TASK II

IDENTIFY/ASSESS EXISTING RESOURCES FROM ALL PARTICIPATING AGENCIES

Executive Summary

This study involves the identification and assessment of existing resources from all of the participating agencies of the Austin Area-Wide ITS Early Deployment Project. This report involves a portion of one task of a multi-task effort for the development of an Intelligent Transportation System (ITS). The study will assist in the development of the functional requirements to support the user services identified in the user service plan. The user service plan includes traffic control, incident management, public transportation management, en-route and pre-trip travel information, emergency vehicle management, and commercial fleet management. Each user service has some existing technology already applied in the Austin area to accomplish several functions.

Study Area

The study area for this project includes the City of Austin metropolitan area, as shown in **Figure II-i**. The City of Austin is the capital of Texas and has a metropolitan area population of approximately 600,000 persons.

As shown in Figure II-i, the study area includes the City of Austin and adjacent urban and suburban areas which are served by freeways and other major roadways. Austin is served by the IH 35, US 183 and MOPAC freeways in the north-south direction and by US 290/SH 71 in the east-west direction. These highways are supported by corridor streets which serve motorists in using the freeways to reach their destinations and in making short thru trips within the area. The freeway and major highway system is in various stages of construction/reconstruction which is expected to continue beyond the life of this study and for the next twenty years as identified in the Austin Transportation Plan.

The freeway service roads, highways and street networks within the area which are served by traffic signals are anticipated to be served by an expanded traffic signal system. In addition, public transportation is provided which will play an ever increasing importance in the movement of people


Study Area
Austin Area - Wide ITS
Austin, Texas
LEGEND
MAJOR HIGHWAYS
OTHER ROADWAYS
WATERWAYS
SCALE IN MILES
AUSTIN
North American Controls Corporation
Advanced Traffic Engineering
Kessmann & Associates
WILBUR SMITH ASSOCIATES
CONSULTING ENGINEERS AND PLANNERS
HOUSTON, TEXAS

within the area. The State, under the jurisdiction of the Texas Department of Transportation, has programmed/planned portions of the freeway management system for the Austin Area. The City of Austin has an existing traffic signal system and has planned an expanded traffic signal system. Capital Metro, the area transit agency, has planned or is planning a SMART Bus Program, High Occupancy Vehicle (HOV) lanes, and light rail system. Other Public Safety agencies, such as Fire and Police, have been involved in transportation development programs. These efforts toward enhancing transportation with some coordination between agencies have been largely independent. As these projects move from the independent internal planning stage toward implementation, a need is developing for these new "intelligent" transportation systems to interphase with the other transportation system providers.

Many existing streets cannot be widened because of right-of-way (ROW) limitations and neighborhood opposition to widening. In addition, the Colorado River divides the study area between north and south Austin. The present street widening limitations and the Colorado River provide constraints to a free flow of traffic. Funding constraints have also limited or delayed needed transportation projects. The City of Austin and TxDOT are planning on utilizing an ITS to supplement the existing and planned street and highway network.

Systems Applications

Because of ongoing roadway construction, restricted capacity across the Colorado River and street widening restrictions, ITS and other advanced applications need to be implemented in order to assure optimum mobility and safety within the study area. ITS and other advanced systems can be utilized prior to, during and after roadway construction. In addition, the use of bus, vanpool and carpool ridership and other transportation demand management activities are planned to be part of ITS applications.

Incident management is proposed to be implemented as part of the overall system development. Approximately 55 to 60 percent of congestion has been found to be caused by incidents. The overall effectiveness of an area wide traffic management system will be limited if incident management is not included. This includes coordination between Public Safety

Agencies (PSA) and Traffic Management Personnel. Incident management also includes traveler information on traffic conditions within the area (eg. home and office information via television and telephone, information kiosks, commercial radio broadcasts) and in-vehicle advisory information for motorists (eg. cars, trucks) with the system (including alternate route advisories).

A Traffic Management Center (TMC) which provides offices and space in a traffic control center would provide the most effective manner for traffic and incident management for all vehicles within the system. Initial flexibility and modular design of the Traffic Control and EMS systems would need to be provided for future ITS applications with adequate provisions provided initially within the TMC.

ITS applications, together with implementation of other systems and incident management would provide efficient and safe traffic operations within the Austin area today and in the future. The purpose of this report will be to provide input into the ITS development process for the Early Deployment Study for the Austin metropolitan area.

Study Findings

This report summarizes the work effort involved with three (3) work authorizations encompassing nine (9) combined work tasks. These tasks include the following:

- Austin Traffic Signal System;
- Freeway Traffic Management System;
- Public Transportation Management;
- Incident Management;
- Emergency Vehicle Management;
- Commercial Fleet Management;
- Traffic Management Center State-of-the Practice Review;
- Multi-Agency Traffic Management Center; and,
- Disseminating Traveler Information.

Each work task provided a conceptual overview of a particular area and was not intended to provide a design or detailed discussion of a topic. Several of the work tasks addressed specific questions.

All of the areas provided a summary of the following areas:

- facilities;
- equipment;
- maintenance;
- personnel;
- funding; and,
- implementation phasing.

The findings are summarized on **Table II-i**

Implementation and Phasing Strategy

The implementation of an ITS for the City of Austin would be an ongoing process over many years. Since many agencies have similar needs as discussed in other sections, the concerned agencies should pool and coordinate their funding, planning, and design efforts. One building for a Traffic Management Center could house many agencies and have one communications hub center.

Recommendations for implementation consist of the following:

1) Form an Operations Management Committee comprised of a representative of each participating agency to oversee ITS development. Consideration should be given to establishing an operating entity with an Executive Director as done in Las Vegas, Nevada and Houston, Texas.

2) Develop a Deployment Plan for submittal to the MPO <u>immediately</u> showing expenditures vs. time. This step could be done simultaneously with Step #1 and could be completed prior to the completion of Step #1. Steps #3 and #4 below could proceed while Step #1 is being completed. With the January, 1996 Initiative, "Operation Time Saver," announced by Secretary Pena, it is imperative that the Austin area develop and submit its deployment plan to qualify for potential federal funding.

Table II-i
Summary of Findings
Austin Area-Wide ITS
Austin, Texas

SYSTEM COMPONENT		FACILITIES SUMMARY	EQUIPMENT SUMMARY	MAINTENANCE SUMMARY	PERSONNEL SUMMARY	FUNDING SUMMARY	IMPLEMENTATION/ PHASING SUMMARY
City of Austin Traffic Signal System (TSS)		+ $5M Traffic Management Center (TMC)	$42M total	$3M per year	Need additional staffing Management Engineering Operations Maintenance plus existing staff	Federal - ISTEA State - TxDOT Local - Bond and General funds	Establish Operating Entity Deployment Plan Funding Design Deployment Operations & Maintenance
TxDOT Freeway Traffic Management System (FTM)		+$4M Traffic Management Center (TMC)	$1M/mile or $63M	Maintenance Contract with a Manager	7-20 total staff Managers: 2 - 4 persons Operations: 2 - 8 persons Maintenance: 3 - 8 persons	Federal - ISTEA State - TxDOT	65 miles of FTM 25 miles of HOV
Public Transportation Management (PTM)		Part of Capital Metro central dispatch and/or TMC	$10,000 per bus	Part of dispatch function	existing staff	Federal, State, and Local	Integrated part of SMART Bus Program
Roadway Incident Management (RIM)		TMC & Emergency Safety Center (ESC)	Same as TSS and FTM	Part of TMC & ESC function	3 persons per system, TSS and FTM	Part of TMC	Combine operations of ESC and TMC
Emergency Vehicle Management (EVM)		Part of ESC with Public Safety Agencies (PSA); 800 MHz system with all agencies	Detailed study being conducted by PSA	Part of 800 MHz system	Same as maintenance	Detailed study being conducted	Part of 800 MHz system
Commercial Vehicle Management (CVM)		TMC plus private companies	No additional equipment required by public sector other than software ($100K)	No additional major funds needed	No additional funding needed other than software in TMC	No additional funding needed other than software in TMC	Needs to be incorporated into TMC implementation
Disseminating Traveler Information		TMC with integrated software and hardware for Traveler Information System (TIS)	Hardware and software $1.6M plus TIS $42K	10% equipment costs plus telephone costs	2 full time staff	Federal, State, and Local part of TMC	same as TMC
Multi-Agency Traffic Management Center (TMC)	Centralized	One TMC - minimum of 25,000 sq. ft.	$8 to 13 million PC system - minimum of 40 workstations	$2.1 M per year	10-15 administration staff plus minimum 1 person per agency depending upon task	Federal State Local	Development of plan, phased implementation, creation of special agency, closer coordination between agency personnel
	Distributed	Each agency would need ≈ 1,300 sq. ft.	Equipment costs 10 to 20% greater, $6.5 to 9.5 million uses existing facilities	$2.1 M per year	Uses existing personnel with some new personnel plus TIC personnel	Sources same as centralized	Same as centralized, but easier to phase, use of existing facilities

3) Obtain funding for system upgrade. Potential funding for the recommended ITS system could come from two possible sources; these being local funding sources such as transportation related tax monies or capital improvement bond funds, and various federal funds administered by the Metropolitan Planning Organization (MPO) and/or Texas Department of Transportation. The metropolitan planning provision of Intermodel Surface Transportation Efficiency Act (ISTEA) has an enhanced role for local governments. The MPO is responsible for developing, in cooperation with the State, a long-range plan, and the Transportation Improvement Progarm (TIP) must include all projects in the Austin area that are proposed for funding with ISTEA monies. Areas with populations of over 200,000, such as the Austin Area, must be designated as Transportation Management Areas (TMA). Projects in these areas are selected by the MPO in consultation with the State. Also, in each TMA, a congestion management plan must be prepared. The Austin ITS system should be a primary component of this plan. Under ISTEA, two programs offer funding for a project such as the Austin ITS. These programs are the Surface Transportation Program (STP) and the Congestion Mitigation and Air Quality Improvement Program (CMAQ). The first step in securing Federal funds is getting ITS projects added to the TIP;

4) Commission Design Plans, Specifications, and Estimates (PS&E). This step will involve the design of the recommended system including: the preparation of plans, specifications, estimates, and bid documents, process, receipt of bids and award contracts. It is during this step that a plan will be prepared that indicates exactly where and when components will go on the new ITS;

5) System Deployment. This step will include system development and integration, system testing and acceptance, training, and field installation.

6) A Freeway Traffic Management System deployment as should be made over a maximum of six years.

7) The Transportation agencies and Public Safety Agencies should be on a common communication system.

8) The Transportation agencies should incorporate commercial vehicle management and traveler information in a deployment plan.

9) Transit Management Systems should be incorporated in a deployment plan including Capital METRO's smart bus program and signal preemption.

10) The city of Austin Transportation and TxDOT groups should work with the Public Safety Agencies to have an integrated Traffic Management Center.

The first priority is the development of a preliminary engineering report which would include a detailed deployment plan. The deployment plan would include funding strategies. The report would be the basis of securing funding from local, state, and federal sources. Currently, federal and state dollars have been available for projects that have a local match, including design plans for construction.

The City of Austin should work with TxDOT, Austin District, to secure possible State and Federal Funds. The City should concentrate their internal planning efforts for the concerned groups, including Public Works, Capital Metro, and Public Safety Agencies. The City should secure local funding for the initial design and local match for State and Federal Funds. One possible option would be a bond election in the Spring of 1996.

With the passage of a bond election in the Fall of 1996, the funds could be available by Spring 1997. A deployment plan could also be in place by Spring 1997. Critical portions of the traffic system could be designed during 1997 such that plans would be ready for construction during 1998. Approximately 100 intersections could be upgraded per year with the existing signal contractors. A Traffic Control Center would probably be needed by 2000. An interim center would be needed in 1998. The system would be "fully" implemented by 2005.

Other technical questions to be determined are the type of controller to be utilized, selection of system software, detection methods in selected areas, and communication media utilization. Staffing levels and maintenance/operation funding would need to be adjusted as the system is implemented.

The TxDOT, Austin District, should coordinate its ITS efforts with the City of Austin and other Austin Area agencies. It is recommended that the Freeway Traffice Management be installed within six years. The system should be installed in usable sections not in short segments. Consideration should be given installing the initial sections along IH35 even as an iterim design.

A key factor for the successful implementation of an ITS/traffic signal system for Austin would be the establishment of an impartial group of individuals to coordinate and direct implementation effort. This organization would be similar to working groups in Houston and Las Vegas.

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Figure No. **Page**

CITY OF AUSTIN TRAFFIC SIGNAL SYSTEM
SCOPE OF WORK

Task 1 - Evaluate existing City of Austin traffic control system

Task Description and Milestone

The City of Austin desires a computer controlled signal system which is at least capable of the following functions in the order of importance:

- Accommodates existing system characteristics;
- Integrates signal control, preemption, cameras, signs, and flashers;
- Integrates video from a mobile source;
- Utilizes a distributive architecture;
- Supports a variety of communication mediums;
- Perform multiple tasks simultaneously;
- Provide remote access;
- Automatically adjust signal timings to accommodate traffic demand;
- Evaluate operations based on real-time speeds, travel times, and queue lengths;
- Continuously collect operational characteristics;
- Continuously update color coded maps;
- Display the network in different colors based on congestion;
- Recommend streets which can accommodate diversion during an incident;
- Provide emergency/bus preemption;
- Distinguish emergency/non-emergency preemption;
- Maintain signal coordination during preemption;
- Identify time, agency, and impact of preemption; and,
- Share data with other agencies.

The engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

The work generally consists of identifying and summarizing the facilities and equipment comprising the existing traffic control system. Existing maintenance, personnel, and funding of the system should also be identified along with any planned improvements. Recommendations regarding the ability of the existing resources to provide the functions above in the future should be determined.

Facilities include structures of enclosures necessary to house and operate eqipment and personnel and its cost. Existing equipment includes hardware, software, and communications items and their cost. Equipment costs should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes existing persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of any existing phased implementation plan should be included.

CITY OF AUSTIN TRAFFIC SIGNAL SYSTEM SCOPE OF WORK

Task 2: Recommend a signal system capable of desired functions.

Task 3: Recommend improvements to the existing City of Austin traffic control system.

Task Description and Milestone

The City of Austin desires a computer controlled signal system which is capable of the following functions in the order of importance:

- Accommodates existing system characteristics;
- Integrates signal control, preemption, cameras, signs, and flashers;
- Integrates video from a mobile source;
- Utilizes a distributive architecture;
- Supports a variety of communication mediums;
- Perform multiple tasks simultaneously;
- Provide remote access;
- Automatically adjust signal timings to accommodate traffic demand;
- Evaluate operations based on real-time speeds, travel times, and queue lengths;
- Continuously collect operational characteristics;
- Continuously update color coded maps;
- Display the network in different colors based on congestion;
- Recommend streets which can accommodate diversion during an incident;
- Provide emergency/bus preemption;
- Distinguish emergency/non-emergency preemption;
- Maintain signal coordination during preemption;
- Identify time, agency, and impact of preemption; and,
- Share data with other agencies.

The engineer shall provide the following services for each of the above tasks (1 and 2).

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

The work generally consists of developing a conceptual overview of a traffic signal system for the City of Austin. The work effor will consist of the following two parts: (1) recommending a system capable of the above functions and (2) improvements to the existing traffic control system over the next three years that will be compatible with the recommended system. In addition summarize the advantages and disadvantages traffic signal preemption will have on the signal system and traffic. Separate summaries of the facilities, iquipment, maintenance, personnel, and funding of these systems should be identified along with a phased implementation plan.

For 1:
Facilities include structures or enclosures necessary to house and operate equipment and personnel and its cost. Equipment includes hardware, software, and communiations items and their cost. Equipment costs should be identified as capital, operations, and maintenance. Maintenance ncludes routiena dn preventative actions, as well as, life-cycle costs. Personnel includes persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of a phased implementation strategy should be included.

For 2:
Facilities include any expansion of existing structures or enclosures necessary to house and operate additional equipment and personnel and associated costs needed during the three year interim. Equipment includes additional hardware, software, and communications items not included in (1) and their cost for the existing system. Costs for additional equipment for the existing system should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes additional persons needed in the interim to design, operate, and maintain facilities and equipment. Funding includes both public and private sources for additional improvements. Documentation of a phased implementation strategy of additional improvements that would be compatible with the recommended system should be included.

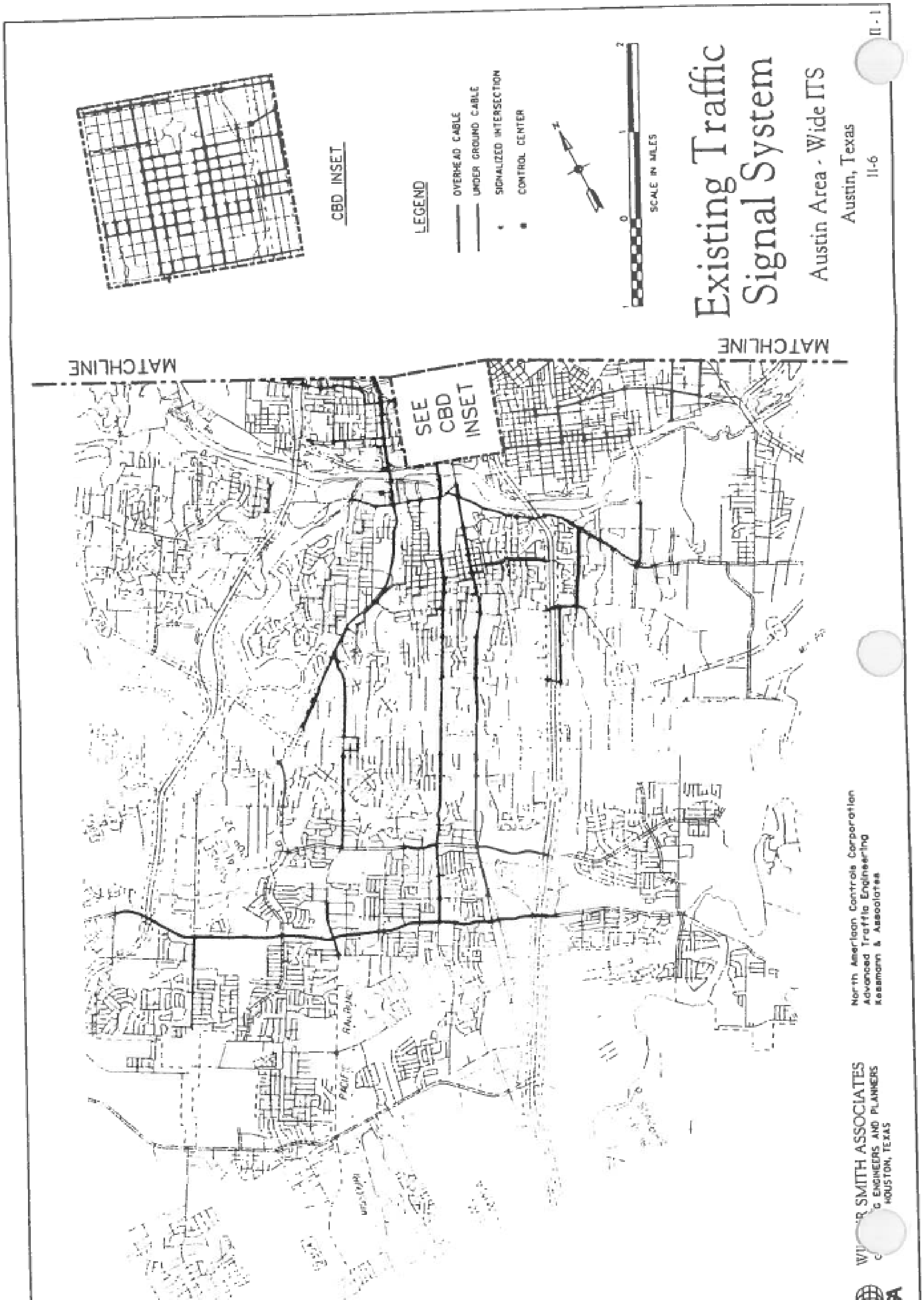
City of Austin Traffic Signal System

The City of Austin implemented a modified Urban Traffic Control System (UTCS) in 1986 using a central computer system and Type 170 traffic signal controllers. This system replaced an IBM 1800 controlled system installed in 1969. The UTCS software was designed to accommodate 800 traffic signals, with emergency vehicle preemption and bus priority capabilities. A personal computer (PC) now controls approximately 400 of the approximately 600 traffic signals located throughout the City, as shown in **Figures II - 1** and **II - 2**. Communications between the central PC and the local intersections are completed over City owned twisted wire pair cable using time division multiplexing. The current PC based system is currently used only to download time of day timing plans to local intersection controllers. The UTCS based operating system is <u>not</u> working as originally designed and has been modified considerably by the City of Austin Staff. The interface has undergone considerable changes.

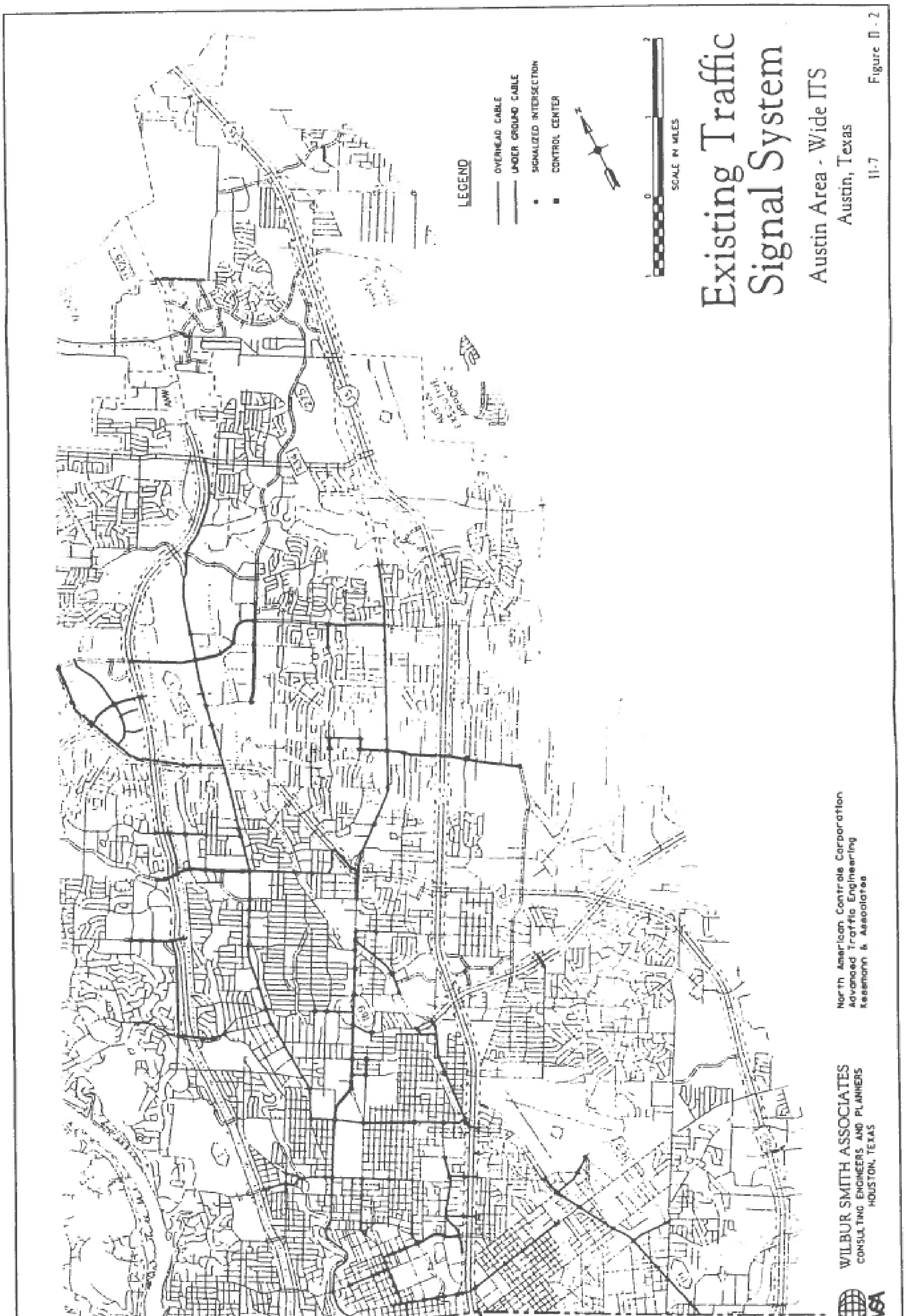
Existing Facilities Summary

Existing facilities for the City of Austin's Traffic Signal System consists of a Traffic Control Center located on Toomey Road, Transportation Division staff offices located in One Texas Center, and local intersection controller cabinets and hardware.

<u>Traffic Control Center</u> - The City of Austin has a 30' x 18' Traffic Control Center that is housed in the Department of Public Works and Transportation's building at 1501 Toomey Road. This Control Center contains a Data General computer system installed in 1985 that has not been used for some time and a personal computer (PC) system that is currently being used to manage the signal system. There are three desks and a bank of file cabinets in the front section of the Control Center. The PC system resides on these desks. The rear section of the Control Center contains the Data General computer, peripherals, and communications multiplexors. The Control Center has a raised floor; handicapped access; is acoustically treated; has a separately controlled heating, air conditioning, and ventilation; a power source for both 120 and 230 volts at 60 hertz with regulated power to all computer and communications equipment; fire protection system with audible alarm and a halon gas



Existing Traffic Signal System
Austin Area - Wide ITS
Austin, Texas
II-6
CBD INSET
LEGEND
OVERHEAD CABLE
UNDER GROUND CABLE
SIGNALIZED INTERSECTION
CONTROL CENTER
SCALE IN MILES
0
1
2
MATCHLINE
MATCHLINE
SEE CBD INSET
North American Controls Corporation
Advanced Traffic Engineering
Kessmann & Associates
HOUSTON, TEXAS


LEGEND
OVERHEAD CABLE
UNDER GROUND CABLE
SIGNALIZED INTERSECTION
CONTROL CENTER
SCALE IN MILES
Existing Traffic
Signal System
Austin Area - Wide ITS
Austin, Texas
II-7
Figure II - 2
WILBUR SMITH ASSOCIATES
CONSULTING ENGINEERS AND PLANNERS
HOUSTON, TEXAS
North American Controls Corporation
Advanced Traffic Engineering
Kessmann & Associates
MATCHLINE

fire extinguishing system; a dedicated telephone line as well as telephone lines from the City's telephone system; overhead lighting; and floor-to-ceiling clearance of 8.5 feet.

Controller Cabinets - The traffic signal controllers at local intersections are housed in Model 332 and 336 type controller cabinets. The majority of the existing cabinets are in usable condition and are less than 10 years old.

One Texas Center - Transportation Division personnel, including management, engineers, and support staff, have offices located on the 8th floor of the One Texas Center building located on Barton Springs Road. Traffic signal system personnel are located at the Traffic Control Center on Toomey Road, parking enforcement personnel are located at the parking meter shop on Rio Grande Street, while all other personnel are located at One Texas Center.

Existing Equipment Summary

The City of Austin Traffic Signal Control System operates with a variety of equipment and components, including traffic signal controllers, system hardware, system software, and communications equipment, as described in the following paragraphs.

Traffic Signal Controllers - The City of Austin's Traffic Signal System consists of 610 traffic signal controllers. There are 410 traffic signals currently operated using the modified UTCS based system controlled by a central PC, with local intersections operating using Type 170 traffic signal controllers. The current system is essentially a closed "loop" pretimed type of system. Each controller assembly includes:

- Type 170 Controller;
- Model 200 Switch Packs with L.E.D. for Output as well as Input;
- Model 204 Flasher Unit;
- Model 210 Conflict Monitor Unit;
- Model 222 Two-Channel Loop Detector Sensor Units;
- Model 242 Two-Channel DC Isolator;
- Model 400 Modem Rev. F with Switch Selectable Anti-Streaming;
- Model 412B Memory Module (256K EPROM and 32K of EEPROM. Configured to run W4IKS software);

- Wapiti Micro Systems' W4IKS with W4IKS software program for communication protocol;
- Model 336 or Model 332 cabinet;
- Associated Input/Output Files and Power Distribution Assemblies;
- Pull Out Drawer;
- Cabinet mounting hardware; and,
- Model PDA-2 Power Supply.

The Type 170 Traffic Signal Controller is a standardized controller that is tried and proven. The controller is built to ensure complete interchangeability of all modules, even those of different manufacturers. The controller is structured around a microprocessor, with the architecture of the device allowing for great flexibility. Flexibility comes from the fact that its operation is controlled by software, which can be changed to accommodate changing situations. Software packages are available for the Type 170 controller from several different software providers. However, the Type 170 controller has reached the end of its life-cycle from an operational standpoint and is inadequate to perform the tasks required by modern ITS type traffic signal control systems and those characteristics identified by the City of Austin for a proposed traffic signal system. The Type 170 controller uses 1970's technology.

The City of Austin's Traffic Signal Local Controllers are running the Wapiti W4IKS software. W4IKS is a proven software package for the Type 170 and is a package that is often included with the Safetran Type 170 controller. Despite its maturity, this software is limited. Pre-set timing plans by time of day are used without the capability to adjust the timing sequence/split and reassign lanes based on traffic demand. W4IKS has no traffic responsive capability and does not satisfy existing operational needs (Force Offs/Left Turn). The handling of specialized intersections must be done through the "command box" which is very time consuming and not easy to use. W4IKS allows only for up to 8 phases with overlaps.

Hardware - The City of Austin's Traffic Signal System Central Computer is made up of a network of IBM-compatible PCs at the Toomey Road facility running TransLink software under Windows NT. The PC network consists of a 90 MHZ Pentium acting as the Windows NT Server and additional 486/Pentium workstations which are utilized for updating the database.

More than half of the present intersections do not have detectors. At one point there were about 80 system detectors in the city on various arterials. They have not been used for some time and their status is therefore unknown. There is a high probability that the majority of these detectors do not work.

Software - The City of Austin's Traffic Signal System Central Computer is currently running TransLink software, a software package developed and supported by a Safetran employee. This central computer program is designed to operate in a Wapiti Closed Loop System. It is a Window's Based application, and the package is very user friendly and easy to use. The updating and modification of timing plans of the local intersection via dial-up line is very simple, straight-forward, and relatively quick.

The graphical intersection display software, included in the PC system, has the ability to be easily modified to reflect the actual local intersection configuration. Although numerous screens are available, most screens can only be viewed one at a time. The Zone display allows monitoring of more than one intersection at a time, but only A-Phase Green is shown. To monitor all intersection data, an intersection display must be called. This display is not viewable concurrently with the zone display or additional intersections displays, and only one Zone may be viewed at a time.

The system also provides for emergency pre-emption and transit signal priority, with Opticom. The system distinguishes between emergency and non-emergency preemption and logs the time and vehicle ID number. During non-emergency pre-emption, the software system maintains signal coordination, but during emergency pre-emption, the signals are "kicked out" of coordination. The system is capable of identifying time and the agency prompting the pre-emption, but it does not identify impact.

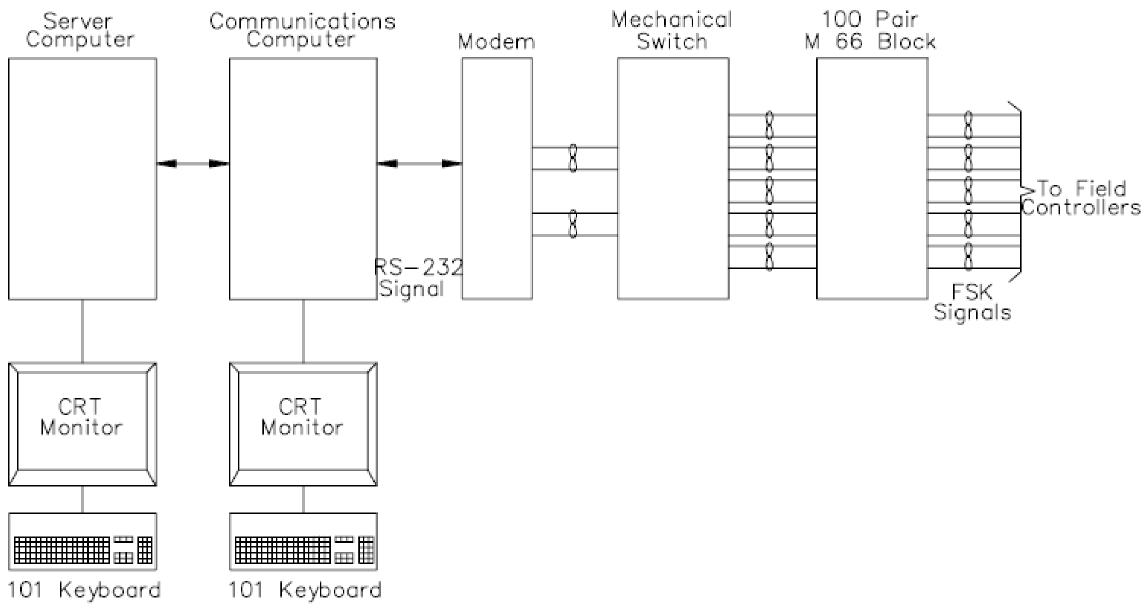
The software does not provide any map displays or the capability to display the network in different colors based on congestion. The system also does not have the capability to recommend alternate routes for diversion during an incident. There is no sharing of the data available in the system by agencies, and the system does not integrate signal control and flashers (school). In addition, cameras, signs, or video capabilities are not being controlled by the system. The system does no hardware failures diagnostics (i.e. no indication of signal on flash, loop failure, bulb burned out).

Communications - The existing traffic signal communications control system is illustrated in **Figure II - 3**, Existing City Traffic Control Center. This figure illustrates the twisted pair input system using 100 pair and 150 pair cables over a frequency shift keying (FSK) communications network. The network utilizes a 1200 Baud FSK modem for all sequential transmission throughout the city infrastructure. Increased baud rates appear to generate more communications tries, which slows the communications throughput. Therefore, this results in a poor Bit Error Rate of the existing copper cable plant system. The existing copper cable plant with modification could be utilized to provide most of the desired system characteristics for a traffic signal system except real time video.

The functional operation of the system is via two computers accessing the field controllers. First, the communications computer controls all input/output communications to the field cabinets. Second, the server computer (or applications computer), connected to the communications computer, selects the application to be run for intersection controls.

The Server computer communicates to 410 local intersection controllers using the city's own twisted pair communications network. Communications to the PC is through a digiboard which is tied to the server, as shown in **Figure II - 4**. The fact that the system is communicating via the digiboard limits the capabilities of what the central computer can monitor at one time. Only A-Phase Green is able to be monitored on more than one intersection at a time. This is done by the Zone Display, not multiple intersection graphic displays.

The cable plant design is based on a 66 M Block system with common termination throughout the networks, as shown previously in Figures 2A and 2B. Redundancy in communications is missing. If there is a failure in communications with the local controller, drift occurs on the controller clock.



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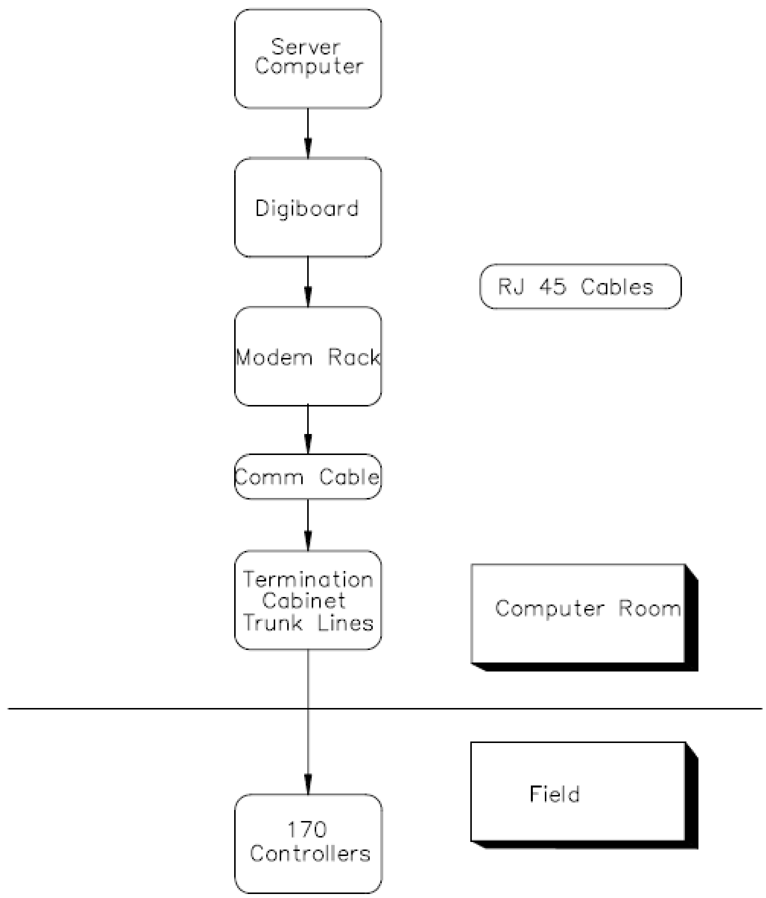
ADVANCED TRAFFIC ENGINEERING
KESSMANN & ASSOCIATES

Existing City Traffic Control Center Communications System
Austin Area-Wide ITS
Austin, Texas

Figure II-3



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NORTH AMERICAN CONTROLS CORPORATION
ADVANCED TRAFFIC ENGINEERING
KESSMANN & ASSOCIATES

Communications Block Diagram
Austin Area-Wide ITS
Austin, Texas

Figure II-4

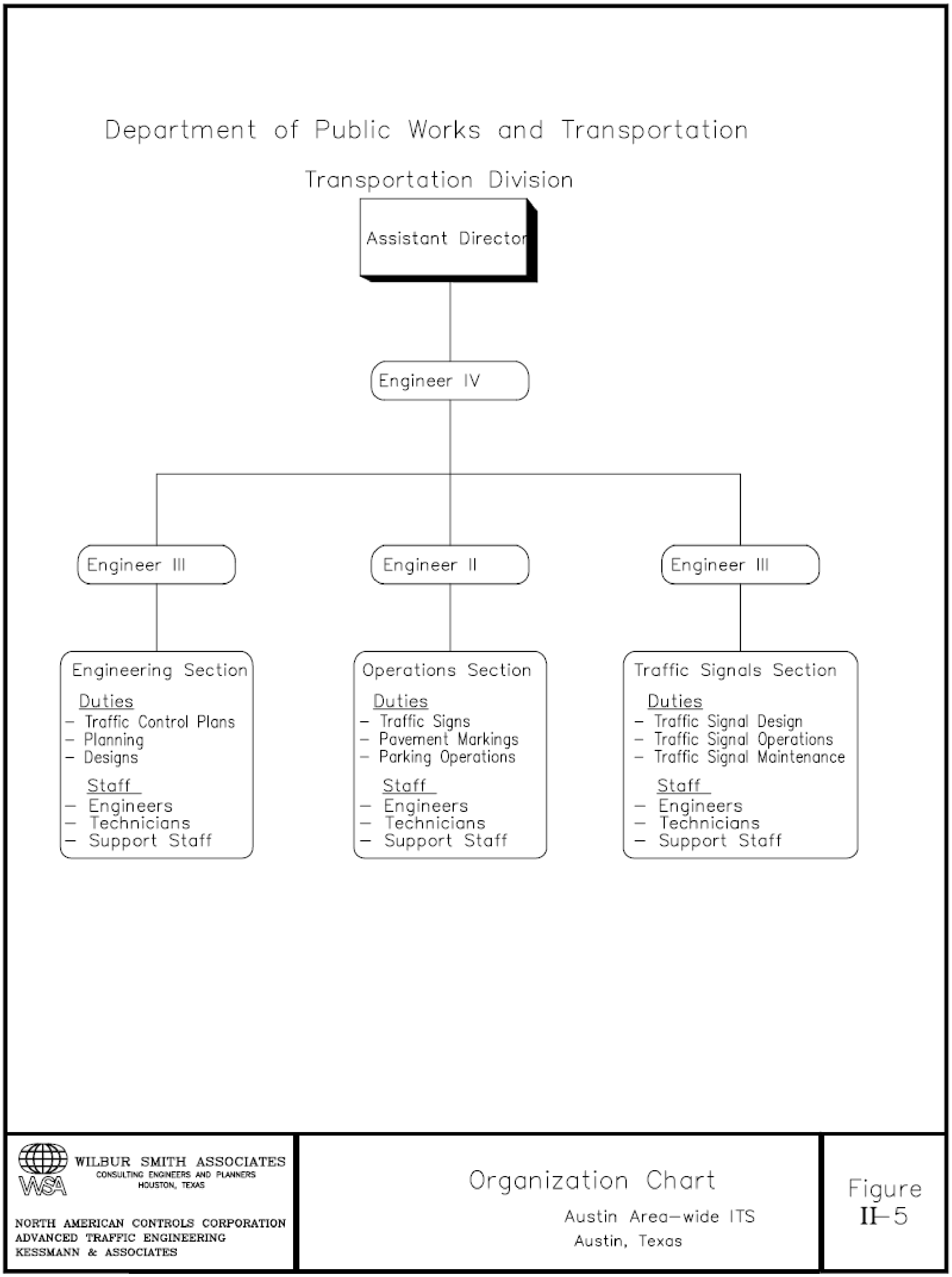
Existing Maintenance Summary

Existing maintenance for the City of Austin's Traffic Signal System is completed in house with existing maintenance personnel. Maintenance operations consist of response maintenance, which includes all maintenance activities that occur due to an equipment failure or citizen complaint. A preventive maintenance program, in which traffic signal installations are routinely inspected and repaired before major problems occur, is currently not underway. Funding constraints only permit a minor amount of preventive maintenance per year. The City staff have updated and maintained traffic control patterns so that the system probably operates as well as it can under fixed time operation. This area of operational maintenance has offset some of the deficiencies noted in achieving the desired traffic signal operations.

Personnel Summary

A chart depicting the current organization of the City of Austin Department of Public Works and Transportation, Transportation Division is shown in **Figure II - 5**. The division is divided into three sections, with the Engineering Section responsible for citizen concerns, traffic control plans, planning, and design; the Operations Section responsible for traffic signs, pavement markings, and parking operations; and, the Traffic Signals Section responsible for traffic signal design, operations, and maintenance. The Transportation Division currently occupies three offices, with the traffic signal section and sign shop located at the Traffic Control Center on Toomey Road, the parking enforcement section on Rio Grande Street, and the engineering and operations sections located at One Texas Center.

The Traffic Signal Section currently employs 2 engineers (with one additional engineering position currently vacant), 3 signal operations technicians, 9 installation/communications technicians, and 6 maintenance technicians. The signal operations technicians have between 7 and 22 years experience in traffic signal systems. The maintenance technicians, however, range from 1 to 12 years of experience in traffic signal maintenance, with 5 technicians at 6 years of experience or less. Seven employees have experience in the installation of communications cable, with experience ranging from 3 months to almost 14 years. Five of the seven employees have five years or less of communications installation experience. Based on the education, and type and years of experience reported for



Department of Public Works and Transportation
Transportation Division
Assistant Director
Engineer IV
Engineer III
Engineer II
Engineer III
Engineering Section
Duties
- Traffic Control Plans
- Planning
- Designs
Staff
- Engineers
- Technicians
- Support Staff
Operations Section
Duties
- Traffic Signs
- Pavement Markings
- Parking Operations
Staff
- Engineers
- Technicians
- Support Staff
Traffic Signals Section
Duties
- Traffic Signal Design
- Traffic Signal Operations
- Traffic Signal Maintenance
Staff
- Engineers
- Technicians
- Support Staff
WILBUR SMITH ASSOCIATES
CONSULTING ENGINEERS AND PLANNERS
HOUSTON, TEXAS
NORTH AMERICAN CONTROLS CORPORATION
ADVANCED TRAFFIC ENGINEERING
KESSMANN & ASSOCIATES
Organization Chart
Austin Area-wide ITS
Austin, Texas
Figure
II-5

communications maintenance employees, it appears that the majority of the communications staff lack the skills needed to operate and maintain a complicated fiber optics communications system. The communications and maintenance staff should be trained in fiber optics before implementing an advanced fiber optics communications system. The equipment necessary to maintain an advanced traffic signal system/communications system will need to be obtained.

Table II - 1 identifies the average staffing levels of major metropolitan areas in 1984. Due to budget cuts in most metropolitan areas, staffing levels have not grown significantly in the past ten years and are assumed to be similar to the 1984 levels. According to the table, the City of Austin, with a population of approximately 600,000, should have a staffing level of approximately 16 professionals, 18 traffic engineering technicians and 60 maintenance workers to be at an average level compared to other metropolitan areas. These staffing levels are for the entire Transportation Division, including the engineering section, the operations section, and the traffic signal section (including sign and pavement marking staff). Parking enforcement staff is not included.

The City of Garland, Texas conducted a personnel survey in 1992 to compare staffing levels at numerous cities throughout Texas. The City of Austin reported a technical employment level of 68 persons, including 5 registered engineers, 18 engineering assistants/draftsmen, 19 signal technicians, 15 sign and marking technicians, and 11 other personnel. In addition, the City reported 34 office and clerical personnel. Therefore, the City of Austin's current staffing level is consistent with the average staffing level of other metropolitan areas. The entire personnel survey from the City of Garland is included in **Appendix II - A**.

