X	X
High Occupancy Vehicle Facilities	?	?	X
Traffic Management Team Coordination	X	X	X
Lane Control Signals	X	X	X
Cellular Communications Program	*	X	X
Emergency Call Boxes	?	I	NP
Accident Investigation Sites	X	NP	X
In-Vehicle Guidance	?	X	?
Extent of System (miles)**	300	138	420

LEGEND:

X - Planned component
? - Questionable at this time
* - Private sector activity
** - Values reflect completion of total program
NP - Not planned
I - In isolated locations

Funding

How can political support be obtained for that funding in a climate of financial competition between other more traditional programs?

1. We must be able to sell the concept of traffic management and show that these projects have a large impact with a relatively small investment.

2. Through enhanced public relations we can sell the idea of advanced traffic management. The improvements obtained through the use of such systems need to be well documented in before and after studies. Long-term support for IVHS and freeway traffic management systems will not be much of a problem given suggested increases in traffic operations, traffic management, and IVHS in the proposed federal highway bill. Also, the new Clean Air Act will ultimately change what we currently regard as standard operating procedure. Finally, the current budgetary issues being debated on the state level will have a significant impact on the operating structure and the mission of the SDHPT. However, short-term budget deficits will no doubt make for immediate problems with the financing of traffic management projects.

3. The education and selling of traffic management concepts to political officials and local lobbying groups will be essential to provide for total support.

4. Administration support is essential if projects are to compete with the more traditional projects at the local level. Also, other funding sources should be considered whenever possible (FHWA, UMTA, private sources, etc). Dedication of funds for such activities should be discouraged due to the lack of flexibility in their usage.

5. The availability of future funding is questionable given the current budget shortfall. Total support for such projects will be required in order to obtain and maintain future funding.

Please identify proposed costs and funding sources for the following areas of system operation.

Fort Worth

Area of System	Proposed Cost	Proposed Funding Source
Initial System *	$53 Million	SDHPT *
Operations (Annual)	5% to 10% of project	SDHPT
Maintenance (Annual)		SDHPT
Research and Development (Annual)	?	?
Future Improvements	?	SDHPT & ?

* Presently federal funds are available of the capitol costs but not for operations and maintenance

San Antonio

Area of System	Proposed Cost	Proposed Funding Source
Initial System *	$145 Million	SDHPT
Operations (Annual)	?	SDHPT
Maintenance (Annual)	?	SDHPT
Research and Development (Annual)	?	?
Future Improvements	?	SDHPT & ?

Houston

Area of System	Proposed Cost	Proposed Funding Source
Initial System	$119 Million	SDHPT (67%) and METRO (33%)
Operations (Annual)	10 to 20% of project	SDHPT/METRO City/County
Maintenance (Annual)	?	SDHPT/METRO City/County
Research and Development (Annual)	?	SDHPT
Future Improvements	?	SDHPT

Facilities

Briefly describe the type and location of proposed facilities to be utilized by your system, particularly as they relate to the categories set forth in the introduction.

Fort Worth

Facility	Response
Central Control Center Area (sq. ft.)	7500
Size of Central Computer (computing capability)	Unknown
Number of Fleet Vehicles in Service Patrol (vehicles)	4
Other (describe)	-

San Antonio

Facility	Response
Central Control Center Area (sq. ft.)	30,000
Size of Central Computer (computing capability)	2 - VAX (4000) to be expanded 5 total
Number of Fleet Vehicles in Service Patrol (vehicles)	3
Other (describe)	-

Houston

Facility	Response
Central Control Center Area (sq. ft.)	20,000
Size of Central Computer (computing capability)	2 - VAX (4000)
Number of Fleet Vehicles in Service Patrol (vehicles)	Operated in cooperation w/ Harris County Sheriff's Office and no expansion is imminent in this project
Other (describe)	-

Personnel

Please identify proposed staff allocations and minimum experience or education levels for the following areas of system operation on a per shift basis.

Fort Worth

Area Of System Operation	Proposed Number of Shifts	Proposed Number of Required Staff Per Shift	Proposed Experience or Education Level *
Operations Center	2	3	Engr. Tech.
System Maintenance	1	3	Engr. Tech.
Service Patrol	3	6 to 8	Engr. Tech.
Research and Development	1	1	Engr. Tech.
Planning and Design	1	3 to 4	Engr. & Engr. Tech.
Other (Identify) Admin.	1	3	Engr. & Engr. Tech.

San Antonio

Area Of System Operation	Proposed Number of Shifts	Proposed Number of Required Staff Per Shift	Proposed Experience or Education Level *
Operations Center	3 - 8 hr	6 to 8 peak 3 to 4 off	Engineering Technician
System Maintenance	1 - 8 hr	4 people 2 trucks	Signal Tech. w/ additional training
Service Patrol	when Dist. not open	6	Maintenance Technician
Research and Development	?	?	?
Planning and Design	1 - 8 hr	10	Engineers and Engr. Tech.
Other (Identify)	-	-	-

Houston

Area Of System Operation	Proposed Number of Shifts	Proposed Number of Required Staff Per Shift	Proposed Experience or Education Level *
Operations Center			
System Maintenance	not		
Service Patrol		yet	
Research and Development			determined
Planning and Design			
Other (Identify)			

Training

Briefly describe your proposed recruiting and training programs for each of the personnel categories previously mentioned.