Existing Funding Summary

The City of Austin Transportation Division currently obtains funding from the City of Austin through both the General Fund and the Capital Improvement Program (CIP). In fiscal year 1994-1995, CIP funding for the Traffic Signal Section totaled approximately $2.207 million, while funding from the General Fund totaled $1.187 million. Funding levels for the Traffic Signal Section for fiscal year 1995-1996 are anticipated to remain constant at approximately $2.3 million CIP funds and $1.2 million General funds. Annual salaries, benefits, and overhead costs total approximately $1.18 million.

Table II - 1
Urban Traffic Engineering Agency Staffing, 1984
Austin Area-Wide ITS
Austin, Texas

		Personnel per 100,000 Population*								
		Traffic Engineering								
	No.	Professionals			Technicians			Maintenance Workers		
Population Group	of Cities	Mean	Median	Range	Mean	Median	Range	Mean	Median	Range
50,000 - 100,000	33	3.3	3.1	1.1-7.4	2.8	1.6	0.0-15.7	13.0	12.2	3.4-28.7
100,000 - 250,000	31	2.8	2.3	0.6-6.9	2.4	1.9	0.0-11.8	12.1	10.9	2.5-29.9
250,000 - 500,000	12	2.4	2.0	0.8-5.9	2.9	1.9	0.4-11.0	16.3	14.3	7.9-34.9
500,000 - 1,000,000	8	2.7	2.8	0.5-5.1	3.2	2.8	0.5-06.5	11.1	10.5	7.2-17.4
All Cities	84	2.9	2.6	0.5-7.4	2.7	1.9	0.0-15.7	13.0	11.9	2.5-34.9

* 1980 Census

SOURCE: Traffic Engineering Handbook, Fourth Edition, Institute of Transportation Engineers, 1992.

During the past three years, between $1.5 and $2.1 million per year has been provided for signal system improvements, which include new signal installations, loop detector installations, communications cable, signal system upgrades (i.e. left-turn signal heads, signal timing plans, etc.), and salaries of maintenance and operations personnel who perform these tasks. The amount of funding is dependent upon City Council approval and will vary from year to year.

Table II - 2 identifies average funding levels for traffic engineering agencies in 1984. Due to budget cuts in most major metropolitan areas, funding has not increased much or kept up with inflation. Current funding levels are assumed to be similar to 1984 funding levels. For the entire Transportation Division, including the engineering section, operations section and signal section, funding for a City the size of Austin should average approximately $5 million.

Funding levels are not anticipated to vary greatly from present levels in the near term. However, funding for recommended improvements to the existing City of Austin Traffic Signal System will more than likely have to come from another source. Potential funding sources for recommended improvements are discussed in the cost and funding section.

Desired System Characteristics

The City of Austin has identified 18 characteristics or functions which they desire their traffic signal system to be capable of performing. The functions include many Intelligent Transportation System (ITS) strategies which are accomplished using state-of-the-art technology. The desired functions, listed in order of importance by the City, include the following:

- Accommodates existing system characteristics;
- Integrates signal control, preemption, cameras, signs, and flashers;
- Integrates video from a mobile source;
- Utilizes a distributive architecture;
- Supports a variety of communication mediums;
- Perform multiple tasks simultaneously;
- Provide remote access;
- Automatically adjust signal timings to accommodate traffic demand;
- Evaluate operations based on real-time speeds, travel times, and queue lengths;

Table II - 2
Urban Traffic Engineering Agency Funding, 1984 (Dollars per Capita*)
Austin Area-Wide ITS
Austin, Texas

		Budget Category								
	No.	Maintenance			Operations & Engineering			Both Categories		
Population Group	of Cities	Mean	Median	Range	Mean	Median	Range	Mean	Median	Range
50,000 - 100,000	17	8.30	5.0	0.5-28.8	4.05	2.05	0.9-18.5	12.4	8.30	2.3-31.4
100,000 - 250,000	22	5.50	4.7	2.1-17.7	3.15	1.70	0.7-10.4	8.7	6.85	3.1-23.3
250,000 - 500,000	10	8.70	6.5	2.6-22.1	2.70	2.10	0.6- 7.4	11.4	7.80	3.4-29.4
500,000 - 1,000,000	5	5.10	4.2	1.3-10.4	3.30	3.50	0.9- 5.0	8.4	8.00	2.2-15.4
All Cities	54	6.95	5.1	0.5-28.8	3.40	2.05	0.7-18.5	10.3	7.60	2.2-31.4

* 1984 dollars; population as per 1980 Census

SOURCE: Traffic Engineering Handbook, Fourth Edition, Institute of Transportation Engineers, 1992.

- Continuously collect operational characteristics;
- Continuously update color coded maps;
- Display the network in different colors based on congestion;
- Recommend streets which can accommodate diversion during an incident;
- Provide emergency/bus preemption;
- Distinguish emergency/non-emergency preemption;
- Maintain signal coordination during preemption;
- Identify time, agency, and impact of preemption; and,
- Share data with other agencies.

Each of these items are important to the City to be included in a traffic signal control system. However, since the goal for the greater Austin area is the eventual completion of a multi-agency Traffic Management Center, the desire to share data with other agencies should be near the top of the list of importance, not at the bottom. Now is the time to coordinate and communicate with other agencies to determine a standard communications medium and protocol so that data from all agencies will be available to everyone.

Existing System Conclusions

The current system is not capable of accomplishing all of the desired functions identified above. In order to accomplish these tasks, a system which includes Intelligent Transportation Systems (ITS) technologies should be implemented. Several different modes of system operation are needed to achieve the operation that will be required in the future. Implementation will be investigated in later sections. In addition, limitations for installing and maintaining advanced technologies exist with some personnel, primarily maintenance and communications staff. The current funding levels for construction, maintenance and operation of the existing traffic signal systems are not compatible with the needs of a system to satisfy the requirements of a system that has the City of Austin's desired characteristics.

Proposed Traffic Signal Functions

The City of Austin's Traffic Signal System, proposed by the City of Austin to have the previous identified characteristics, is to be a hybrid traffic signal system architecture utilizing distributed control intelligence, a central database, non-proprietary components, off-the-shelf standard hardware interfaces, and open compatibility with future ITS (Intelligent Transportation

Systems) capabilities. The system should support the use of video surveillance as a critical component of the control and surveillance systems. It should also be capable of utilizing a variety of recommended communication mediums, including the existing Austin-owned twisted pair cable, Greater Austin Area Telecommunications Network (GAATN), and leased lines.

The Austin Traffic Signal System should have the capability of four modes of traffic signal timing plan generation on a subsystem basis. These modes are:

- time-of-day traffic signal control;
- 1.0 generation traffic signal control;
- 1.5 generation traffic signal control; and,
- real-time, traffic-adaptive signal control.

The time-of-day mode calls for the system to operate in a fixed time coordinated mode through use of time base coordination. The intersection controller can implement preselected traffic control patterns on a time-of-day basis. The preselected patterns should be stored in each intersection controller and additional patterns can be down loaded from the central computer.

The based 1.0 generation traffic signal control software selects from traffic control patterns for each subsystem based on information from detectors at selected locations within the subsystems. The change from one traffic control pattern to another would be made through a software package that provides operator established threshold values which are based on the database developed from the selected detectors. Subsystems can be redefined by the central computer on an as needed basis.

The 1.5 generation traffic control mode should perform all on-line functions supported by the 1.0 generation software package. Included in the package is the ability to collect and store traffic count data from vehicle detectors. This data will be used to compute design hour total flow volumes for use in TRANSYT-7F network files. This integrated package would automatically detect and log inefficient timing plan performance while the system is operating in the on-line mode. The on-line man/machine interface would allow the operator to schedule off-line functions for execution as well as display or print timing plans or performance statistics which have been generated in the off-line mode. The control functions would include selecting and implementing signal timing plans in the traffic signal network, commanding the local controllers to follow the timing plans, providing for surveillance of traffic flow conditions, and monitoring the operational status of field equipment. Since the 1.5 generation software provides data required for use in the TRANSYT-7F model and detects and logs inefficient timing plan performance, it could require more detectors than the 1.0 based generation traffic signal control.

The real-time, traffic-adaptive signal control mode would allow traffic patterns to be implemented in advance of the need for them on the street. This would be done through the use of a predictive model simulating anticipated origin and destination movements. This mode of traffic signal control would be open-ended by allowing sufficient Random Access Memory (RAM) to be reserved in the local controller software to accommodate the future developments in the real-time traffic adaptive control area. The real-time mode could require system detectors on all approaches to traffic signal controlled intersections.

The traffic signal system should be designed for subsystem operation as is done with the existing system. Each of the four modes of operation should be available for use in each subsystem. The selection of the mode for each subsystem would be dependent on level of service (LOS) and traffic pattern variations (including incident management). One subsystem for example could operate on a time-of-day basis throughout the day while the adjacent subsystem could operate time-of-day during the off-peak and traffic adaptive during peak periods and/or incident conditions based on traffic demand. When any two adjacent subsystems are operating time-of-day, and or real time, it should be optional through central computer control to require both subsystems to operate in an integrated manner with coordinated offsets when both systems are operating at the same cycle length. The subsystems could be reconfigured quickly by the central computer on an as needed basis.

Timing Plan Selection - Under the real-time traffic-adaptive control mode, timing plans will be automatically generated on a real-time basis in anticipation of travel patterns predicted to exist on the street. For 1.0 and 1.5 generation control modes, algorithms will be prepared to provide for timing plan selection based on threshold values for volume, speed, and/or occupancy. Timing plan selection for time-of-day traffic control mode will be based on historical data to determine necessary changes in timing plans, based on variations in traffic volumes historically recorded in the central computer data base.

Under both real-time, traffic-adaptive control mode and 1.0 and 1.5 generation control modes, subsystems are dynamic in that intersections may be added or dropped from subsystem structures. Under both real-time, traffic-adaptive control mode and 1.0 and 1.5 generation control mode, if a detector in the system fails then the system reverts to historic data to make a traffic control decision. If no historic data is available, then the subsystem will revert to time-of-day time-based coordination operational control.

Timing Plan Implementation and Operation - All timing plans or software components which are brought together by the local controller to formulate a timing plan, are resident and operational at the local intersection level. Mirror images of these timing plans are resident in the central computer database. A major advantage to having the timing plans resident in the local controllers, is that time-of-day changes will be locally available to provide backup capabilities. Under traffic adaptive and 1.5 generation control mode, timing plan changes are commanded from central control and downloaded to the local controller using the local database. If communication is lost to just one intersection of a group, then the entire subsystem will fall back to the predetermined time-of-day control mode.

Timing Plan Evaluation - Traffic signal timing plans should be able to be evaluated through the use of three methods. Evaluation capabilities should be provided through a tiered-level security access system. The first method is the use of a time-space diagram program used to evaluate signal control operation, through use of the 1.5 generation and traffic adaptive control software and properly located/designed intersection detectors. These programs should accumulate real-time field color returns and plot a time space diagram using this data for the selected grouping of intersections. The operator may then implement split, offset, and phasing changes to improve the green band coordination on the coordinated street. A second mode of signal timing plan evaluation involves the use of traffic simulation/optimization models such as TRAF-NETSIM/PASSER/SYNCHRO. Measures of effectiveness from the models and field detectors would be used to determine delay and number of stops. The final method of signal timing plan evaluation will involve the combined use of video surveillance cameras and average vehicle speeds. The cameras should be strategically located throughout the Austin system to provide the capability of monitoring critical locations in the network. Upon observing substandard conditions through the use of a camera, the operator may implement strategies to alleviate those conditions. The traffic responsive system needs system detectors only at key locations. Traffic adaptive control generally need more system detectors. However, with predictable traffic patterns at known locations, the number of detectors needed are essentially the same. If changes in phasing to accomodate cross streets or turning vehicles is needed, more system detection inputs are also needed.

Distributed Traffic Signal Systems

There are two types of distributed systems used in the United States which respond to changes in traffic functions. These are traffic responsive and traffic adaptive. Traffic responsive systems match adaptive systems traffic control patterns provided accurate threshold values are given for parameters (e.i. volume, occupancy). The traffic responsive system traffic control patterns function for a period of time (five to fifteen minutes) before changes can occur at each intersection through the use of traffic actuated controllers which provide detections for the pedestrians, turns, and/or cross street phases.

Traffic adaptive controllers are more adaptable to changes in traffic patterns in that the system can change traffic control patterns each cycle length. Further, adaptation to traffic patterns for time of day, traffic responsive, and traffic adaptive modes can occur at each intersection through the use of traffic actuated control.

There are also some functional differences in the concepts of traffic responsive and traffic adaptive control. Traffic responsive systems have the flexibility of activating patterns based on either maximum band width (e.g., UTCS, Eagle Monarch, BI-Trans) or minimum delay whereas a traffic adaptive system operates on either a minimum delay (e.g., SCOOT, OPAC) or fractional peak period progression band (e.g., SCATS). Also, traffic responsive operation permits changes in left turn sequence (dual left, lead lag) to further improve the progression band width. These differences can be important when deciding whether optimum delay or maximum band width is the most important criteria in system or subsystem operations.

The extent to which traffic control needs to respond to changes in traffic patterns depends on the:

- number of significant changes in traffic patterns during a week;
- relationship between intersection capacity and traffic demand; and,
- predictability of traffic pattern change.

When traffic pattern changes are predictable and do not change very often, pretimed system control is satisfactory. When traffic pattern changes are not predictable and/or change often, either traffic responsive or traffic adaptive control can provide the best traffic control. Depending on the number of detectors in the system, traffic adaptive should provide a better operation during periods of saturated traffic flow (V/C >1.0). With the use of traffic actuated control, however, the difference in improvement between traffic responsive and traffic adaptive control may be quite small during periods of saturated traffic flow.

Traffic Responsive Operation

Most of the more recent traffic responsive systems store traffic control patterns (turning phases or components when tied together by the computer forming traffci conrol patterns) in the intersection controller and the central controller. Where an on-the street master controller is provided, it also stores the timing pattern. New timing plans developed at the central computer are downloaded to the intersection controller. System detector information is usually gathered by intersection controllers and periodically (e.g., 10 seconds to one minute) sent to the master and/or central computer. Major forms of traffic responsive systems include:

- Computran Modern Traffic Control System (MTCS)
- PB - Farradyne Management Information Systems for Traffic (MIST);
- JHK Series 2000;
- B1 - Trans;
- Sonex Escort; and,
- Kessmann, and Associates /State of Nevada System, and New York State Systems.

System detector data is sent directly to the central computer on a second by second basis in one or more of these systems. There are some differences between the commercial systems, but the operation of these systems has been found to provide successful operation. All these systems can provide the following:

- Subsystems control - different signal timing for different subsystems.
- Critical Intersections Control (CIC) which permits a saturated intersection to assign splits based on traffic demand.
- Development of traffic patterns on an off line basis in the 1.5 generation mode.

The 1.5 generation systems permit the development of traffic patterns using the TRANSYT-7F model and should be able to do so (with modification) using the PASSER II, III and IV models. The selection of the model to use is dependent on whether maximum band width or optimum delay is preferred for a given set of conditions within a subsystem during a given period of the day. If a new traffic pattern is selected, it can be downloaded into the computer. The traffic signal system in Los Angeles is a 1.5 generation traffic control system.

Traffic Adaptive Operation

There are presently two types of traffic adaptive traffic signal systems in operation within the United States - SCOOT(2, 3, 4) and SCATS(5, 6) .

SCOOT - Detection data is transmitted to the central computer on a second by second basis. Signal timing is calculated at the central computers and downloaded to the local controller as each phase changes. SCOOT uses a derivative of the TRANSYT computer model. Although TRANSYT can be based on designated factors and provides for progression on selected streets, it is generally used in determining optimum delay signal timing.

SCOOT permits increases and decreases in cycle lengths in small increments each cycle. By placing or utilizing existing detectors far enough upstream of a subsystem on selected streets, it is feasible to "predict" future traffic control patterns and implement them more rapidly.

SCATS - As with SCOOT, SCATS increases cycle lengths and splits more rapidly than with traffic responsive systems. It utilizes a preferential progression design providing optimum affect during high volume periods and two-way progression during lower volume periods. As with other systems, the cycle length is determined at the master or central computer. Split adjustments are made at the local intersection.

Others - The Federal Highway Administration (FHWA) is currently analyzing three new type systems under its Real Time Traffic Adaptive Control Systems (RT TRACS) master project. These systems, which are traffic adaptive, are not ready for implementation at this time but will be in the future.

Another system is being developed in France. Known as PRODYN[8], the system provides for two-way communications between intersection controllers as well as two way communications between the central computer and each intersection controller. This type of system has not been considered for the City of Austin because of its complexity and cost of communications.

Analysis - There are intersections in Austin which operate well at present under pretimed control and intersections that could benefit from traffic responsive operation during portions of the day. Frontage roads and freeway corridor streets fit into this category as do high volume streets. (e.g., US 183, Lamar Blvd., US 290, William Cannon Blvd.). As traffic increases, traffic patterns may increase on certain streets so that progression breaks down and afternoon delay becomes the primary design factor. Traffic adaptive control would be suited to a location where the signalized intersection is expected to function an as interchange (e.g. intersections along South Lamar, FM 2222, North Lamar/Burnet Road Corridor, and US 183 north and south).

There are options to traffic adaptive control. These include the use of Critical Intersection Control (CIC) as is being done in Los Angeles and holding back traffic upstream of the point of saturation as is being done on Manhattan Island. Also, timing plans using PASSER models could be developed using the 1.5 generation for off peak periods and TRANSYT for saturated traffic conditions. The latter will not be as efficient as the traffic adaptive approach (assuming both system operates in a fine-tuned manner) because it will not have the "prediction" approach or cycle by cycle change.

The operational concept recommended by the WSA team provides the optimum operation for each subsystem for the next 15 year period. However, there are options which could be selected as a result of the system design study. These include, but may not be limited to,

(1) Pretimed plus 1.0 generation system;
(2) Pretimed plus 1.0 and 1.5 generation system; and,

(3) Pretimed plus 1.0 and 1.5 generation plus Traffic Adaptive (SCOOT, SCATS, RTTRACS) now or in the future.

It may be desirable to install pretimed plans 1.0 generation software now with the ability to add the other two options in the future as traffic develops. Or it might be desirable to choose the second option (up to 1.5 generation) now with the option to add traffic adaptive control in one or more subsystems in the future. If initial installation with future expansion is desired, the step from UTCS 1.5 generation to traffic adaptive would not be as great as the step from UTCS 1.0 generation to traffic adaptive.

A cost estimate for increasing costs of each addition to the system is given in **Table II-3** along with the reason for the added costs. If the city decides not to install traffic adaptive control at first, it is recommended that a UTCS 1.5 based system be installed with the capability of adding traffic adaptive control in the future.

Recommended Traffic Signal System Premises

The traffic signal system recommended for the City of Austin is based around the following premises gained from carefully reviewing comments received from both the City of Austin and TxDOT regarding the existing systems and the prescribed Scope of Work:

1) Be enduring. The Austin Area desires an ITS System that would have a lifespan of at least 10 to 20 years.

2) Be easily expandable. The desired system would provide for ease of additions, deletions, and expansion.

3) Be reliable and easily maintained. The desired system would maximize reliability and fail safe operations. In the event of a failure, traffic operation's performance should not be severely compromised.

4) Be flexible. The desired system would provide all functionalities present in the existing systems yet be capable of adapting to changing short and long term patterns and needs easily.

Table II - 3

Cost Comparison of Control Methods
Austin Area-Wide ITS
Austin, Texas

Type of Control	Cost per Intersection	Components*
1.0 Generator Control	$50,000	Hardware & software for 1.0 generation operation plus average of two system detectors per intersection
1.5 Generation Control**	$65,000	Add to 1.0 generation operation an average of seven detectors per intersection and new turning movement count detectors.***

* All systems shown include fiber optics, 2070 ATC Controllers, and CCTV.
** Expansible to Adaptive Traffic Control in selected subsystems in future (under future contract).
*** Left turn phase detectors should be of the traffic counting type.

5) Be easily operated. The desired system would improve traffic operations and flows. The system would make the traffic flow more efficiently, would reduce congestion and delays, decrease fuel consumptions and emissions, and reduce accidents.

6) Be self-monitoring. The desired system would provide the ability of the system to monitor itself and report on system performance.

7) Be implemented at minimal life cycle costs with minimal negative impacts or disruptions. The desired system would be capable of being implemented with minimal negative impacts related to the deployment of new hardware, software or control algorithms while utilizing as much as the existing equipment or communications structure as possible to reduce costs. This would require making maximum use of existing communications system; minimizing traffic flow disruptions during changeover or deployment; making maximum use of existing staff knowledge and skills.

8) Be easily accessible. The desired system would provide the traffic engineer with easy access to the remote controllers from a central or lap-link location.

9) Be easily monitored and controlled. The desired system would provide the traffic engineer with the capability to quickly and easily monitor the system operational status and be capable of doing this from remote locations as well as the TMC. This status includes controllers failed, controllers in flash, controllers in pre-empt, in fully traffic actuated operation, or coordinated operation.

To this end, it is our professional opinion based upon evaluating, designing and deploying computerized Traffic Signal Systems throughout the U.S. and around the World for over 25 years that such a system must adhere to the following **system objectives**:

1) Open Systems/Open Architecture
2) 1.0/1.5 Generation Control

The system shall be designed on Open System Interconnection (OSI) and Open Software Foundation (OSF) standards to insure compatibility, inter-compatibility, and portability of system components and software. The software shall be in the public domain and be easily portable to different computers. All interfaces between components shall be of Electrical Industry Standard (EIS) design. All communication protocols shall be public domain to insure compatibility.

Open Systems Interconnection (OSI) is a standard coordinated by the International Standards Organization to put an end to problems of multi-vendor networking.

Open Software Foundation (OSF) is a non-profit, industry-supported research and development organization founded in 1988. OSF functions as an integrator and implementer of technologies, building on existing standards and specifications, and helping in the definition of new standards where none currently exist. More than 130 organizations are members of OSF.

Traffic Signal Pre-emption

There are several methodologies available for pre-emption of signals. Two of the most prominent methods are hard pre-emption and soft pre-emption. Under the hard pre-emption scenario, the signal coordination is immediately disrupted to service the pre-empt phase when the pre-empt signal is received. Under the soft pre-emption scenario, the signal continues its normal phase sequencing. However, the pre-empted phase may be either advanced or extended depending upon when the pre-empt signal is received during the controller sequence.

Hard pre-emption is very disruptive to the coordinated flow of traffic in a grid network. However, this method gives the pre-empting vehicle the immediate right of way. Hard pre-emption is utilized for fire, police, and emergency vehicles.

Soft pre-emption is less disruptive to the coordinated flow of traffic. However, the pre-empting vehicle may have to be delayed before the pre-empted phase becomes active. Soft pre-emption has been utilized for transit vehicles.

would allow the traffic engineer to define when and how in the signal cycle to allow a pre-emption to occur. Consideration should be given to providing far-side or mid-block bus stops if soft pre-emption is utilized.

Soft-premption allows a transit vehicle to have a higher probability of receiving a green light at an intersection. Without progression, a transit vehicle might have a 50-50 chance of arriving at an intersection on red. With progression the probability might rise to 70% of arriving on green. With progression soft pre-emption the probability of a bus passing through the intersection might rise 90% or higher. There will be some delay or disruption to vehicle flow on the side streets with preemption. Overall person flow should be increased if the buses are traveling on the major approach. However, consideration in assessing the effectiveness of soft pre-emption should be given to vehicle -delay, person-delay, fuel consumption, and emissions before finalizing an overall pre-emption strategy.

Recommended Facilities

The City of Austin should continue to utilize the facility at Toomey Road as an interim Traffic Control Center. The facility allows adequate room for the recommended system and space for supporting personnel. This facility should be utilized until funds are available for a Traffic Management Center (TMC) that would house additional Traffic Management participants.

Consolidation of the City of Austin Transportation Division operations into one facility should also be provided for in conjunction with TxDOT. The current separation of the City of Austin transportation operations into two separate facilities (One Texas Center and Toomey Road) prevents direct communication and access to needed data. Engineers working on traffic control plans or roadway designs should have direct access and communications with traffic signal timing plans, signal technicians, and available traffic signal operations data. It would be good for them to work together in the development of traffic signal plans and the mitigation of recurring and non-recurring congestion.

Recommended Equipment and Cost

Equipment needs for operating the recommended traffic signal system should include utilization of existing equipment as much as possible. Equipment needs include traffic signal controllers, controller cabinets, vehicle detectors, system hardware, system software, and communications.

Cost of Facilities - The facility cost estimate is based on estimates obtained from the Los Angeles Automated Traffic Surveillance and Control system. The estimated cost is $39,000,000 for 600 intersections or $65,000 per intersection. This includes the cost of computer hardware and software, intersection controller with software, detectors, CCTV and fiber optics communications cable and connections with the FTM and GAATN cable systems. No major upgrades to the intersection are included in these costs. Major upgrades include improving geometrics, replacing most arms and signal heads, adding pedestrian signal heads and push buttons, improving and/or adding wheelchair ramps. The estimated costs for adding a controller and cabinet ($12,000 and eight loop detectors ($8,000) is $20,000). It is estimated that CCTV cameras would be located at major intersections with the ability to install additional CCTV cameras at the remaining signalized intersections. Costs for facilities, maintenance, and operation of the system are summarized later in this chapter.

Traffic Signal Controllers - The City of Austin should continue to utilize intersection Traffic Signal Controllers that are based around complete interchangeability of all Type 170 modules such as NTCIP. Open systems, open architecture, industry standards, non-proprietary protocols are a must. Future controllers should have additional capabilities not available in the Type 170 in order to perform the operations desired by the City of Austin's Transportation Division which should have faster processors and additional memory (see attached **Table II-4**). The future controllers should be one of the following types:

- The Model 170 or,
- 170/Add in Board (170/AIB); or,
- The 2070 ATC (Advanced Transportation Controller).

The City of Austin should begin to evaluate Traffic Signal Controller software and hardware requirements for the 2070, 170/AIB, and the Model 170 controllers which would best serve the City's needs. This evaluation should include future possible ITS requirements (CMS, LCS, Lane Designation Signs). All controller software and communications protocol should be non-proprietary. All modules should be programmed in the C programming language to the maximum extent possible. The software should offer all the functions currently present in Wapiti W4IKS. The local controller software should also have the capability to adjust the timing split, phasing, phase sequence changes, and reassign lanes based on demand, offer traffic responsive capabilities, satisfy existing operational needs (Force Offs/Left Turn), and be user friendly without the need to handle specialized intersections through a separate "command box". The software should also offer more than 8 phases with overlaps.

The City of Austin is interested in the 170/AIB controller as compared with the 2070. The City is considering utilizing Opticom preemption with 170/AIB controller module. If the City desires to

Table II - 4
Comparison of Traffic Signal Controllers
Austin Area-Wide ITS
Austin, Texas

Category	170	170/AIB	2070
Processor:	Motorola 6802	Motorola/Intel 68000/ 80C186	Motorola 68030
Processor Speed:	765 Khz	16 bit/32bit 16 Mhz 18 bit/12.5 Mhz	32 bit/25 Mhz
RAM:	16K	32 K/256 KSRAM	32K/256 KSRAM
ROM:	512K	512K	2 Mb
Modem Capability:	1200 band	19.2 baud	19.2 baud
Potential Signal Phases	8 phases	32 phases	32 phases

use the 170/AIB, the software provided should work with the board as well as with the 2070. The three major addin board suppliers which provide 170/AIB are Safetran, Matrix, and Eagle Signal. The following is a general comparison of 170/AIB.

170/AIB

The 170/AIB have the following features:

1. Output ports are provided which can operate at different baud rates or the same baud rate if desired.

2. Up to two hardware units (e.g. preemption devices, detector devices, environmental monitoring) are applied to each port provided the two devices (hardware units) operate at the same band rate and use the same protocol. As as alternate, up to 14 detectors can be tied to one port (sec. detector work stations) or four video ringing cameras operating throught a video usage process.

3. Output port can be used to carry out diagnostics of the conflict monitor.

4. Up to 56 local controllers can be communicated with per distributed master 170/AIB master controller. Also the central computers can monitor the operation of each controller through each master controller.

5. As a minimum the video imaging function using one port can achieve one still image picture or in 30 seconds or four still image pictures (one for each of four approaches) in two minutes.

6. The 170/AIB output ports connect to separate hardware units for different functions (e.g. preemption, detector, environmental monitoring) and as such serves an interface between the hardware units and the TMC with information to and/or from each hardware unit and the TMC processed at the same board note (e.g. up to 115 k band).

7. The 170/AIB have either faster Motorola or INTEL chips (16 Mhz 16/32 bit).

8. The modem rates are faster (19,200 baud).

9. More RAM and ROM and capability of handling greater than 8 phases.

The cost of a 170/AIB module varies from $700 to $2,000 depending on complexity of the operation. In addition a 170 base unit (dispatcher) which operates the intersection costs $900. This totals to $1,600 to $2,900 per 170/AIB in a new 170 dispatcher unit.

2070

The 2070 has the following features:

1. It has the capability through four traffic signal control related modules (non VME card slots and four to eight (or more) serial ports per VME slot for each of four VME card slots to handle 16 or more internal hardware unit functions. One supplier presently has a VME card that has four serial ports per VME slot in the back of the unit and could make one that would provide input with eight or more serial ports per slot. The diagnostics for the conflict monitor is part of the four modules and not part of the VME bus cards.

   An example involves the controller unit for a chargeable message sign (CMS). The control functions for the CMS would be on one VME card and communications with the CMS would be through one of four (or eight) serial ports from one VME board. The separate CMS controller would not be needed in the field.

2. The control functions could either be internal (as with the CMS control noted above) an external as with the 470 AIB. An internal Video Imaging hardware unit is being developed at present which will fit into the 2070 and will take two of four VME card slots. This is because all of the video imaging processing is being done by the VME cards. If an external hardware unit is used for the video imagin processor (e.g. Autoscope control unit), only one of four (or eight or more) serial ports for that VME card would be used for communications between the external video imaging processor and the 2070. Where the video imaging processor is internal as now being designed, there would still be four (or eight or more) serial ports for each of the other two cards. Assuming a total of eight serial ports (four for each VME card where the other two VME slots are used for the internal imaging hardware), they could provide internal hardware/software for:

   (1) CCTV video control
   (2) HAR control
   (3) CMS control
   (4) Roadside to vehicle communications
   (5) CCTV image processing to the TMC
   (6) Environmental Monitoring
   (7) Spare for future ITS operation
   (8) Spare for future ITS operation

3. Each control unit output on a VME card can operate at a different baud rate from the other control units.

4. The cost of a 2070 is between $3,500 and $5,000 at present depending on quantity. The 2070 can also provide video pictures to the TMC at a T1 based rate compared with the 470 AIB 115 K based rate. The use of T1 boud rate can provide for foster CCTV image transmission.

<u>Comparison</u>

1. The 2070 could at present provide internal control for 16 control units (up to 32 if eight processors and serial ports are provided per VME card) as compared to three to maximum six control unit functions (as discussed above). The 170/AIB controller would still need external hardware for each of the three to six hardware units.

2. The internal software (operating software) for the 170/AIB would be propietary and could limit competition. But then only limited companies make the 2070 at present.

3. Depending on complexity (number of functions), the 170/AIB could cost $2,900 on a small order basis compared with $5000 for the 2070.

4. Both the 170/AIB and the 2070 utilize NTCIP communications protocol. The 2070 is preferred for its flexibility and low maintenance cost (one 2070 with all control unit provided internally should provide a lower maintenance cost than a 170/AIB and all of its external hardware). Also, a 2070 will permit many more ITS functions to be carried out which could be important over the 10 year life of the controller.

   If the need for many ITS functions (more than two from a practical standpoint) is not warranted at selected locations, then the 170/AIB might be the best for selected locations. The added cost of $2100 per intersection for a 2070 might also be a factor. If so, it might be possible to provide 170/AIB controllers at some intersections and 2070 at others with software that could permit a 2070 to be provided at an intersection with a 170/AIB at a later date if this is found to be needed. If it is determined to use T1 communications with fiber optics, this will not be possible since the 170/AIB communicates at 115 K.

The recommended system should consist of a local intersection controller that follows the philosophy of the Type 170/179. Specifically, this philosophy consists of providing a public domain and standard specification which can be met by many suppliers. Controllers that are in this category are the Model 170/179, the Type 170/AIB (add in boards) and 2070/ATC. There are several types of AIB's and they would allow the City of Austin to retain their existing Type 170s as these products are merely board enhancements to the Type 170. This would allow for cost savings by not having to purchase new controllers. However, the availability of non-proprietary, public domain software that offers all the functions requested by the City of Austin's staff for these controllers is unknown. The 2070/ATC provides all the benefits of being an Open Systems/Open Architecture Local Controller and there is non-proprietary, public domain software currently under development for this device that meets all the requirements put forward by both the City of Austin Traffic Signal staff and TxDOT and incoporates 1.0/1.5 Generation Control Algorithm. A

System Design specification for the Local Controller hardware and software needs to be prepared and bids taken to determine which package to utilize.

Controller Cabinets - The existing traffic signal controller cabinets are generally large enough to accommodate both traffic signal controllers (Type 170 or 2070), so cabinet replacement would probably not be required. However, for intersections where numerous vehicle detectors, ITS components, or CCTV cameras are in operation, a larger cabinet would be required. The existing cabinets provide for up to 16 load switches, which should be sufficient for average intersections, but would be inadequate for intersections with CCTV or ITS capabilities.

Vehicle Detectors - The City of Austin should evaluate several different detector technologies for use throughout the signal system. Queue length detection at intersections should be included in the analysis. Methods to be considered include inductive loops, video image processing, microwave detectors, and infrared detectors. New technologies for detection could be applied initially in the form of demonstration projects. An example could be a 2070 with internal video image processing. The 2070 with detection could be installed as an actual controller at complex high volume intersections and freeway diamond interchanges. Inductive loop detectors should be used for much of the local intersection detection. Where the results of the demonstration projects of newer detection technologies show favorable, these technologies should replace inductive loops.

Traffic Flow Surveillance - Timing plan evaluation will also include monitoring variations in traffic flow and comparing these variations to archived data. These data are continuously compared to track changes in traffic flow patterns. When predetermined thresholds are reached the new timing plans are implemented which will better accommodate the observed traffic flow patterns. These thresholds are operator selectable.

It would be desirable for all system detection locations to be sufficient for supporting 1.0 generation and 1.5 generation control modes and real-time traffic-adaptive control mode requirements. Where it is not possible to provide for traffic flow surveillance in all subsystems at first, the system should be designed for this capability in some subsystems initially with expansion capabilities for the eventual application to all subsystems. Traffic data derived from the traffic flow surveillance system will be stored and used in several ways: for transportation planning, traveler information, commercial vehicle information, transit system management, public safety agency information, and for timing plan development and evaluation. For transportation planning, raw data would be used to develop traffic count files and for supporting transportation programming decisions. For timing plan development and evaluation, local intersection detector data would be fed into an algorithm which will be used to estimate turning movement volumes at the local intersection. The turning movement volumes would be automatically dumped into a traffic signal timing optimization model for continuous evaluation. The model would continuously evaluate the operation of the actual timing plans in the field. Potential improvements to timing plans would be identified for the operator to evaluate. The general traffic flow/operation information could be shared interested agencies (public and private).

Equipment and Maintenance Database - All traffic signal equipment should be inventoried and assigned a unique bar code that can be scanned by a portable bar code reader to access the maintenance database. Upon accessing the maintenance database, an operator would have a complete historic record of all prior maintenance involving this piece of equipment. Included in these records would be maintenance and operations-related performance measures such as mean time before failure and mean time to repair data.

The display modes would include A-Phase Green status, failure status, critical intersection control status, and threshold (volumes, speed, occupancy) status. In conjunction with the video surveillance capabilities, an operator will have the ability to observe a group of intersections under failure status mode and at the same time actually observe the traffic conditions by watching the CCTV picture returns.

Each workstation should be capable of generating its own custom reports. Standard reports to be generated include failure status, maintenance status, and volume summary.

Intersection Monitoring and Failure Diagnostics - The system should have the capability of monitoring any or all intersections on a once per second basis. It should also have time slicing capabilities to allow once per second polling in addition to simultaneous timing plan download/upload capabilities. The system should have capability of monitoring the failure status of each intersection on a 30 second basis. If a failure is detected, an alarm will be sent to the Traffic Control Center. Appropriate failure diagnostics would be in effect to allow the operator to fully understand the degree of failure.

Soft failures would be self-corrected and logged to the central computer system. Surveillance data would be uploaded to the Traffic Control Center every five minutes if so desired. The communications system should be capable of supporting a worst case scenario of once per second intersection monitoring occurring at the same time as uploading traffic count data, uploading a signal timing plan for verification, and conducting failure status poll.

Central Hardware - The City of Austin should continue on their present course of implementing a distributed central computer system of networked PC workstations. The computer system should consist of a dedicated server that is a Pentium-type PC with multiple processors. Workstations of the Pentium-type PC type with a minimum of 21" monitors should be available to transmit the data to the Local Controllers plus monitoring and controlling all intersections on the system. Linkage to the local intersections should be over a LAN with bridger and routers. This approach should employ open system requirements so that future computer resources may be easily added as the need may arise. Open system standards provide for the following options:

- choice of the best hardware product from multiple vendors;
- integration of hardware from diverse manufacturers regardless of the underlying technology;
- distribution of processing power to improve individual and organizational productivity; and,
- preservation of investment in applications software.

With this approach, additional users should be able to be added to the system via the network even if they do not reside in the same facility. Having proper authorized access, any of the workstations on the network should be capable of using all the resources of the system. Security should be provided to prevent unauthorized access.

Control Displays and Reports - Each system workstation should have a large monitor (minimum of 21"), with an additional 72" monitor provided in the Control Center. Each display would have the capability to display an entire system or operator definable sections in color. The displays would be capable of viewing different locations or different system functions, including video surveillance pictures, at the same time.

Software - The City of Austin should implement a distributed Windows NT Central computer system that is a multi-user, client-server, networked environment using PC workstations. The central computer software should offer all the capabilities mentioned above under Existing Software. This software should be non-proprietary and not tied to any computer hardware vendors' equipment. All applications should be programmed in the C++ programming language to the maximum extent possible and should be comprised of preexisting off-the-shelf modules. The 1.0/1.5 General Control type software is a proven software that has been utilized by many agencies. This type of software is provided by several vendors. It provides flexibility in the traffic signal operations by allowing the operation of the system in a fixed time mode. The local or system master to select an operation pattern based on threshollds, or the conintual recalculation of timing patterns based upon detector inpts. At a later date portions of the system could be upgraded to a traffic responsive/adaptive system at a later time. Our recommendations are that the system consist of a Central System of PCs running Windows NT Operating System and non-proprietary Public Domain Traffic Control software programmed in C++. Alternative Central Systems would not meet the above premises or system objectives. There are such packages currently available or under development that meet the recommended system (i.e. Las Vegas Area Computer Traffic System). Possibly the supplier of the City of Austin's existing Central System would be willing to make the modifications and additions needed to that package to incorporate the functions that are presently non-existent plus provide the City of Austin with source code, if they have not already done this, so that the City's own staff or selected provider could maintain/enhance/modify the package in the future. A System Design specification for the Central System needs to be prepared and bids taken to determine what software package to utilize.

The system should employ software components that are non-proprietary, none-copywritten, Public Domain to the maximum extent. The source code should be written in a language which is industry standard and portable to machines of differing makes and models. Source code should be provided in Austin. This approach provides for the future modification/enhancement and maintenance of all software by the City of Austin/TxDOT personnel or their selected provider and ensures future life of the software. It also provides the benefits of being able to extend this software to additional platforms without having to pay additional royalties. All software should be written in C++ or C language so that the software may be ported to future platforms.

The system should employ a control strategy that provides for the capability to generate traffic signal timing plans on-line, and in real-time in an operator-selectable, higher-generation control mode. The control logic (software) for this mode should be developed and implemented to accommodate current and projected traffic flow data. The system should also provide for a 1.5 Generation mode in which automatically generated timing plans are retrievable for analysis and fine tuning by the operator. In addition to the above modes, the system should provide for Manual and Time-of-Day Modes.

The software should include continuously updated color coded maps and have the capability to display the network in different colors based on congestion on a once-per-second basis. The capability to monitor multiple intersections simultaneously is a must. More data (intersection operation, phasing, detector actuations, and signal indicators) than just A-Phase Green should be provided on multiple intersection displays. The ability to evaluate operations based on real-time speeds, travel times, queue lengths and to estimate and obtain MOEs whenever needed is also an important part of the system.

Through the use of 1.0 and 1.5 generation traffic control and traffic adaptive control, the system should be able to identify incidents and offer alternative routes, have the ability to control cameras and signs plus integrate flashers (school) and signal control, and be capable of automatically diagnosing hardware failures, (i.e. notification of loop failure, signal on flash, etc.) and why the failure occurred. The central computer should also be able to interface with Local Controller software other than W4IKS, since W4IKS does not meet all of the future traffic signals operation requirements. Additionally, there should be sharing of the available system data with other agencies as discussed in the Freeway Traffic Management Section.

Emergency/non-emergency pre-emption should be provided and the goal should be that some coordination be maintained during pre-emption or the system be brought back online as soon as possible in order to minimize the impact on traffic. The system should be capable of distinguishing between emergency and non-emergency preemption and identifying time, agency, and impact of each preemption. Software currently existes that provide these functions.

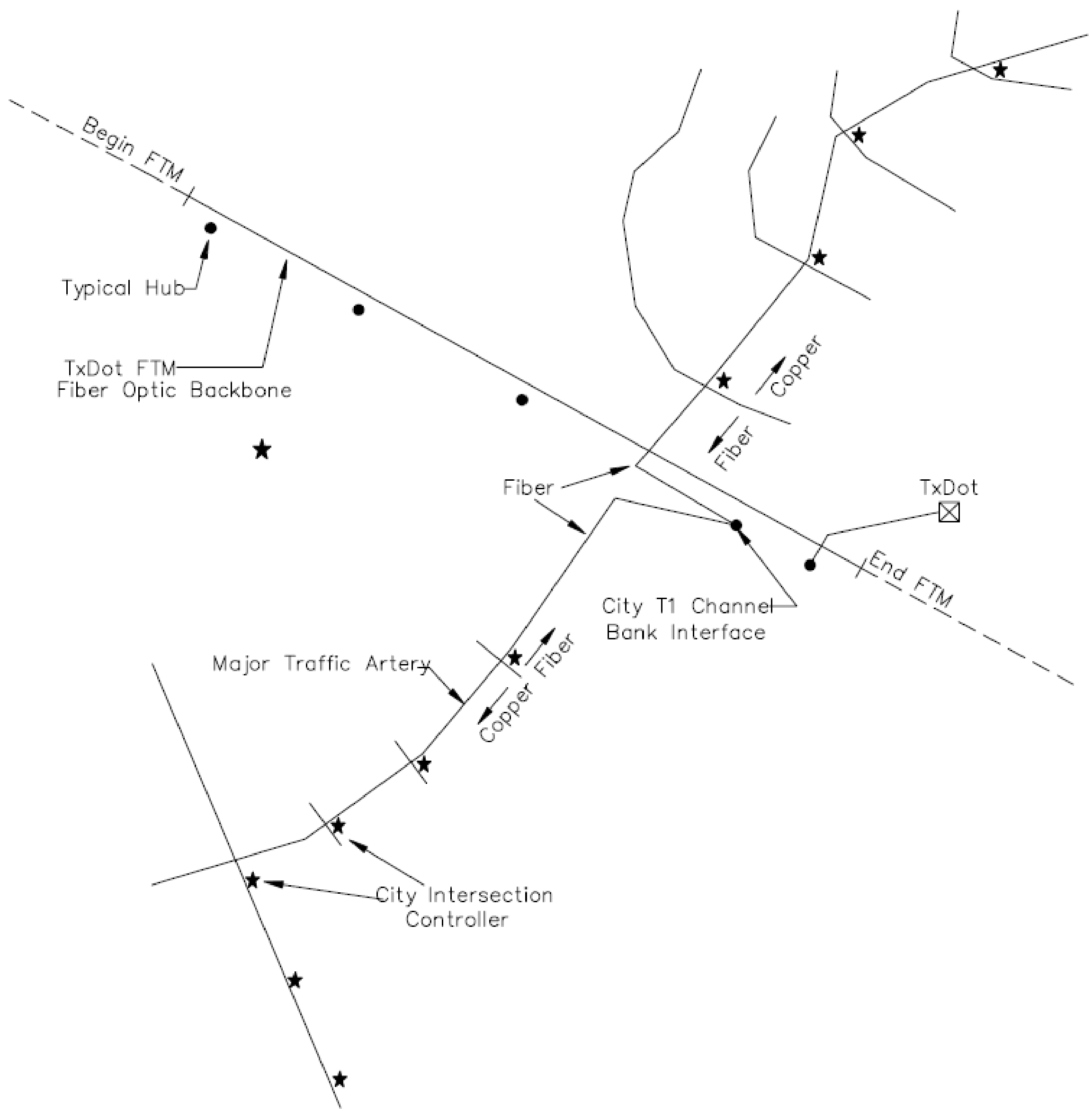
Recommended Communications System

The currently recommended communications system for the Austin area is threefold that will include the Freeway Traffic Management System (FTM), Greater Austin Area Telecommunications Network (GAATN), and temporary Cellular phone systems. However, the Austin Area should carefully monitor the experiences of METRO in Houston Areas. METRO is considering utilizing private companies to provide the communication system for Houston Area traffic signal systems. A local telephone system made an unsolicited offer to provide communication to 2800 signals and maintain and operate the system for 20 years for $35 million. METRO is in the process of requesting a cost proposal from 3 communication companies. The companies werepreviously selected based upon technical and qualification proposals. The companies include a local telephone company, a cable TV group, and a local communication integrator/provider. If the Austin Area had a similar process, the communication costs might be less than $10 million for all freeway and arterial communiction systems.

FTM System - The FTM system fiber optics communications backbone infrastructure can be used as a temporary or permanent communications system as the FTM is being implemented throughout the major corridors in Austin. **Figure II-6**, Typical FTM System Communications Interface, illustrates how
TxDOT's FTM and High Occupancy Vehicle (HOV) lane system Fiber Optics Backbone System can effectively provide the communications infrastructure needed to control the major arterials off the main lanes of the freeway, for all data, voice, and video communications. A T1 carrier system is recommended due to the fact that this technology provides:

- standardization;
- commonality;
- maintainability; and,
- portability.

The cost of the communications system is resident only to the major arterial crossing an operation FTM system. Where the major T1 carrier interface the major city street, the FTM communications backbone would require 2 fibers for all data, voice and video controls.



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Typical FTM System
Communications Interface
Austin Area-Wide IVHS
Austin, Texas

Figure
II-6

An additional 2 fibers would be required for video transmission back to Central. The approximate costs of the interface are as follows:

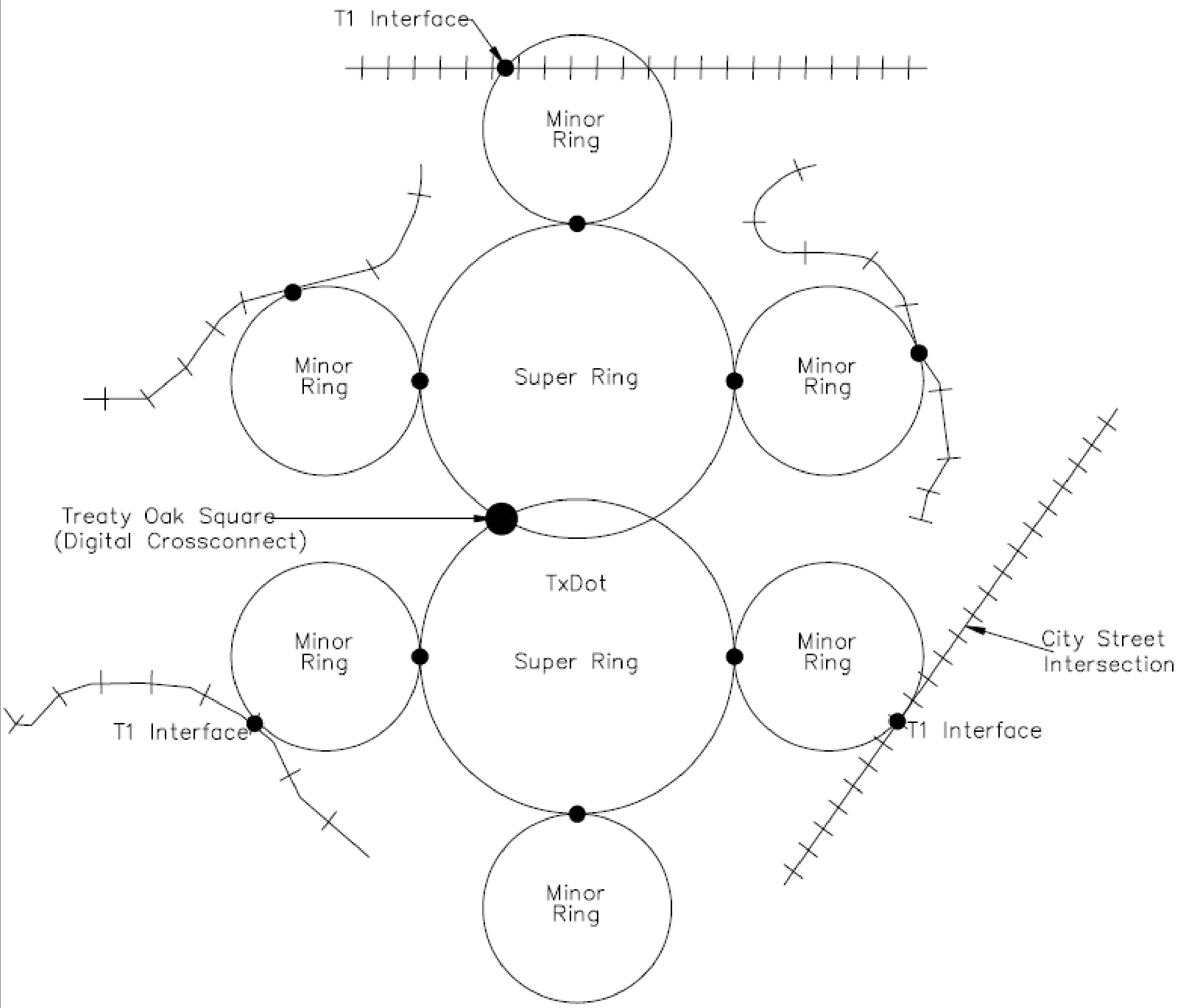
T1 channel bank$	12,500	
T1 transceiver	1,300	
Mis. Fiber optics	2,400	
Interface cabinet	0(None Required)	
Average Fiber Optics	30,000	(Run = 3,000 ft.)
Limited distance Modem	2,500	
TOTAL	**$ 48,700**	

Approximately 25 to 30 traffic signal intersections can be interfaced adequately to one T1 channel bank DSO. The capability of such an interface in a star configuration can yield upwards to **400 intersections or more** per T1 channel.

GAATN System - The GAATN system offers a wide geographical area potential for controlling the City intersection controller systems. Since the GAATN network consists of six minor rings and two super rings over a large span of the City of Austin, as illustrated by **Figure II-7**, the minor ring network system lends itself by providing DS3 access to most any portion of the Austin area. This access is commonly partitioned in bandwidth to accommodate several T1 carriers over 2 fibers in the entire City.

Figure II-7 illustrates how the T1 interface, which can bring in upwards of 400 intersections per T1 channel bank can be distributed throughout the minor ring infrastructure. At this time for a 600 intersection deployment plan, no more than 10% of the bandwidth of a DS3 channel will be occupied. That is to say, that for the Austin area, it is possible to control all of the city intersections with a bandwidth of less than 4.5 MHZ (i.e. less than 3 T1 carrier channels for the entire City of Austin). A further discussion of bandwidth is included in the Transportation Management Center section.

A digital cross connect at the Treaty Oak Square is recommended to ensure that the data streams of the Minor T1 rings are switched properly from the super rings to the Traffic Management Center and/or City Traffic Signal System facility at different parts of the City.



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GAATN Telecommunications System

Austin Area-Wide IVHS
Austin, Texas

Figure II-7

The estimated cost of this deployment of the T1 interfaces and digital crossconnect is as follows:

Minor ring T1 Interface	
T1 Channel Bank Chassis and Electronics	$ 12,500
T1 Line interface unit	1,800
Limited distance modems	2,500
DS3 subrate T1 gear	8,500
Each T1 interface total:	$ 25,300
Treat Oak Square	
Digital Crossconnect System	$ 58,000
Network set up	8,000
Treaty Oak Square total: (One Time Cost)	$ 66,000

Cellular Telephone/Telephone Line Drops - A cellular telephone system offers a unique advantage during construction phases of the city streets in that control of the intersection system can be accomplished in even the most remote areas where a telephone line drop, FTM or minor rings of the GAATN are not available. This approach can be done on an interim basis during the construction and can be done on demand. This is to say that the cost factor is on the minutes used on the air during communication. The typical bandwidth of this channel is 2400, 9600 or 14,400 (compressed) Baud. A maximum of 25 to 30 intersections can be adequately handled using one interface of this type.

The cost of each interface that will interface 25 controllers is as follows:

Cellular Phone	$ 200	
Digital interface	650	
Modem	350	
Monthly bill	$ 150	(per month per interface)

Maintenance Requirements of Recommended System

Maintenance activities will need to be restructured once the recommended traffic signal system is complete. Current maintenance activities can largely be categorized as response maintenance activities, meaning that traffic signal system components are not maintained until they are not functioning as designed. Maintenance activities of the new traffic signal system should be preventive maintenance, meaning that traffic signal system components are maintained on a regular interval. Preventive maintenance and response maintenance activities are described in the following sections.

Preventive Maintenance - Routine preventive maintenance is an important element in an effective risk management program. If a defect in traffic signal control equipment has existed for an unreasonable period of time, the City should have discovered the defect and is therefore assumed to have received constructive notice of its existence. Faulty traffic control system equipment causes increased motorist costs, increased maintenance, increased liability, and poor air quality. Preventive maintenance programs help to eliminate many equipment failures and reduce the consequences.

Preventive maintenance typically requires the largest committment of maintenance personnel time, with approximately 75% time allocation to preventive maintenance and 25% to other maintenance. **Table II -5** identifies estimated time requirements for recommended typical preventive maintenance items. Each of these time estimates was developed assuming equipment is identified and labeled and maintenance manuals and wiring diagrams are available.

Response Maintenance - Response maintenance is the inital response to any reported traffic signal system malfunction. Response maintenance activities typically have five steps:

- Receive notification from public;
- Secure the site;
- Diagnose the problem;
- Perform interim repairs; and,
- Document the activity;

Activity documentation should include the date and time of initial report, location and description of the problem, date and time of response acttivity, and idetnification of personnel completing the maintenance. Response maintenance activities can vary greatly because they are dependent upon characteristics of the signal equipment and unpredictable occurances. Responses maintenance activities are unavoidable, but can be kept at a reasonable level by a regular preventative maintenance schedule. Response maintenance activites require an average of approximately 20% to 25% of maintenance personnel time allocation.

Table II-5

Summary Preventive Maintenance Time Estimates
Austin Area-Wide ITS
Austin, Texas

	Maintenance Interval and Time *			
	Months		Years	
Item	**3**	**6**	**12**	**2 to 5**
Cabinet (per unit)	--	7	19	3 hr.
Signal Heads (per unit)	--	27	12	1 hr.
Nighttime Check (per approach)	--	10	--	--
Mast Arms and Poles (per unit)	--	--	20	8 hr.
Span Wire and Poles (per unit)	--	--	25	--
Dectector				
Sensors (per approach)	2-5	--	--	--
Amplifiers (per approach)	20	--	--	--
Junction Boxes and Handholes (per unit)	--	--	10	--
Electromechanical Control Equipment (per unit)	--	--	8 hr.	--
Solid State, Analog, and Microprocessor-based Control Equipment				
General (per unit)	--	5	20	--
Conflict Monitor (per unit)	--	--	10	--
Load Switches (per unit)	--	--	5	--
Auxilliary Logic (per unit)	--	--	30	--
Relays, Flashers, Switches, and Terminal Connections (total)	--	--	25	--
Interconnect Equipment (per unit)	--	--	25	--
Miscellaneous			As Required	

* Time in minutes except as noted.

SOURCE: Traffic Signal Installation and Maintenance Manual, Institute of Transportation Engineers, 1989.

Maintenance Costs - A study conducted by the General Accounting Office indicated that the cost of operation and maintenance of advanced traffic signal systems will be approximately 7.6% of the cost of the installation. Based on their information, it is estimated that the cost of maintenance and operations will be $2,964,000 per year when complete and that the total for the 15 year design life of the system will be $33,460,000.

Personnel Requirements of Recommended System

Personnel needed to operate and maintain the recommended traffic signal control system consist primarily of the existing staff, with additions desired in a few technical areas, including communications and maintenance. The recommended system includes new communications requirements, which will require communications specialists with extensive training with fiber optics and cellular communications. Maintenance and operations staff will also need to be trained for proper operations and maintenance of the recommended traffic signal controllers. Required personnel can be categorized into the following four functional categories:

Management Staff - Management staff typically consists of the director of an agency's transportation department or divison. Much of the day to day management of traffic signal system operations and maintenance is usually performed by key members of the engineering staff. Support personnel, such as secretaries and administrative assistants, are also part of the management staff.

Engineering & Technical Staff - Both traffic signal technicians and transportation engineers are needed for successful and efficient operation of a computerized traffic signal system. The traffic signal technicians should have extensive training and knowledge in electronics, software, and operations of all equipment. The traffic signal technicians are also responsible for diagnostics and repair of signal controllers. The transportation engineers are responsible for traffic signal design, design modifications, traffic signal timing plans, and administration of traffic signal installation and maintenance. The transportation engineers should have the appropriate training (i.e. college degree(s)) and be registered professional engineers.

Operations Staff - Operations staff include system operators and software specialists. System operators are responsible for the day to day operation of the traffic signal control system. The operator can identify system problems and notify appropriate maintenance personnel. The system operators should be computer literate and capable of performing many computer-related skills. If the traffic signal control system is operated in a traffic management center, the system operator will also need to be familiar with operating other management system functions, such as changeable message signs and ramp metering.

Software specialists provide a support function to assist in maintaining the signal system software and keep it operating. Real-time signal system software is typically maintained by contract, but there is still a need for programming support within the operating agency. Software specialists may or may not work on a full-time basis, but are necessary to support the systems operators.

Maintenance Staff - Maintenance staff can be classified into three groups: Traffic signal mechanics, communications specialists, and traffic signal technicians. Traffic signal mechanics are responsible for diagnostic maintenance up to the device exchange level in the field, including maintenance of traffic signal controllers. Traffic signal mechanics should also be capable of performing routine maintenance on traffic signal installation components (i.e. signal heads, replacement of lamps, etc.) and diagnosing a failure and initiating corrective action.

Communications specialists keep the communications system running so that operations staff can communicate with the local intersections as much as possible. Communications specialists must be trained in electronics and a variety of communications systems supporting both voice and data transmissions. Communications specialists provide the critical link in making the traffic control system work, and are perhaps the most important members of the staff.

Traffic signal technicians are responsible for assisting the traffic signal engineer with troubleshooting and testing of new equipment as well as the implementation of new traffic signal timings in the field (as specified by an engineer) if communications systems fail for extended periods of time.

Cost and Funding Summary

The estimated life cycle cost for the traffic control system, as shown in **Table II-6** will be $72,460,000. This includes an initial installation cost of $39,000,000 for 600 intersections and $34,460,000 for operation and maintenance. Costs for facilities, operations, and maintenance were itemized in previous sections of this Chapter. Funds for the implemention of the traffic control system for the Austin Area should be obtained from three sources: Federal, State and local. The Federal funding would fall under ISTEA.

The various titles and programs of ISTEA include the following:

Title I - Surface Transportation - This title includes a number of programs and provisions oriented toward providing funding primarily for highway related projects. Some of the key programs within this title include the following:

- *National Highway System (NHS)* - includes funding for highway improvements on Interstate routes, a large percentage of urban and rural principal arterials, and national strategic highways;
- *Interstate Highways* - specifically allocates funds, beyond those included under NHS, for the completion and maintenance of the Interstate Highway System;
- *Surface Transportation Program (STP)* - is a block grant type program that may be used by states and local governments for any road (including NHS) that are not functionally classified as local or rural minor collectors. Each state must set aside 10 percent of STP funding for safety construction activities (i.e., hazard elimination and rail-highway crossings) and 10 percent for transportation enhancements (highway beautification, bicycle/pedestrian facilities, etc.);
- *Congestion Mitigation and Air Quality Improvement Program* - directs funds toward transportation projects in Clean Air Act (CAA) non-attainment areas for ozone and carbon monoxide. The City of Austin is currently not a non-attainment areas for both ozone and carbon monoxide; and,
- *Surface Transportation Program (STP)* - is a block grant type program that may be used by states and local governments for any road (including NHS) that are not functionally classified as local or rural minor collectors. Each state must set aside 10 percent of STP funding for safety construction activities (i.e., hazard elimination and rail-highway crossings) and 10 percent for transportation enhancements (highway beautification, bicycle/pedestrian facilities, etc.);

Table II-6
Estimated Cost of Traffic Signal System
Austin Area-Wide ITS
Austin, Texas

Installation Costs		
Traffic Control Room		
Hardware	$1,000K	
Software	2,000K	
		$ 3,000K
Intersection Control * 65K x 600 intersections		39,000K
	Subtotal	$42,000K
New Traffic Control Center Building		Minimum $2,000K
Maintenance Costs Over 15 Year Life of System	= $42,000K x .076 x 15 / 1.33 ** =	$36,000K
Total Cost =		$78,000K

* Includes new intersection controllers, detectors, fiber optic cable and connection with FTM and GAATN Cable Systems.

** Assumes installation for 600 traffic signals, requires 7.5 years and the system has a 15 year design life.

- *Congestion Mitigation and Air Quality Improvement Program* - directs funds toward transportation projects in Clean Air Act (CAA) non-attainment areas for ozone and carbon monoxide. The City of Austin is currently not a non-attainment areas for both ozone and carbon monoxide; and,

- *Special Projects* - includes federal funding for 539 Congressionally designated highway projects in 6 broad groups, including High Cost Bridges; Congestion Relief; High Priority Corridors; Rural and Urban Access; Priority Intermodal; and, Innovative Projects.

The National Highway System (NHS) and the Surface Transportation Program (STP) are two key programs included under this title which are likely to offer the most amount of funding resources available for the recommended City of Austin traffic signal system.

Additional ISTEA Titles - ISTEA provides additional funding opportunities through the remaining titles and programs in the Act. A summary of the remaining titles are as follows:

- *Title II - Highway Safety* - Funding opportunities are offered through this title for non-construction highway safety programs, including state and community grants through the 402 Program to develop initiatives for reducing injuries and deaths caused by speeding, alcohol or drug use, and motorcycle or bus accidents;

- *Title III - Federal Transit Act Amendments of 1991* - Transit formulas (Sections 9 and 18) and discretionary programs (Section 3) from previous laws are extended through this title, with greater flexibility in the transfer of funds between highway and transit projects. Authorizations are provided for traditional rail and bus programs with initiatives provided for transit planning and research, as well as equipment needs related to requirements of the Clean Air Act (CAA) and Americans with Disabilities Act (ADA);

- *Title IV - Motor Carrier Act of 1991* - This title of ISTEA relates to motor carriers and reauthorizes the Motor Carrier Assistance Program and sets deadlines for state participation in federal registration, fuel taxation, and operations for motor carriers;

- *Title V - Intermodal Transportation* - Intermodal transportation is promoted through this title which makes grants for the development of intermodal transportation plans.

- *Title VI - Research* - This title covers research development in the following three areas: 1) Programs, Studies and Activities; 2) Intelligent Vehicle-Highway Systems Act (IVHS); and, 3) Advanced Transportation Systems and Electric Vehicles. Significant opportunities are offered to state and local agencies for the conduct of engineering, planning, and research studies, the development and implementation of prototype IVHS systems, and development of electric/alternative fuel transit systems;

- *Title VII - Air Transportation* - This title concerns amendments to the Metropolitan Washington Airports Act of 1986; and,

- *Title VIII - Extension of Highway-Related Taxes and Highway Trust Fund* - Highway-related user taxes and the Highway Trust Fund are extended under this title with certain modifications.

Title III, Federal Transit Act Amendments of 1991, is a key title which may provide additional funding if the function of the City of Austin's traffic signal system incorporates the desires of and will benefit Capital Metro.

To receive ISTEA funding, transportation projects must be included in the area Transportation Improvement Program (TIP). The Austin Transportation Study (ATS), which serves as the Metropolitan Planning Organization (MPO) for the Austin metropolitan area, annually prepares the area TIP. The TIP identifies those transportation projects (including roadways and transit) which are planned to be implemented in the Austin metropolitan area, and indicates project priority, year of initiation, and funding source(s). Steps should be taken as soon as possible to effectively coordinate with ATS and to ensure that traffic signal system improvements recommended in this study are included in the TIP.

Once the eligibility of projects for ISTEA funding are determined, the funding should be diligently pursued. There is considerable competition at the national and state levels for use of the federal funds. Unless actively pursued by local officials with strong support by their congressional and legislative representatives, the project could be "lost", assigned a low priority or postponed to some future year. The issue of securing ISTEA funding should be a cooperative effort with ATS.

State Funding - State funding for transportation related projects is obtained through the Texas Department of transportation (TxDOT). TxDOT's funds are obtained from a motor vehicle gasoline tax, vehicle registration, and vehicle inspection revenues. State funds are typically available for transportation related improvements on State operated and maintained roadways. State funds for the Austin area are administered through TxDOT's Austin District office.

Local Funding - Local funds from the City of Austin for transportation related improvements are typically obtained from either the General Fund, the Capital Improvement Program (CIP), or a municipal bond election. For the purposes of implementing the recommended traffic signal system, the General Fund and existing, authorized CIP funds are not anticipated to be able to provide the needed amount of funding. It is anticipated that funding for the signal system will involve a municipal bond election, in conjunction with funds received from the Federal government and TxDOT.

Implementation and Phasing Strategy

The implementation of a traffic signal system for a City the size of Austin would be an ongoing process over many years. Since many agencies have similar needs as discussed in other Chapters, the concerned agencies should pool and coordinate their funding, planning, and design efforts. One building for a Traffic Management Center could house many agencies and have one communications hub center.

Recommendations for improvements to the existing system over the next three years consist of:

1) Form an Operations Management Committee comprised of a representative of each participating agency to oversee the Traffic Management System. Consideration should be given to establishing an operating entity with an Executive Director as done in Las Vegas, Nevada and Houston, Texas.

2) Develop a Deployment Plan for submittal to the MPO immediately showing expenditures vs. time. This step could be done simultaneously with Step #1 and could be completed prior to the completion of Step #1. Steps #3 and #4 below could proceed while Step #1 is being completed. The first priority is the development of a preliminary engineering report which would include a detailed deployment plan. The deployment plan would include funding strategies. The report would be the basis of securing funding from local, state, and federal sources. Currently, federal and state dollars have been available for projects that have a local match, including design plans for construction.

3) Obtain funding for system upgrade. Potential funding for the recommended ITS system could come from two possible sources; these being local funding sources such as transportation related tax monies or capital improvement bond funds, and various federal funds administered by the Metropolitan Planning Organization (MPO) and/or Texas Department of Transportation. The metropolitan planning provision of ISTEA feature has an enhanced role for local governments. The MPO is responsible for developing, in cooperation with the State, a long-range plan and the TIP must include all projects in the Austin area that are proposed for funding with ISTEA monies. Areas with populations of over 200,000, such as the Austin Area, must be designated as Transportation Management Areas (TMA). Projects in these areas are selected by the MPO in consultation with the State. Also, in each TMA, a congestion management plan must be prepared. The Austin ITS system should be a primary component of this

plan. Under ISTEA, two of the programs offer funding for a traffic control project such as the Austin ITS. These programs are the Surface Transportation Program (STP) and the Congestion Mitigation and Air Quality Improvement Program. The first step in securing Federal funds is getting this project added to the TIP.

4) Commission Design PS&E. This step will involve the design of the recommended system; the preparation of plans, specifications, and estimates; bid documents, bidding process, receipt of bids and award contracts. It is during this step that a plan will be prepared that indicates exactly when each intersection will go on the new system.

5) System Deployment. This step will include system development and integration, system testing and acceptance, training, field installation.

6) Retire existing System.

The City of Austin should work with TxDOT, Austin District, to secure possible State and Federal Funds for a City/State integrated system. The City should concentrate their internal planning efforts for the concerned groups, including Public Works, Capital METRO, Fire, Police, and EMS. The City should secure local funding for the initial design and local match for State and Federal Funds. One possible option would be a bond election in the Fall of 1996.

With the passage of a bond election in the Fall of 1996, the funds could be available by Spring, 1997. A deployment plan could also be in place by Spring, 1997. Critical portions of the traffic system could be designed during 1997 such that plans would be ready for construction during 1998. Approximately 100 intersections could be upgraded per year with the existing signal contractors. A Traffic Control Center would probably be needed by 2000. An interim center would be needed in 1998. The system would be "fully" implemented by 2005.

Other technical questions to be determined are the type of controller to be utilized, selection of system software, detection methods in selected areas, and communication media utilization. Staffing levels and maintenance/operation funding would need to be adjusted as the system is implemented.

A key factor for the successful implementation of an ITS/traffic signal system for Austin would be the establishment of an impartial group of individuals to coordinate and direct implementation effort. This organization would be similar to working groups in Houston and Las Vegas.

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FREEWAY TRAFFIC MANAGEMENT SYSTEM
SCOPE OF WORK

Identify resources for sharing data between TxDOT's FTM, HOV and City traffic control systems.

<u>Task Description and Milestone</u>

TxDOT Traffic Management Systems

TxDOT Traffic Operations Division has developed a modular, microcomputer based, distributed processing system architecture to manage the movement of traffic on streets and highways. Four management systems have been developed:

- Freeway Traffic Management (FTM)
- High Occupancy Vehicle (HOV)
- Arterial Traffic Management (ATM)
- Signal Coordination System (SCS)

Of these only FTM and HOV have been selected for further development.

These systems consist of the following components:

- Multi-tasking Manager
- System Control Unit (SCU)
- Local Control Unit (LCU)

The first system deployed in Austin is planned for November 1995. An FTM system will be deployed along US 183 from the Williamson county line to IH 35. This system will include the following technologies:

- inductive surveillance loops
- changeable message signs (CMS)
- lane control signals (LCS)
- closed circuit television (CCTV) cameras

Communications within this system will take place over twisted wire pair, coax, and fiber optic cable. Inductive loops and duct bank have been installed. Communication protocols for each of the components have been defined by the TxDOT Traffic Operations Division.

<u>Task Description and Milestone continued</u>

City of Austin Signal System

The City of Austin desires a computer controlled signal system which is capable of the following functions in the order of importance:

- Accommodates existing system characteristics;
- Integrates signal control, preemption, cameras, signs, and flashers;
- Integrates video from a mobile source;
- Utilizes a distributive architecture;
- Supports a variety of communication mediums;
- Perform multiple tasks simultaneously;
- Provide remote access;
- Automatically adjust signal timings to accommodate traffic demand;
- Evaluate operations based on real-time speeds, travel times, and queue lengths;
- Continuously collect operational characteristics;
- Continuously update color coded maps;
- Display the network in different colors based on congestion;
- Recommend streets which can accommodate diversion during an incident;
- Provide emergency/bus preemption;
- Distinguish emergency/non-emergency preemption;
- Maintain signal coordination during preemption;
- Identify time, agency, and impact of preemption; and,
- Share data with other agencies.

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

The work generally consists of identifying the data that should be shared between the two traffic control systems. Summaries of the facilities, equipment, maintenance, personnel, and funding needed to share this data should be listed. A phased implementation plan for sharing data between traffic control systems should also be devised.

Facilities include structures or enclosures necessary to house and operate equipment and personnel and its cost. Equipment includes hardware, software, and communications items and their cost needed for sharing data. Equipment costs should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of a phased implementation strategy should be included.

Freeway Traffic Management System

Freeway Traffic Management (FTM) begins with freeway construction and continues through day-to-day operation. As discussed below, FTM improves the total operation and safety of a freeway through providing traffic control where needed, traveler information, and incident management. FTM should be included both to minimize the impacts of highway construction and as ongoing activity to reduce accidents, vehicle emissions, fuel consumption and vehicle delay while increasing overall vehicle throughput.

FTM includes the following Intelligent Transportation Systems (ITS) functions:

- Advanced Traffic Management Systems (ATMS);
- Advanced Traveler Information Systems (ATIS);
- Advanced Public Transportation Systems (APTS); and,
- Commercial Vehicle Operations (CVO).

The limitation of roadway construction funds has reduced the ability to meet the freeway traffic demands. In the Austin area, for example, highway and street construction has not been able to keep up with current traffic demand. In addition, Austin borders on becoming a non-attainment area for vehicle emissions. Because of this, there is a need to make optimum use of all of the major transportation arteries; to provide for improved public transportation and to encourage an increase in High Occupancy Vehicle (HOV) ridership. An important aspect of assuring optimum operations includes traffic safety which occurs as part of improved operation along freeways through Freeway Traffic Management (FTM). The utilization of Changeable Message Signs (CMS), Lane Control Signals (LCS) and Highway Advisory Radio (HAR) provides an opportunity to advise motorists of congestion ahead and of alternate routes which are available. In so doing, congestion can be decreased and the chance of accidents reduced.

In addition, ramp meter control can reduce accidents and delay while increasing main lane throughput when in use as part of FTM along high volume freeways which are operating under low speed conditions (e.g. below 40 mph). Examples of this would be IH 35 and MOPAC Loop 1 during peak periods and incident conditions. A study of seven Freeway Traffic Management systems found that after ramp meter control was installed accidents were reduced by an average of 31% and reduced congested freeway travel by an average of 65% while increasing average main lane speed by an average of 20% (including ramp delays) or 29% if ramp delays are not included.[1]

A 1981 installation of three isolated (non interconnected) traffic responsive ramp meter controllers located along the northbound lanes of IH 35 between Ben White Blvd. and Riverside Drive in Austin increased vehicle throughput along the main lanes by 10% while reducing the total travel time delay by 152% while ramp meters were in operation.[2] The ramp meter control was removed because congestion was eliminated when IH 35 was widened.

An analysis of the effects of Freeway Traffic Management as it applies to Texas freeways with continuous frontage roads was conducted by the TxDOT Division of Traffic Operations during 1988-1989. Consideration was given to the effects of system computer control, ramp metering, CMS, LCS, CCTV, and incident management for the freeway main lanes and use of multiphase sequence (three phase and four phase) traffic responsive traffic signal control, lane designation signals and split changes along the frontage roads. The results of the study showed that total throughput for a six lane freeway (three lanes in each direction) could be increased by 25% through application of the Freeway Traffic Management functions noted above. This increase did not include the effects of HOV lanes located within the center median.

Incidents on freeways have been found to cause 55% to 60% of the delay on freeways[3]. A study in Los Angeles showed that where incident management is applied as part of FTM, 4 to 5 minutes of delay was saved by each motorist for each minute that vehicles are removed from the freeway.[3]

The Freeway Traffic Management System being developed in Austin should be designed to include each of these at present or in the future through:

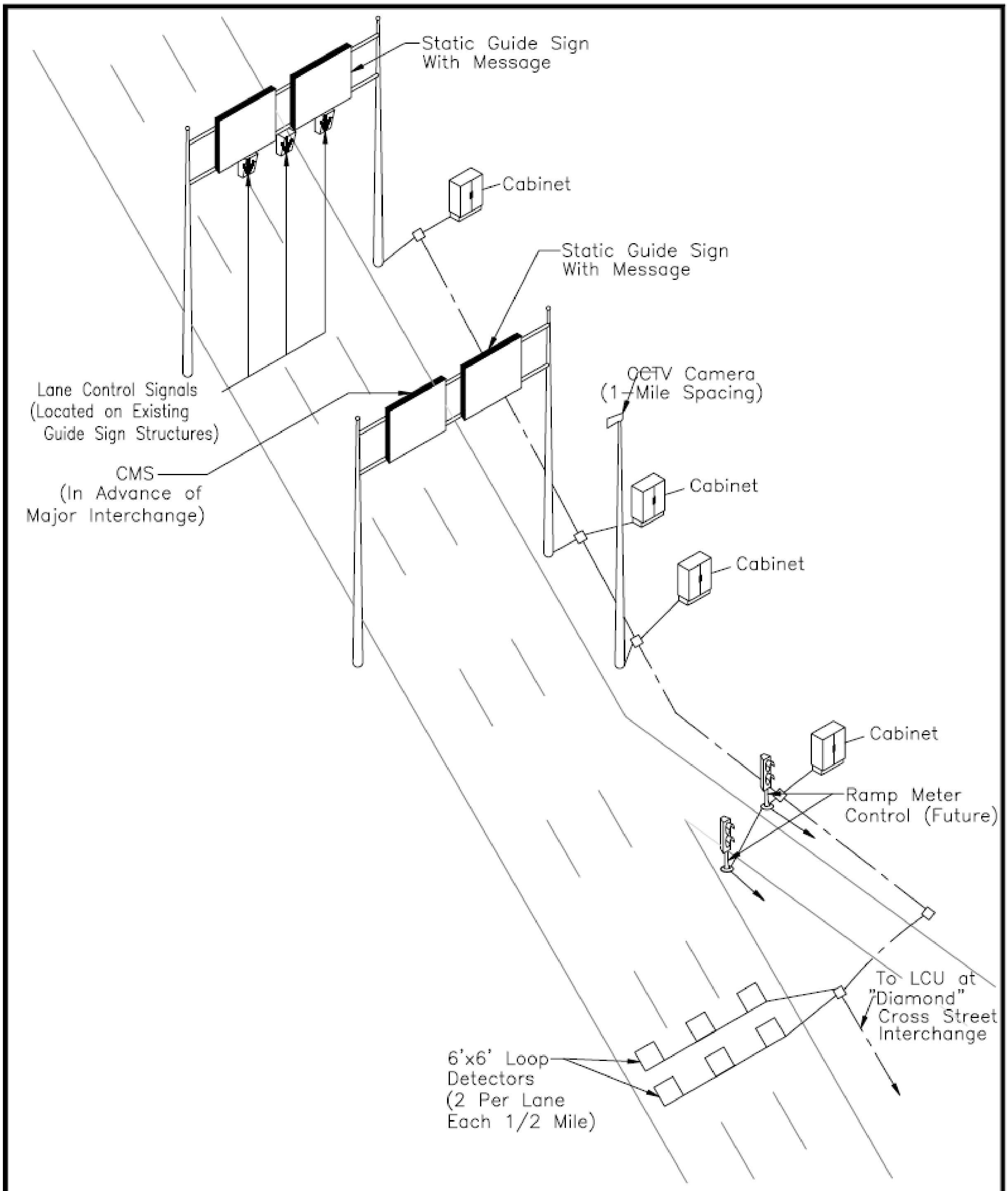
- Traffic Control and Information (CMS, HAR, LCS, CCTV, Ramp Control, Coordination with other Traffic Control Systems);
- High Occupancy Vehicle (HOV) Operations (HOV Lanes with Traffic Control and Enforcement);

- Traveler Information and Information on Alternate Routes for all vehicles including Commercial Vehicles;
- Incident Management (e.g. Accidents, Vehicle Breakdown, Motorist Assistance such as "May Day" calls, Road Construction/Maintenance, Special Events);
- Close Coordination (e.g. Integration) with City Traffic Control Public Safety Agencies (PSA) providers;
- Automatic Vehicle Location (AVL);
- Automatic Vehicle Identification (AVI);
- Weigh-In-Motion (WIM);
- Improved Incident Detection (through use of 911 or a Separate Three Number Telephone Reporting System in place of 911 such as Star -- to supplement vehicle detectors) for reporting Incidents on freeways and streets;
- Route Diversion; and,
- Improved Speed Determination (e.g. Use of vehicles such as trucks as probes).

Some of these applications are shown in **Figure II - 8**.

The Freeway Traffic Management System needs to be flexible in design in order to carry out all of these and other functions along a freeway corridor within the region. To be most effective, FTM should be carried out on a corridor and regional basis. The design and application of the functions mentioned above will require a close working relationship between agencies within the Austin region. These include:

- Texas Department of Transportation (TxDOT);
- City of Austin Public Works and Transportation Department;
- City of Austin PSA (Police, Fire, EMS, 911);
- City of Austin PSA Center;
- Capital Metro;
- Texas Department of Public Safety;
- Austin Airport Authority;
- Travis, Williamson, Hays and Bastrop Counties; and,
- Other Cities in Region (e.g. San Marcos, Bastrop, Round Rock, Georgetown, Cedar Park, West Lake Hills).



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Freeway Traffic Management
Field Installation Components
Austin Area-Wide ITS
Austin, Texas

Figure
II-8

A working committee should be organized to carry out the close working relationship initially during design and later during ongoing operations.

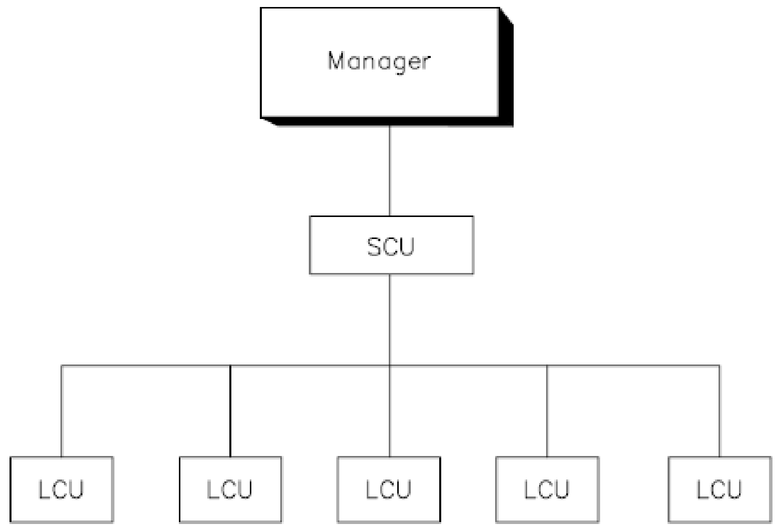
In addition, a close working relationship will also need to be developed with private organizations such as motorist information (e.g. radio, television), railroad, truck (freight and delivery including air cargo), and bus (e.g. Greyhound, charter, sight seeing companies). This working relationship should include firms from Mexico and Canada with the anticipated increase trade due to the North American Free Trade Agreement (NAFTA).

Freeway Traffic Management System Overview

It is not anticipated that all of the functions and services previously described will be carried out immediately but Austin's Freeway Traffic Management System should be designed and developed to provide for those not installed under initial contracts. This can be done through the construction of a Traffic Management Center, in conjunction with cooperation, coordination and communication between the agencies.

The Austin District freeway design calls for vehicle volume and speed detectors located each one-half mile, CCTV cameras located each mile (plus additional cameras where needed at cross street grade separation), CMS at approximately two to three mile spacings and LCS on existing overhead guide sign bridges.

The FTM system hardware is shown graphically in **Figure II - 9**. Local Control Units (LCU) provide for control and traffic data collection at field units (e.g. vehicle detectors, ramp gates, ramp meter control). The System Control Unit (SCU) which is located in a satellite building located
along a freeway gathers traffic data information from LCUs and, in turn, distributes traffic control information to each of these units. The SCU also determines traffic control patterns for one or more freeways on a stand alone real time basis (no personnel required at the satellite building) and automatically implements these traffic control patterns. The SCU advises the Manager (PC) located at the Traffic Control Center of action being taken.



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Basic Freeway Traffic Management System
Austin Area-Wide IVHS
Austin, Texas

Figure II-9

The operator at the Manager monitors and modifies SCU traffic control patterns as required. When an incident occurs, it is noted by the LCU/SCU combination and the operator is advised through the Manager. Where entrance ramp control exists, the SCU can automatically activate the proper ramp meter or ramp gate. The SCU can also recommend CMS messages and LCS displays for operator implementation at the TMC. The FTM system design is the same as that being implemented in Houston, Fort Worth and El Paso.

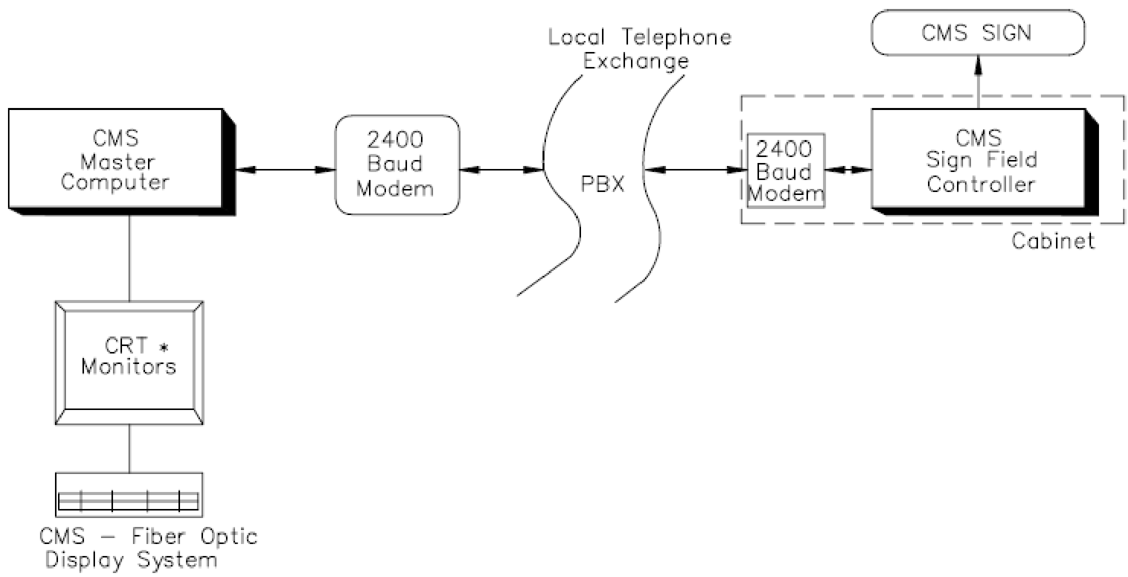
Existing TxDOT Austin District Freeway Traffic Management System

Facilities Summary - The Freeway Traffic Management (FTM) system in Austin presently consists of two Changeable Message Signs (CMS) and supporting Lane Control Signals (LCS) located at each end of the "express lanes" bridge structure on IH 35. The CMS and LCS can be operated either from a PC computer console located at the City of Austin police station or from the TxDOT Austin District traffic control room. The District also has a Systems Control Unit (SCU) and Manager which are not in operation at present.

The CMS and the LCS are presently operated through the CMS and LCS computers. The current fiber optic message type CMS system, replaced a combined CMS/LCS system installed in the early 1980s. The LCS, which was part of the original CMS system (original CMS and LCS operated by the same PC computer), are still operated by the original CMS system computer. The District plans to incorporate the CMS and LCS systems into the existing SCU and Manager through use of Windows 95.

CMS messages and LCS displays are presently stored in computer memory. Additional messages and displays can be developed as requested by the City Police and stored for use in the future by the TxDOT engineer and police dispatch as needed. The development of new CMS messages and LCS displays on a real time basis is not carried out at present. Real time development of messages and displays will be possible when the TxDOT operator is located at the TMC.

As shown in **Figures II - 10 and II -11**, communications between the District Office (and the City police system) and the CMS and LCS system are carried out through use of leased telephone



* One Monitor Located at TxDot District Office and the Second at the City of Austin Police Station.

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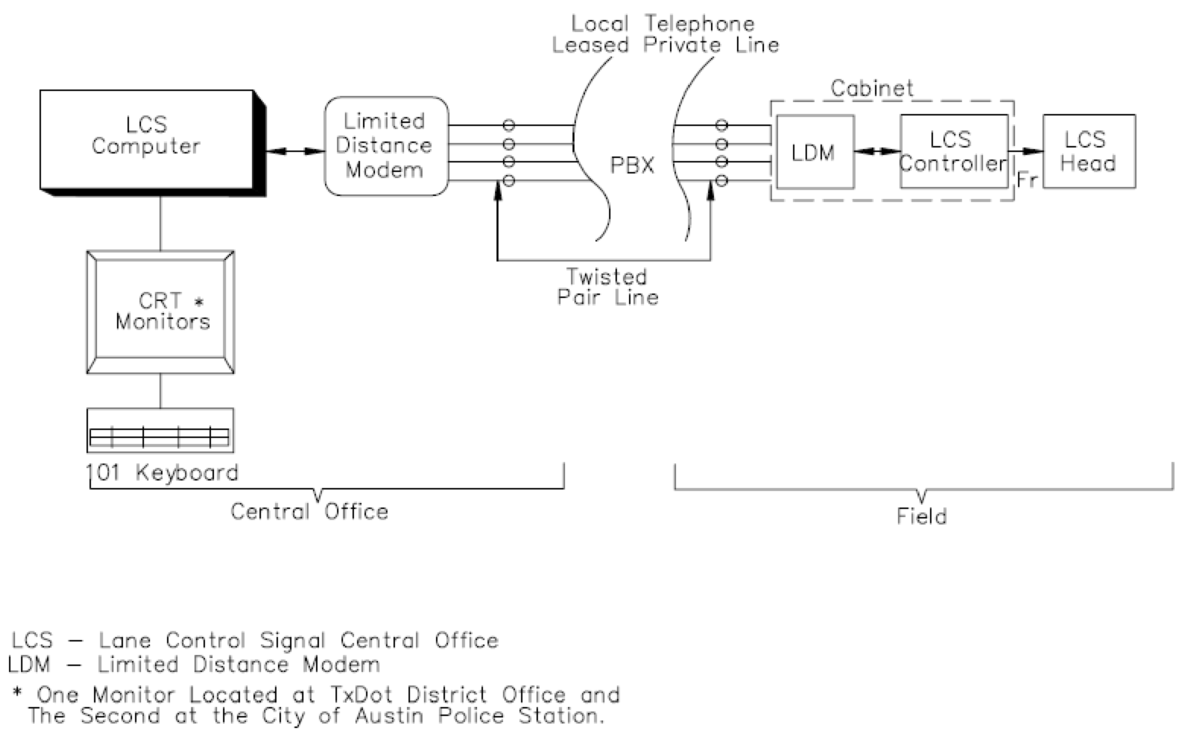
Changeable Message Sign Controls System
Austin Area–Wide ITS
Austin, Texas

Figure II-10



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Existing Lane Control Signal System
Austin Area–Wide ITS
Austin, Texas

Figure II–11

lines. The police and/or TxDOT Control Center operator can select the desired CMS message and LCS displays from available combinations; however, implementation by the police must be made by making two telephone calls -- one to the CMS computer and the second to the LCS computer. The need to make two phone calls and the communications problems with the LCS noted below has discouraged use of the LCS by the police department dispatchers.