1. Training and recruitment will follow existing departmental policy. Additional on-the-job training will be received as operations are expanded.

2. First, establish a good system then show off that system and the employees, all of whom, were instrumental in the success of the system and this will sell and attract qualified people. Additionally, it is essential to make the job well diversified in order to keep the job interesting.

3. The core personnel will come from the existing Traffic Section which will be replace with new personnel. Then the section will grow with the system.

4. Training and recruiting efforts will continue according to policy.

How will your agency keep pace with ever changing technology?

1. Technological advancement is not perceived to be a problem. Mostly, a review of the available literature and in-house technology transfer will supplement assistance fron the Texas Transportation Institute. Additionally, "being in the business" will bring salesmen of new products to you for demonstrations.

2. A combination of added research with a change in emphasis toward traffic operations and advance traffic management systems and employee enthusiasm. Colleges and universities can be a place to start in the educational process then we can supplement that education with on-the-job-training. We must seek to educate our personnel in non-traditional areas and provide training across the various disciplines in order to provide for long-term development. If an employee is technically proficient in one area, through cross-training we can develop a well rounded employee.

3. Most of the technology will primarily be developed in-house with some input from various research agencies.

4. Keeping pace with changing technology should not be a problem as long as you make use of existing standards such as the national communication market specifications for communications and military standards for software. This will insure that products will be compatible and not obsolete upon installation. Also, a 20 to 40 year design life and expansion capability should be considered.

5. Membership on statewide committees and ongoing research efforts will help keep pace with changing technology. Additionally, in-house group education, travel to visit other systems, and FHWA technology sharing will provide tremendous benefits.

Will training provided in-house or through consultants (universities, etc.)?

1. Training will be provided from in-house, contractor, and Texas Engineering Extension Service sources.

2. Cross-training is essential in providing opportunities for personnel advancement.

3. Most of the training will be conducted in-house in cooperation with the Texas Transportation Institute.

4. Training will come from in-house sources, outside sources, and vendors depending on the type of training required.

5. Training will be provided in-house in cooperation with the Texas Engineering Extension Service.

Miscellaneous

In your opinion, what should be the major areas of concern for agencies planning to implement a freeway traffic management program?

1. The major areas of concern should be the areas of continued maintenance and operations and staff funding and support.

2. In Texas, we are extremely enthusiastic about advanced traffic management systems. Success will come about only by breaking down artificial organizational barriers that exist in many agencies. Additionally, we must go out on a limb rather than exist in a comfortable state if we are going to make significant advancements in traffic management. The major area of concern should be personnel, which should include the attraction of good people and their development throughout their career.

3. Funding is probably the biggest area of concern. We need some type of mandate to change the present allocation of funding to provide for traffic management systems.

4. The most important issue is the availability of funding for continuing operations and maintenance.

5. Funding or the lack thereof is by far the most important issue. Without adequate funding the others do not come into play.

6. The main issue is the funding issue for support and maintenance. There are existing funds available for capitol improvements, yet, none exists for operations and maintenance. Consideration should be given to connections between federal funds for traffic management projects and other federal fund allocations. Also, the personnel issue is important, especially since the SDHPT currently has no career ladder for some of the highly specialized fields required in the freeway traffic management systems arena.

Cite and describe any positive experiences that may be beneficial to others.

1. The lead agency should take on the responsibility of designing and building the system with some review by other agencies. This will prevent unnecessary delays.

2. Take a look at all available technology and design a system that is both reliable and redundant. Also, provide for system support from the onset.

3. The group training concept has been most beneficial to all those involved. Also, having the same people design and inspect the subsequent construction has led to better quality control and better future designs. Having "one foot in the field" has proven to be very beneficial.

Cite and describe any negative experiences that may be beneficial to others.

1. Tight specifications are essential and thorough contract monitoring is required in order to get the desired end product.

2. Carefully consider all equipment installed on the project as there will not be enough funds to revamp the system later.

3. Funding for support and maintenance of the system is essential for the success of the system. We cannot keep building these systems without a commitment for their support and operation. Also, the technical decisions for such systems should be made by the technical people rather than bureaucrats when considering the need for budget allocations for various department related projects. Finally, consideration should be given to the problems of priority of improvements, compatibility of equipment for projects, and issues of similar concern.

Additional comments.

1. The equipment for the freeway traffic management system should be state-of-the-art, off-the-shelf, proven, and capable of being expanded. The system should be over designed with respect to communications and a distributed system is probably the most appropriate design. System design should be conducted in one office and construction should be accomplished by competent personnel.

2. The agency should consider a distributed type of system architecture due to reduced costs and greater reliability.

3. The differences is system designs in the state are primarily due to the varying viewpoints on system operation and requirements to provide the particular level of operation.

4. There are both pros and cons to the use of distributed systems and the system design should reflect a system that will allow the user the flexibility he needs to effectively operate the system. Considerations should also be given to the links between the urban and rural areas.