Figure II - 10 illustrates the existing communications infrastructure for the CMS consists of Southwestern Bell PBX (Public Telephone Exchange) service. The CMS master computer provides all the applications and communications control to the 2400 Baud modem with autoanswer and autodial functions for a standard telephone line. The CMS master computer controls the two existing sign field controllers . All field connections to the communications infrastructure (PBX) are provided with a telephone line drop. One CMS master computer and modem have the capability to control over 150 CMS. Access times are slow if the number of signs increase beyond 10 signs with a one modem configuration and the access repeats are numerous. This is due to the diagnostics and the maintenance functions of the master controller software (overhead) for keeping the signs current and active.

Figure II - 11 shows the present configuration for the LCS system. The communications medium is over a leased private line system provided by the local telephone company. The modem system in this case is a limited distance modem (LDM) that is designed to operate over a private twisted pair copper communications cable plant system. The twisted pair system is leased from the local phone company. At this time, the communications performance needs to be improved. Basically, the LCS are non-functioning due to communications problems. In order to examine and resolve the communications problem, a random 511 character communications tester (such as HP-4952A) will be required. This device will examine and pinpoint the fault of the present communications system.

The tester can be connected at the Master computer site RS-232 asynchronous communications line and a loop back plug installed at the field controller site over the LDM interconnection and the local telephone leased lines. This test will examine bit error rate and bandwidth and yield absolute performance measurement numbers.

The District also plans to purchase a Highway Advisory Radio (HAR) unit and is presently working with the Division of Traffic Operations in doing so. The District is also awaiting installation of freeway detectors for integration of the CMS and LCS systems at the SCU. Work is also underway to develop a Courtesy Patrol.

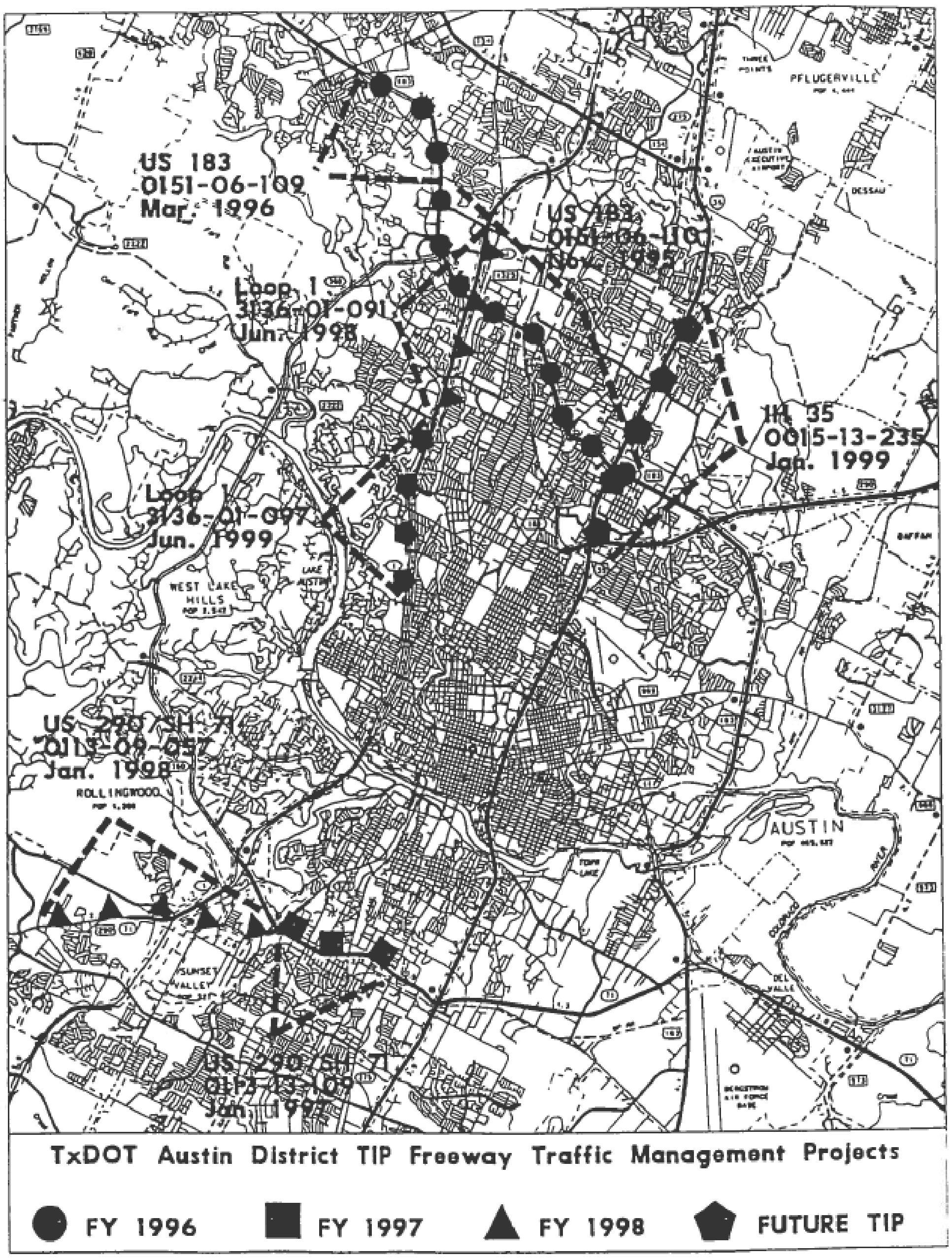
TxDOT Operations and Maintenance - TxDOT originated CMS messages and LCS displays are implemented by one Engineer on a part-time basis. He is the only person who can fix a problem involving the control center hardware/software. Maintenance of the two CMS and the LCS is currently carried out by District traffic signal maintenance personnel.

The integration of operations of the total CMS, LCS, SCU/Manager system should be given immediate priority. Integration of the various components appears to be best handled through use of the SCU/Manager and through use of Windows 95 (or similar computer model). In addition, a second TxDOT operator needs to be trained to operate the system. There is also a need to overcome the current CMS and LCS communications problems as soon as possible.

Further, there is a need for TxDOT to coordinate more closely with the City of Austin police personnel in determining and implementing new CMS messages and LCS displays. Close coordination is also required to develop and implement the Courtesy Patrol. These activities could be done along with improving the existing CMS, LCS, SCU/Manager System by making additional personnel available.

Funding and Personnel Summary - Additional emphasis needs to be given to the FMS program. This includes increased funding and time for upgrading the existing CMS, LCS and SCU/Manager System and provisions made for an additional employee for Freeway Traffic Management development. The additional employee(s) would serve as an alternate operator for the operation of the CMS, LCS and SCU/Manager System and work on the development of PS&E for the FTM System.

Implementation/Planning Summary - As is shown in **Figure II - 12**, the District has scheduled the initial development of FTM along IH-35, US183, US290/SH7 (Ben White Blvd.) and Loop 1 (Mopac) over the next five years with planned extensions along these highway during the following seven years. Additional installation beyond 2012 is in the planning stage. Initially, FTM development will involve the installation of loop vehicle detectors, CMS, LCS, HAR and CCTV. Communications will be carried out through the use of fiber optic cable



SOURCE: Texas Department of Transportation, Austin District

WILBUR SMITH ASSOCIATES CONSULTING ENGINEERS AND PLANNERS HOUSTON, TEXAS NORTH AMERICAN CONTROLS CORPORATION ADVANCED TRAFFIC ENGINEERING KESSMANN & ASSOCIATES	Freeway Traffic Management System Field Installation Schedule Austin Area-Wide ITS Austin, Texas	Figure II-12

installed as part of the FTM installation on the projects shown in Figure II - 12. Traffic management is planned to be initially controlled at an interim traffic control room at the District office.

In addition, studies are underway on the desirability of incorporating HOV lanes along IH-35 similar to the design being applied in Houston and planned for in Dallas. There is also a study underway to develop mitigation approaches at freeway bottleneck locations. These approaches may utilize ITS applications.

FTM applications by TxDOT will improve operations and safety along freeways and freeway corridors. Even better operation and safety can be expected through coordination in sharing and utilizing information with other public agencies and the private sector in improving operations and safety in the Austin region. This could best be done through agencies being located in one Traffic Management Center and development of a means of integrating their traffic management activities.

Recommended Method of Sharing and Utilizing Data

In order to carry out a regional traffic management system, there is a need for all agencies to share and utilize traffic and other related information. It is also necessary to work closely with private companies such as the news media and passenger/goods movement companies. Included in this is the management of incidents along freeways and streets and notification of traffic conditions to travelers and motorists in adjacent cities (e.g. Georgetown/Round Rock, Leander/Cedar Park, San Marcos, Bastrop). In this way, improved operations will be achieved throughout the city and the entire region - both from a mobility and traffic safety standpoint. Although it is not essential for all transportation operations agencies to be located in one Transportation Management Center (TMC), communications, cooperation and coordination could be greatly improved if they were located within one TMC. In addition, it would be desirable for the City and TxDOT to share and utilize traffic data through an integrated approach.

It would be highly desirable to complete the IH-35, US 183, Mopac, SH 290 fiber optic cable loop at an early date. It would also be desirable for this cable to be available for use in both FTM and City traffic signal control. It is recommended that consideration be given for the cost of installation of the fiber optic cable loop be shared equally between the City and TxDOT. This approach would provide a trunk line for FTM and traffic signal control and permit the city to change to the use of fiber optic cable as desired. This could include installation of CCTV at selected signalized intersections (e.g. spacing each 0.5 to 1 mile between cameras). The Houston District and Metro have shared the installation costs for fiber optic cable along the freeway system in the Houston area. The trunk line would also provide a two-direction traffic control and data input between the TMC and field units.

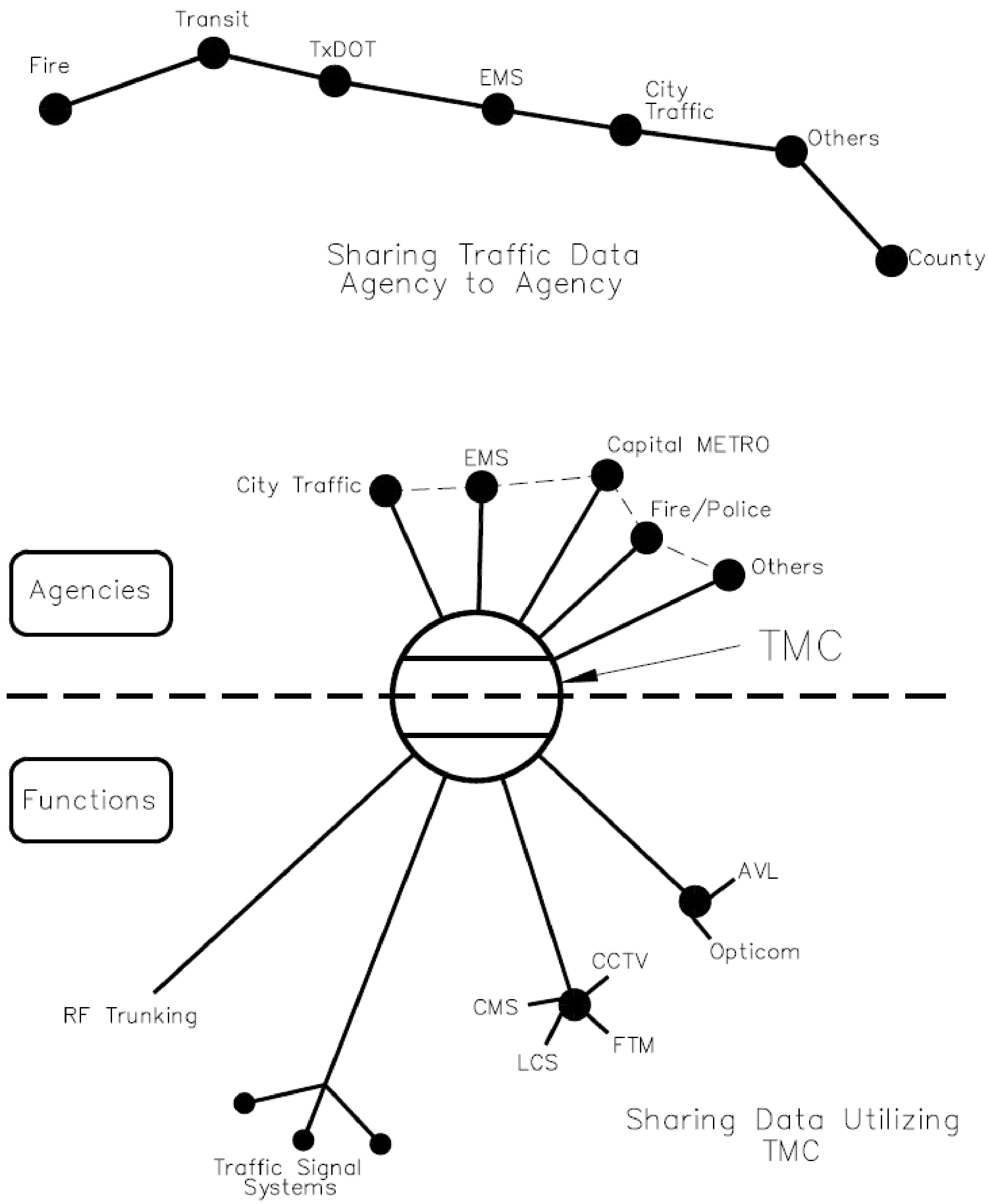
Shared Data - It is essential in providing good traffic management for public agencies and private sector participants to share traffic data and other related information, and to work together in utilizing this information. A listing of traffic data and other information which can be shared is given in **Table II - 7**. The listing shown is the basic information needed. This information will need to be summarized and tabulated to meet each public and private sector needs. The organization of how the information is presented to each organization will need to be developed as part of overall system development.

Two approaches of sharing information are given in **Figure II - 13**. In the first, each agency Traffic Management Center or Communication Center sends information to other Agency Centers. In the second, also shown in Figure II - 13, information is transmitted to a Traffic Management Center where it is organized and tabulated. The resulting information is then sent to each organization as requested and/or as a standard format. Each agency will determine the information its personnel can use and request the needed information. All information will not need to be sent to each agency. For example, PSA organizations may want to know where major congestion exists and/or CCTV pictures of a particular accident where they are available.

In addition to sharing traffic data, additional information needs to be considered (e.g. location of incidents, work zones, inclement weather conditions, fire scene activity, 911/CCTV noted problems). Incorporating these reports into the data analysis routine (known as data fusion) will assist in determining traffic control patterns being called for (or recommended) by the computer(s).

Table II-7
Agencies and Information to be Shared
Austin Area-Wide IVHS
Austin, Texas

TxDOT Freeway Management	City Traffic Management	County Sheriff/Road Districts	Capital Metro	City of Austin Emergency Management Systems
Main Lane, HOV Lane and Frontage Road, Traffic Volumes/Lane Occupancy, Average Speed, Travel Time	Major and Minor City Arterial and Collector Street Traffic Volumes, Lane Occupancy, Average Speed, Travel Times	Location of Accidents and Severity	Location of Buses (AVL)	911 Reports on Emergencies Best Handled by City or TxDOT Traffic Management Operators
Incident Locations, HOV and Main Lane Queues, Estimated Delay	Incident Locations on City Streets, Queues, Estimated Delay	Roadwork on County Roads	Travel Time along Routes	Reports on Accidents/Fires and Public Disturbances and Extent of Problem
Queues along Frontage Roads and Cross Streets at Freeway "Diamond" Interchanges	Level of Service and Available Capacity on Major and Minor City Arterials and Collector Streets	Possible Alternate Routes for Traffic and EMS	Reports on Observed Incidents that May not Have Been Reported	Reports on Problem Locations Noted by Officers in the Field (Officers work through their organization to report incidents)
Location of Courtesy Patrol Vehicles	Construction Underway on City Arterials and Collector Streets		Reports on Motorists Who are Driving in an Erratic or Hazardous Manner	Traffic Management Underway at Incident Locations
Level of Service and Available Capacity on Main Lanes, HOV Lane(s), Frontage Roads, and cross streets at "Diamond" Interchanges	Maintenance Activities along City Arterials and Collectors		Reports on Signalized Intersections Where Pedestrians Do Not Have Time to Cross the Street Safely	
Estimated Traffic Diverted along Frontage Road(s) caused by Ramp Control (when installed) and Need for Frontage Road Traffic Signal Coordination to Better Handle Traffic Diverted by Ramp Control	Traffic Signal Equipment Malfunctions		Reports on Signalized Intersections and Arterial Locations Where Delay Exists	
Need for Change in Traffic Signal Sequence at "Diamond" Interchanges	Accident and Fire Locations, Estimated Delay and Alternate Routes which are available to Motorists		Location of a Bus Breakdown	
Location of Wreckers Available for Incident Management (e.g. Removal of Vehicles from Freeways and Other Major State Arterials	Effects of Preemption of Traffic Signals by Buses and EMS Vehicles			
Location and Information on "Thru Traffic" Commercial Vehicles (AVI, AVL, WIM, Permit Limitations)				
Construction Activities Along Freeways and Other Major State Arterials				
CMS and HAR Messages and LCS Displays				
Maintenance Activities along Freeways and Other Major State Arterials with Lane Closures Where Applicable				
Traffic Control and Traveler Information Malfunctions				
Traffic Management Underway at Incident Locations				



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Two Concepts for Traffic Data Sharing
Austin Area-Wide ITS
Austin, Texas

Figure II-13

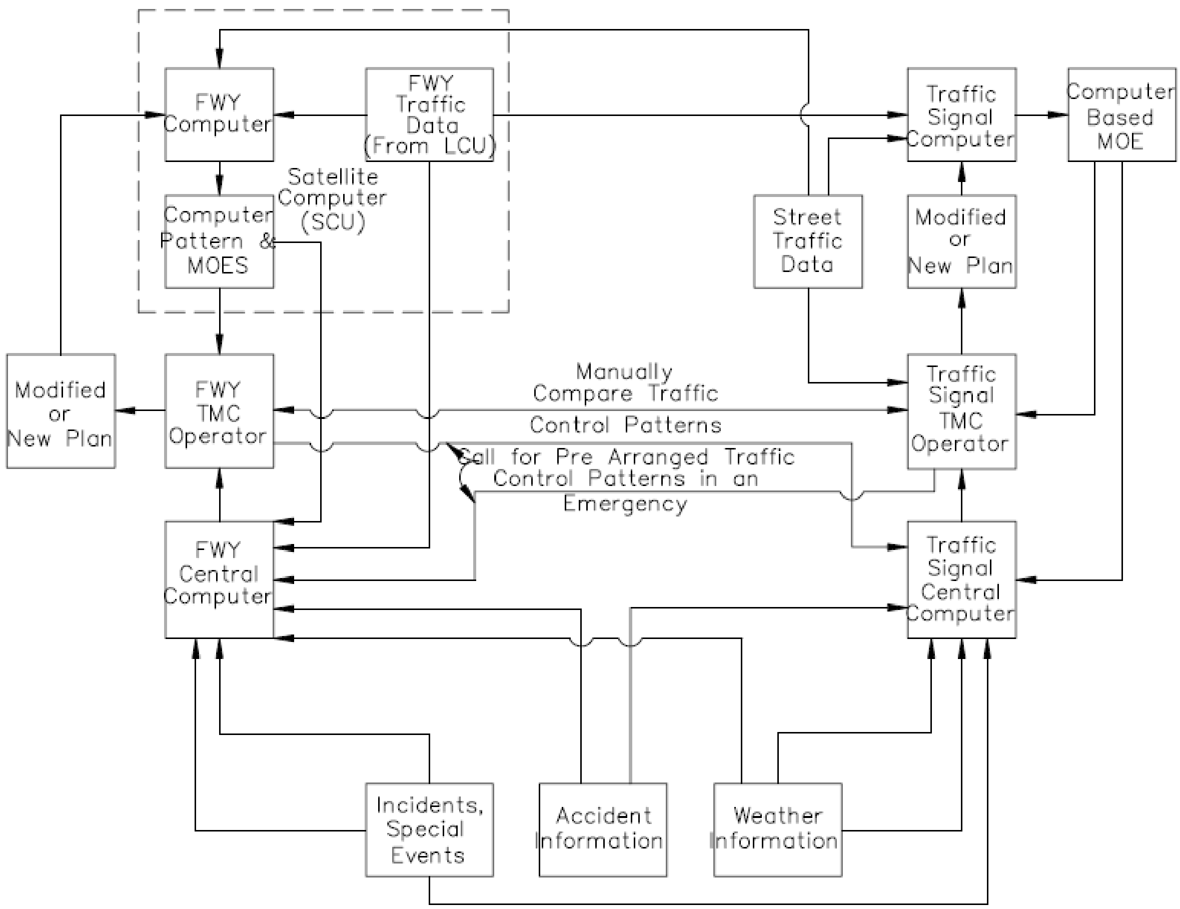
In addition to sharing traffic data and other information, it is important to develop an approach for utilizing the information during both recurring and non-recurring congestion and to provide incident management. This can best be done through a form of integrated traffic control between the City of Austin and TxDOT Traffic Management systems -- preferably at one Traffic Management Center. Integration can be carried out in one of three approaches as discussed in the following scenarios:

1. Sharing Detector Information. This approach permits both the City and TxDOT to request detector information and CCTV pictures from the other agency as needed -- the requested information can be displayed through the use of Windows on one computer or preferably on a second computer screen at the work station. Utilizing the same detector and CCTV information within a corridor will permit operators of the two systems to decide on similar courses of action. Each computer will determine traffic control patterns through independent action. The traffic control patterns can be modified as verbally agreed upon by both operators.

   This approach is the least complex from a hardware/software standpoint but does require the utilization of two operators agreeing under pressure which traffic control patterns need to be implemented. Even with the operators located at one TMC, this approach would be the least desirable.

2. Utilization of Each Other's Detector Data. This approach, which is shown in **Figure II - 14**, will permit each agency's computer(s) to automatically receive selected detector information from the second agency's system. As an example, the City of Austin computer would receive detector data from the freeway system as well as from the street system. The City computer could then provide a traffic control pattern based to a certain extent on freeway as well as street data, if desired, the computer could also provide recommended alternate routes along the freeway corridor using both street and freeway detector information. The TxDOT computer could likewise recommend improved traffic control patterns -- including recommended alternate corridor routes (e.g. providing frontage road and parallel street progression patterns when the demand by traffic desiring to enter the freeway is too high -- especially where ramp control is provided). Traveler information messages could also be recommended by each agency's computer.

   The cost for Approach 2 should be approximately the same as that for Approach 1. The traffic control patterns and traveler information recommended by the two computers could be compared by the two operators, as in the first scenario. This scenario will permit the operators to make a more educated decision on which traffic control patterns to select for the two systems.



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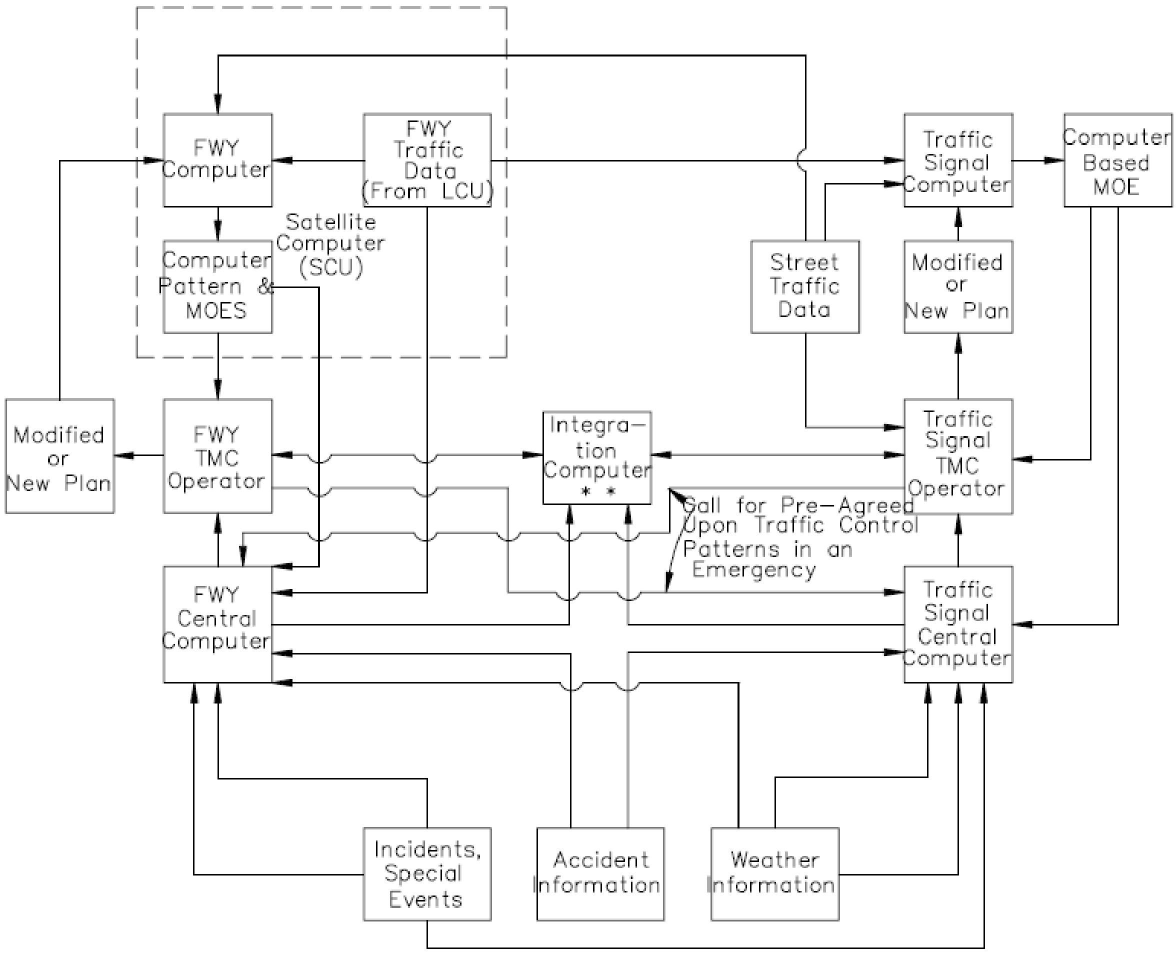
Traffic Management System Integration (Scenario 2)
Austin Area-Wide ITS
Austin, Texas

Figure II-14



** Frontage Road, Corridor Streets Agreed Upon Traffic Control Pattern

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Traffic Management System Integration (Scenario 3)
Austin Area–Wide ITS
Austin, Texas

Figure II–15

3. Coordination for Two Computers. In this scenario, which is shown in **Figure II - 15**, a third computer would utilize the traffic data from both traffic management agencies as in Scenario 2 and provide an expert system based diagnostic routine as an assisted approach to the two operators. The diagnostic routine could also consider other information as part of the analysis.

   This scenario is more complex than the first two scenarios but could provide the best approach since diagnostic assistance is provided to the two operators in their determining which traffic control pattern to implement.

Of the three scenarios, the third would be the best and is recommended as part of either the freeway or city traffic control system design. Implementing the third scenario as part of the Freeway Traffic Management system implementation will permit the use of diagnostic analysis at an early date. The cost for the third computer and software could increase the overall cost of the FTM system by $300,000. This amount will need to be added to the TMC costs shown later in Table II - 10.

With any of these scenarios, it will be desirable for the operator from either agency to be able to call for pre-agreed upon traffic patterns within both systems during emergency conditions. In this way, certain actions can be taken in an emergency should one agency operator be absent from his/her work station.

Although the functions noted above could be carried out to some extent through separate TMC's, it would be best to have one TMC. One TMC will permit greater efficiency because the operators would be able to work together in the same location. Personnel working together can make better coordinated decisions and better developed traffic control patterns for both the traffic signal and freeway traffic management systems. Further, one TMC provides a greater opportunity for Public Safety Agencies (PSA) personnel to have input to development of traffic control patterns and jointly analyze resulting outputs. The PSA personnel will also be readily available with the system operators during incident management emergencies.

<u>Facilities Needed to Share Data</u> - It is recommended that one TMC be provided for all agencies and that work stations be located in one traffic control room within the TMC. This would include one or more work stations for each Public Safety Agency (PSA) and for Capital Metro. The work station concept will enable personnel to discuss problems face to face and work together closely during major incidents and special events. These personnel can more easily solve problems caused by accidents and recurring congestion. In order for the TMC and traffic control room to operate efficiently, it is recommended that the design be carried out by a committee represented by all agencies to be housed in the TMC.

It is also recommended that the two Traffic Management Systems be integrated to the extent discussed previously in Approach 3 as shown in Figure II - 15. If this is not possible at first, Scenario 2 should be implemented as shown in Figure II - 14 with provisions made to implement Scenario 3 at a later date.

The TMC should also provide hardware and software which will:

- Display the freeway and street a network traffic conditions <u>on a regional map</u>. Different colors (e.g. red, yellow, green) could be used to represent different levels of operation along each arterial. In addition, CCTV monitors should be provided in conjunction with wall map.

- Display traffic conditions as described above together with MOS and CCTV monitors at each work station.

The computers will need to communicate with each other through a standard communications protocol.

In addition to use of CMS, LCS and CCTV, consideration should also be given to incorporating entrance ramp control (i.e. ramp meter control and ramp closure control) as part of the initial system along IH 35 and Mopac/Loop 1 (and possibly US183 and Ben White Blvd. (US290) when average main lane speeds fall below 45 mph).

The Freeway Traffic Management Computer must be flexible enough to incorporate the HOV system when it is implemented and capable of expansion to incorporate additional FTM and ITS components and application of future real time algorithms. It is anticipated that the FTM System will operate for a minimum of 15 years provided that the computer(s) and field equipment will be replaceable and/or upward compatible with future hardware and software, and provided satisfactory maintenance is carried out.

Equipment Needed to Share Data - The computer hardware previously discussed is required for the FTM system. The design will require one or more local conrol units (LCU's) at each frontage road/cross street "diamond" interchange. The LCU(s) will collect freeway and street system loop detector information and periodically send consolidated information (e.g. each 30 seconds) to the SCU. The LCU also provides control for the LCS and for entrance ramp control where provided. The LCU(s) could also operate the CMS and CCTV camera controls when software is developed to do so. A 2070 controller could function as a LCU.

Communications to and from the CMS and CCTV control is brought to the frontage road/cross street interchange where it is sent to the SCU. The LCU and associated field equipment is housed in a field cabinet located at the interchange.

The SCU gathers information from the LCUs and in turn, transmits traffic control information to the CMS, LCS, CCTV and entrance ramp control. The one SCU, which is located within a building along a freeway, is designed to provide data acquisition and traffic control for one or more freeways (e.g. US183 and Mopac). Using the traffic data received from the LCUs, the SCU makes initial calculations for traffic control for the freeway(s) it controls and implements needed traffic control patterns as well as recommending messages and displays for the CMS and LCS. The SCU is a stand-alone unit; however, a Laptop computer can be used to provide manual control.

The SCU, in turn, transmits the traffic data received from the LCU and its traffic control actions to the Central Computer at the TMC.

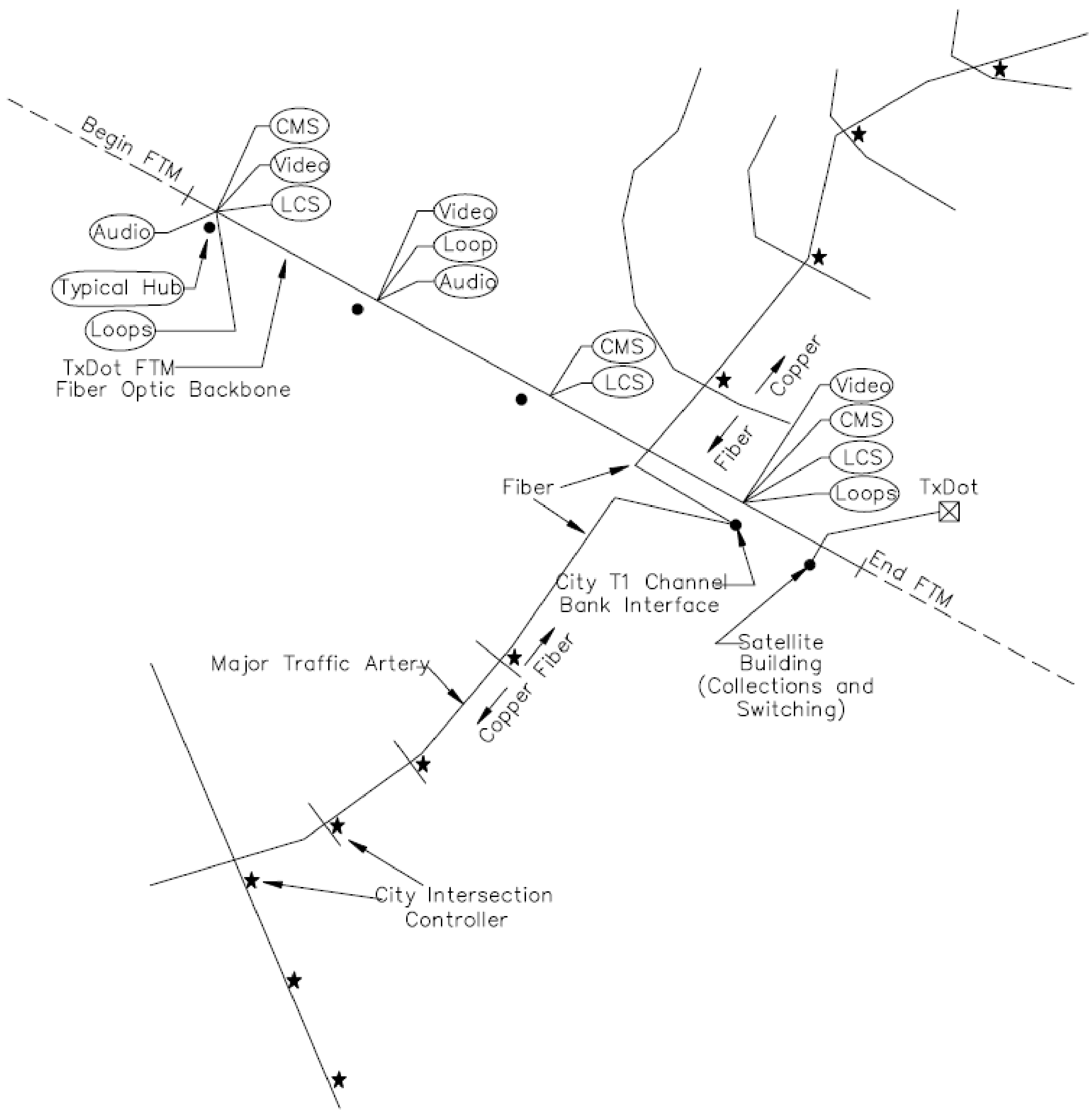
Recommended Communications - The type of shared data needed for an Integrated Traffic Management System involves Multi-Agency use in Voice communications, Video communications for verification and Digital Data for computer resources.

The recommended communications system predicates an Information system that will lend itself to provide voice, video and digital data throughout different parts of the City of Austin and the surrounding community, including the Traffic management Center with equipment and a network configuration that will provide:

- Standardization
- Commonality
- Maintainability
- Portability

The recommended system is two-fold and consists of the TxDOT Freeway Traffic Management system fiber optic communications backbone system and the Greater Austin Area Telecommunications Network (GAATN), using a fiber optics backbone system.

1. TxDOT FTM System Communications. The on-going FTM system fiber optics communications backbone system can be used as temporary or permanent communications system along the major corridors in Austin. **Figure II - 16** illustrates how TxDOT is integrating their FTM system with Video Camera for verification, LCS, CMS, Traffic speed and occupancy and other functions such as HOV along the major corridors. By implementing a fiber optic backbone system with a standard T1 carrier system or a DS3 system, all data, voice and video can be transported because most all of the carrier manufacturers can interface into this protocol standard. A proper deployment plan coupled with a phased implementation plan to allow communications to the TMC via Austin's major corridors, effective use of the backbone by many agencies can be realized. This type of effective shared or collective agency cooperation is now being implemented in the East Coast, Central Florida I-4 and in Houston, Texas. This backbone system in a shared environment can carry over 800 city intersection controls, County functions, as well as PSA functions including audio, digital data and video over a 48 fiber cable plant system, leaving 36 fibers to TxDOT functions. As discussed, a proper deployment plan, identifying the end equipment interfaces for the different agencies will result in



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Typical FTM System
Communications Interface
Austin Area–Wide ITS
Austin, Texas

Figure
II–16

decreased bandwidth allocation for the shared functions of the backbone system thus allowing for spare bandwidth allocation for the present and future.

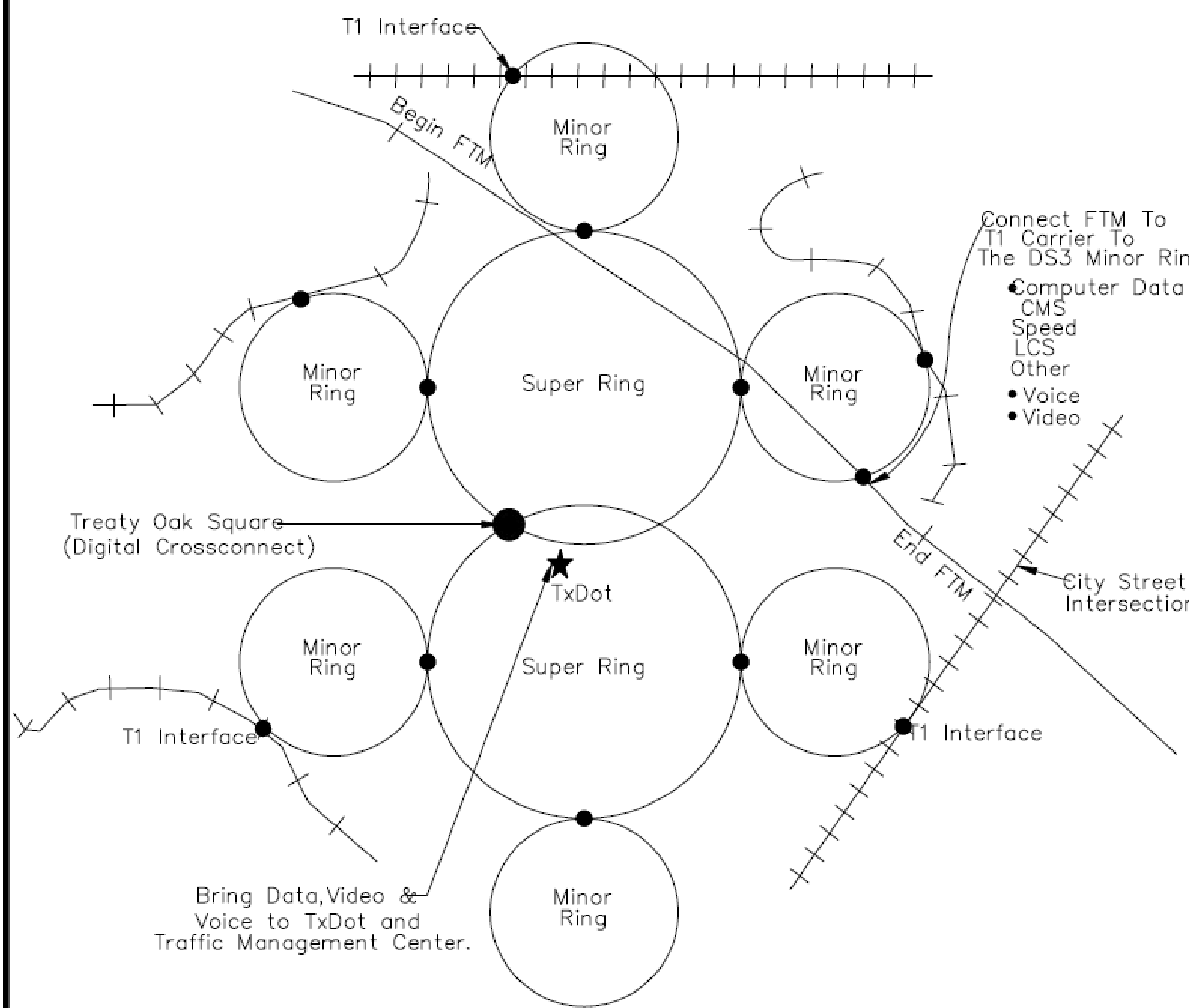
2. GAATN Communications System. The GAATN, an existing system communications infrastructure, offers a wide geographical area potential for providing communications for TxDOT functions along the major corridors of Austin. Other agencies have been striving for this type of city wide communications, the systems have been late in deployment, and are costly to implement, due to local area geography. The GAATN system is available for use at this time and appears to be in its infancy. Proper care in bandwidth allocation deployment will be needed in carrying out the design of the communications system. For instance, at what points will the GAATN system be bridged with the FTM system communications?

   Due to the freeway project phasing, some of the planned FTM fiber optic backbone systems will be in different parts of the City of Austin, with no communications tie ins with the TxDOT traffic management center (during construction). GAATN lends itself to tie in these projects by integrating the Satellite Building communications electronics into the minor rings of the GAATN network system.

   This approach can be effective in that the upgrades of the major corridors for FTM systems can be widely segmented throughout the county with little impact on communications and controls. The primary impacts will be the interface cost to the minor ring and should not exceed $90,000 per connection to the ring, including video. This amount is included in the cost estimate shown later in Table II - 10.

   Figure II - 17 illustrates how an FTM corridor can bring in voice, video and computer data from a remote part of town to the TxDOT facility or a traffic management center. The FTM system will bring voice video and data to a hub on the minor ring of GAATN. This minor ring will transfer the information at the Treaty Oak Square digital cross connect switch allowing any minor ring or super ring information, including voice, digital data and video, to be shared by any agency on the rings and by TxDOT.

3. Possible Alternative System. Although the confirmation of the use of State owned fiberoptic cable and the GAATN is recommended, consideration should be given to a private communication system as previously discussed.



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GAATN Telecommunications System

Austin Area-Wide ITS
Austin, Texas

Figure II-17

Maintenance Summary - Maintenance of the City and State traffic management system computers could be carried out through a maintenance contract. Since computer maintenance costs will increase with time, the cost of the contract should be low at first and increase over the remaining life of the system. The maintenance contract should require that the contractor provide replacement parts along with normal maintenance. The maintenance contract should also call for preventative maintenance inspection. Routine maintenance of the field equipment should be carried out on a scheduled basis, along with periodic visual inspection of the CCTV, CMS and LCS equipment and daily review of system computer logs for intermittent failures. Visual inspection could be carried out by the Courtesy Patrol drivers and by the District personnel traveling to and from work sites as well as by system maintenance personnel.

A minimum of two sets of demonstration equipment should be purchased as part of the system to demonstrate and visually check the appropriate operation of two CMS and LCS stations. This would permit the operators to implement strategies and visually analyze the results before implementing a message/lane control concept in the field. Demonstration equipment parts could be used as replacements to faulty equipment and replaced by the maintenance personnel.

Routine maintenance can be handled initially by one trained maintenance crew that also maintains TxDOT traffic signals. Eventually, however, full time personnel will be required. Once full time personnel are required, consideration should be given to entering into a maintenance contract with a qualified contractor. The response time for replacement of faulty parts will need to be included in the agreement.

The use of maintenance contracts will require qualified inspection by the District to assure that the maintenance work is carried out properly in accordance with the specification(s) and agreement(s). The person inspecting maintenance work could also work with the Project Engineer and Chief Inspector on inspecting FTM components (e.g. fiber optics, loop detectors) installed as part of construction projects.

If agency personnel maintain the system, qualified personnel will be required with scheduled training provided to assure that the maintenance personnel will be able to make needed repairs. The personnel will need an increased budget for repairs and diagnostic/maintenance/installation equipment.

Personnel Required to Share Data and Carry Out System Engineering, Operations and Maintenance - An essential part of traffic management involves the personnel needed to operate and maintain the system. There is a need to have a staff sufficient in size to carry out the required work.

It is proposed that the Traffic Management Center (TMC) be operated as a minimum from 6:00 a.m. until 7:00 p.m. Monday through Friday. It is also recommended that the TMC operate on Saturdays and Sundays when special events are scheduled (e.g. football games, AquaFest) and when emergencies occur. The City of Austin police dispatch personnel presently have access to the two CMS. It is recommended that the procedure be continued for all CMS, LCS, and HAR units on a 24-hour, seven-day basis.

A survey was conducted of three existing Freeway Management Systems by TxDOT[4] during 1988. The systems and 1988 freeway center line miles were:

- Detroit, MI — 32+ miles
- Minneapolis, MN — 37 miles (scheduled to be increased to 74 miles)
- Seattle, WA — 78 miles

These three systems had characteristics and system components similar to the Houston and Ft. Worth freeway systems being planned at that time and the Austin freeway system at present. The Detroit, Minneapolis and Seattle systems operated approximately 13 hours each day from Monday through Friday and had CMS, ramp meter control and CCTV. In addition, the Minneapolis system provides traveler information by radio.

Based on the results of the survey, the initial full time Freeway Traffic Management engineering operations and maintenance staffing along with that required by 2002 and by 2007 are given in **Table II-8.** The recommended allocation of full time personnel are based on 13 to 16 hours of operation for the TMC and overtime work when necessary on Saturdays and Sundays. Engineering and maintenance personnel are shown in Table II - 8. Vehicles will also be required and these are given in **Table II - 9**.

Additional personnel from other agencies will also be needed in the TMC for their agency operations together with one additional person who will provide overall management of the TMC as discussed previously.

Cost Summary - As shown in **Table II-10**, funding for the Freeway Traffic Management (FTM) System portion of the overall ITS plan includes the cost of the TMC, the FTM system, the HOV system and maintenance over a 12 year period. The estimate assumes that half of 25 miles of HOV lanes will begin operation over a seven year period (2000-2007) and that the TMC will be in operation during 2000.

The estimated 1995 cost for installation is an average cost based on information obtained on the Houston and San Antonio FTM system costs and Austin District cost estimates for conduit and detectors. The resulting cost estimate was $1,000,000 per mile. This included:

Conduit and Detectors =	$ 260,000 per mile
Field Equipment (SCU, CMS, LCS, Ramp Meter Control) =	$ 740,000 per mile
Total =	$1,000,000 per mile

Table II - 8

Full Time Personnel Needs for Estimated Center Line Miles
Freeway Traffic Management
(Based on 13-16 Hrs. Operation at TMC)
Austin Area-Wide ITS
Austin, Texas

Center Line Miles of Freeway	10 Miles	35 Miles	65 Miles
Estimated Date	1997	By Year 2002	By Year 2007
Management/Traffic Management			
Supervising Engineer	1	1	1
Assistant Engineer	0	2	2
Secretary or Administration Tech.	1	1	1
	2	4	4
TMC Operations			
Supervisor	*	1	1
Traffic Control Specialist (Two Shifts)	2	3	4
Software Programmer**	0	1	1
Communication Specialist**	0	1	1
Secretary or Administration Tech.	0	0	1
	2	6	8
Maintenance***			
Supervisor	1	1	1
Field Maintenance Technicians	1	4	5
Shop Technicians	1	1	1
Administration Technicians	0	0	1
	3	6	8
Total No. of Personnel	**7**	**16**	**20**

* Function carried out by supervising engineer
** Traffic Operations Division may be able to take care of this work.
*** Function could be carried out by Contract, but at least one inspector would still be needed to assure that the work is done properly.

Table II - 9

Vehicles Needed for Engineering, Operations and Maintenance
Austin Area-Wide ITS
Austin, Texas

Year	1997	By 2002	By 2007
Engineering/TMC Operations			
Automobiles	1	2	2
Maintenance			
Field Vehicles (Equipment Vans)	1	2	2
Automobiles or Vans	1	1	2
"Cherry Pickers"	1	1	1
Total	4	6	7

Table II - 10

Life Cycle Costs*
65 Miles of FTM and 25 Miles of HOV by 2007
1996-2007
Austin Area-Wide ITS
Austin, Texas

Construction			
Freeway Traffic Management	65 Miles x $ 900 k/mi	=	$58,500 K
HOV	25 Miles x $ 200 k/mi	=	$5,000 K
TMC	Building, Hardware, Software**	=	$4,000 K
Subtotal			$67,500 K
Maintenance and Operation			
FTM (9%/yr) =	$58,500 K x .09 x 12 yrs / 2	=	$31,590 K
HOV (9%/yr) =	$5,000 K x .09 x 7 yrs / 2	=	$1,575 K
TMC =	$4,000 K x .09 x 7 yrs	=	2,520 K
Subtotal			$35,685 K
Total			$103,185 K
Cost/Year	$104,427 K/12 yrs	=	$8,599,000/yr
		≅	$8,600,000/yr

* Life cycle costs should be based on a 15 year period. The information available as shown in Figure II - 12 is only for a 12-year period. Costs do not include those for the City Traffic Signal System.

** Does not include additional $300,000 for approach 3 of the integration computer hardware and software discussed previously.

<u>Cost Summary</u> - As shown in **Table II-10**, funding for the Freeway Traffic Management (FTM) System portion of the overall ITS plan includes the cost of the TMC, the FTM system, the HOV system and maintenance over a 12 year period. The estimate assumes that half of 25 miles of HOV lanes will begin operation over a seven year period (2000-2007) and that the TMC will be in operation during 2000.

The estimated 1995 cost for installation is an average cost based on information obtained on the Houston and San Antonio FTM system costs and Austin District cost estimates for conduit and detectors. The resulting cost estimate was $1,000,000 per mile. This included:

Conduit and Detectors =	$ 260,000 per mile
Field Equipment (SCU, CMS, LCS, Ramp Meter Control) =	$ 740,000 per mile
Total =	$1,000,000 per mile

Allowing for conduit and loop detectors being installed as part of some roadway construction projects, an average cost of $900,000 per mile was calculated for use in the estimate (The $900,000 per mile provides for ramp metering at two entrance ramps [$30,000 per ramp]). Since HOV control and surveillance will be required for the HOV lane, a separate estimated cost of $200,000 per mile was allocated (this does not include HOV roadway construction costs). This amount is based on a discussion with the Austin Central Office personnel.

It is estimated that a building of approximately 25,000 s.f. is needed to house the agencies. The estimated cost of $4,000,000 for the TMC is based on the cost for the Fort Worth District cost which includes:

Building = $2.5 million

Hardware/Software/Integration = $1.5 million

This includes offices for personnel and the hardware/software costs for integration of the traffic signal and freeway systems. The cost of the TMC will be worthwhile since it brings all engineering and operations personnel together in one location.

From a review of the information obtained from the 1988 TxDOT survey mentioned previously and a survey conducted in 1991 on freeway operations projects in North America,[(5)] it was found that operations and maintenance costs vary between 7.5 and 11 percent. A value of 9% was selected for this project.

As is shown in Table II - 10, the life cycle cost for the FTM and HOV systems and the TMC will average $8,700,000 per year for installation operation and maintenance (including the TMC costs). This amount includes personnel and vehicle costs.

Funding Summary - It appears at present that funding for the TMC and system implementation will need to be provided from District construction and maintenance/operation funds from State and Federal sources. If Austin becomes a non-attainment area, CMAQ funds may be available as has been the case for the TMC at the Fort Worth District office.

Recommended Implementation/Phasing Summary

Implementation/Phasing Summary - The District's implementation plan shown in Figure II - 12 is based on the installation of 65 miles of FTM. In addition, 25 miles of HOV by 2007 has also been included. It is estimated that the design life of the FTM system will be 15 years. The design life is based on the system components being upward compatible so that minimal changes to the software will be required during the life of the system. The TMC building should be designed for expansion so that its effective design life will be 30 years or more. The implementation plan will be possible to achieve if the system is properly designed at this time to include ITS function and equipment expected to be installed over the next 15 years.

<u>Recommended Phasing Time Schedule</u> - It is anticipated that the new city traffic signal system will begin to be installed by 1998 with completion of the 600+ traffic signal system by 2005. Based on this estimate, it is recommended that a building suitable to house all agencies be completed by 2000 so as to house the entire city/state/public transportation control center at that time. It is also recommended that TMC operators have work stations within the same control room. As previously stated, it is recommended that work stations be provided for each agency in the traffic control room.

It is recommended that the Freeway Traffic Management system be installed within six years. Dividing the installation of systems into relatively short segments as shown in Figure II - 12 will increase the cost per mile of installation. Reducing the installation time from 12 years to five to six years will reduce total cost of construction, permit the implementation of traffic management along an entire section of freeway, and provide information on alternate routes along US 183 West, MOPAC South, and Loop East and/or US 183 South or US 290 East, and SH71 West in lieu of IH 35 during an incident. Reducing construction time to five or six years will also permit more refined integration with the city traffic signal system and the city Public Safety Agencies for incident management on a city wide basis. For these reasons, it is recommended that the planned schedule of deployment shown in Figure II - 12 be escalated to be completed in five to six years. It is also recommended that additional funds be provided for the design of the Freeway Management to assume that the system will be completed within six years.

Regarding the implementation plan, it is recommended that consideration be given for overhead fiber optic cable to be placed as an interim installation along IH-35 as soon as possible with temporary overhead microwave detectors mounted on bridge structures and guide sign structures, CCTV cameras mounted on existing poles, and ramp meter control for use until construction for widening the freeway is carried out. If properly located, most of the equipment could be used during and after widening of the freeway.

References

(1) Traffic Engineering Handbook, 1992, Chapter 12, pp 368 and 369, Institute of Transportation Engineers, Washington, DC.

(2) Marsden, Blair, "Ramp Meters and Travel Quality in Austin, Texas", April 1981, Texas Department of Transportation, Austin, Texas.

(3) Traffic Engineering Handbook, 1992, p 362.

(4) "Operations and Maintenance Needs for Freeway Control and Surveillance", October 1988, Traffic Operations Division, Texas Department of Transportation.

(5) "Freeway Operations Projects in North America - Inventory Update", compiled March 1991, Transportation Research Board, Washington DC.

PUBLIC TRANSPORTATION MANAGEMENT WORK ORDER SCOPE OF WORK

Task - Identify metropolitan areas with desirable AVL/radio characteristics

<u>Task Description and Milestone</u>

It is desirable for an area wide AVL/radio system to have the sollowing characteristics:

- Architecture common to all local agencies
- Equipment compatible among multiple vendors
- Share a common database with traffic control and incident management

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

The work generally consists of compiling summaries of the facilities, equipment, maintenance, personnel, funding, and implementation of a system exhibiting the above characteristic deployed in other metropolitan areas. Two metropolitan areas should be considered.

Facilities include structures or enclosures necessary to house and operate equipment and personnel and its cost. Equipment includes hardware, software, and communications items and their cost. Equipment costs should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of a phased implementation strategy should be included.

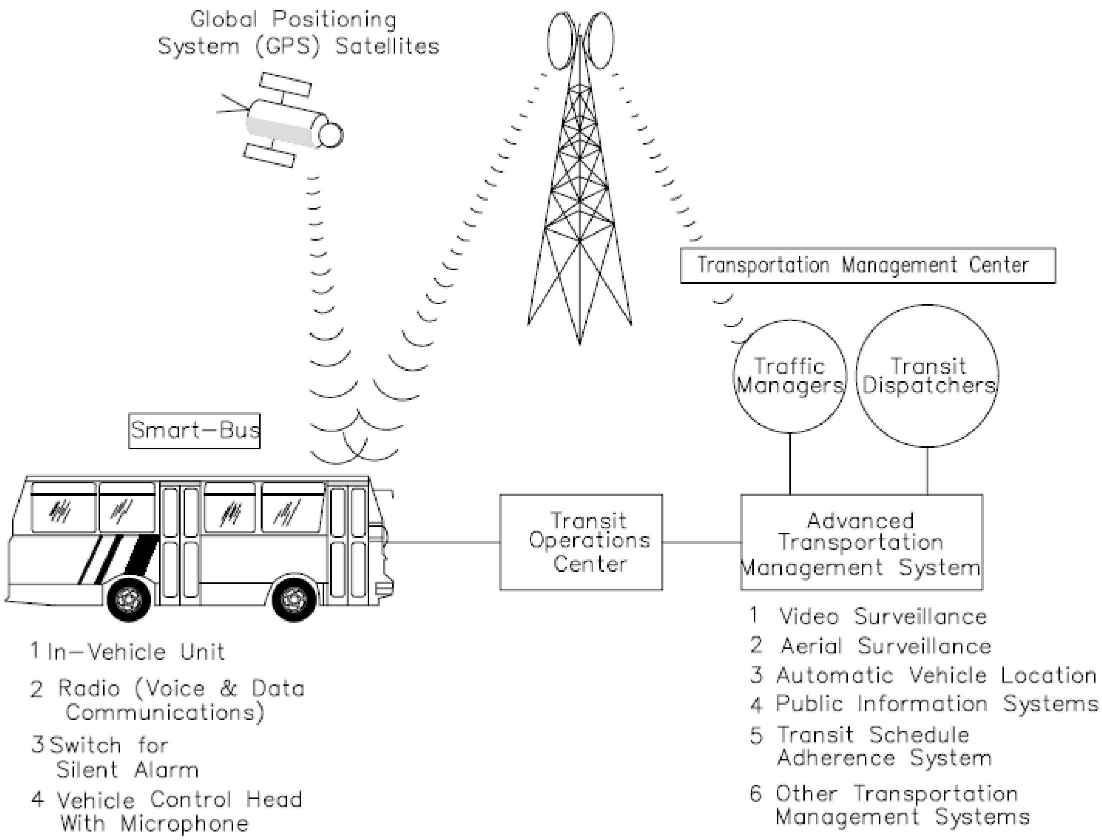
Public Transportation Management

Intelligent transportation systems (ITS) are finding increased applications in public and private agencies especially in the management of large vehicle fleets (i.e., mass transit, emergency vehicles, and transportation fleets). Public and private agencies are incorporating computer-aided dispatch (CAD) systems and satellite based automatic vehicle location (AVL) systems as an integral part of their transportation management strategies. Several transportation management systems using AVL systems were surveyed to develop a basic understanding of the technologies presently used in intelligent transportation systems.

Automatic Vehicle Location System

An AVL system is composed of several sub-systems having specific tasks. In general, an AVL system is formed by a control center, Global Positioning System (GPS), in-vehicle tracking unit, and communications link system. **Figure II - 18** shows the components of an intelligent transportation system using AVL. The GPS was developed by the U.S. Department of Defense for the purpose of providing worldwide navigation data. It consists of 21 satellites that transmit navigation data at all times at no cost to the user. The in-vehicle tracking unit gathers the navigation data provided by GPS and sends it through a communication link to the control center. The in-vehicle tracking unit also transmits vehicle identification and other vehicle status data. The communication link is a system of two-way radio (UHF or VHF) and/or cellular transmission that transmits data from the in-vehicle tracking unit to the Control Center. The Control Center is the brain of the AVL system; in that it processes and analyses the data for the purpose of providing a more reliable and efficient transit system. The Control Center is formed by several components which may vary according to the needs of the specific traffic management system. The principal components are the main computer, mapping controller, and a database bank that form the computer aided dispatch (CAD). **Figure II - 19** shows the components that form the control center for an AVL/CAD system.

An AVL/CAD system can improve transit service reliability, increase the safety of both passengers and drivers, and reduce operation expenses by providing the following features:



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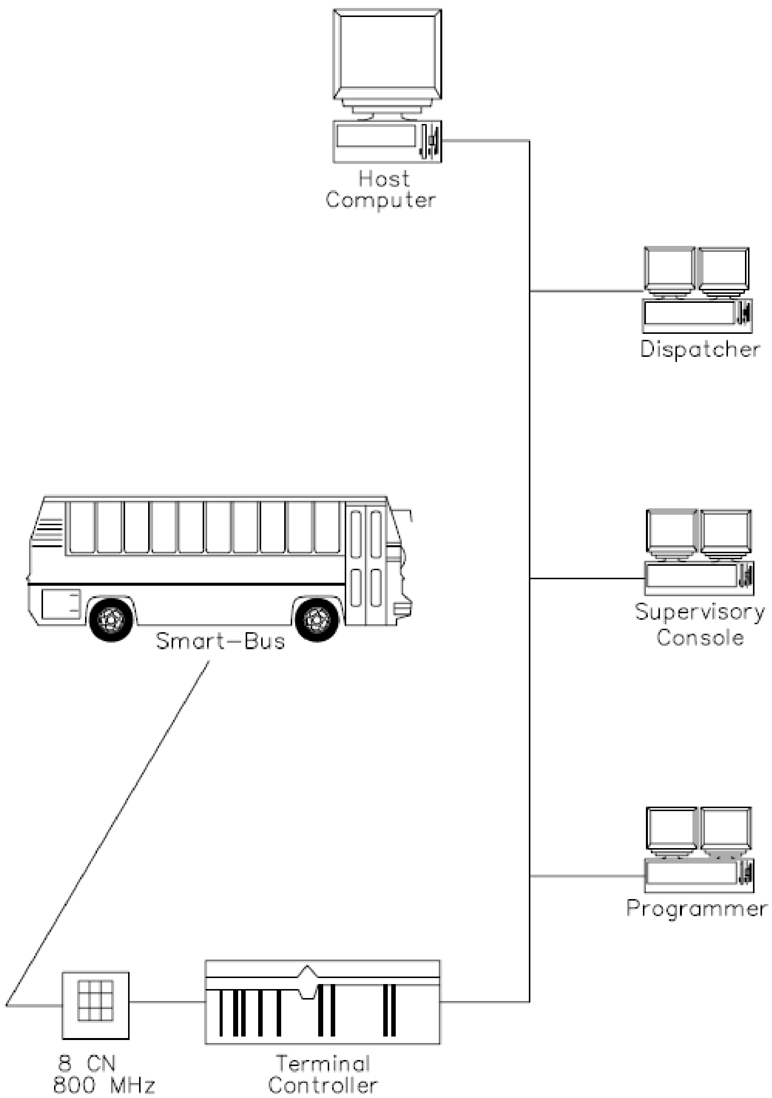
Intelligent Transportation System Using AVL

Austin Area-Wide ITS
Austin, Texas

Figure II-18



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Automatic Vehicle
Locator System
Austin Area–Wide ITS
Austin, Texas

Figure
II–19

- Real-time bus location;
- Difference between scheduled and actual location;
- Location of bus bunching;
- Bus demand information;
- Bus information on current assignment and vehicle status;
- Tracking of off-route busses;
- Recording of incidents, locations, and other data used for management reports and analysis;
- Improving response for emergency and routine situations;
- Improving communication between bus drivers and the control center;
- Providing an alarm system for security of operators and passengers;
- Providing information for planning, scheduling, and information management;
- Providing location of bus stops, time point and land marks; and,
- Providing address matching and temporary detours.

Agency Survey

Five transit agencies located in different geographic regions of the country responded to a survey during August and September, 1995 to gather information regarding current activities in AVL. The principal agencies and/or systems which provided information are:

- Maryland Department of Transportation Mass Transit System in Baltimore, Maryland;
- Minnesota Guidestar Program Travlink, Minneapolis-St. Paul, Minnesota;
- Denver Rapid Transit District, Denver, Colorado;
- Milwaukee County Transit System, Milwaukee, Wisconsin; and,
- Los Angeles Metropolitan Transportation Authority Freeway Service Patrol, Los Angeles, California.

The following other systems were contacted but did not fully respond to the survey: Des Moines METRO Transit System; Orleans Levee District; Scranton's County of Lackawanna Transit System; Oklahoma City's KFOR-TV Fleetservice; New York ITS Real-Time Customer Information System; Detroit's Suburban Mobility Authority for Regional Transportation AVL System; and, Dallas Area Rapid Transit System.

Data obtained from the agency survey of existing AVL systems is summarized in **Table II - 11**. The data identifies that a GPS-based AVL system has been implemented in all five transit/service systems, while data transmission to the control center was conducted using a radio signal varying between 450 and 900-MHZ. The number of dispatch locations varies from one to seven and the number of vehicles equipped with radios, GPS systems, or both vary from 150 to more than 1,000 vehicles.

Milwaukee County Transit System (MCTS)

After the initial survey was complete a more in depth discussion was held with the Milwaukee County Transit System. The Milwaukee County Transit System most closely resembles the City of Austin and Capital Metro of the cities served. The Milwaukee County Transit System in Milwaukee, Wisconsin recently implemented an AVL/radio system with characteristics similar to those desired by Capital Metro and the City of Austin. The MCTS includes an 800 MHz trunked radio system that provides a common voice communications system that will be shared with many other county entities.

Facilities Summary - The MCTS includes 582 buses, 68 non-revenue vehicles, the communications system, and control center. The AVL system has been installed on approximately 525 vehicles to date. The control center includes an 800 MHz trunked radio system at one site (with a planned expansion to a four-site simulcast system with AVL data capability at two sites), four dispatch workstations, and daily download of schedule data to support route and schedule adherence processing.

Equipment Summary - The radio communications system consists of a trunked 800 MHz radio system which is comprised of 8 channels and 1 repeater site. Eventual expansion of the 800 MHz system will result in a total of 15 channels and 4 repeater sites, of which 2 will be AVL data capable. The system also includes the CFE Microwave System. Four workstations for AVL are provided in the operations center, with an additional workstation for radio only communications. AVL equipment is also installed on all buses and non-revenue vehicles.

Table II - 11

Existing AVL Systems
Austin Area-Wide ITS
Austin, Texas

	MARYLAND MTA	MILWAUKEE CTS	DENVER RTD	MINNESOTA TRAVLINK	LOS ANGELES MTA - FSP
System Type	CAD/AVL	CAD/AVL	CAD/AVL	CAD/AVL (ATIS)	CAD/AVL
Equipment:					
Buses with radios	305+	643	1167		
Buses with GPS	200+	582	899	80	
Light Rail Veh. w/GPS	70		22		
OEM Buses	45		244		
Other vehicles	28	61	80		
ATIS Kiosks				3	
Bus stop monitors				2	
CMS at Transit Station				4	
Tow truck with radios					153
Dispatch Locations	4	4	7	1	3
Radio System	490 MHZ 4 voice channels 5 frequencies 3 antenna sites 1 database station per site 4 microwave radios 3 microwave hops	800 MHZ 8 channels 1 repeater site CFE microwave system	450 MHZ 22 base stations 7 voice channels 2 data channels 3 antenna sites 5 microwave hops	450 MHZ 1 data channel 1 database station	900 MHZ 14 base stations 5 voice channels 2 data channels
Service Area	Baltimore City and surrounding Cities.	Milwaukee County	6 counties	Hennedin County	Los Angeles County

Maintenance Summary - Maintenance of the AVL system is currently the responsibility of Westinghouse, because the system has not been officially accepted by the MCTS. Maintenance operations are handled by one Westinghouse maintenance employee and an associate who is occasionally needed to help makes repairs to the system. The one year maintenance contract between Westinghouse and MCTS cost approximately $300,000.

Personnel Summary - The MCTS AVL system is controlled by a small team of dispatchers who operate the workstations in the control center, in addition to the numerous bus drivers required to drive the buses. During heavy time periods, two to three dispatchers are required to operate the system, with an additional employee supervising the operation. All four workstations in the operations center are not operated at one time.

Funding Summary - Funding for the MCTS AVL system totaled approximately $8.3 million dollars. This included approximately $5.2 million for an 800 MHz trunked radio network (including all hardware) and $2.6 million for the AVL system for a total of $7.8 million. In addition to the $7.8 million, approximately $300,000 was allocated for maintenance and $200,000 for change orders for a grand total of approximately $8.3 million.

The 800 MHz trunked radio network includes the infrastructure to operate up to 15 channels, with 6 channels reserved for the transit system. The cost also includes the installation of radios and other hardware for 600+ buses and other vehicles operated by the MCTS. The remaining 9 channels will be available for use by other agencies, such as the police department, fire department, and emergency medical services, with those agencies funding their own radios and other hardware. Each radio/hardware system for each vehicle cost approximately $1,800.

The implementation costs for the AVL system totaled approximately $2.6 million and included equipment and installation for approximately 600 vehicles. The AVL equipment was estimated at approximately $3,500 per bus. The software system designed for both the AVL and 800 MHz systems cost approximately $1.6 million, but it is unknown how much of this cost was attributed to each system. The software cost is included in the total cost of $7.88 million.

Implementation/Phasing Summary - The system was initially implemented beginning in 1992 with Phase 1 including a test of all hardware and prototype software on 15 buses. Phase 1 was completed in June 1994. By the spring of 1995, installation was complete on approximately 602 total vehicles, including both buses and other non-revenue vehicles. The control center and workstations began operations in January 1995 under the direction of the contractor. The contractor must complete an extensive testing and evaluation phase before the MCTS will accept the system and provide payment for services. Final acceptance testing is anticipated in February, 1996 at which time the MCTS will assume responsibility for the entire system.

Cost Estimate for AVL Systems

There are four components used to determine the cost of implementing an AVL system. These components are as follows:

- Number of buses and support vehicles using AVL and radio systems;
- Type of radio system, number of channels and capabilities of data processing;
- Number of dispatch locations required and number of remote dispatch locations; and,
- Type of software implemented in the scheduling of buses.

The cost of the control center is rather small on a per bus system for a transit system as large as Capital Metro (375 buses). The central office cost portion of the system is generally covered by the installation of a new radio system. If a new system is added to an existing system that has the capabilities of accommodating an AVL system, the central office portion is only several hundred thousand dollars. A general guideline used by the systems surveyed in determining the cost of installing an AVL system is an estimate of $10,000 per bus. The maintenance and operating costs were covered in the Cities' general dispatch systems. Systems have been installed using a combination of federal, state, and local funds. The Capital Metro is in the process of upgrading their radio system as part of their SMART BUS Program.

ROADWAY INCIDENT MANAGEMENT
SCOPE OF WORK

Task - Identify resources to share traffic control with emergency vehicle management

Task Description and Milestone

The work generally consists of recommending data that should be shared between traffic control and emergency management services. A centralized emergency computer-aided dispatch (CAD) system is housed at the Austin Police Department. There is no direct link to traffic control services, though one is desired.

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

Summaries of the facilities, equipment, maintenance, personnel, funding, and implementation needed to share the recommended data should be provided.

Facilities include structures or enclosures necessary to house and operate equipment and personnel and its cost. Equipment includes hardware, software, and communications items and their cost. Equipment costs should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of a phased implementation strategy should be included.

Roadway Incident Management

It is estimated that the population of Austin will increase from 510,637 in 1995 to 672,700 by 2005 which is a 32% increase. It is also estimated that the Austin Metropolitan area will increase from 657,136 people in 1995 to at least 876,289 people during 2005 which is a 33% increase. This anticipated increase in population will significantly add to the number of vehicles on city freeways and streets over the next 10 to 15 years as well as develop a demand for increased use of public transportation.(1)

In addition, the number of trucks are expected to increase -- especially along IH 35 as a result of the North American Free Trade Agreement (NAFTA) as discussed in The Commercial Fleet Management Section of this task. Unless steps are taken to improve traffic management along IH 35 and Loop 1 (MOPAC), an increased number of incidents with increasingly significant delays can be expected over time. This applies both to delays during peak periods caused by normal congestion recurring each week day and to delays caused by incidents. Because of this, measures must be taken to locate incidents and to overcome the effects of these incidents as quickly as possible.

"An incident is any non-recurrent event which causes reduction of roadway capacity or abnormal increase in demand."(2) Roadway incidents can include:

- accidents;
- vehicle breakdowns;
- roadwork activities;
- special events;
- inclement weather (snow, ice, flood); and,
- disruptive activities adjacent to the roadway.

Roadway incidents have been found to constitute an average delay of 55 to 60% on freeways.(5) This can be explained to a certain degree by noting the results of a study conducted along IH 45, Gulf Freeway, in Houston. As is shown in **Table II - 12**, reductions in capacity from 26% to 79% were found to occur on the three-lane freeway during an incident.(6) It is important to note that an accident or other incident on a shoulder can reduce the capacity of three lanes by 26%. Also, the blockage of one of three lanes reduces the capacity of three lanes by 48 to 50% whereas one lane normally carries

Table II - 12

Typical Capacity Reduction
Austin Area-Wide ITS
Austin, Texas

ROADWAY INCIDENT TYPE	CAPACITY REDUCTION (PERCENT)
Normal flow (three lanes)	-----
Stall (one lane blocked)	48
Noninjury accident (one lane blocked)	50
Accident (two lanes blocked)	79
Accident on shoulder	26

33% of the traffic. The same phenomenon applies to the blockage of two lanes. The blockage of two of three lanes, which normally carry 67% of three lanes, reduces the total capacity by 79%.

In addition, roadway incident caused congestion can lead to secondary accidents. A study on one freeway in Minneapolis, Minnesota showed that 13% of all peak period accidents occurred as a result of a preceding roadway incident.(3) The effects of roadway incidents on pedestrians must also be considered. Studies have shown that 20 to 30 percent of pedestrian fatalities on freeways involved disabled vehicles.(4)

Roadway incident management is an important factor in reducing delay and, as a result, secondary accidents. A study in Los Angeles showed that for each minute of delay due to an incident, the delay to each motorist would be four to five minutes.(5) This finding is supported by a separate study on IH 45 (Gulf Freeway) in Houston. It was estimated in the IH 45 study that a one-lane blockage on the Gulf Freeway lasting 18 minutes would cause 800 vehicle-hours of delay. If roadway incident management cut this in half (9 minutes), only 200 vehicle hours of delay would result.(6)

The same hardware and software systems needed for Traffic Management identified in Chapter 3 and 4 are also needed for incident management. These include:

- Traffic responsive traffic signal system;
- Freeway Control (e.g., ramp meter control, CMS, LCS);

In addition, traveler information provided to motorists approaching the city and to commuters leaving their home and office apply to both traffic management and incident management.

The proposed Traffic Management Center (TMC) plays a vital part in both traffic management and incident management in that it provides for:

- Integrated Traffic Management between the City and the State traffic control systems;
- Close coordination of personnel within the agencies;
- Sharing of information between agencies;
- Coordination with multi-modal transportation (buses, trucks, HOV); and
- Rapid information dissemination to the news media.

The integrated City-State traffic management system and proposed TMC are only one part of roadway incident management. Roadway incident management involves much more and involves additional agencies. These are the police, 911, fire, emergency medical services, motorist aid patrols or courtesy patrols, sheriff, constables and volunteer fire (collectively known as Public Safety Agencies). Transit agencies are also involved.

Roadway Incident Management System Concepts

A Roadway Incident Management (RIM) system can be applied to all roadways. This system would include both the arterial and freeway network if desired. The following discussion is oriented towards the freeway system since TxDOT has already programmed the implementation a RIM system. However the same concepts could be applied to the Austin Area arterial street network. There are several elements of roadway incident management. All parts must fit and work together if:

- roadway incidents are to be detected and verified quickly;
- roadway incident management vehicles are to be dispatched without delay;
- vehicles involved in an incident are to be rapidly removed;
- motorists are to be advised of hazardous conditions and congestion (or slow speeds) ahead;
- traffic is to flow smoothly to and from a special event; and,
- traffic is advised of roadwork ahead.

The overall concept must be to improve communications, cooperation and coordination. This can be achieved through the addition of each of the following applications.

Preplanning - There is a need for agencies to work together in preplanning so as to assure that each agency will know what to do in the event of a specific incident. This is especially important for handling major incidents.

For accidents, each agency's responsibilities needs to be known. Also, it is important to know who is in charge. For example, in a hazardous spill and fire (or potential fire) situation, the fire department would appear to be in charge with the other agencies providing support as agreed upon in prior discussions. The police would be in charge at major accidents involving several agencies and special events. PSA would be in charge where injuries are involved until those injured are cared for (e.g., removed from the scene). For roadwork, vehicle breakdowns, and inclement weather, the city or state traffic management personnel could be best suited (depending on conditions). An understanding needs to be developed as to which agency will be in charge. In unusual circumstances not covered by normal conditions, it would appear that the police would be in charge.

Preplanning for alternate routes, traffic signal changes, CMS/LCS messages, frontage road priority use, special event coordination, as examples, eliminate the chance of making an incorrect decision and/or confusion during an incident.

It would also be desirable to develop a Roadway Incident Management Team consisting of trained personnel from the different agencies. Personnel from each agency will not be required in each type of incident. When called upon to participate, each team member called upon to work as part of the team for a particular incident will need to know ahead of time his or her responsibilities and what steps need to be taken and who will do them. The team should have back-up members who can either substitute for or be called up when additional personnel are needed. The team members would be drawn from city/county/state personnel who have other full time jobs but can be made available as necessary. This approach is carried out effectively in California. The Roadway Incident Management Team should have vehicles equipped for incident management, which could include a command vehicle used in major incidents.

Preplanning could also be carried out through the existing Austin Traffic Management Team (TMT) concept with joint meetings at the proposed TMC. The TMT consists of second level supervisors from city, county, public transportation, state and federal offices including some or all of the following:

- Manager of the proposed TMC;
- Police lieutenants in charge of traffic;
- Public transportation operations coordinator;
- Fire department supervisor;
- EMS supervisor;
- Department of Public Safety lieutenant;
- County engineer; and,
- MPO representative.

The TMT members discuss traffic and transportation problems involving mobility and safety -- usually at monthly meetings. The TMT would discuss roadway incident management problems and provide support to a Roadway Incident Management Team as part of a preplanning process. The TMT would also provide an approach for overcoming institutional issues which might occur regarding support for the Roadway Incident Management Team. Examples include:

- Smoothing the way for acceptance between all agencies where incidents might involve several organizations (e.g., more than one city or city and county);
- Help in developing procedures which involve others not normally involved;
  - Contractors in construction areas;
  - Utility companies in construction areas;
  - Maintenance personnel not normally involved;
- Assist in obtaining necessary personnel and materials from agencies by being a "spokesperson"; and,
- Assuring that proper commercial wrecker services are provided.

The TMT could be the supporting arm of the Roadway Incident Management Team in providing the necessary assistance.

Incident Detection/Reporting - There are several modes of roadway incident detection typically used in urban areas throughout the country. These include:

- 911 and/or a separate number of reporting incidents;
- Electronic detection (detectors), vehicle transponders (toll tags);
- Motorist Aid Patrol (Courtesy Patrol);
- Other Public Vehicles (Maintenance, Police, Bus) through use of proposed 800 Mhz frequency;
- Commercial traffic information services;
- Aerial surveillance;
- Call boxes;
- Fixed observers; and,
- CCTV.

These modes of detection, when brought together in one location such as a TMC, can each provide traffic information which can be effectively used to provide the operator of the proposed TMC with an effective picture of what the problem is and how the problem can be overcome.

Dispatching and Information Dissemination - When an accident or vehicle breakdown is detected, verified, and required action determined, the traffic management operator together with personnel from other agencies at the proposed TMC will call for the agency(ies) or the Roadway Incident Management Team to take care of the problem. During the preplanning activity, coordinated activity can be determined (e.g., who will be needed to do what) under different levels of incident severity. For instance, where a vehicle is stopped on the shoulder or adjacent lane, the courtesy patrol called to provide for the vehicle needs. If necessary, the vehicle(s) will be removed from the freeway by the courtesy patrol vehicle or wrecker. If necessary, the courtesy patrol can ask for police assistance in convincing the motorist that the vehicle needs to be moved.

At this stage, as well as Levels I-V discussed below, it is essential to remove vehicles from the freeway main lanes and shoulder as quickly as possible. In fact, Chapter 4, Uniform Act, Section 39 of the Texas Traffic Laws, issued by the Texas Department of Public Safety requires that motorists involved in an accident must move their vehicles from the freeway if all vehicles involved in the accident can be driven. Also courtesy patrol assistance should be provided free of charge (e.g., gallon of gas, water in the radiator, tire inflator kit, radiator stick) sufficient to get a stalled vehicles off the freeway as quickly as possible. Courtesy patrol vehicles should be provided with bumpers designed to push vehicles from the main lanes of the freeway. If a vehicle cannot be started, it should be pushed from the freeway for the protection of the driver and his vehicle, the courtesy patrol vehicle and all motorists on the freeway. Removing vehicles eliminates "rubber necking" by motorists in opposing lanes of traffic.

In addition, vehicles should be towed or pushed to Accident Investigation Sites (AIS), where available, or to a location out of the main lanes. Moving vehicles so they cannot be seen by motorists on the freeway main lanes is essential in eliminating "rubber necking" by freeway motorists. Accident investigation should be made at the AIS or at a location off the freeway and out of sight of freeway motorists. The use of AIS has been found to have a 28 to 1 benefit to cost ratio.

There are five levels of response which are required when the incident problem is beyond the stage noted above. These levels are determined during the preplanning activity and reviewed periodically to assure that everyone understands and agrees to the action required. The following is based on the incident management procedures developed for the IH 287 New York State Freeway in Rockland County, New York. The complete procedure is provided in **Appendix II - B**.(2)

1. **Level I** - When a roadway incident occurs that has serious implications, initial preparation should be taken to handle a more serious event if it occurs.

   - Police/fire/wrecker(s) are dispatched;
   - The commercial radio stations are advised;
   - CMS, LCS and HAR are placed in service;
   - Preplanned alternate routes are inspected and the best route chosen for possible use. Each alternate route has permanent fold out signs; and,
   - Detours may be required (e.g., use of shoulder and/or frontage road).

2. **Level II** - Traffic is light and expected to be cleared before heavy traffic demand occurs.

   - Level I action is taken;
   - The Primary Alternate Route is to be used for local traffic. This may be the frontage road. Traffic signal timing patterns are changed along the route;
   - Commuters are advised to carpool or take transit by radio and television;
   - The Alternate Route signs are opened; and,
   - Agencies prepare to provide added personnel.

3. **Level III** - Congestion has occurred and it is timely for motorists to take the Alternate Route.

   - Levels I and II actions must be taken;
   - Motorists are advised to use the Alternate Route; and,

- Personnel from agencies assign personnel to emergency points to prevent grid lock along the Alternate Route.

4. **Level IV** - At this level, congestion is affecting congestion on the surrounding roadway network. Motorists should take the extra time to divert.

   - Levels, I, II, and III actions must be taken; and,
   - Motorists are advised by radio which entrance ramps are closed and possible alternate routes to be taken.

5. **Level V** - At this level, the roadway will be closed for a long period of time -- for as long as one or more days.

   - Levels I-IV are implemented;
   - Special signing is installed for long term diversion; and,
   - Work with the Emergency Management Center.

An approach for alternate plan development is given in **Appendix II - C**.[(2)] For Type III-V accidents, a command post should be established at the scene of the accident. The command post provides a location for all involved in management of the incident to report to initially and throughout the incident. Roadway incident management personnel finalize the preplanned incident management procedure at the command post. The command post is also the communication center for reaching the TMC control center and field personnel.

The command post can be a designated car or truck, a tent, or a specifically designated command vehicle (van or mobile home type vehicle). Specially designed command vehicles are used for major sites in California.

Roadwork - Generally, construction and maintenance roadwork can be scheduled in time to let agencies know. The maintenance work can be coordinated between the maintenance foreman and the manager at the proposed TMC. Affected agencies can be advised and appropriate action scheduled as needed.

Construction work should be reviewed by the design/project engineer and TMT members and the design/project engineer. Since roadway construction affects the surrounding areas for a long period of time, all agencies should know ahead of time about the sequence of work and how it will affect them. The manager of the TMC will coordinate operations with the project engineer and other agencies during construction and as detours are made.

Special Events - Special events are scheduled ahead of time which gives the TMT and those scheduling the event time to develop plans for handling traffic, locating park and ride lots to encourage bus ridership and developing special bus routes to and from the event. The various agencies affected will be able to coordinate with the TMC manager prior to, during and after the event. It has been found that preplanning pays big dividends in traffic handling and utilization of buses at the special event.

Inclement Weather - Inclement weather comes in many forms. It may consist of rain or ice which could cause accidents requiring various levels (Levels I-IV) of roadway incident management depending on severity and length of time. Normally, people stay home if the weather persists for more than one day and night. However, preplanning is needed to determine action to be taken by each agency.

Review of Actions Taken - A review needs to be made of the actions taken during the incident once the incident is cleared. This action permits the agencies to know what went well -- or bad -- and what can be improved the next time. The conclusion should be entered into a log and the plan changed as necessary.

Existing Emergency Operations Center

The Travis County/City of Austin E911 Communications Center, referred to in this report as the Emergency Operations Center (EOC), located within the City of Austin Police station houses personnel from:

- Police Department;
- 911;
- Fire Department; and,
- Emergency Medical Services (EMS).

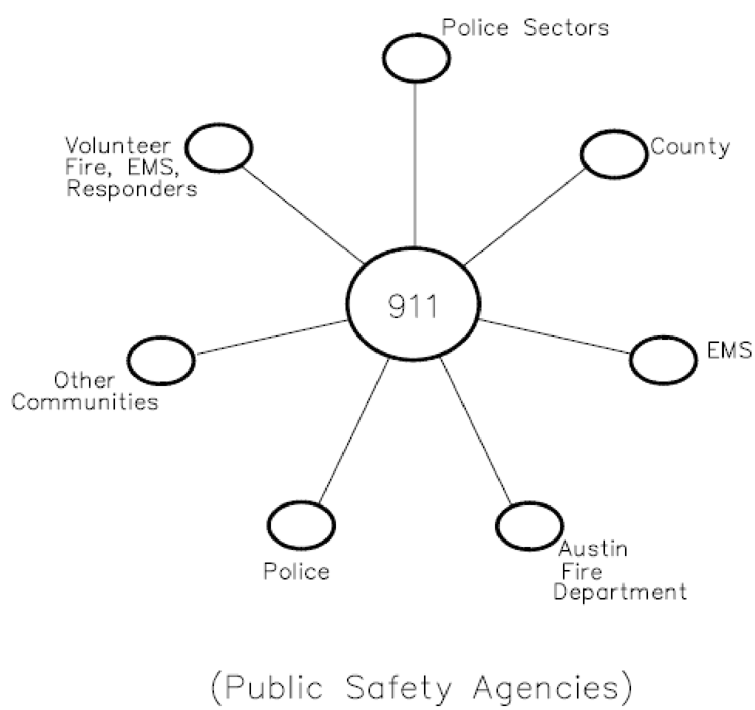
The personnel are located together on one floor and have communications with each other by telephone and voice. The organization works well because of the personnel's desire to work together and the support provided by the city administration.

Basically, 911 is the main communications used for the Emergency Operations Center. As is shown in **Figure II - 20**, calls are received and distributed by the 911 operators. The Computer Aided Dispatch (CAD) system is also used as a communications medium by 911 operators as well as by the other public safety agencies. Public safety agencies have recently begun rerouting non-emergency 911 calls to a non-emergency 911 center. Police, Fire and Emergency Medical Services (EMS) share a common CAD system. The police utilize a computer aided dispatch system in managing calls. The Police Department handles enforcement and accident calls received by 911 operators. All injury reports go to the police and then are routed to EMS. The Police Department works with TxDOT in the operation of the Changeable Message Signs (CMS) and Lane Control Signals (LCS). This function will increase as more CMS and LCS are installed within the city.

The Fire Department and EMS handle calls involving their services. The Fire Department often sends one of its units to a 911 call first and the EMS unit takes over when its unit reaches the scene. The Fire Department also uses an additional personal computer based radio dispatch system to alarm fire stations. A flow chart of the management of calls is given in **Figure II - 21,** and **Appendix II - D**. The CAD system includes a software package that gives the length of travel time for each link which can be of help in routing vehicles. Travel times are determined by driving the links.

System Expansion - Several studies are underway for the development of an updated emergency services system which will provide improved service response and the development of an improved communication system. The studies include an analysis of the:

- 911 System and Operations;
- Computer Aided Dispatch (CAD);
- Geographic Information System (GIS);
- 800 Mhz Radio Trunking System;
- Mobile Data Terminals (MDT); and,
- Global Positioning System (GPS).



Source: City of Austin, 1995.

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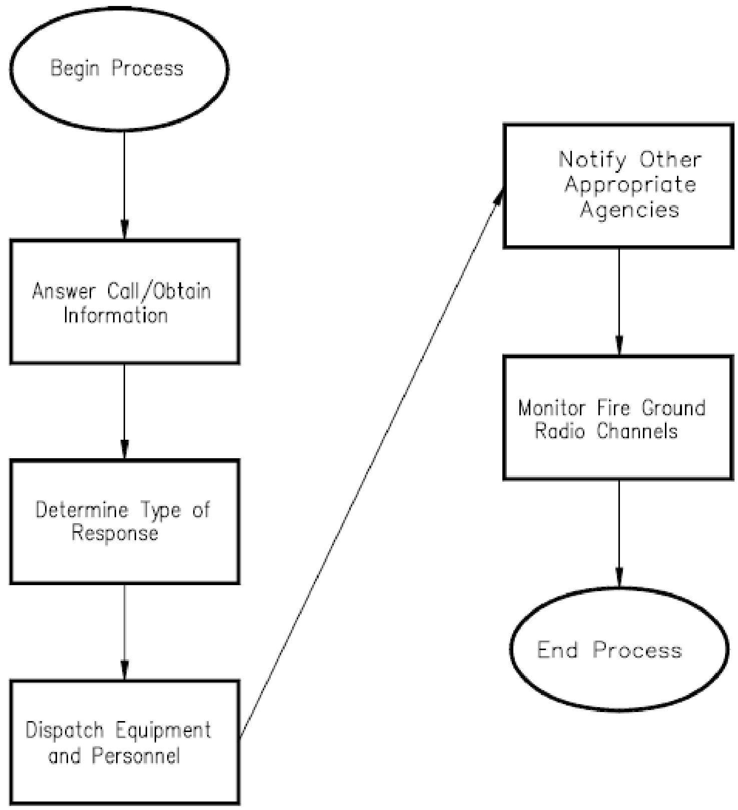
Existing 911 Operations
Emergency Operations Center
Austin Area-Wide IVHS
Austin, Texas

Figure II-20



Source: City of Austin Fire Department, 1995.

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Austin Fire Department Dispatch Process

Austin Area-wide ITS
Austin, Texas

Figure II-21

These studies are being carried out in three phases:

- Phase 1 - Needs Assessment, Conceptual Design and Cost Estimates;
- Phase 2 - Licensing, Specifications, Evaluation and Funding; and,
- Phase 3 - Contract Award and Implementation.

It is planned for the system to have improved land line and radio communications, and to have a GIS system which will provide more accurate information. Cost estimates and conceptual design information for the proposed system expansion are undetermined at this time.

One of the studies involves finding a more desirable location for the EOC or Emergency Safety Center (ESC) and building. The building will be approximately twice the size of the present center. It would be desirable for the Center to be located:

- Away from a major public building;
- Away from a freeway;
- Where there are two access routes;
- At a site where high water due to floods is not a factor; and,
- In a secure site with restricted access to visitors.

Sharing Traffic Control Data

A primary objective of the Public Safety Agencies is to operate more efficiently and achieve a more rapid response in providing their services. The agencies also mentioned a desire to develop a joint TMC but they also have the need to meet the location requirements mentioned above. They agree that a joint center will permit a closer coordination with state and other city transportation agencies in traffic handling and reaching the scene of an accident or other emergency. All agencies involved have expressed a strong desire to work together in sharing information and data.

There is also a need to maintain close contact with the proposed Emergency Safety Center (ESC) or Emergency Operation Center (EOC). The proposed (ESC) is being designed to bring agency administrators together in case of a disaster. This could include a Type V accident discussed previously. The proposed TMC will also need to maintain close contact with the proposed ESC. It would be desirable to coordinate information to the proposed ESC from a TMC.

Information of Benefit to the Public Safety Agency - The integrated city/state Advanced Traffic Management System (ATMS) should be designed to make available all traffic data and CCTV to the PSA personnel. This would include EMS work stations located at the TMC traffic control room. Information which the Emergency Management System personnel do not initially consider useful may be found to be useful in the future. Also, since the ATMS will be flexible and modular in design, it should be possible to modify software so as to provide desired information which would be of benefit to the PSA personnel at a later date.

Selected information which could be of benefit to each PSA agency is given in **Table II - 13**. This information can be used as desired. Other information given in Table II - 5, shown previously, can also be made available.

Information of Benefit to the Proposed Traffic Management Center - It would be of considerable value to know traffic conditions and problems being experienced by the PSA personnel. The information needed is given in **Table II - 14**. The information received will be of benefit in carrying out traffic management during incidents as well as during normal periods of congestion.

The sharing of information and coordination between agencies will be of significant benefit. In addition, person-to-person contact and knowing who to contact in case of an emergency will be of primary importance in managing an incident.

Locating one or more police officers in the TMC control room will permit the police to have direct police contact with the officer at the scene of an incident. The officer at the TMC can monitor the CCTV at the same time as the traffic management personnel and agree on action that needs to be taken. The officer at the TMC can then recommend actions to the officer in the field. The same approach could apply for the management of traffic around fires through direct communications between the fire, police and traffic management personnel in the TMC control room.

Table II - 13

Traffic Information Provided to Public Safety Agencies by the City and State Traffic Management Agencies
Austin Area-Wide ITS
Austin, Texas

Information
Incidents located by TMC
Wall Map Display of Level of Service in Color or Arterials (Red for Congestions, Yellow for Crowded Lane Conditions, Green for Free Flow). Also available on PC monitor for Operator use in conjunction with GIS System.
Incident Location Shown on PC and/or Wall Map
Travel Time Along Links on Major Arterials
Status of Queue Lengths Due to Incidents
Estimated Delay Caused by Incident Along or Adjacent to Freeway, Major Streets and Major County Roads
Location of Courtesy Patrol Vehicles
CMS and HAR Messages and LCS Displays*
Location of Water Across Highways and Streets and Icy Road Conditions
Maintenance and Construction Activities Underway on Freeways, Major Streets and County Roads
CCTV Pictures as Requested
Additional Information Can be Provided Upon Request
Request for Support by City, State or Capital Metro
* Utilized as needed by each agency.

Table II - 14

Information Provided to the Traffic Management and Capital Metro from the Public Safety Agencies
Austin Area-Wide ITS
Austin, Texas

Information
Location of Emergencies Reported to 911 Which Could Affect Traffic Conditions (Accidents, Fires, Public Disturbances)
Reports on Locations with Congestion Which Need Traffic Improvements and High Accident Experience Locations Which Need Enforcement
Location of Water Across the Street or Highway and Icy Road Conditions
Emergency Vehicles Dispatched which Affect Vehicle Preemption of the Traffic Management System
CMS and HAR Messages and LCS Displays in Effect*
Request for Support by TxDOT or City
* Recommend Coordination with TMC Before Implementing Messages and Displays

Recommended Roadway Incident Management Program

The recommended Roadway Incident Management Program for the Greater Austin area involves closer coordination between various service providers and an areawide operations center. The following paragraphs identify facilities, equipment and personnel needed for the program, as well as summaries of maintenance activities, funding, and implementation.

Facilities - Based on the above discussion, it is recommended that a closer coordination be obtained between the Traffic Management and Public Service Agencies. This can best be handled through a joint Austin Regional Operations Center (herein called the TMC). The proposed TMC would locate the Traffic Management Control Room and the Public Service Agencies Control Room contiguous to each other on the same floor. The police officer stationed in the Traffic Management Control Room during the peak periods could be available to work with the traffic management personnel as needed during peak periods while working full time in the Public Service Agencies Control Room during off peak periods. The Traffic Management Center Control Room will have work stations available for TxDOT, City and County traffic management personnel and for Public Service Agencies and Capital metro personnel. An "Operations Room" should be available next to the TMC Control Room for traffic management and emergency services personnel to develop strategies prior to and during incidents. Information would be available in a Work Station format for the personnel in the Operations Room to analyze and telephones available to personnel in each agency. In addition, communications, including video, should be provided for video conferences and data sharing between the Operations Room and the Emergency Operations Center. Radio communications should also be provided as a back up when land line communication is not available. The video conference communications should be provided through the GAATN system.

It is estimated that the joint Traffic Management and Emergency Management Control Area (Operations Control Area), including the Operations Room or Rooms, will be 16,000 sq. ft. Two Operations Rooms may be desired - one for Public Safety Agencies and one for Traffic Operations. This would provide 11,000 sq. ft. for the Public Safety Agencies and 5,000 sq. ft. for traffic management. The 16,000 sq. ft. would provide for up to 100 Public Safety personnel and 40 personnel from Traffic Management and Transportation Information related organizations (e.g., Capitol Metro, Texas Department of Public Safety, Courtesy Patrol) listed later in Table II - 21. It is recommended that the Operations Control Area be located so that it could be expanded in some manner in the future (e.g., locating offices adjacent to the Operations Control Area which could be removed to make way for expansion of the Operations Control Area, when needed).

Since the Emergency Management Services Control room will be in operation for 24 hours a day, consideration should be given to allowing preagreed upon traffic management strategies to be carried out by the Police Department.

Equipment Summary - The hardware previously recommended for the Traffic Signal System (TSS) and the Freeway Traffic Management System (FTMS) is also capable of supporting Incident Management/Verification/Response simultaneously with Traffic Signal and Freeway Traffic Management control. The hardware includes:

- TSS Local Intersection Controller/FTMS Local Control Unit:
  - 2070/ATC
  - 170/AIB
- Vehicle Detectors:
  - Inductive Loops
  - Video Image Processing
  - Microwave Detectors
  - Infrared Detectors
- Roadway Surveillance Equipment
  - CCTV
- TSS Central System/FTMS Computer Unit
  - Networked Pentium-type PC workstations with bi-directional links to Police/Fire/EMS CAD System

Additional hardware would need to be provided on the Police/Fire/EMS CAD System to allow for this bi-directional link.

Software that provides roadway incident detection capabilities and data sharing capabilities should be added to the software recommended in Chapters 3 and 4. Roadway Incident Detection Software for the Local Controller should provide incident alarms to the TSS/FTMS Central/Computer Unit. These alarms are calculated by measuring parameters i.e. volume, speed, and occupancy at each vehicle detector location (upstream and downstream). A roadway incident is detected based upon any of these parameters exceeding threshold limits.

When an alarm occurs, CCTV could be used at the TSS/FTMS to verify the incident. A computer message would then be sent from TSS/FTMS to the Police/Fire/EMS CAD system once verification is complete. The software referenced previously in the City of Austin Traffic Signal System Section and in the TxDOT FTM Section (i.e. ramp metering, signal coordination, emergency vehicle pre-emption, changeable message signs with diversionary route information, routing alternatives, etc) would be initiated by the TSS/FTMS system.

Linkage Software for Bi-Directional Communications between the TSS, FTMS, and Police/Fire/EMS CAD System to allow messages to be sent between the TSS, FTMS and Police/Fire/EMS CAD System should also be implemented so that all agencies are notified of incidents. The TSS and FTMS should be notified of all incidents that might have an effect on traffic flow. The TSS and FTMS could be utilized to improve response to the incident and increase safety.

Maintenance Summary - Since the electronic equipment used within the total system is basically the same as that used in the FTM and Traffic Signal Systems, it is anticipated that the maintenance costs percentage will be about the same. This could amount to between five and seven percent per year of the cost of the equipment and software, depending on the complexity of the E911 Communications System and whether maintenance personnel are available or if a maintenance contract is used. The maintenance cost noted does not include operations costs which are included in the operational costs of the Traffic Management Center.

Personnel Summary - The Emergency Safety Center staff is expected to double (which should require at least twice as much space as is available at present) in the future. The staffing in the TMC Control Room for the TSS and FTM system will also double from three personnel each for TSS and FTM (six total) to six personnel each for TSS and FTM (twelve total) over the next 10 year period. The remaining personnel shown in Table II - 21 should remain unchanged during this period.

Funding Summary - It is concluded that the additional funding for data sharing should be negligible and absorbed in the traffic management system costs previously discussed if the system is designed initially to accommodate the traffic and incident information requirements.

Implementation/Phasing Summary - It is important for the Traffic Management and Public Safety Agencies personnel to work together in incorporating data sharing needs into their systems at this time so as to assure that it will be available when the new systems are implemented. This will reduce overall costs and improve efficiency in operation.

The Integrated Emergency Safety Center/Traffic Management system should be designed so that they can be operated at separate locations if necessary until a permanent Austin Regional Operations Center is built. Communications can be carried out over GAATN, a fiber optic loop along the freeway system, radio and telephone. It would be desirable, however, to initially provide for all services in one Austin Regional Operations Center.

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2. Freeway Incident Management Handbook, July 1991, U.S. Department of Transportation, Federal Highway Administration, Washington, DC.
3. Lari, Adeel, et al, "IH 35 Incident Management and the Impact of Incidents on Freeway Operations", Minnesota Department of Transportation, January, 1982.
4. Ulmer, Robert, et al, "Analysis of the Dismounted Motorist and Road Worker, Model Pedestrian Regulations", DOT-HS-806-445, NHTS, August, 1982.
5. Traffic Engineering Handbook, Fourth Edition, 1992, Chapter 12, Institute of Transportation Engineers, Washington, DC.
6. Dudek, Conrad L., Freeway Incidents and Special Events: Scope of the Problem, Circular 326, December 1987, Transportation Research Board, Washington, DC

EMERGENCY VEHICLE MANAGEMENT SCOPE OF WORK

Task - Identify resources to monitor 800 Mhz radio network transmissions

Task Description and Milestone

The work generally consists of identifying methods to use an 800 Mhz radio network to detect and verify incidents.

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

Summaries of the facilities, equipment, maintenance, personnel, funding, and implementation needed to share the recommended data should be provided.

Facilities include structures or enclosures necessary to house and operate equipment and personnel and its cost. Equipment includes hardware, software, and communications items and their cost. Equipment costs should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of a phased implementation strategy should be included.

Emergency Vehicle Management

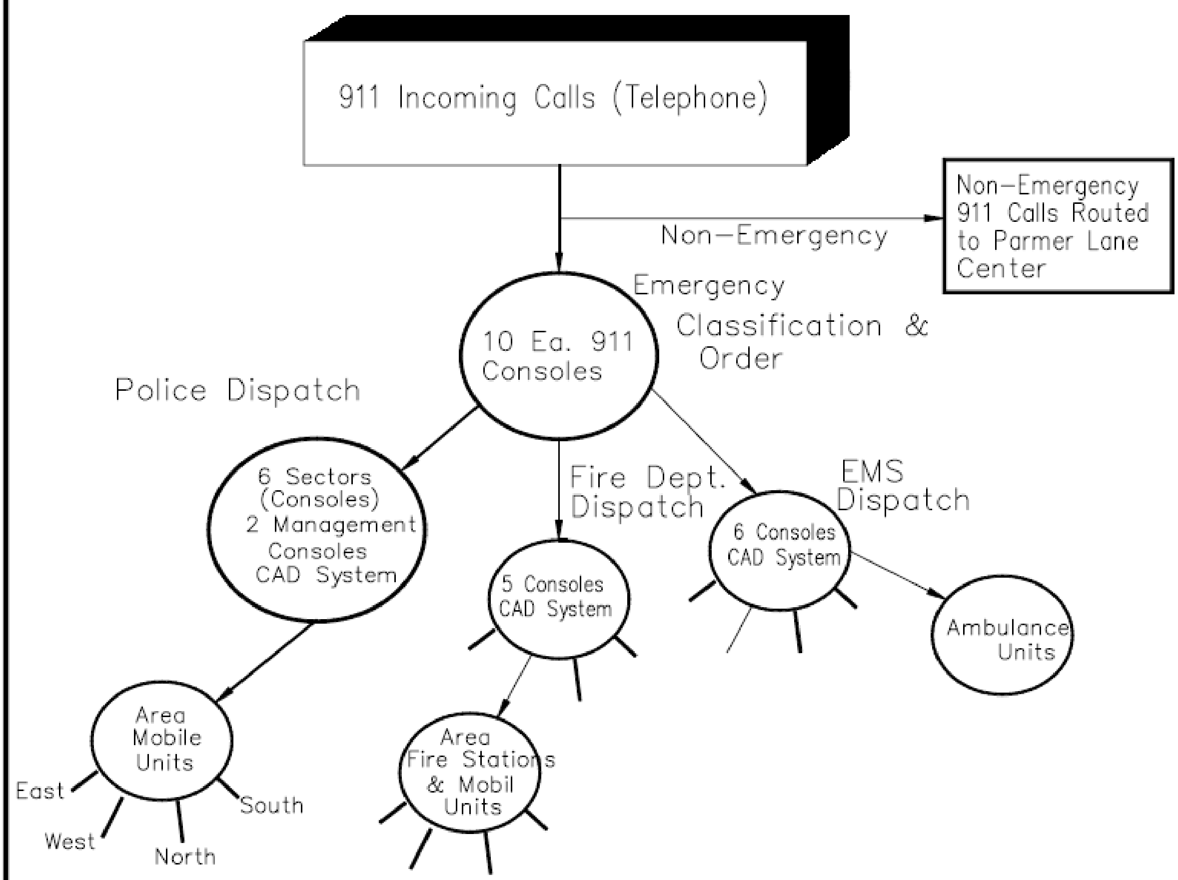
It is important for agencies to communicate with each other in carrying out traffic and incident management. This is especially true when several agencies exist within a regional area. Part of this communication includes the utilization of radio communications between the agencies. Rapid communication can be achieved when traffic and management emergency vehicles have access to the same radio frequency.

Emergency Vehicle Management Concepts

Radio communication has proven itself over the years through communications between maintenance vehicles and between emergency vehicles within the same agency and the communications of these vehicles with the agency base station. The radio is used to report incidents, advise on conditions in the field and to ask for additional support and/or material (e.g., traffic control signs, maintenance equipment, wreckers, sand). The utilization of a common frequency becomes important as a region becomes more urbanized and begins to involve several agencies.

It is the management of communications that predicates the successful integration of multiagency operations to form a unified operational Emergency Vehicle Management System. The key factor is the coordination of Police Department, Fire Department, Ambulance, Hazardous Materials (HAZMAT) and other responsive agencies at the lowest level of mobile communications in order to respond, process and closeout the Emergency Incident (or a major disaster).

Figure II - 22, Present Public Safety Agency System Communication, illustrates how the present system communicates to the lowest level of the responsive unit. Incoming calls are being processed from the 911 all the way to the mobile response units. However, the Police Department, Fire Department and EMS Dispatch radio communications are on more than three different frequencies with no field intercommunication between mobile units. Some coordination exists between the Dispatch operators that operate common patitioned floor space area at the Austin Police Department. A figure illustrating an alarm dispatch of a multi-company response by the Austin Fire Department is included in **Appendix II - D**.



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Present Public Safety Agency System Communications Infrastructure
Austin Area–wide ITS
Austin, Texas

Figure II–22

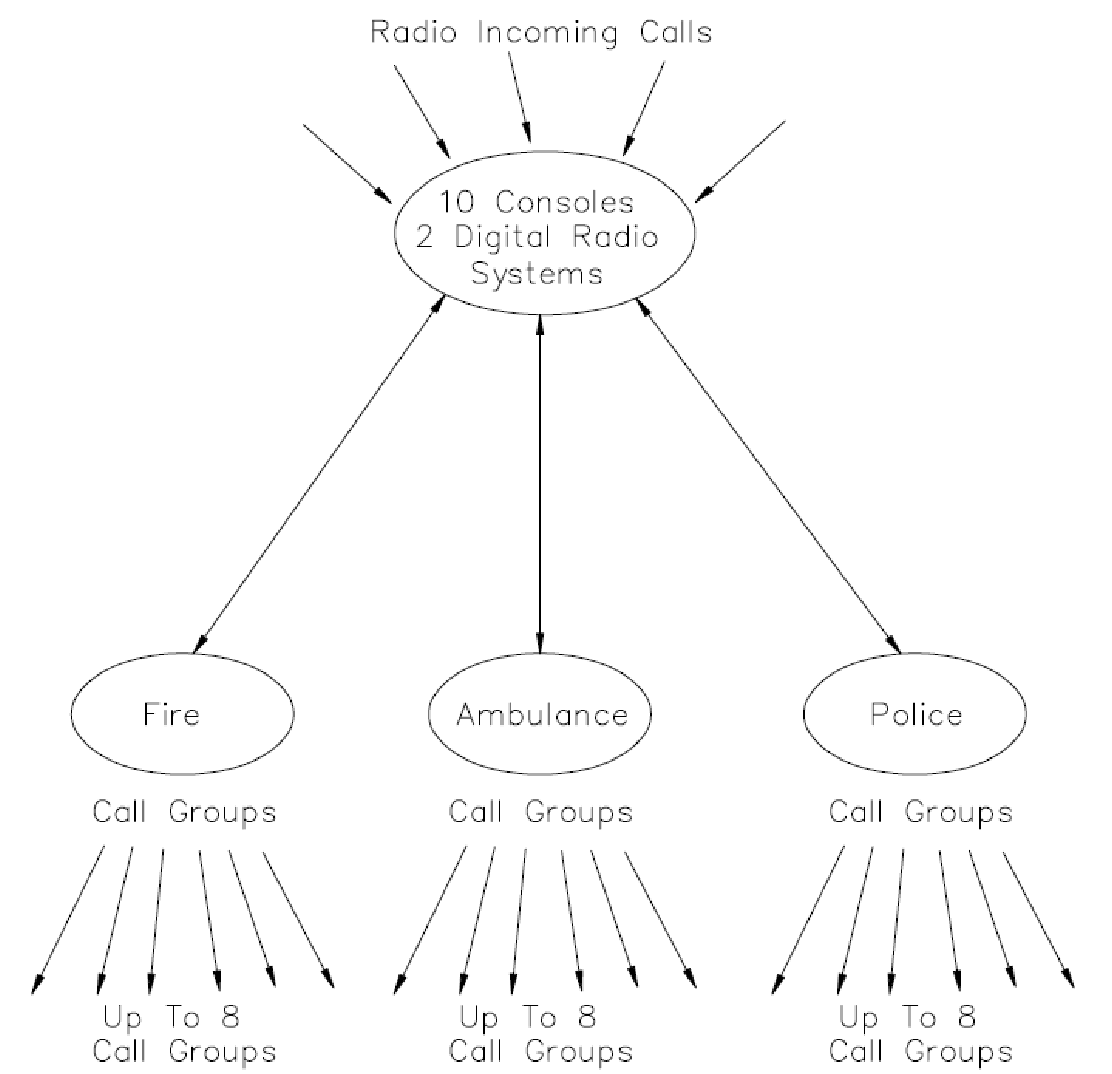
Marked improvements can be achieved in coordination and communications by utilizing an 800 MHz radio trunking system in order to let the responsive mobile units, with dispatch supervision, to communicate, coordinate, and closeout the incident at the lowest level. A conceptual diagram of the proposed 800 MHz communications system for the Austin area is shown in **Figure II - 23**.

Detecting and Verifying Incidents with 800 MHz Radio Network

Identifying, verifying, and managing incidents becomes complicated in an urban region where freeways and streets pass in and out of two or more jurisdictions. Some streets can only be reached by first traveling into another agency. When an accident is noted by a police officer or highway maintenance employee in an area outside his/her jurisdiction, it would be desirable at times to initially ask for assistance of a vehicle from another city and to quickly advise of an accident noted in an outlying area of another city. Similarly, if a vehicle from one jurisdiction is close at hand to an accident, it may be desirable for that vehicle to be the first on the scene, to verify the accident, advise on the severity, and provide initial support. A 800 MHz system will permit rapid reporting of an incident and rapid communicating between agencies in such instances. A conceptual plan for such a system is shown in **Figure II - 24**.

The 800 MHz system will also allow the agencies involved in incident management to communicate over the same frequency during incident management (e.g., accidents, inclement weather conditions, special events, vehicle breakdown, debris on the highway). This will permit the rapid deployment of personnel and equipment. A 800 MHz system will also permit an agency to contact another in reporting debris on the street or highway and a traffic management equipment malfunction (CMS, traffic signal).

The lower tier call groups will be able to call in to their dispatch console the report of incident (detection). The dispatch will notify the manager console for consideration with other lower tier call groups, i.e., fire, police. The call groups frequency management as well as channel allocation is dynamic at all times for coordination efficiency.



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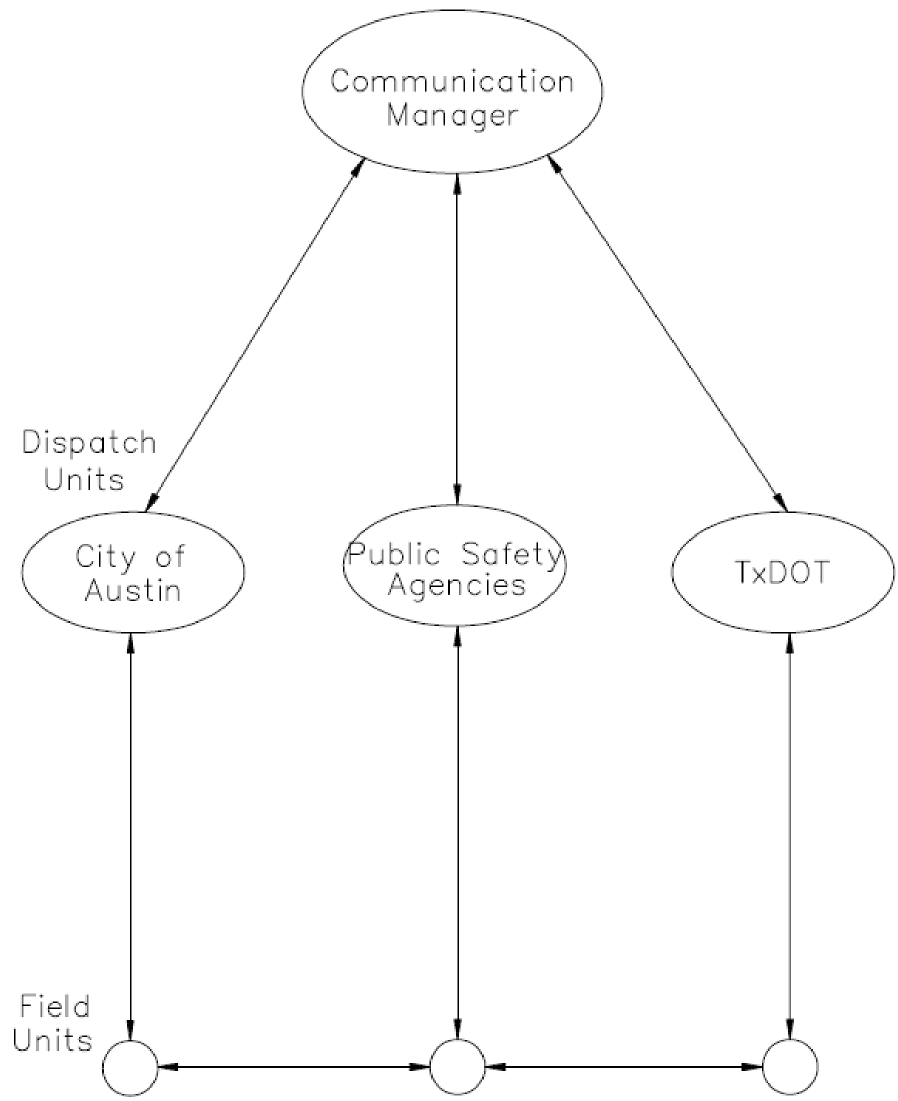
Conceptual Diagram of
800 MHz Communications System
Austin Area-Wide ITS
Austin, Texas

Figure
II-23



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Incident Detection/Verification System
Austin Area-Wide ITS
Austin, Texas

Figure II-24

In addition, the TMC can contact a vehicle in the field (e.g., courtesy patrol, maintenance vehicle and police vehicle) to confirm a reported incident and advise on the assistance needed. This will be of particular benefit where CCTV is not available. There are also times when an incident is first noted by a vehicle in the field (e.g., courtesy patrol, police) and the 800 MHz radio can be used in reporting the incident and requesting assistance in personnel and equipment.

Interagency radio communications as described above is not possible at present. The City of Austin Police Department operates on a 462 MHz frequency whereas adjacent cities (e.g., Georgetown, Round Rock and Williamson County) operate at an 800 MHz frequency. Public Safety Agencies in the Austin area utilize 450 - 470 MHz on UHF, while West Lake Hills and Rollingwood operate on VHF. Most agencies appear to have cellular phones and pagers which operate at a 900 MHz band, which is helpful as long as all vehicles have cellular phones or pagers. Since all vehicles have portable radios, it would be most desirable for each jurisdiction to operate on an 800 MHz frequency. By utilizing a 800 MHz frequency, it will be possible for vehicles to communicate on one frequency. Portable radios could be used to communicate with officers and other personnel that are away from their vehicles.

The existing area 800 MHz trunking systems are being utilized by Williamson County, Georgetown and the City of San Antonio. In San Antonio, the agencies that are using the 800 MHz trunking system are listed as follows:

- Police Department
- Fire Department
- Water and Wastewater Departments

Since the intent of the 800 MHz trunking system is to facilitate the integration of the mobile units and interagency coordination between the Fire Department, Police Department, and EMS, it is clear that a seamless implementation can be achieved for an Austin area wide communications as well as for the surrounding community.

Facilities Summary - The facilities and building size needed by the Public Safety Agencies to operate an 800 Mhz trunking system are currently being addressed in several other ongoing studies. Preliminary indications are that the existing facility will need to be expanded to accommodate a new 800 MHz system.

Equipment Summary - The existing communications equipment of the 800 MHz trunking system currently being programmed by the City of Austin consists of the following list:

- Police Department Dispatch:
  - 3 Radio systems (including VHF, UHF, and 800 MHz) for 8 Dispatchers and 8 data interfaces;
  - 1 Voice Switcher;
  - 3 Prime Repeaters;
  - 20 Secondary Repeaters for Metroplex wide coverage (for Mobile Data Terminal (MDT) use only);
  - 300 Mobile units with data interface (6 Sector x 50 units/sector); and,
  - 300 Portable radio (talkies).
- Fire Department:
  - 2 Dispatch Radio Systems for 5 Dispatchers and 5 data interfaces;
  - 2 Prime Repeaters use the Police Departments secondary repeaters for metroplex wide coverage;
  - 125 Mobile radios with mobile data terminal interface;
  - 101 Emergency vehicle radios; and,
  - 59 Portable radios.
- EMS Department:
  - 3 radio interfaces and 5 phone interfaces; 4 Dispatchers and 6 computer aided dispatch (CAD); and,
  - 28 Mobile radio units (with any 17 operational at one time)
  - 80 portable radios on UHF and VHF frequencies.
- Traffic Management Center Radios-(permanent mounts) will be needed as follows:
  - 2 for City of Austin Police Department;
  - 1 for Capital Metro Police;
  - 1 for Courtesy Patrol;
  - 1 for Travis County Sheriff; and,
  - 1 for Department of Public Safety.

The 125 mobile radios require a data interface such as the police radios do. These are the fire engine type radios. The secondary type radios (101) are for support vehicle with no digital data interfaces.

It will also be important for TxDOT to be part of the 800 Mhz radio network in order to make personnel and equipment available to assist the Public Safety Agencies. Radio equipment needs will initially include

- 4 for District Road Maintenance;
- 3 for Emergency/TMC Operations;
- 4 for Traffic Management Maintenance; and,
- 3 for Courtesy Patrol.

The radios located within vehicles could either be permanently mounted within the vehicle or portable. In addition, two 800 MHz scanners should be provided at the District office.

Maintenance Summary - The maintenance requirements for an 800 MHz Trunking System must provide for a minimum of 10% of the equipment budget per year; or an ongoing maintenance agreement (on site) would be highly recommended as opposed to having the agency maintain the radio system.

Sophisticated spread spectrum, coupled with a digital radio system carrier, and subcarrier switching and voice/data compression requires expensive and costly maintenance test equipment, as well as a facility with floor space and several technicians for maintaining the radio system. The digital radio system provides dynamic channel allocation as well as management for lower tier intercommunications. This function increases the interagency coordination. This technology was commonly being used in Vietnam and more currently in the Gulf War. The Battlefield coordination and troop deployment was based on the same functionally as the 800 MHz.

Personnel Summary - The operations personnel required for 800 MHz trunking are more than the existing operations. Personnel requirements are currently being identified as part of other ongoing studies. Preliminary indications are that additional personnel will be needed to operate and maintain the proposed 800 MHz system.

Funding Summary - Funding for the equipment has been programmed to be incorporated into a future Communication Center. The funds for the Communication Center will be provided by the agencies operating budgets and future bond programs. Detailed cost estimates are currently being prepared by the City of Austin implementing agencies. An approximate estimated cost for equipment needed for an 800 MHz trunking system are identified in **Table II - 15**.

Implementation/Phasing Summary - The implementation and phasing of the 800 MHz Radio Trunking System is currently being developed as part of other ongoing studies.

Table II - 15

Budget Estimate for Two Site 800 MHz Trunk Radio System Equipment

Austin Area-Wide ITS

Austin, Texas

#	Item	Unit Costs	Total Cost	
20	Repeaters	$12,000 ea	$240,000	
4	5 channel antenna systems	$35,000	$140,000	
2	Central Trunking Controllers	$55,000	$110,000	(-55,000)
2	Equipment Shelters with fence	$35,000	$70,000	(-35,000)
1	System Manager	$50,000	$50,000	
1	Engineering & Installation	$100,000	$100,000	(-25,000)
3	Consoles	$25,000	$75,000	
1	Console Common Electronics	$75,000	$75,000	
28	800 Mhz Control Stations	$ 4,700	$131,600	
	Grand total fixed equipment for all 3 agencies		$991,600	
	To share the Water & Waste Water system deduct			($115,000)

<u>Mobiles and Portables by agency:</u>

Police	300 mobiles	$2,400ea	$720,000
	300 portables	$2,200	$660,000
Fire	125 mobiles/interface	$2,800	$350,000
	101 mobiles	$2,400	$242,400
	59 portables	$2,200	$129,800
E.M.S.	17 mobiles	$2,400	$40,800
TxDOT	14 mobiles	$2,400	$33,600
	25 scanners	$ 400	$800
TMC	6 radios at work stations	$5,000	$30,000
Grand Total Mobile/Portables with no accessories or installation cost.			**$2,207,400**

NOTE: All prices may change depending on exact application and requirements.

COMMERCIAL FLEET MANAGEMENT WORK ORDER
SCOPE OF WORK

Task - Identify resources to share information with other services

Task Description and Milestone

The work generally consists of identifying and dissemination information useful for commercial vehicle operations.

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

Summaries of the facilities, equipment, maintenance, personnel, funding, and implementation needed to identify and disseminate this information should be presented.

Facilities include structures or enclosures necessary to house and operate equipment and personnel and its cost. Equipment includes hardware, software, and communications items and their cost. Equipment costs should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of a phased implementation strategy should be included.

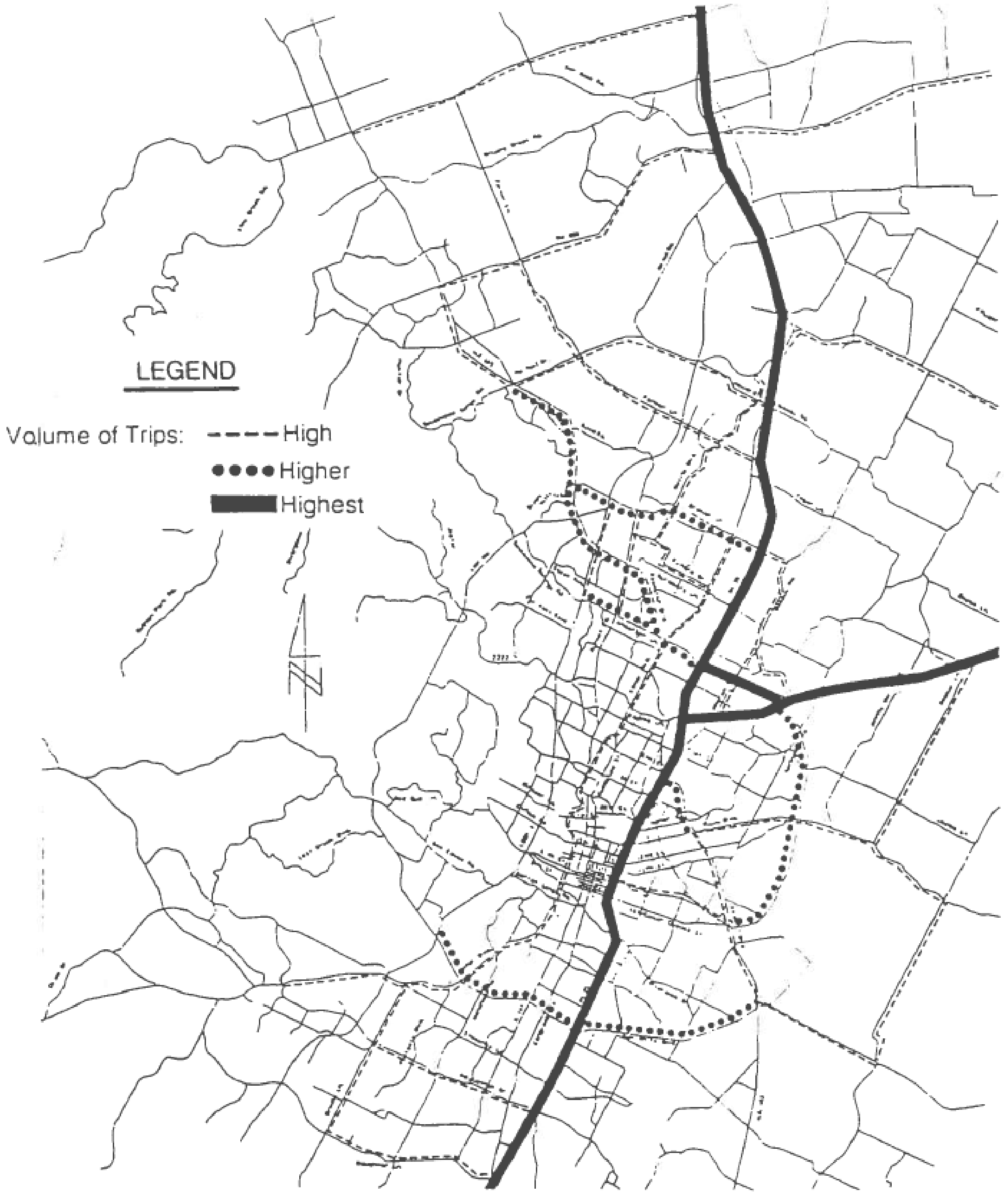
Commercial Fleet Management

Commercial vehicles are becoming an increasingly important factor in the operation of highways within Austin. It is anticipated that there will be a significant increase in truck traffic along IH 35 after December 18, 1995 when the North American Free Trade Agreement (NAFTA) begins to allow trucks from Mexico to travel throughout the state and after 2000 when Mexican trucks can travel throughout the United States.

Between October 1991 and December 1993, Austin experienced a 40% increase in southbound cross-border truckloads and 30% increase in northbound truckloads. This amounted to an increase of 5,000 truckloads southbound per month and 1,900 truckloads northbound per month. It has been estimated that truck traffic will continue to increase at a rate of 20% per year through 1998 and begin leveling off after 1998 to 10% per year.(1) Assuming this projected rate is accurate, the number of trucks involved with NAFTA along IH 35 in 1995 can be expected to more than double by 2000. In addition, trucks not involved with NAFTA trade will also increase, possibly as much as 10% per year (or as much as 60% by 2000).

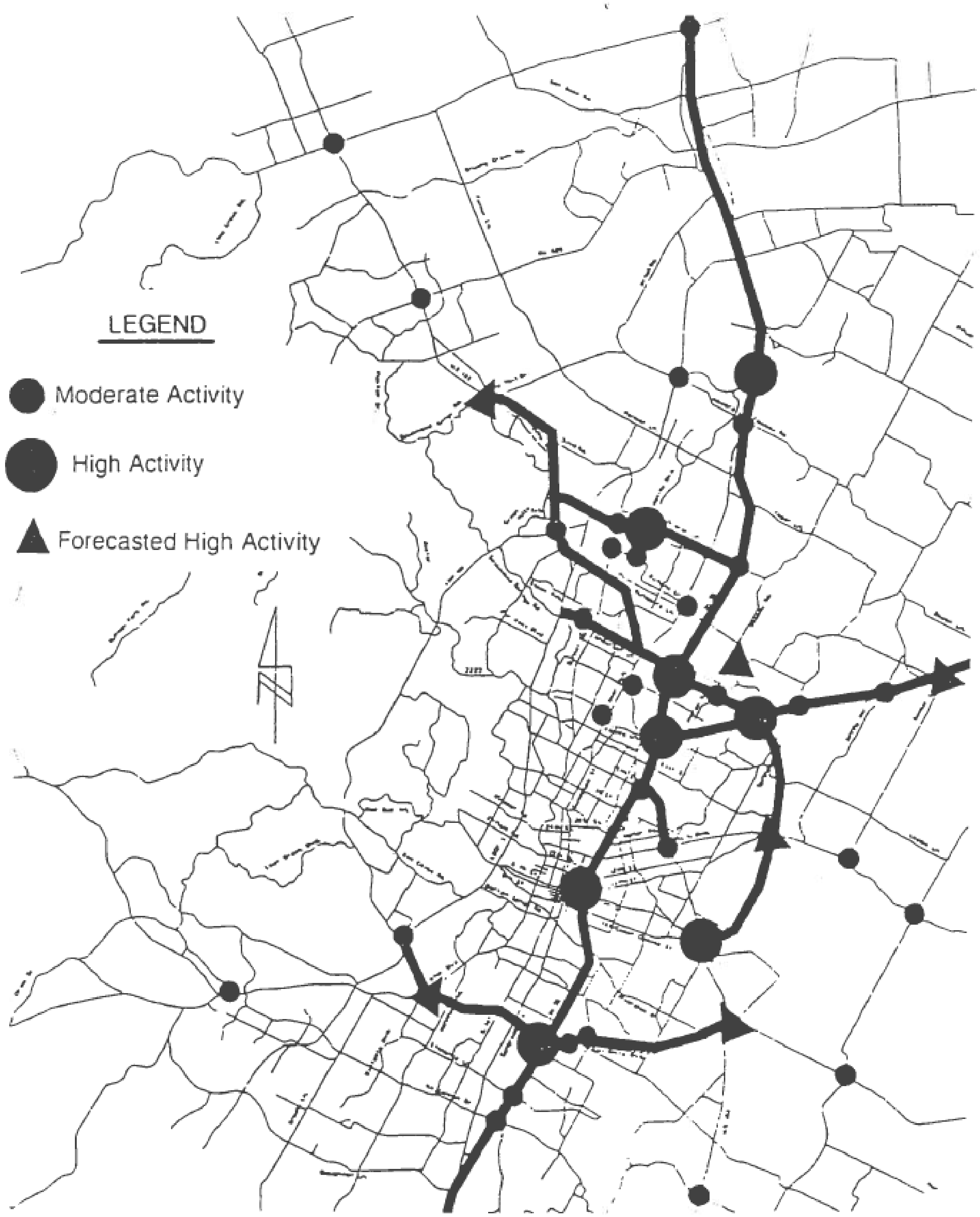
The increase in truck traffic will place a greater burden on an already overloaded highway facility. **Figure II - 25** and **Figure II - 26**, from the Austin Metropolitan Area Transportation Plan(1), show that truck activity exists on major routes in addition to IH 35. This includes US 183 and SH 71 to the east of IH 35. US 183 and SH 71 are already crowded, if not congested, and increased problems can be expected until they are developed into freeways and SH 130 is constructed around the east side of Austin. The "Freight Element Section" (Section 4.6) of the Austin Metropolitan Area Transportation Plan provides further effects of truck traffic and recommended solutions and is included in **Appendix II - E** of this report.

The effects of trucks on the freeway and major thoroughfares necessitate the application of traffic and incident management at an early date along all freeways and major highways, especially IH 35. It may also be desirable to limit heavy truck traffic to off peak periods and preferably at night. Various ITS User Services apply to Commercial Vehicle Operations. As noted in **Table II - 16**, four are discussed in this section.



Source: Austin Metropolitan Area Transportation Plan, Austin Transportation Study, Adopted December 12, 1994.

WILBUR SMITH ASSOCIATES CONSULTING ENGINEERS AND PLANNERS HOUSTON, TEXAS WSA NORTH AMERICAN CONTROLS CORPORATION ADVANCED TRAFFIC ENGINEERING KESSMANN & ASSOCIATES	Austin Area Roadway Freight Corridors by Volume of Trips Austin Area-wide ITS Austin, Texas	Figure II-25



Source: Austin Metropolitan Area Transportation Plan, Austin Transportation Study, Adopted December 12, 1994.

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Areas of Concentrated Roadway Freight Activity
Austin Area-wide ITS
Austin, Texas

Figure II-26

Table II - 16

ITS User Services Which Would Benefit Commercial Vehicle Operators
Austin Area-Wide ITS
Austin, Texas

Enroute Driver Information*	· Specific Information for Trucks provided from TMC to Dispatcher · General Information for all Motorists via Radio available to all Truckers
Route Guidance*	· Available through possible use of TEMPO or other information from TMC to Dispatchers
Electronic Payment	· Could be utilized if Toll Roads are built in Austin
Commercial Vehicle Automated Roadside Safety Inspection (and Enforcement)*	· Available through advanced enforcement system central computer and use of WIM, AVI and AVC roadside equipment
Commercial Fleet Management*	· Use of GPS on trucks assists dispatching in locating commercial vehicles in conjunction with Enroute Driver Information and Route Guidance

Commercial Fleet Management Technologies

There are basically two types of commercial trucking fleets which must be managed on a day to day basis: 1) single unit delivery vehicles and heavy trucks which originate or enter the city to deliver goods but do not pass through; and, 2) heavy trucks which pass through the city.

- ***Local Roadway Freight*** - The delivery vehicles and heavy trucks which deliver goods are generally required to meet delivery deadlines to businesses within the city. If deliveries are made on a routine basis, the company dispatchers and truck drivers are generally aware of normal traffic conditions along their routes. Of primary interest to the company dispatchers and truck drivers is the location of an unusual delay (e.g., in excess of 20 minutes) on a freeway or major arterial. With this information, the dispatcher and/or truck driver can select an alternate route.

- *Through Roadway Freight* - Trucks traveling through a city also have delivery deadlines outside of the area. Short haul through trucks have the same problem as the delivery vehicles in this regard, but long haul trucks may have some time built into their schedule.

Improved communications systems to provide critical transportation information to drivers and dispatchers and to receive weight and location information from vehicles are currently under development and testing using various Intelligent Transportation System (ITS) applications. Commercial vehicle operations (CVO) systems are systems that apply various ITS technologies to improve the operations, safety and efficiency of commercial vehicles. CVO systems are targeted to provide a variety of benefits, including safety, productivity, and mobility. Safety benefits include advanced screening, targeted inspections, correction verification, roadside monitoring, on-board monitoring, and emergency response. Productivity benefits include reduced delays, reduced paperwork, enhanced auditing, shipper needs, and driver/vehicle monitoring, while mobility benefits include increased intermodalism and international competitiveness and opportunities.

Implementation of CVO systems are being driven by three national CVO goals:(2)

- *Transparent Borders* - An electronic network that would allow commercial vehicles to travel from one state to another as easily and smoothly as passenger cars. Compliance with registrations, licenses, and permits would be verified electronically through mainline monitoring and mileage reported automatically;

- *Electronic Commercial Driver/Vehicle Safety Inspections* - An electronic network that verified information such as a vehicle's current Commercial Vehicle Safety Alliance (CVSA) inspection decal and a driver's Commercial Drivers License (CDL); and,

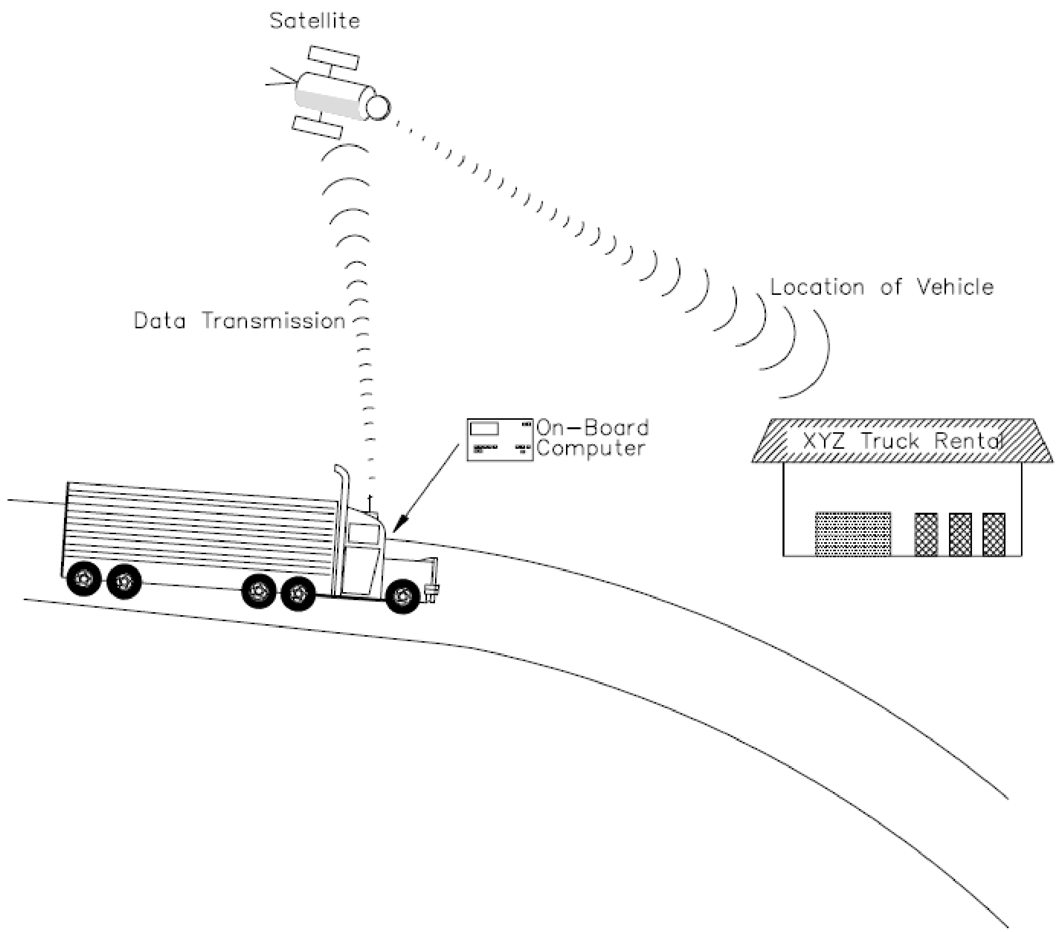
- *One-Stop Shopping* - A concept allowing carriers to comply with all trucking regulations at one geographic location. All states would be computerized and linked together for issuance and collection of taxes, permits, authorities, insurance, and other items.

Provided with information far enough ahead of time, the trucking company dispatcher may be able to route the truck so as to bypass Austin or determine if another alternate route within the city (e.g., US 183 or MOPAC/SH 71/US 290 or an alternate route to IH 35) can be used. It may be determined to stay in the stream of traffic if the estimated delay time is short or have the trucks stop at a truck stop until the cause of the incident has been overcome and traffic is beginning to flow normally again.

Real-time traffic information provides numerous benefits to commercial truck fleets, including an increase in fleet productivity, an improvement in customer service, improvement to the truck driver's environment, and a reduction in costs. For example, when the upper level of the George Washington Bridge in New York was closed on a weekday morning at 2:44 AM, an overnight package delivery service was able to inform its drivers to use an alternate route and allow them to meet critical aircraft departure schedules at Newark International Airport(3). The traveller information provided permitted packages to arrive on time, which reduced service costs, increased customer service, and increased productivity of the vehicles.

Truckers traveling through Austin are often not familiar with the highway system. Increased information and guidance are usually needed. Without adequate information on conditions ahead and available alternate routes, a heavy truck driver can become a real problem as he tries to take an alternate route on his own volition within unfamiliar territory.

Technologies used to provide or obtain travel information from commercial vehicles include Automatic Vehicle Location (AVL) and On-Board Computer (OBC) systems. **Figure II - 27** illustrates AVL and OBC concepts, which provide dispatchers with vehicle location information and truck drivers with route and travel information. AVL and OBC technologies are the



Source: Commercial Vehicle Operations and Institutional Barriers (COVE) Study: Texas Working Group Kick-off Meeting Presentation, Booz-Allen & Hamilton, Inc., September 1, 1993.

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Automatic Vehicle Location (AVL)
and On-Board Computer (OBC) Concepts
Austin Area-Wide ITS
Austin, Texas

Figure
II-27

technologies which can provide the greatest solution to managing commercial truck traffic in the greater Austin area. A Discussion of AVL systems is provided in the Public Transportation section.

The Control Center is the brain of the AVL system; in that it processes and analyses the data for the purpose of providing a more reliable and efficient transportation system. The Control Center is formed by several components which may vary according to the needs of the specific traffic management system. The principal components are the main computer, mapping controller, and a database bank that form the computer aided dispatch (CAD).

An AVL/CAD system can improve commercial fleet service reliability, increase the safety of both commercial truck drivers and other drivers on the road, and reduce operation expenses by providing the following features:

- Providing real-time commercial vehicle location;
- Providing alternate routes to avoid known traffic delays;
- Improving communication between commercial truck drivers and the control center;
- Providing information for planning, scheduling, and information management;
- Recording of incidents, locations, and other data used for management reports and analysis; and,
- Providing address matching and temporary detours.

Several companies exist that track commercial truck traffic and provide traveler information to truckers and/or dispatchers on a subscriber basis. One of these is Qual.Comm which is a nationwide service with a nationwide marketshare of approximately ninety percent (90%). They charge a fee of approximately $150.00 per month per vehicle regardless of the amount of information transmitted or connect times. Qual. Comm monitors the location of trucks through GPS and provides two-way communication between the dispatcher and the truck as a service. Knowing the location of the truck, the Qual.Comm operator could provide information on delay and possible alternate routes to take. However, they would not be interested in providing this service on a city by city basis. If transportation data was available on a nationwide basis from a series of TMC's, they would be interested in providing traveler information to their client's dispatchers and/or individual vehicles. Other companies use cellular based systems with lower upfront costs but higher operating fees.

Commercial Vehicle Enforcement - An area of interest to the public sector is the weight, registration and safety of vehicles and drivers. Vehicles can now be checked through use of Weigh-In-Motion (WIM) and Automatic Vehicle Classification (AVC) equipment for registering and monitoring vehicles traveling along the highway system. There will be means in the future also to check the condition of the vehicle and to a certain extent the condition of the driver.

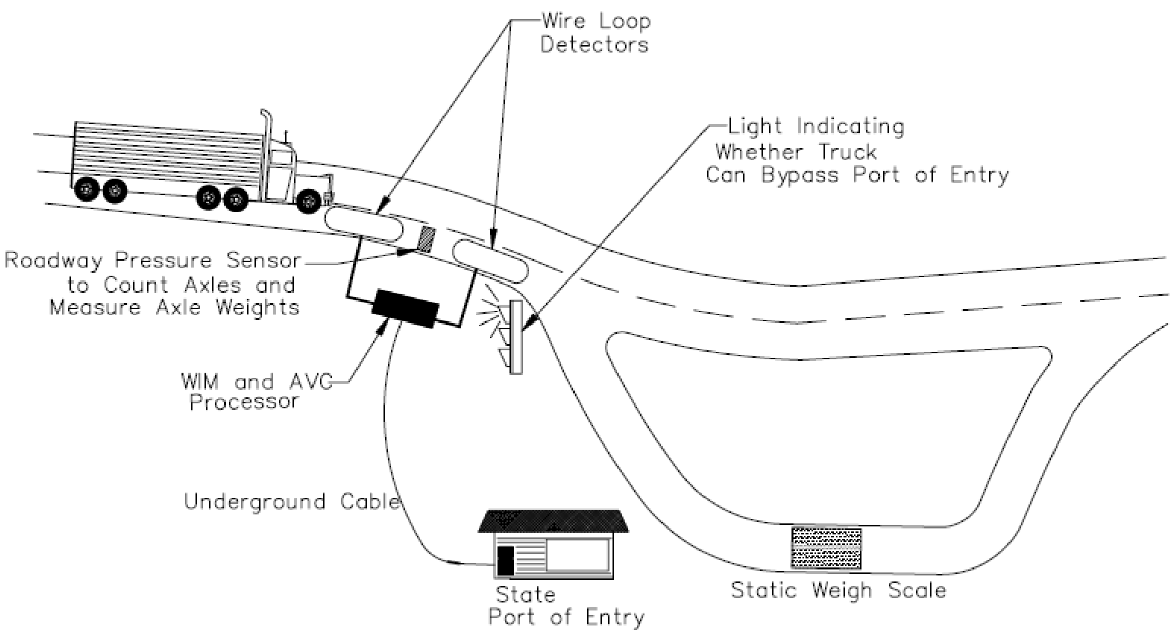
Figure II - 28 illustrates AVC and WIM concepts, which permit commercial vehicles to pass weigh stations without stopping if weight and vehicle classifications comply with State laws. WIM and AVC will provide information to governmental agencies about whether a commercial vehicle is complying with regulations, but will not help a great deal in providing real-time traffic information.

Provisions can be made for monitoring the above referenced equipment at the TMC for the purpose of locating trucks that are over weight and/or not properly registered for the cargo they carry. When a vehicle is noted that does not meet the necessary requirements, the Department of Public Safety would be notified by an operator at the TMC.

Identifying and Disseminating Information

As previously stated, the primary concern of trucking companies and truck drivers is the location of unexpected delays along their route, along with additional information on the condition of possible alternate routes. This basic traveller information should be made available to trucking companies or commercial information services (e.g., Qual.Comm) at the TMC. The trucking company or commercial information service could then carry out its own analysis and dissemination of traveller information to its subscribers.

The basic information should include speeds, travel times and level of service (LOS) along segments of a freeway and major highway or street such as those shown in Figures II-25 and II-26 which carry a heavy amount of truck traffic. Information should also be included on normal recurring delay and delay caused by incidents. The information should also be included on the



Source: Commercial Vehicle Operations and Institutional Barriers (COVE) Study: Texas Working Group Kick-off Meeting Presentation, Booz-Allen & Hamilton, Inc., September 1, 1993.

WILBUR SMITH ASSOCIATES CONSULTING ENGINEERS AND PLANNERS HOUSTON, TEXAS NORTH AMERICAN CONTROLS CORPORATION ADVANCED TRAFFIC ENGINEERING KESSMANN & ASSOCIATES	Automatic Vehicle Classification (AVC) and Weigh-in-Motion (WIM) Concepts Austin Area-Wide ITS Austin, Texas	Figure II-28

Internet for the benefit of all motorists and commuters as they prepare to leave their homes, and should be provided to the public media for distribution via cable companies, radio, and television.

Other information such as travel time and speed along various highways and streets could be utilized to determine travel time along possible alternate routes for trucks. A PC version of travel time analysis along routes has been developed at the University of Texas at Arlington. The computer model, known as TEMPO. It would be desirable to apply this model in real time for rerouting commercial vehicles when delays occur along a given route normal due for congestion or an incident. Real time information on speed and travel time for each available route would be fed into the PC from the computer. The TEMPO model would determine the available capacity and travel time for the route along which a delay exists and along each possible alternate route. The model would then advise the trucking agency on the travel time for each route and/or provide recommended routing instruction. Information from the PC for TEMPO would be made available at an interface point in the TIC at the TMC for use as a computer link with the trucking company dispatcher(s). Communications would involve a modem provided by the trucking company at each end of the transmission and a print out at the dispatchers office. The same approach could be applied in providing information to Metro Traffic and other media companies which in turn would provide information to the trucking company dispatchers.

An alternative approach to the dissemination of information to trucking companies would involve the joint funding of an outside agency such as HELP, Inc., to distribute information to subscribe trucking companies. HELP, Inc. is organized to work with states and trucking companies in developing and implementing services which help motor companies. Application of the TEMPO model for Austin could be one such service.

By providing information for routing trucks, TEMPO would also be of value to the public by reducing overall delay to all motorists. If designed on a public/private partnership basis, it is suggested that the TEMPO output not be placed on the Internet. Doing so would defeat the purpose of providing information only to trucking companies.

Communications between the TMC and the trucking companies or services could be via a variety of sources, including a computer network, telephone, fax or pager. The TRANSCOM program in the New Jersey/New York City area uses an 80 character alphanumeric pager to communicate with trucking companies. The pager is typically installed in the trucking company or service's office, and the dispatcher is trained to read the coded message and then relay the information to drivers. It is the company's responsibility to read the messages and relay the information to their drivers, not the responsibility of the governmental agencies[(3)]. In addition, the same approach could be provided as discussed above for TEMPO in providing traffic information to trucking companies and Metro Traffic. The use of an interface point where commercial companies can obtain information has been successful in the Chicago TMC. The commercial company provides the equipment and communications it needs for obtaining desired information.

Regardless of the communications media used in the Austin area, the responsibility of disseminating traffic information to commercial fleets should belong to the trucking companies or service providers. Traffic information should be provided to commercial fleets or service providers through the TMC, but relaying that information to appropriate commercial vehicles should be up to the trucking company's dispatcher. Providing specific information to each truck would be difficult. Direct communications with the truck driver could also create confusion for the dispatcher and the truck driver. Providing information to the dispatcher which is specifically for use by commercial vehicle operators rather than directly to the truck driver would also place liability for a resulting incident on the commercial operator.

Facilities Summary - Additional facilities should not be required for providing information to truckers if the computer hardware and software at the Traffic Management Center or Operations Center includes the information for use by all motorists. This includes the Austin Home Page and Internet which would include information on highway conditions for Austin. As previously discussed in the previous paragraph , a communications interface point should be provided for commercial companies to tie their hardware and communications to. These companies would also be responsible to provide the equipment which might be needed at their dispatch/information facilities (e.g., modems, P.C.).

Equipment Summary - Except for information provided by TEMPO and the advanced ITS type enforcement equipment such as AVL and OBC, the information provided by the FTM system can be a part of the software development for the central computer and should not require additional equipment. The AVL, OBC, or pager equipment should be provided by commercial vehicle companies or other agencies with connections at interface points in the TMC.

The TEMPO model should be provided as a separate stand alone PC with output through the central computer to the trucking agencies. The estimated cost for the hardware/software and interface between the PC and computer should be less than $100,000 which, as previously stated, could be shared 50-50 through a public/private partnership. The output of the PC would be provided to the Commercial Vehicle Operators as previously discussed. The equipment beyond the interface point would be the cost of the commercial companies.

The advanced enforcement system central computer equipment could either be housed in the TMC or at a Department of Public Safety (or other) office. The cost of the equipment (hardware and software) should be paid for by the enforcement agency and would not be a part of this project. The TMC system operator could be alerted, however, when a non-registered truck passes the enforcement station on the field and CCTV information sent to the DPS or other enforcement agency for their use in tracking the vehicle along the freeway system. If the enforcement agency provides this service
from the TMC, it should provide for the costs of the needed interconnect between the advanced enforcement system computer equipment and the TMC work stations(s). As with the implementation of the TEMPO model, the cost for interconnection to the enforcement agency should be less than $100,000.

Maintenance Summary - Since most of the information provided to truckers and their dispatchers can be handled through the central computer, the maintenance costs (except for TEMPO) could be included as part of the overall TMC maintenance costs. Maintenance costs for TEMPO would be approximately $1000 per year which could be paid for by TxDOT as part of its maintenance for the TMC. The information for the trucking companies would benefit all motorists and as such should be paid for through the public sector. The maintenance for the advanced enforcement system equipment could be paid for by another agency if located within the TMC.

Personnel Summary - Additional personnel should not be needed to provide information to the truckers and trucking companies. The information would be provided as part of the overall operation of the TMC.

Funding Summary - As previously stated, added funding will not be required except for the TEMPO software and any advanced enforcement system equipment housed in the Center (see equipment summary).

Implementation/Planning Summary - The overall information provided to travelers and trucking companies should be included in the initial design of the proposed TxDOT FTM system. If TEMPO is not included, provisions should be made for adding this type of system at a later date. The possible addition of TEMPO should be included as a planned part of the system.

References

(1) Austin Metropolitan Area Transportation Plan, Austin Transportation Study, Adopted December 12, 1994.

(2) Commercial Vehicle Operations and Institutional Barriers (COVE) Study: Texas Working Group Kick-off Meeting Presentation, Booz-Allen & Hamilton, Inc., September 1, 1993.

(3) "The Utilization of Real-Time Traffic Information by the Trucking Industry," IEEE Transactions on Vehicular Technology, Vol. 40, No. 1, February, 1991.

DISSEMINATING TRAVELER INFORMATION
SCOPE OF WORK

Task - Identify resources to disseminate en-route and pre-trip travel information from other services to travelers.

<u>Task Description and Milestone</u>

En-route and pre-trip travel information provides information used in making informed trip decisions. Travel information is largely provided by traffic control, incident management, and public transportation management services. This information has the following desirable characteristics:

- Useable
- Timely
- Reliable
- Accurate

Trip decisions include:

- Departure times
- Transportation modes
- Routes

The work generally consists of recommending methods to disseminate information from other services meeting the above criteria to travelers.

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

Summaries of the facilities, equipment, maintenance, personnel, funding, and a phased implementation plan to disseminate en-route and pre-trip travel information methodologies should be presented.

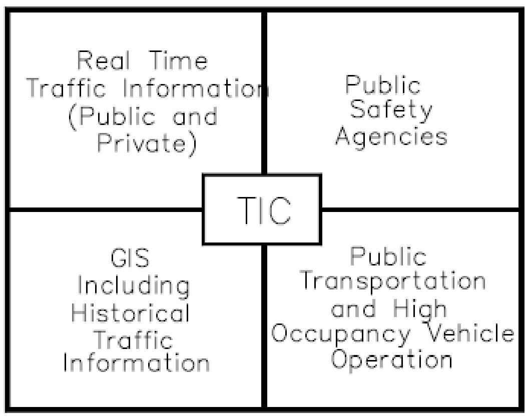
Disseminating Traveler Information

The Austin metropolitan area is the second fastest growing region in the United States[1]. Highway and street networks are becoming more congested which increases the potential for accidents. Assuming that the existing growth rate continues (or increases even more), congestion will continue to increase. Austin is on the borderline of becoming a non-attainment area. Vehicle emissions will increase as traffic increases. The increase in congestion and vehicle emissions increases the need for intermodal integration. For instance, the development and implementation of a multimodal plan which would reduce single occupant vehicles (SOV) by 10% could reduce vehicle congestion by as much as 48%.[2] Reducing the number of SOV and improving mobility necessitates increased information to commuters and public transportation operators as well as to commercial vehicle operators and other motorists.

The dissemination of accurate and timely information to motorists is dependent on available information from many sources and on how this information is analyzed. The best means for obtaining and analyzing traffic information is through the development of a Transportation Information Center (TIC). The TIC provides a platform to build on for improved movement of people, goods, and services. The TIC is an integral part of the TMC as is shown in **Figure II - 29** and **Figure II - 30**, the TIC interfaces with the TMC work stations and the transportation and enforcement agencies within the region and in turn disseminates information in a manner useable by these agencies and the traveler. The TIC should be located in a room adjacent to the TMC Control Room if and/or when one TMC is provided and adjacent to the FTM Control Room when separate City/State Control Centers are provided.

Transportation Information Center

The TIC should serve as the hub for current operations and for the future ITS user services within the Austin metropolitan area and region. The focal point of metropolitan ITS rests with collection and use of information. Without adequate and timely information, all aspects of ITS suffer, and this will make the application of advanced systems unpopular with the user. In order to achieve accurate and timely information and apply it properly to all areas of ITS, there is a need



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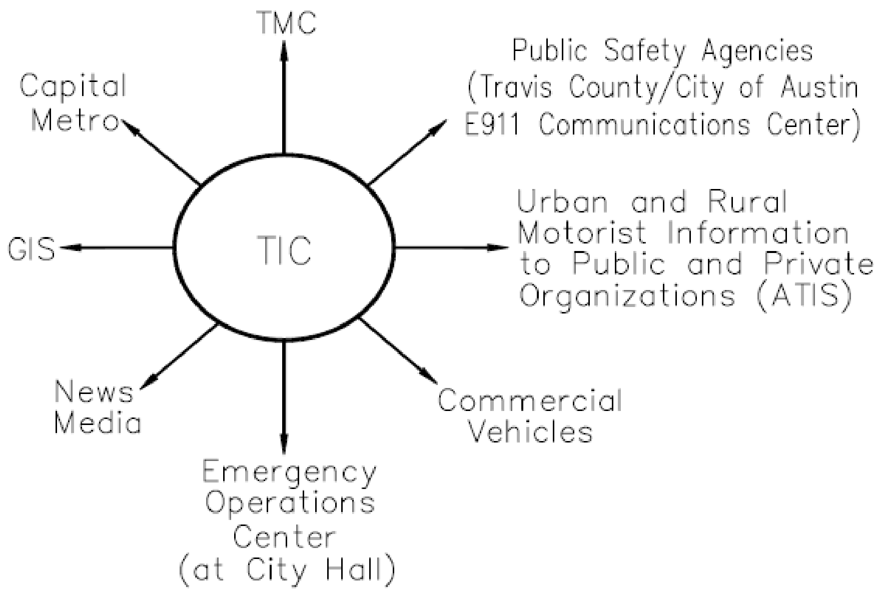
Relationship of Transportation Information Center(TIC) With Other Operations

Austin Area-Wide ITS

Austin, Texas

Figure II-29



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TIC Traffic Related Information Dissemination
Austin Area-wide ITS
Austin, Texas

Figure II-30

for a central collection and distribution point. This applies regardless of whether the traffic management approach is centralized or decentralized. The TIC provides this capability.

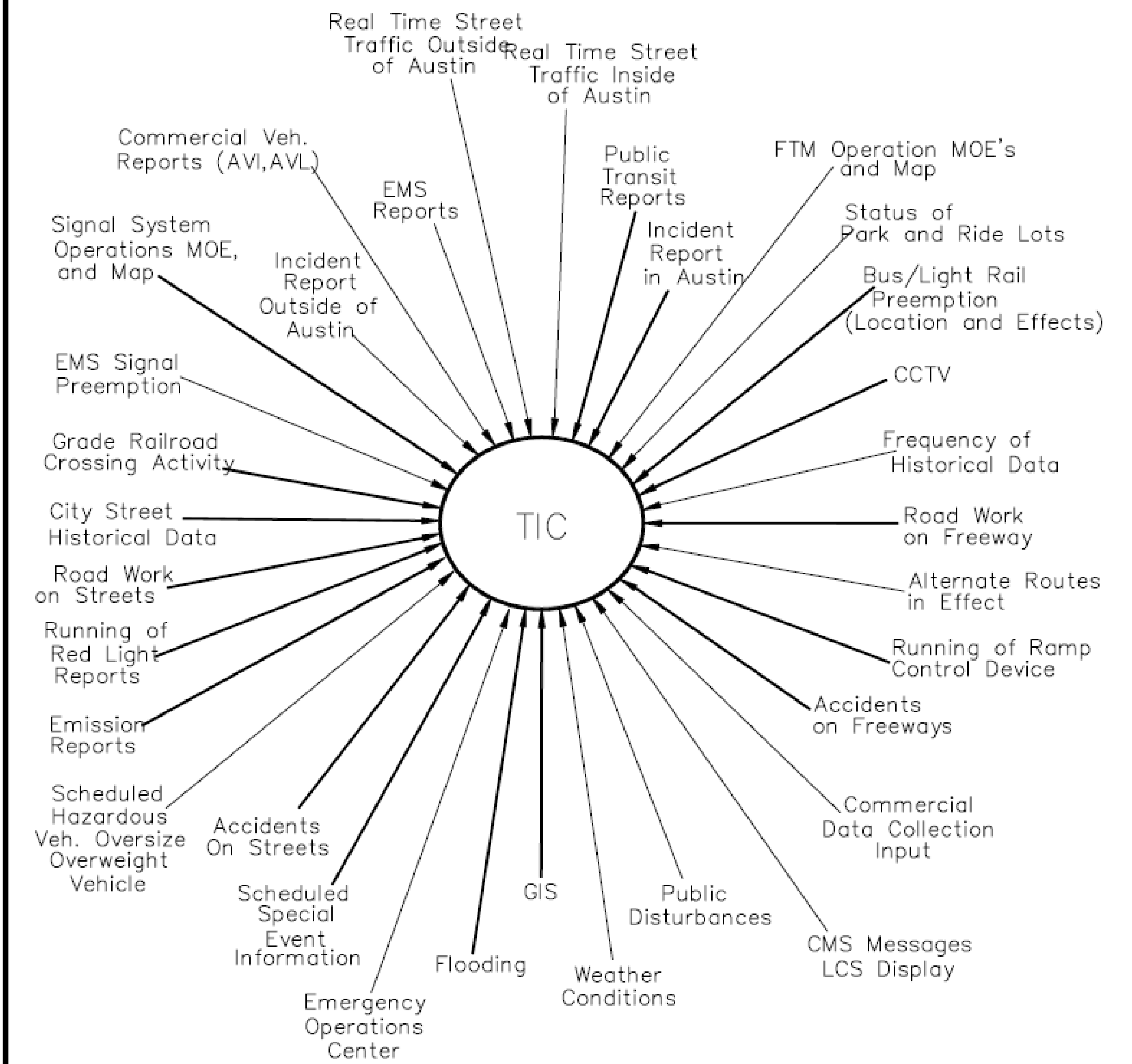
As is shown in **Figures II - 31**, **II - 32**, and **II - 33**, the TIC provides for data gathering from many sources, sorting and analysis of data and distribution to various users. Traffic information must be timely and accurate. This can best be achieved through one TIC. It is important to note that information can be prepared at the TIC and sent to the news media as shown in Figure 35. The news media can provide important support for the overall concept of intermodal integration and traffic management.

The collection, analysis and distribution of information should be carried out as a separate but integral part of the TMC. That is, the TIC should have its own personnel who receive, analyze and provide information to the transit, TMC and Public Safety Agency personnel in a centralized traffic management approach and to the traffic control centers in a decentralized approach. The TIC should be operated and maintained jointly by the city, transit, and state traffic management personnel.

The TIC data base should be part of a regional Geographic Information System (GIS). The TIC will not need to be at the same location as the GIS, which would probably be maintained by the city or county public works department. The GIS will, among other things, provide the following information:

- freeway and street geometric information (e.g. lane width, street width) and capacity;
- traffic control locations and traffic signal timings;
- historical traffic, accident and enforcement data;
- speed zones;
- fire station and PSA locations;
- designated fire runs and fire plug locations;
- bus routes and bus stops;
- railroad crossings and train schedules;
- low water crossings and areas subject to flooding; and,
- school locations and school zones.

This information will permit the TIC operators to combine real time and historical traffic information with information provided by the Public Safety Agencies Center to assist in overall mobility and safety.



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Examples of Data Input

Austin Area-wide ITS
Austin, Texas

Figure II-31

* Information Determined Based on Input From Figure 33

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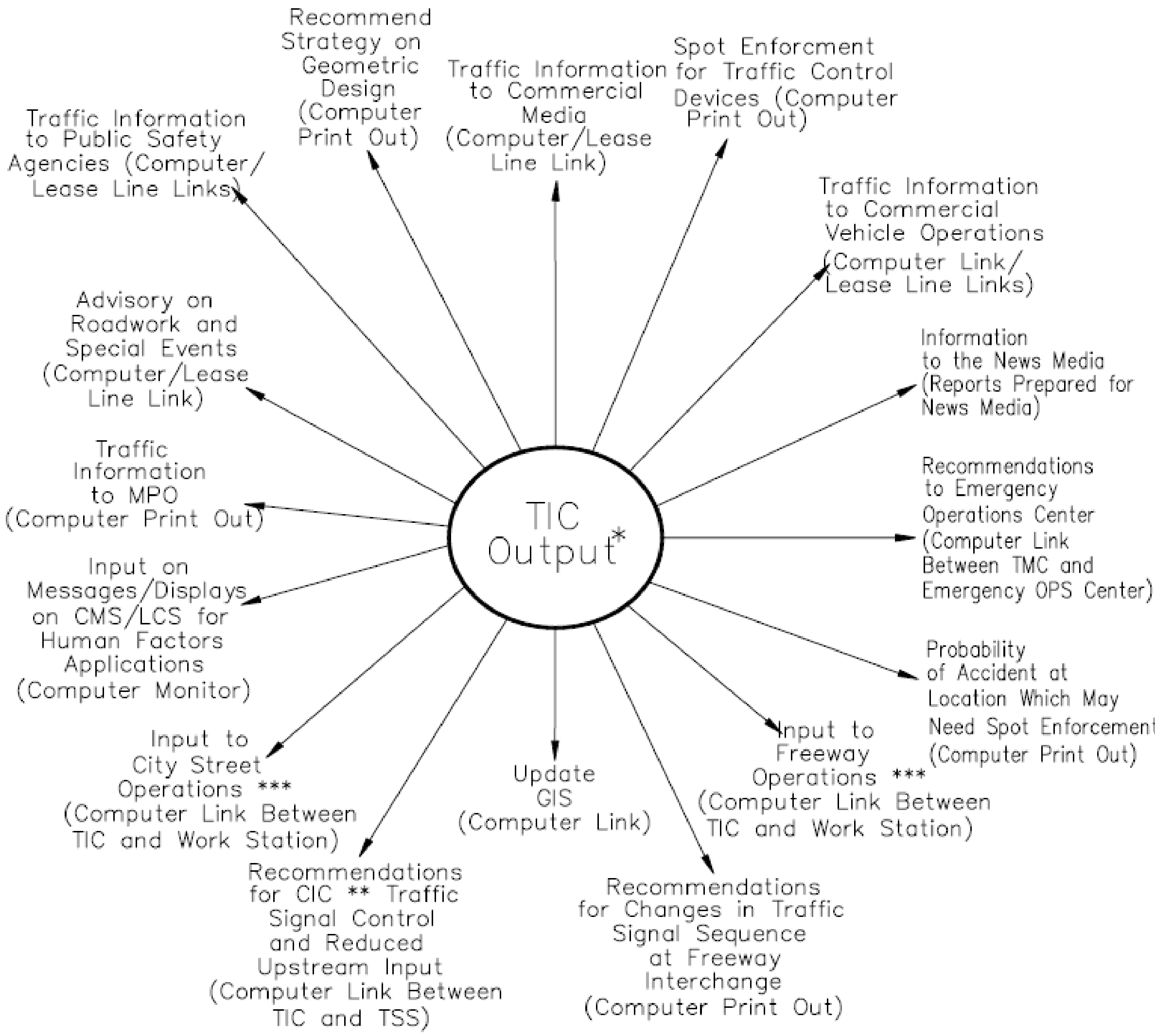
Examples of Traffic Data Analysis (Data Fushion) at TIC
Austin Area-wide ITS
Austin, Texas

Figure II-32



* Parentheses shows how the information is disseminated to use
** Critical Intersection Control
*** Alternate Route Input Around High Emission and Anticipated Flooding

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Examples of Information Dissemination

Austin Area-wide ITS
Austin, Texas

Figure II-33

In a centralized traffic management approach, the TIC will be an integral part of the TMC. Traffic data provided from vehicle detectors used in selecting traffic control plans (timing plans) is supplemented by the other information which the traffic control operators need to know to manage traffic during periods of recurring and non-recurring (e.g. incidents, special events) congestion. In the decentralized traffic management approach, the TIC should be located at one of the traffic control centers and information transmitted to the other centers.

One TIC is needed for providing information to travelers, be they commuters or motorists entering or passing through the metropolitan area. Information also needs to be provided to Public Safety Agencies operators, public transportation operators, commercial vehicle operators and the commercial news and traveler information media. The TIC will also be the center in the future for providing route guidance to all motorists. Traveler information needs to be:

- Useable;
- Timely;
- Reliable; and,
- Accurate.

This applies to all persons involved in using the street and highway system within the region. All aspects of Traveler information must be applied with these characteristics in mind.

Although there is a need to provide accurate information to travelers within the city, there is also a need to provide information to those who are entering the region. This information needs to be provided far enough in advance to permit the traveler to take an alternate route if desired. The same applies to the commuter who may decide to take an alternate mode of transportation or alternate route, leave at a different time than usual, or stay at home (e.g. ice, snow, disaster). Good information and analysis will provide information which meets the above requirements.

Data Resources

Various forms of traffic related information should be made available at the TIC. Bringing this information and making it available in a useable form is known as data fusion. The information includes:

Traffic Control Data - Traffic control data includes the traffic volume, lane occupancy, speed, and motorist delay information which is obtained from vehicle detectors and CCTV. Traffic control data also includes traffic control patterns (timing patterns) in effect. Traffic signal timing plans can provide information to technicians in the TIC such as the progression band for a particular arterial and the capacity of that arterial.

Vehicle detectors used for traffic management provide invaluable information which is used to provide accurate and timely information to the news media and to the traveler selecting the best mode of travel or travel route.

In addition, information obtained from the commercial media (e.g. helicopters, airplanes, mobile, and stationary observers) and courtesy patrol vehicles are also part of the traffic data. As with CCTV, this information can provide added information and serve as the "eyes" of the TIC to confirm information received from vehicle detectors.

Since weather affects traffic conditions, it also needs to be considered part of the traffic data. A partnership should be developed with the conventional news providers in obtaining this information (flooding, iceing conditions, high winds, etc).

Incident Management Data - Incident management data includes the traffic control data noted above plus information from the Public Safety Agencies. This includes information received from 911 operators and from EMS and traffic management vehicles on the scene of an incident. This information permits the TIC operators to recommend a change in the traffic control patterns and provide motorists with needed traveler information.

Traffic information obtained from vehicle detection can provide valuable information for the PSA Computer Aided Dispatch (CAD) operations by providing real time information along major arterials. This can be used in determining travel times on intersection to intersection links. This same vehicle detector information is used in 1.5 generation traffic responsive and traffic adaptive traffic signal control during incidents.

The San Antonio Traffic Management Center has access to Channel 54 on general T.V. The channel allows instantaneous viewing of incident location by key personnel with access to a

T.V. on a 24 hour a day basis. The director of maintenance can ascertain the equipment needs of an incident from his home in the middle of the night and call out the appropriate machines and personnel. At non critical times the T.V. channel can provide traffic information to the general populous. The display can be provided by the public or a private company.

As with recurring congestion and conditions, commercial data collection agencies (such as Shadow Traffic and other helicopter services which collect traffic data) provide valuable information during incidents that occur during the peak hours of travel. A partnership between TxDOT, the City of Austin, and commercial data collection agencies for obtaining traffic data similar to that used for obtaining weather information should be utilized.

Public Transportation Management Data - Capital Metro is determining which type of Advanced Vehicle Location (AVL) system it will install in its buses in the future. This system will provide information on the location buses and estimated time of arrival at bus stops. This information will permit the development of a non-preemption priority type operation at traffic signals to service buses when they are behind in their schedules.

The estimated arrival at bus stops can also provide an estimate of travel time and speed between signalized intersections along a route. This information can be used in conjunction with the average vehicle speed obtained from the vehicle detector mentioned previously and from ongoing recorded travel time runs by other vehicles to determine real time changes in link speed and travel times.

Using the 800 Mhz frequency radio, bus operators will be able to report incidents and special conditions along their route which might not be known otherwise. CCTV cameras can then be used to analyze the problem reported by the bus driver.

"Smart" kiosks could transmit this information to regular riders and potential riders at bus stops and other locations such as employment, retail, and entertainment centers. The kiosks could provide an audio message to people with special disabilities with the use of special receiver devices that would minimize the possibility of noise pollution.

Anticipating Accidents

Information gathered by the TIC can be used to help "predict" accidents. Information on existing high accident/high traffic volume locations when combined with demographics involving the make up of drivers involved in accidents (high school and college students) within the area (e.g. school campuses, office complexes) can be combined to point out locations which need a rapid response program, added enforcement and/or added traveler information. The accident, demographic information, rate of growth in traffic and vehicle speed is part of the information which can be used in analyzing traffic conditions. For instance, a rapid increase in traffic within an area which has either congestion or is on the border line of congestion can be an area to flag for a potential increase in accidents.

Types of Travelers

Travelers can be divided into two general groups -- home/business based and out of city based travelers. The home/business travelers are generally familiar with the city and its major thoroughfares. They reach their work, shopping, school or recreation destination without difficulty. They can maintain their sense of direction and be familiar with an alternate route streets and freeways. Even with their familiarity of the area, information and directions on streets and freeways to use in avoiding congestion are still helpful and reassuring. Sometimes, just knowing the location of congestion is of help.

Some out of town travelers may know about routes from past experience and be able to obtain information from travel maps (e.g. "Texas Official Travel Map") which show the freeways and most of the major streets, but many others are not familiar with the city. Additional real time information provides a much needed means for avoiding congestion and keeping from getting lost. The following discusses the needs of each of these travelers.

Home/Business Traveler - The home/business traveler should be able to obtain the following information from the TIC:

- *Pretrip Information* - Real time information can be obtained from television, radio, internet and telephone. This includes locations of incidents, travel time and delay, possible alternate routes, travel time by bus, bus route schedules and car pool parking lot locations. Also, the best bus route schedule can be obtained on a request basis where bus transfers are necessary. The simplest approach is to receive information by radio, telephone, and television broadcasts. This can include a public service television channel and public owned radio and periodic reports on commercial radio/television stations. The best bus route to take where transfers are involved could be obtained by telephone.

The Internet can be used to provide information on specific auto/commercial vehicle routes as will interactive television and computers in the future when fiber optic cable is provided to homes and businesses. Travel time information on predesignated routes and advisory alternates can also be obtained through a commercial information service when suitable information is provided by the TIC. These services should also be able to provide predictions on anticipated traffic conditions over the next five, ten and fifteen minute periods based on a combination of current and historical information. In addition, a public television station, such as the television station approval obtained by the San Antonio TxDOT district, could be provided for to continuously broadcast current traffic conditions by voice and map.

The newspaper provides information on roadway work which should also be part of the real time report. These are approaches which should be planned for over the next five years by the city, state, and Capital Metro. Some approaches can be provided initially as the city and state traffic management systems are implemented. These involve providing real time reports on traffic conditions (including a map), bus schedules, and park and ride lot locations.

· *Information Kiosks* - Information kiosks located at shopping centers, office complexes, and other major traffic generators can provide information on traffic conditions to individuals traveling to their next location. Kiosks can also be provided at bus stops to advise on arrival time for the next bus.

Information kiosks can also show the person at a bus stop which is the best route to take in reaching his/her destination, and the closest bus stop to the desired destination. The kiosks would best be provided as a public service either by a public agency or by a private information service with time provided for advertising (advertising time sold by the private operator). Specific route information could be sold on a pay for information basis (insert your money and select a route). The same could apply for selection of the best bus route to get home. In addition, a map and/or route vending machine could be available for the individual to further plan a route, if necessary. Information kiosks are available and could be implemented as soon as adequate traveler information is available through the TIC.

· *Enroute Information* - Motorists enroute to their destination can be provided with information through:

- AM and FM commercial radio station broadcasts*;
- Traveler Information Stations (TIS) formerly known as Highway Advisory Radio (HAR) located at a preselected location on the AM band;
- Changeable Message Signs (CMS) and Lane Control Signals (LCS);
- CMS on buses to advise on current location and on the next bus stop*;
- Visual display of major routes and conditions (green, yellow, red color code) on an in-vehicle display*;
- Vehicle locator (GPS, towers or beacons) with cellular phone, pager or private radio route information; and,*

- Vehicle locator with visual and voice in-vehicle route guidance (in-vehicle map)*.
- Information for Commercial Vehicle Dispatchers.

* Commercial or Vehicle Owner costs not part of the TMC costs.

The first four of these are in use today within the nation. Commercial radio stations provide valuable information to motorists. Information obtained from a TIC and from subscriber services provide relatively up to date information on a periodic broadcasting basis. The development of a TIC could improve the accuracy and timeliness of the broadcast information. The Illinois DOT allows the broadcasting stations in Chicago to receive freeway traffic data for analysis purposes.(3) One commercial radio station, for instance, utilized the freeway speed data to determine current travel times to various points along each freeway during the peak hours.

TIS equipment has been approved along with higher wattage transmitters (up to 10 watts) and selectable AM broadcasting radioband locations. The higher wattage provides for wide area transmission. Lower wattage transmission provides for a specific area or section of highway along with the ability to synchronize TIS units and permits the use of two or more units in tandem in order to broadcast a longer message.(4)

The Minnesota Department of Transportation (MnDOT) utilizes a public service station to broadcast messages related to incidents. Signs with flashers are located along each freeway. The motorist is instructed by the sign to tune to a designated frequency when a message applies to traffic on that freeway.(5)

CMS and LCS are scheduled for installation as part of the Austin FTM system being designed by TxDOT. Supplementing CMS could be installed along city streets in advance of the freeways which would advise on freeway and corridor street conditions. Automatic fold out signs could be used in addition to the CMS could be used to direct motorists along an alternate route around an incident.

In-vehicle visual display of roadway conditions has been installed as a private venture in the United Kingdom. A public/private effort could be carried out as a public/private venture through data gathering and dissemination at the TIC with private sector in-vehicle displays.

The same public/private partnership approach could be applied to the combined use of GPS and/or towers and cellular phone and/or pager information -- both initially for: (1) more current route information than commercial radio broadcasting can provide, and (2) route guidance information. An alternate to route guidance by cellular phone involves the use of two-way beacon to locate the vehicle and in turn broadcast route guidance information through use of beacons located throughout the city. The approach is being used in Oakland County Michigan.(6)

Each of the approaches discussed are in use or are viable for use in Austin either now or in the future provided a TIC is constructed as part of the city/state/Capital Metro traffic management system. As noted, most of the motorist information can be provided through a public/private partnership. The use of TIS, CMS, and radio broadcasting will be available to those who cannot or do not desire to use the private subscriber services. The traffic information provided free of charge to the public should be as accurate and up to date as that provided to in-vehicle subscriber services.

Out-of-City Travelers - Travelers from out of town who are either delivering goods within the metropolitan area, stopping for a period of time or traveling straight through are not often familiar with the city. These travelers are generally not familiar enough with recurring traffic conditions along their route to know what to expect. In addition, these travelers are not familiar enough with the city to take an alternate route on their own. It would be beneficial for them to know what problems exist in time to either divert or be prepared to stop for a time, if necessary. For instance, if a major incident occurs blocking southbound IH 35 in Austin, a southbound IH 35 motorist hearing of the incident in Temple could take SH 95 and SH 21 around Austin provided motorists know about the problem as they approach Temple. Closer in to Austin, a southbound motorist on IH 35 could take US 183 and SH 71 east of town or FM 1325/MOPAC and US 290 west of IH 35.

Because of the existing traffic conditions and potential for major accidents along IH 35, it would be desirable to provide advance traveler information both north and south of the metropolitan area along IH 35.

The "Texas Official Travel Map" is excellent in showing state highways available for travel around Austin and major arteries within the city (and other major cities in Texas). Each vehicle in Texas should have a copy of this map in its vehicle glove compartment. A wider distribution of the travel map would be beneficial. In addition, vending machines provided at Rest Stops along the Interstate Highways where motorists could purchase the map. These maps can, and should, be used for pre-trip planning and be available for reference along the trip. Approaches for motorist information include:

- Communications with commercial vehicle operations dispatchers via computer telephone links;
- Coordination with other radio stations (e.g. Waco, Temple/Killeen, San Antonio) by TIC personnel to provide announcements on major incidents in Austin and along IH 35 in rural areas;

- Installation of short range and long range Traveler Information Stations (TIS) with signs and flashing beacons advising motorists that there is a message on an incident ahead. The TIS stations could be located at points where motorists can decide whether to take an alternate route or stop for lunch, dinner or the night to avoid the congestion;

- TIS can also be used to provide information on how to reach park and ride lots for bus service to special events (e.g. football games, Aqua Fest) as they enter the city; and,

- Commercially available computer stored "yellow pages" located within the vehicle provide information on services and addresses for these services. In the future, the yellow pages could be integrated with route guidance systems to help the motorist locate the desired business.

The same approach noted above could be carried out on other major highways routed through Austin (e.g. US 183, US 290, SH 71). In addition, the TIC could work with the EMS Center in handling "May Day" calls when accidents occur within the metropolitan area and region.

Recommended TIC Approach

The collection, analysis and dissemination of information within one location provides an organized process for providing information to travelers. This can be provided through the Traffic Information Center (TIC) with personnel dedicated to the process.

In addition, field equipment such as Traveler Information Stations (TIS), Changeable Message Signs (CMS) and Lane Control Signals (LCS) are part of the public owned traveler information system. Information is provided for pretrip planning, such as the use of a public television channel, Internet, and radio broadcasts. This would also apply to coordinating information with radio stations within Austin and in other cities. It would be desirable to coordinate radio reports in San Antonio with the TxDOT TMC in San Antonio. Information kiosks and travel maps at rest stops would best be provided by the TIC staff or through contract with a private agency.

The TIC staff will also provide information to the TMC operators and to Public Safety Agencies from the personnel. The primary control of the CCTV should rest with the TMC operators but the CCTV use will be coordinated with TIC and other agencies when they need to use it.

The remaining traveler information shown below in this chapter will be the joint function of the public/private sectors:

- "Yellow Pages";
- Subscriber network information for route information and route guidance;
- Information to commercial vehicle dispatchers;
- Information kiosks at shopping centers, offices, airport, truck stops, and bus stops.

Information will be provided by the TIC personnel in these instances and disseminated further by the private sector.

Facilities Summary - The TIC functions can be carried out through the use of same type computer system as that being installed in the traffic management system within the TMC or one of the traffic control centers (preferably the TxDOT center). It would be desirable to provide for the TIC hardware and software facilities as part of the city or state traffic management system. As an integral system with the traffic management system, the TIC facilities will be included as part of the traffic management control facilities.

Equipment Summary - It is estimated that $1,600,000 will be required for hardware and software to adequately carry out the TIC functions previously described. Since the traveler information system will be of benefit to travelers using city streets, freeways, public transportation and enforcement activities, the cost of the TIC system should be shared between the various agencies involved. As the need/response for additional service develops, new and/or expanded services could be added on an incremental basis. The TIC function cost include $200,000 to provide access to a general T.V. channel. These channel costs might increase if some of the costs cannot be deferred to the private sector.

There are additional costs, which will involve the Traveler Information Stations (TIS). The cost for a central 10-watt TIS located in Austin and having a 10 to 15 mile broadcasting radius would be approximately $22,000 ($11,000 for the equipment and $11,000 for the installation). A lower wattage unit installed along the freeway in rural areas would cost approximately $15,000 ($7,000 for the equipment). A second unit tied in tandem with the first and spaced approximately 10 miles apart would cost an additional $10,000 ($1,500 for the equipment) plus lease line costs for interconnecting the two units. If broadcast range is not a problem, a central TIS could cost less and still achieve the same broadcast radius.(7) Various Home/Business Traveler Services would best be handled by Commercial development or through vehicle owner purchase.

Maintenance Summary - Maintenance for the TIC should be part of the maintenance for the TMC or agency traffic control center. As with the TMC, maintenance at the TIC could be carried out through a maintenance contract. Since the TIC is for the benefit of both the city and the state, the maintenance costs for the TIC should be shared by the city, state and Capital Metro. The estimated yearly costs for maintenance of the TIS would also be approximately 10% of the equipment costs (plus telephone lease line costs).

Personnel Summary - In order to properly carry out the TIC functions, two personnel should be utilized on a full time basis. During peak periods and incidents, these personnel will help analyze conditions and support the traffic management personnel. During other periods, they will obtain information (e.g. roadwork, special event, historical, GIS, weather) analyze the information and work with others (TMC, EMS, commercial media) in providing the needed information. As with installation and maintenance costs, it is recommended the salaries be a shared cost.

Funding Summary - Funding for installation of the TIC and the TIS should be available through the same bond funds and/or Federal funds as for the traffic management system funds.

Implementation/Phasing Summary - The TIC functions should be included as an integral part of the TMC or traffic control center (preferably the TxDOT control center). The initial information should be disseminated to traffic management system operators, public safety agencies, public transportation personnel, commercial radio stations, commercial vehicle operators, and to a central TIS for the city. It is also important to incorporate the traffic data into the city GIS.

Additional TIC functions can be carried out by working with the private sector and installing additional TIS in rural areas. It is anticipated that the total TIC functions will be implemented in full within five years with the exception of route guidance. Plans should be made to implement the program over five years and expand it as the city traffic signal system comes on line.

References

(1) Austin American Statesman, October 7, 1995.

(2) Presentation by Michael Bolton, General Manager for Capital Metro at ITS Conference on October 13, 1995.

(3) McDermott, Joseph, Chief Bureau of Traffic, Illinois Department of Transportation, Schaumberg, Illinois.

(4) National Travelers Information Radio Exchange News, Volume 5, Issue 1, Spring 1995, Zeeland Mi.

(5) Carlson, Glen, Manager of Traffic Control Center, Minnesota Department of Transportation, Minneapolis, Minnesota.

(6) Jim Barbaresso, Oakland County Department of Transportation, Oakland County, Michigan.

(7) Bill Baker, Travelers Information Systems, Zeeland Mi.

MULTI-AGENCY TRAFFIC MANAGEMENT CENTERS

Task 1 -Identify metropolitan areas with traffic control centers capable of desired functions
Task Description and Milestone

The City of Austin desires a computer controlled signal system which is capable of the following functions in the order of importance:

- Accommodates existing system characteristics;
- Integrates signal control, preemption, cameras, signs, and flashers;
- Integrates video from a mobile source;
- Utilizes a distributive architecture;
- Supports a variety of communication mediums;
- Perform multiple tasks simultaneously;
- Provide remote access;
- Automatically adjust signal timings to accommodate traffic demand;
- Evaluate operations based on real-time speeds, travel times, and queue lengths;
- Continuously collect operational characteristics;
- Continuously update color coded maps;
- Display the network in different colors based on congestion;
- Recommend streets which can accommodate diversion during an incident;
- Provide emergency/bus preemption;
- Distinguish emergency/non-emergency preemption;
- Maintain signal coordination during preemption;
- Identify time, agency, and impact of preemption; and,
- Share data with other agencies.

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

The work generally consists of compiling summaries of the facilities and equipment, maintenance, personnel, funding, and implementation of a system capable of the above functions by other metropolitan areas. Two metropolitan areas should be considered.

Task 2 - Identify factors influencing the location of a multi-agency traffic control center

Task Description and Milestone

The work generally consists of identifying the advantages and limitations of both a centralized traffic management center and a distributed traffic management approach. A centralized center houses a variety of transportation stakeholders. A distributed approach enables each stakeholder to operate from their own facility while in direct communication with other stakeholders.

The Engineer shall provide the following services:

- Facilities Summary
- Equipment Summary
- Maintenance Summary
- Personnel Summary
- Funding Summary
- Implementation/Phasing Summary

Summaries of the facilities, equipment, maintenance, personnel, funding, and implementation needed to share the recommended data should be provided.

Facilities include structures or enclosures necessary to house and operate equipment and personnel and its cost. Equipment includes hardware, software, and communications items and their cost. Equipment costs should be identified as capital, operations, and maintenance. Maintenance includes routine and preventative actions, as well as, life-cycle costs. Personnel includes persons needed to design, operate, and maintain facilities and equipment. Funding includes both public and private sources of innovative financing. Documentation of a phased implementation strategy should be included.

Multi-Agency Traffic Management Centers

Traffic Management Centers (TMC) currently play an important role in helping to increase efficiency along roadway systems in cities nationwide. The most valuable services provided by TMCs to the public include real-time traveler information, incident detection and response management, motorist assistance, monitoring and surveillance of highway systems, and real-time traffic signal control.

Existing Traffic Management Centers

A survey recently conducted by The Urban Transportation Monitor identified 33 TMCs located in cities across the country. Twenty-four of the cities responded to the survey with information regarding their current operation and future plans. Summary tables from the September 15, 1995 and September 29, 1995 issues of The Urban Transportation Monitor are shown in **Table II - 17** and **Table II - 18** on the following pages.

Table II - 17 identifies summary characteristics about all facilities surveyed. The average number of personnel working at TMCs includes three traffic engineers, five traffic technicians, eleven dispatchers, and seven other personnel (computer scientists, supervisors, computer programmers, and system operators). Annual operating and maintenance budgets averaged $2.1 million per year, with 12 TMCs operating 24-hours per day, 7 days/week. Ten of the TMCs surveyed have a full-time police officer assigned to the center.

During October 1995, six TMCs were contacted by Wilbur Smith Associates to gather more detailed information regarding each TMCs facilities, equipment, maintenance, personnel, funding, and implementation/phasing schedule. Five of the TMCs (San Antonio, Texas, ; Montgomery County, Maryland; Houston, Texas; Los Angeles, California; and Minneapolis, Minnesota) responded to the survey by the date of this report, with one other location (Seattle, Washington) not responding at this time. Available information gathered from each location is summarized in the following sections.

Table II - 17

Summary of TMC Characteristics
Austin Area-Wide ITS
Austin, Texas

	% TMCs that have this presently installed	% TMCs that will install this in future
PRESENT. FUTURE EQUIPMENT/TECHNOLOGIES		
For collecting traffic information:		
Inductive loops/loop detectors	79	36
Closed-circuit television	86	46
Video surveillance cameras	71	39
Ramp meters	57	39
Vehicles as probes	18	36
Surveillance aircraft	18	11
Roadside mounted radar detectors	21	14
Satellites	4	4
Cell phone lines	54	25
Radio communication (CB, agency radio)	86	29
Telephone	79	29
Video imaging detection system	36	39
For distributing traffic information:		
Variable message signs	89	46
Highway advisory radio	50	54
Radio broadcast	64	25
Radio—CD, agency radio	57	18
Cable television	43	43
Personal computer/modem	64	39
Information kiosk	25	71
Telephone	68	36
Telephone - auto dialing	39	32
Displays at activity centers	29	61
For display:		
CRT displays	71	36
Map graphics display	79	46
PRESENT. FUTURE CAPABILITIES/FUNCTIONS OF TMC		
Incident management coordination	89	39
Special event coordination	96	36
Data backup	71	29
Media coordination and cooperation	96	39
System software support and maintenance	75	29
Traveler information services	54	61
Video surveillance	75	43
Traffic responsive signal control	50	50
Variable message sign control	89	43
Integrated transit and traffic operations	25	50
Integrated police/fire dispatching	29	43
HOV system coordination and cooperation	39	54
Emergency response vehicle management	32	25

SOURCE: The Urban Transportation Monitor, September 29, 1995, p. 7.

Table II - 18
Transportation Management Centers Survey Results
Austin Area-Wide ITS
Austin, Texas

NAME OF TMC	Monitor Traffic Operations Center, Milwaukee County WI		Houston TranStar, Houston TX		VDOT Suffolk District Traffic Management System Control Center, Virginia Beach VA		Traffic Systems Management Center, Seattle WA	
NAMES AND ROLES OF ORGANIZATIONS PARTICIPATING IN TMC	Milwaukee Cty Sheriffs Dept, Milwaukee Cty Highway Dept.		Harris County, City of Houston, Metro Transit Authority, TX DOT, Traffic Reporting Services		Virginia State Police		Washington State DOT, Washington State Patrol	
EQUIPMENT TECHNOLOGIES INSTALLED	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future
For collecting traffic information:								
Inductive loops/loop detectors	√	√	√	√	√		√	
Closed-circuit television	√	√	√	√	√		√	
Video surveillance cameras			√	√	√		√	
Ramp meters	√	√	√	√	√		√	
Vehicles as probes			√	√				√
Surveillance aircraft								
Roadside mounted radar detectors			√					√
Satellites								
Cell phone lines			√	√				
Radio communication (CB, agency radio)			√	√	√		√	
Telephone			√	√	√		√	
Video imaging detection system	√	√	√	√		√		√
For distributing traffic information:								
Variable message signs	√	√	√	√	√		√	
Highway advisory radio		√		√	√		√	
Radio broadcast			√	√	√			
Radio—CB, agency radio			√	√	√			
Cable television				√	√			√
Personal computer/modem	√	√	√	√	√		√	
Information kiosks			√	√		√	√	
Telephone	√	√	√	√	√		√	
Telephone - auto dialing	√	√		√				
Displays at activity centers			√	√		√	√	√
For display:								
CRT displays	√	√	√	√			√	
Map graphics display	√	√	√	√	√		√	
Other (as indicated by respondents):	Large screen projection TV	Large screen projection TV						
PRESENT AND FUTURE CAPABILITIES/FUNCTIONS OF TMC								
Incident management coordination	√	√	√	√	√		√	
Special event coordination	√	√	√	√	√		√	
Data backup	√	√			√		√	
Media coordination and cooperation	√	√	√	√	√		√	
System software support and maintenance	√	√	√	√	√		√	
Traveler information services	√	√	√	√	√		√	
Video surveillance	√	√	√		√		√	
Traffic responsive signal control		√		√			√	
Variable message sign control	√	√	√	√	√		√	
Integrated transit and traffic operations		√	√	√				
Integrated police/fire dispatching		√		√				
HOV system coordination and cooperation		√	√	√	√		√	
Emergency response vehicle management			√	√			√	
Other (as indicated by respondents)								
TYPE OF ORGANIZATIONS TO WHICH TRAFFIC INFORMATION IS PROVIDED	Radio traffic reporters, traffic info service, TV station		Traffic reporting services, police		State police, news media, cable television companies, local municipalities		Traffic reporters (radio), TV stations, state patrol, metro transit, large businesses	
NUMBER OF PERSONNEL AT TMC	4 traffic engineers 1 traffic technician 2 dispatchers 2 electronic/computer engineers 1 office manager		7 traffic engineers 3 traffic technicians 6 dispatchers		2 traffic engineers 12 traffic technicians 1 electrical engineer 3 electronic technician supervisors 6 other		9 traffic engineers 3 traffic technicians 12 dispatchers/systems operations specialists 2 programmer specialists	
ANNUAL OPERATING AND MAINTENANCE BUDGET	$1.0 million		$750,000 not including personnel costs		$3 million		$1.3 million (for center only)	
PROVIDE TOURS FOR TRANSPORTATION PROFESSIONALS ?	N/A		YES		YES		YES	
DAYS AND HOURS OF OPERATION	5am to 7pm, M-F		6am to 10pm, M-F		24 hours/day, 7 days a week		6 am to 7pm M-F, Sat. & Sun. 8am to 6 pm Radio/Tunnel operations 24hours/day, 7 days/week	
POLICE OFFICER ASSIGNED TO TMC ?	NO		YES		YES (am and pm rush hours)		NO	

SOURCE: The Urban Transportation Monitor, September 15 and 29, 1995 issues.

Table II - 18 (continued)
Transportation Management Centers Survey Results
Austin Area-Wide ITS
Austin, Texas

NAME OF TMC	Montgomery County Transportation Management Center, Rockville MD		Bridgeport Operations Center, Bridgeport CT		Michigan Intelligent Transportation Systems Center, Detroit MI		I66/I395 TMS, Arlington VA	
NAMES AND ROLES OF ORGANIZATIONS PARTICIPATING IN TMC	DOT Montgomery County Police & Fire and Rescue Maryland State Highway Administration		Parsons Brinkerhoff Smartroutes, inc		DOT		State Police, Metro Traffic Safety Service, County Police	
EQUIPMENT, TECHNOLOGIES INSTALLED	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future
For collecting traffic information:								
Inductive loops/loop detectors	√	√			√		√	√
Closed-circuit television	√	√	√		√		√	√
Video surveillance cameras	√	√	√				√	√
Ramp meters							√	√
Vehicles as probes		√			√		√	
Surveillance aircraft	√						√	√
Roadside mounted radar detectors		√	√					
Satellites								√
Cell phone lines								√
Radio communication (CB, agency radio)	√	√	√				√	√
Telephone	√	√	√				√	√
Video imaging detection system	√	√						
For distributing traffic information:								
Variable message signs		√	√		√		√	√
Highway advisory radio	√			√		√	√	√
Radio broadcast	√							
Radio—CB, agency radio	√		√					
Cable television	√			√			√	√
Personal computer/modem		√	√					√
Information kiosks		√						√
Telephone		√	√			√		√
Telephone - auto dialing		√						√
Displays at activity centers		√				√		√
For display:								
CRT displays	√	√	√					
Map graphics display	√	√	√		√		√	√
Other (as indicated by respondents):	Direct connection to broadcast TV							
PRESENT AND FUTURE CAPABILITIES/FUNCTIONS OF TMC								
Incident management coordination	√		√			√		
Special event coordination	√		√				√	√
Data backup	√		√		√		√	√
Media coordination and cooperation	√		√				√	√
System software support and maintenance	√		√		√		√	√
Traveler information services	√			√			√	√
Video surveillance	√	√	√					√
Traffic responsive signal control	√						√	
Variable message sign control		√	√	√				√
Integrated transit and traffic operations	√				√		√	√
Integrated police/fire dispatching	√		√					√
HOV system coordination and cooperation		√						√
Emergency response vehicle management	√	√					√	√
Other (as indicated by respondents):								√
TYPE OF ORGANIZATIONS TO WHICH TRAFFIC INFORMATION IS PROVIDED	Maryland State Hwy Admin police; media (TV & radio)		State police, freeway operations, State of CT Maintenance, Smartroutes		State police, emergency patrol, Metropolitan Traffic Center		Media, state police, various traffic operation centers	
NUMBER OF PERSONNEL AT TMC	3 traffic engineers 9 traffic technicians 3 dispatchers		2 traffic engineers 1 project manager 1 operation supervisor 8 full-time operators/3 part-time		3 traffic engineers 6 traffic technicians		1 traffic engineer 4 traffic technicians	
ANNUAL OPERATING AND MAINTENANCE BUDGET	N/A		$1 million		$800,000		$700,000	
PROVIDE TOURS FOR TRANSPORTATION PROFESSIONALS?	YES		YES		YES		YES	
DAYS AND HOURS OF OPERATION	18 hours/day, 7 days/week		24 hours/day, 7 days/week		6 am to 7pm, M-F		19 hours/day, 7 days/week	
POLICE OFFICER ASSIGNED TO TMC?	NO		NO		NO		YES	

SOURCE: The Urban Transportation Monitor, September 15 and 29, 1995 issues.

Table II - 18 (continued)
Transportation Management Centers Survey Results

Austin Area-Wide ITS
Austin, Texas

NAME OF TMC	INFORM (Information for Motorists), Hauppauge, NY		COMPASS, Ontario, Canada		Traffic Systems Center, Oak Park, IL		Transportation Management Center, San Diego CA	
NAMES AND ROLES OF ORGANIZATIONS PARTICIPATING IN TMC	Parsons Brinkerhoff; Johnson Electric Corp; TT Wiley & Assoc.; JHK		N/A		IDOT Communications Center and Emergency Traffic Patrol		Caltrans; California Hwy Patrol	
EQUIPMENT, TECHNOLOGIES INSTALLED	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future
For collecting traffic information:								
Inductive loops/loop detectors	√		√		√		√	√
Closed-circuit television	√		√			√		√
Video surveillance cameras	√		√			√		√
Ramp meters	√		√		√		√	√
Vehicles as probes				√				
Surveillance aircraft								
Roadside mounted radar detectors	√		√					
Satellites								√
Cell phone lines				√			√	√
Radio communication (CB, agency radio)	√		√		√		√	√
Telephone	√		√				√	√
Video imaging detection system	√			√				
For distributing traffic information:								
Variable message signs	√		√		√		√	√
Highway advisory radio				√	√		√	√
Radio broadcast	√		√		√			
Radio—CB, agency radio	√						√	√
Cable television	√		√		√			√
Personal computer/modem	√			√	√		√	√
Information kiosk		√	√					√
Telephone	√			√			√	√
Telephone - auto dialing	√				√		√	√
Displays at activity centers	√			√	√			√
For display:								
CRT displays	√		√		√		√	√
Map graphics display	√		√		√		√	√
Other (as indicated by respondents)			Traffic info on pager; [illegible]		[illegible]			
PRESENT AND FUTURE CAPABILITIES/FUNCTIONS OF TMC								
Incident management coordination	√		√				√	√
Special event coordination	√		√				√	√
Data backup	√		√				√	√
Media coordination and cooperation	√		√				√	√
System software support and maintenance	√		√		√		√	
Traveler information services	√			√			√	
Video surveillance	√					√		
Traffic responsive signal control							√	
Variable message sign control	√							
Integrated transit and traffic operations		√		√				
Integrated police/fire dispatching			√				√	
HOV system coordination and cooperation	√			√			√	√
Emergency response vehicle management			√					
Other (as indicated by respondents)			Automatic incident detection					
TYPE OF ORGANIZATIONS TO WHICH TRAFFIC INFORMATION IS PROVIDED	Media (TV & radio), state, county and city police, shadow and metro traffic, government agencies, private enterprise		Media (TV & radio), emergency services (fire & police), newspapers		Media (TV & radio), police, tollway authority, transit agencies, universities, other state agencies		Traffic reporting services, newspapers, radio stations, bulletin boards, internet	
NUMBER OF PERSONNEL AT TMC	2 dispatchers; 13 operators; 1 programmer; 7 state employees		2 traffic engineers; 3 traffic technicians; 23 dispatchers; 15 emergency patrol; 12 maintenance		2 traffic engineers; 3 traffic technicians; 4 electrical technicians; 2 electrical engineers; 2 computer engineers; 1 secretary		3 traffic engineers; 3 traffic technicians; 3 dispatchers; 6 software engineers/systems analysts	
ANNUAL OPERATING AND MAINTENANCE BUDGET	$5.3 million		$4.2 million		$1 million		TBD	
PROVIDE TOURS FOR TRANSPORTATION PROFESSIONALS?	YES		YES		YES		YES	
DAYS AND HOURS OF OPERATION	24 hours/day, 7 days/week		1 center operates 24 hours/day, 7 days/week; 1 operates 16 hours/day, 5 days/week; 1 operates 16 hours/day, 7 days/week		Operates 24 hours daily but only staffed 5am-7pm, M-F		5 am to 6 pm, M-F	
POLICE OFFICER ASSIGNED TO TMC?	NO		NO		NO		YES	

SOURCE: The Urban Transportation Monitor, September 15 and 29, 1995 issues.

Table II - 18 (continued)
Transportation Management Centers Survey Results
Austin Area-Wide ITS
Austin, Texas

NAME OF TMC	Central Valley Transportation Management Center, Fresno CA		Newington Operations Center, Newington CT		Texas Department of Transportation-Fort Worth District TMC (Official name not yet determined), Fort Worth TX		Statewide Operations Center (SOC), Hanover MD	
NAMES OF ORGANIZATIONS PARTICIPATING IN TMC	Caltrans; California Highway Patrol (CHP)		Connecticut State Police		TxDOT Fort Worth/Dallas; Cities of Fort Worth, Arlington, Hurst, etc.		Maryland State Police; Maryland Transportation Authority	
EQUIPMENT, TECHNOLOGIES INSTALLED:	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future
For collecting traffic information:								
Inductive loops/loop detectors	√				√	√	√	
Closed-circuit television	√		√		√	√	√	
Video surveillance cameras	√		√				√	
Ramp meters	√					√		
Vehicles as probes				√				
Surveillance aircraft							√	
Roadside mounted radar detectors			√				√	
Satellites								
Cell phone lines	√		√			√	√	
Radio communication (CB, agency radio)	√		√		√	√	√	
Telephone	√		√		√	√	√	
Video imaging detection system			√			√		
For distributing traffic information:								
Variable message signs	√		√		√	√	√	
Highway advisory radio	√			√		√	√	
Radio broadcast	√		√		√	√	√	
Radio—CB, agency radio					√	√	√	
Cable television				√				√
Personal computer/modem	√		√			√	√	
Information kiosk		√				√		√
Telephone	√		√		√	√	√	
Telephone - auto dialing			√				√	
Displays at activity centers		√				√	√	
For display:								
CRT displays	√				√	√	√	
Map graphics display		√			√	√	√	
Other (as indicated by respondents):							weather, road sensors, signal systems maintenance, logistics	
PRESENT AND FUTURE CAPABILITIES/FUNCTIONS OF TMC								
Incident management coordination	√		√		√	√	√	
Special event coordination	√		√		√	√	√	
Data backup	√		√		√	√	√	
Media coordination and cooperation	√		√	√	√	√	√	
System software support and maintenance	√		√			√	√	
Traveler information services	√			√		√	√	
Video surveillance	√		√		√	√	√	
Traffic responsive signal control			√			√	√	
Variable message sign control	√		√		√	√	√	
Integrated transit and traffic operations				√				√
Integrated police/fire dispatching				√				
HOV system coordination and cooperation	√							√
Emergency response vehicle management							√	
Other (as indicated by respondents):								
TYPE OF ORGANIZATIONS TO WHICH TRAFFIC INFORMATION IS PROVIDED	Media		State police, media, local police, ride share companies		Commercial traffic services		N/A	
NUMBER OF PERSONNEL AT TMC	2 traffic engineers; 5 traffic technicians; 2 dispatchers; 3 CHP officers		4 traffic engineers; 3 traffic technicians; 2-4 dispatchers (state police); 15 systems operators		N/A		traffic and support staff; 18 traffic technicians; Emergency Response Technicians (ERT)	
ANNUAL OPERATING AND MAINTENANCE BUDGET	N/A		$3 million		N/A		$2.4 million	
PROVIDE TOURS FOR TRANSPORTATION PROFESSIONALS?	YES		YES		YES		YES	
DAYS AND HOURS OF OPERATION	5 am to 8 pm, M-F; November '95—24hrs/day		24 hours/day; 7 days/week		13 hours/day; M-F		24 hours/day; 7 days/week	
POLICE OFFICER ASSIGNED TO TMC?	YES		NO		NO		YES	

SOURCE: The Urban Transportation Monitor, September 15 and 29, 1995 issues.

Table II - 18 (continued)
Transportation Management Centers Survey Results
Austin Area-Wide ITS
Austin, Texas

NAME OF TMC	Anaheim Traffic Management Center, Anaheim CA		Georgia Department of Transportation TMC, Atlanta GA		City of Columbus, Division of Traffic Engineering TMC, Columbus OH		Irvine Traffic Research and Control Center (ITRAC), Irvine CA		ADOT Traffic Operations Center Phoenix AZ	
NAMES OF ORGANIZATIONS PARTICIPATING IN TMC	Caltrans City of Irvine Hilton Multivision Cable TV		Georgia State Patrol Georgia Emergency Management Agency		City of Columbus Radio and TV Stations		N/A		Arizona Department of Transportation Federal Highway Administration	
EQUIPMENT TECHNOLOGIES INSTALLED.	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future
For collecting traffic information:										
Inductive loops/loop detectors	√		√		√	√	√		√	
Closed-circuit television	√			√	√	√	√		√	
Video surveillance cameras				√	√	√	√		√	
Ramp meters				√		√			√	
Vehicles as probes			√							
Surveillance aircraft				√						
Roadside mounted radar detectors									√	√
Satellites										
Cell phone lines			√				√			√
Radio communication (CB, agency radio)	√		√		√	√	√		√	
Telephone	√		√		√	√	√		√	
Video imaging detection system				√			√		√	√
For distributing traffic information:										
Variable message signs	√			√		√		√	√	
Highway advisory radio	√			√						√
Radio broadcast				√	√	√				√
Radio–CB, agency radio			√		√	√			√	
Cable television	√		√			√		√	√	
Personal computer/modem	√		√		√	√	√		√	
Information kiosk	√			√		√		√		√
Telephone	√		√		√	√	√		√	
Telephone - auto dialing	√			√			√		√	
Displays at activity centers	√			√		√		√		√
For display:										
CRT displays	√				√	√	√		√	
Map graphics display	√			√		√	√		√	
Other (as indicated by respondents):									Videowall Video Projector	Internet
PRESENT AND FUTURE CAPABILITIES/FUNCTIONS OF TMC										
Incident management coordination	√		√		√	√	√		√	
Special event coordination	√		√		√	√	√		√	
Data backup			√		√	√	√		√	
Media coordination and cooperation	√		√		√	√	√		√	
System software support and maintenance	√			√			√		√	
Traveler information services	√		√			√		√	√	
Video surveillance				√	√	√	√		√	
Traffic responsive signal control		√	√		√	√	√		√	
Variable message sign control	√		√			√	√		√	
Integrated transit and traffic operations	√			√				√		√
Integrated police/fire dispatching	√			√				√		√
HOV system coordination and cooperation			√					√	√	
Emergency response vehicle management			√					√	√	√
Other (as indicated by respondents):									Hazmat advisory Rush management advisory	Area wide traffic coordination
TYPE OF ORGANIZATIONS TO WHICH TRAFFIC INFORMATION IS PROVIDED	State police, media		Traffic reporting stations; police; Georgia Emergency Management Agency		Media, police		N/A		State police; DOT maintenance; DOT construction; news media; personal computer displays	
NUMBER OF PERSONNEL AT TMC	2 traffic engineers 2 interns		5 traffic engineers 6 traffic technicians 12 dispatchers 8 support staff		3 traffic engineers 3 traffic technicians		3 traffic engineers 6 traffic technicians		2 traffic specialists 2 traffic engineers 2 traffic technicians 8 operators 14 support staff	
ANNUAL OPERATING AND MAINTENANCE BUDGET	$1 million (including signal maintenance)		N/A		N/A (not separated from daily operations)		$1.5 million		N/A	
PROVIDE TOURS FOR TRANSPORTATION PROFESSIONALS ?	YES		YES		YES		YES		YES	
DAYS AND HOURS OF OPERATION	7 am to 5:30 pm, M-F (plus events)		24 hours/day, 7 days/week		6 am to 6 pm, M-F		7 am to 6 pm, M-F		24 hours/day, 7 days/week	
POLICE OFFICER ASSIGNED TO TMC ?	NO		GDOT enforcement officer		NO		NO		YES	

SOURCE: <u>The Urban Transportation Monitor</u>, September 15 and 29, 1995 issues.

Table II - 18 (continued)
Transportation Management Centers Survey Results
Austin Area-Wide ITS
Austin, Texas

NAME OF TMC	Traffic Operations Center, New Brunswick NJ		TransGuide, San Antonio TX		Traffic Management Center, Minneapolis MN		Transportation Management Operations Center (TMOC), Portland OR	
NAMES OF ORGANIZATIONS PARTICIPATING IN TMC	New Jersey Turnpike Authority		San Antonio Police, TxDOT, Via Metropolitan Transit, City of San Antonio Traffic Operations, Research Organizations, Police/Fire/EMS/911/Dispatch		Minnesota DOT Metro Division		City of Portland, Metro, City of Gresham, Multnomah County, Oregon State Police, Washington DOT Vancouver	
EQUIPMENT, TECHNOLOGIES INSTALLED:	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future
For collecting traffic information:								
Inductive loops/loop detectors	✓		✓		✓	✓	✓	
Closed-circuit television	✓		✓		✓	✓		✓
Video surveillance cameras	✓		✓		✓	✓	✓	✓
Ramp meters				✓	✓	✓	✓	✓
Vehicles as probes				✓		✓		✓
Surveillance aircraft					✓	✓		
Roadside mounted radar detectors								
Satellites								
Cell phone lines	✓						✓	✓
Radio communication (CB, agency radio)			✓		✓	✓	✓	
Telephone	✓				✓	✓		
Video imaging detection system	✓		✓		✓			✓
For distributing traffic information:								
Variable message signs	✓		✓		✓	✓	✓	✓
Highway advisory radio	✓				✓	✓		✓
Radio broadcast			✓		✓	✓	✓	✓
Radio—CB, agency radio					✓	✓	✓	
Cable television			✓		✓	✓		
Personal computer/modem	✓		✓			✓		✓
Information kiosk		✓		✓		✓		✓
Telephone	✓					✓	✓	✓
Telephone - auto dialing	✓					✓		
Displays at activity centers		✓	✓			✓		
For display:								
CRT displays	✓		✓		✓	✓		
Map graphics display	✓		✓		✓	✓		✓
Other (as indicated by respondents):								
PRESENT AND FUTURE CAPABILITIES/FUNCTIONS OF TMC								
Incident management coordination	✓		✓		✓	✓		✓
Special event coordination	✓		✓		✓		✓	✓
Data backup	✓		✓			✓		
Media coordination and cooperation	✓		✓		✓	✓	✓	✓
System software support and maintenance			✓		✓	✓		
Traveler information services	✓		✓		✓	✓		✓
Video surveillance	✓		✓		✓			✓
Traffic responsive signal control	✓		✓		✓	✓		✓
Variable message sign control	✓		✓		✓	✓	✓	✓
Integrated transit and traffic operations	✓		✓		✓	✓		✓
Integrated police/fire dispatching	✓		✓			✓		
HOV system coordination and cooperation		✓		✓	✓	✓		✓
Emergency response vehicle management	✓		✓					
Other (as indicated by respondents):								
TYPE OF ORGANIZATIONS TO WHICH TRAFFIC INFORMATION IS PROVIDED	Police, media, TRANSCOM		Media; emergency services (fire & police); transit; private transportation companies; general information services		Commercial radio & TV stations; truckers; transit operators; delivery services; utility companies		Media, police, local authorities	
NUMBER OF PERSONNEL AT TMC	13 dispatchers 5 supervisors 1 manager		4 traffic engineers 20 traffic technicians 60 dispatchers		6 traffic engineers 10 traffic technicians 1 computer engineer 1 programmer 1 R & D engineer 27 other		Center is only now being pulled together—no staff is specifically assigned to TMC.	
ANNUAL OPERATING AND MAINTENANCE BUDGET	N/A		$3 million		$4 million		N/A	
PROVIDE TOURS FOR TRANSPORTATION PROFESSIONALS?	YES		YES		YES		YES	
DAYS AND HOURS OF OPERATION	24 hours/day, 7 days/week		4 am to 12 am, 7 days/week		6 am to 9 pm weekdays; 11 am to 7 pm Saturdays & Sundays		Still to be decided—preference is 24 hours/day, 7 days/week	
POLICE OFFICER ASSIGNED TO TMC?	NO		YES		NO		Being considered	

SOURCE: The Urban Transportation Monitor, September 15 and 29, 1995 issues.

Table II - 18 (continued)
Transportation Management Centers Survey Results
Austin Area-Wide ITS
Austin, Texas

NAME OF TMC	TRANSCOM Operations Information Center, Jersey City NJ		San Francisco Bay Area Interim TMC (California Coastal Region), Oakland CA		District 7 TMC, Los Angeles CA		Golden Glades Interchange Control Center, Miami FL		Colorado Traffic Operations Center, Lakewood CO	
NAMES OF ORGANIZATIONS PARTICIPATING IN TMC	Over 200 agencies provide and receive information through TRANSCOM		Caltrans, California Highway Patrol (CHP), Metro Transportation Commission, Regional MPO		Caltrans, California Highway Patrol, Freeway Service Patrol		Florida Department of Transportation, Florida Highway Patrol		Colorado State Patrol, Colorado Office of Emergency Management	
EQUIPMENT TECHNOLOGIES INSTALLED	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future	Presently installed	In future
For collecting traffic information:										
Inductive loops/loop detectors			✓	✓	✓			✓	✓	
Closed-circuit television	✓		✓	✓	✓		✓	✓	✓	
Video surveillance cameras	✓		✓	✓	✓			✓	✓	
Ramp meters			✓	✓	✓			✓	✓	
Vehicles as probes	✓		✓	✓	✓			✓		✓
Surveillance aircraft					✓				✓	
Roadside mounted radar detectors						✓			✓	
Satellites					✓					✓
Cell phone lines			✓	✓	✓		✓	✓		✓
Radio communication (CB, agency radio)	✓		✓		✓			✓	✓	
Telephone	✓				✓		✓	✓	✓	
Video imaging detection system				✓	✓			✓		✓
For distributing traffic information:										
Variable message signs	✓		✓	✓	✓		✓	✓	✓	
Highway advisory radio	✓		✓	✓	✓			✓	✓	
Radio broadcast	✓		✓		✓		✓	✓	✓	
Radio—CB, agency radio	✓		✓		✓				✓	
Cable television					✓			✓		✓
Personal computer/modem	✓		✓	✓	✓		✓		✓	
Information kiosks		✓		✓		✓		✓		✓
Telephone	✓				✓		✓	✓	✓	
Telephone - auto dialing	✓			✓	✓			✓	✓	
Displays at activity centers		✓			✓			✓		✓
For display:										
CRT displays	✓		✓	✓		✓		✓	✓	
Map graphics display	✓		✓	✓	✓			✓	✓	
Other (as indicated by respondents)	alpha-numeric pager, internet & mail									
PRESENT AND FUTURE CAPABILITIES/FUNCTIONS OF TMC										
Incident management coordination	✓		✓	✓	✓		✓	✓	✓	
Special event coordination	✓		✓	✓	✓		✓	✓		✓
Data backup	✓			✓	✓			✓	✓	
Media coordination and cooperation	✓		✓	✓	✓		✓	✓	✓	
System software support and maintenance	✓		✓	✓	✓			✓	✓	
Traveler information services	✓			✓		✓		✓	✓	
Video surveillance	✓		✓	✓	✓			✓	✓	
Traffic responsive signal control			✓	✓		✓	✓			✓
Variable message sign control	✓		✓		✓			✓	✓	
Integrated transit and traffic operations	✓			✓		✓		✓		✓
Integrated police/fire dispatching			✓	✓				✓		✓
HOV system coordination and cooperation			✓	✓		✓	✓	✓	✓	
Emergency response vehicle management				✓	✓			✓		✓
Other (as indicated by respondents):					lane closure coordination, special event coordination		traffic adaptive signals			
TYPE OF ORGANIZATIONS TO WHICH TRAFFIC INFORMATION IS PROVIDED	Transp. agencies, local, county and state police, media, employers, TMA's, transit agencies		Media—TV and radio		Media, transportation partners, public		Media, state police, public		Media, local fire/police, truck firms/truck stops/terminals	
NUMBER OF PERSONNEL AT TMC	1 traffic engineer, 3 traffic technicians, 10 dispatchers, 2 operations managers		2 traffic engineers, 6 traffic technicians, 6 CHP/Media info Officers		8 traffic engineers, 4 traffic technicians, 8 dispatchers, 6 CHP officers		1 traffic engineer, 4 support staff		4 traffic engineers, 6 traffic technicians, 1 support staff	
ANNUAL OPERATING AND MAINTENANCE BUDGET	$1.9 million		$1.4 million		$10 million		$250 K		$2.1 million	
PROVIDE TOURS FOR TRANSPORTATION PROFESSIONALS?	YES		YES		YES		YES		NO	
DAYS AND HOURS OF OPERATION	24 hours/day, 7 days/week		24 hours/day, 7 days/week		24 hours/day, 7 days/week		8 am to 5 pm, M-F		6 am to 7 pm (24 hours/day, 7 days/week as of 11/1/95)	
POLICE OFFICER ASSIGNED TO TMC?	NO		YES		YES		NO		NO	

SOURCE: The Urban Transportation Monitor, September 15 and 29, 1995 issues.

San Antonio TransGuide System

The Texas Department of Transportation implemented the TransGuide system in San Antonio to better manage the heavily congested freeway system. The center is designed to provide transportation officials the opportunity, within two minutes, to react to accidents and incidents on our freeways. At the operations control center, enforcement personnel will determine the type of incident and immediately dispatch emergency medical services and required accident scene clearing services while transportation officials begin a proactive traffic management approach.

Facilities Summary - The TransGuide Operations Center (TOC) was constructed within existing TxDOT right-of-way at the interchange of IH 410 and IH 10 West. The TOC serves as the heart of the system and contains the computer system, numerous workstations, and communications equipment. The computer system is composed of a VAXft 810 mainframe computer and monitors and keyboards at each workstation. The software was developed using tailored Commercial-Off-The-Shelf (COTS) products and custom code developed exclusively for the TransGuide system.

Equipment Summary - To gather traffic information, TransGuide uses induction loop detectors buried one inch below the pavement surface. The loop detectors collect lane occupancy and volume information. Additionally, pairs of detectors are used in some locations to collect travel speed information. High resolution CCTV cameras permit the visual confirmation of congested locations reported by the loop detectors. Changeable message signs and lane control signals are used extensively to relay information to the public.

The communication system provides a single network to transmit data, voice, and video information between field equipment and the TOC. The network uses SONET standard communications protocol transmitted over a fully redundant single mode fiber optic system.

Maintenance Summary - Since the TransGuide system has only been operating for about 2 months, operation and maintenance costs have not been realized. The system is still operating under the initial warranty period provided by the contractor. Annual operating and maintenance costs are estimated at approximately $3 million. A concern exists about future maintenance requirements, and consideration is being given to contracting with a private firm.

Personnel Summary - The TransGuide staff includes 4 traffic engineers, 20 traffic technicians, and 60 dispatchers. TransGuide operates from 4:00 AM to Midnight, seven days per week.

Funding Summary - The total cost of the system is estimated at $151 million. Phase one was constructed at a cost of $32 million. The TOC was constructed at a cost of $6 million. Each mile of the system was installed at a cost of approximately $800,000 per mile, including communications and equipment. Hardware and software costs for the TOC totaled approximately $6 million.

Implementation/Phasing Summary - The first phase of the TransGuide system went online during August 1995, with construction beginning in February 1993. Phase one included 26 miles of the planned 191 mile system, the complete TOC, mainframe computer system, application software, communication switching equipment and all supporting hardware. Additional miles of the system will be added in the near future, with two projects scheduled for construction within the next year.

Montgomery County, Maryland TMC

Montgomery County, Maryland has a population of approximately 800,000 persons and contains about 3,000 miles of roadways. The area is located on the northwestern border of Washington, D.C. and covers an area of approximately 500 square miles. Management of the substantial transportation system has been a priority of the Montgomery County Department of Transportation, with assistance from the Maryland State Highway Administration. The Transportation Management System was developed primarily to control the City's traffic signal system.

The success of Montgomery County's transportation management program is dependent on the coordination and cooperation of multiple agencies. These agencies include police, fire and rescue, environmental, planning, and transportation at the federal, state and local levels. The Transportation Operations and Incident Management Team is composed of representatives from various agencies and meets on a monthly basis to develop and implement transportation management improvements.

Facilities and Equipment Summary - The Advanced Transportation Management System (ATMS) is composed of multiple subsystems that provide real time control. The ATMS features an open architecture that allows for the new technologies to be readily added to the system. The system includes the following capabilities and functions:

- Advanced traffic responsive traffic signal control for over 600 traffic signals. The system is capable of handling up to 1,500 traffic signals;
- CCTV video surveillance. 60 cameras will be operational by the end of 1995 with a total of 200 cameras projected for the future;
- 1,000 loop detectors operational in 1995, with the capability of the system to monitor 3,000 total detectors utilizing various technologies;
- Automated variable message and route guidance sign control under development, and will be tested during 1995-96;
- Travelers Advisory Radio System (TARS);
- Transportation broadcasts on cable television Channel 55;
- Aerial surveillance program;
- Coordination and information sharing with traffic information services;
- Kiosks and information centers implemented during 1995-96; and,
- Integrated traffic operations and transit management.

Montgomery County has been constructing a several hundred mile communication system to support the development of this system since 1980. The original twisted pair copper based system is being enhanced with a fiber optic system using the SONET standard protocol to support data, video, and voice requirements. The fiber optic system is being implemented with the capacity to connect all government, public school, and college facilities in the County.

Maintenance Summary - Annual operating and maintenance budgets or information are not presently available. The TMC operates 16 hours per day, 7 days per week.

Personnel Summary - The TMC has a staff of 15 persons, including 3 traffic engineers, 9 traffic technicians, and 3 dispatchers. A police officer is not presently assigned to the TMC.

Funding Summary - Funding for the system is not available, because the system has been constructed over a period of 15 years as part of numerous projects and appropriations.

Implementation/Phasing Summary - The first computerized traffic signal system component was constructed in 1980, and has been enhanced several times of the past 15 years to provide incident and traffic management features. The majority of the ATMS has been designed and installed within the last five years, with testing of many new features beginning in February, 1994.

Houston TranStar System

Houston TranStar (acronym for the Greater Houston Transportation and Emergency Management Center) is a joint initiative between the City of Houston, Harris County, Texas Department of Transportation (TxDOT), and Harris County Metropolitan Transit Authority (METRO). These agencies have established a separate legal entity, with a managing director not affiliated with any agency, to design, operate, and maintain the system.

Facilities Summary - A 52,000 square foot TMC is currently being constructed, with completion scheduled for late 1995. The center will be responsible for the Computerized Transportation Management System (CTMS) in freeway corridors, the Regional Computerized Traffic Signal System (RCTSS) on arterial streets, the Motorist Assistance Program (MAP), the Smart Commuter project, the HOV lane network, and emergency and disaster assistance. An interim TMC began operating in late 1993 and currently runs many of these programs.

Equipment Summary - The CTMS will eventually control more than 230 miles of freeway corridors, with 35 miles completed in 1994 and a total of 50 miles operational in 1995. The CTMS system will use vehicle detectors to measure speed, lane occupancy, and flow, changeable message signs, highway advisory radio, CCTV, and ramp metering using a fiber optic communications network. The RCTSS program will computerize more than 1,300 traffic signals throughout the area. Ultimately, about 2,800 traffic signals will be modified and upgraded by participating agencies. The RCTSS system will permit signal preemption for emergency vehicles as well as coordinated priority signal operation for buses that need to maintain schedules.

Maintenance Summary - Maintenance activities are not well defined for Houston's TranStar system, since it is the progress of being implemented. However, maintenance activities are currently averaging about $100,000 per year, with future estimates in the $750,000 range not including personnel and operating costs.

Personnel Summary - Houston TranStar currently has a staff of approximately 17 persons, including an executive director, 7 traffic engineers, 3 traffic technicians, and 6 dispatchers. The TMC is operated by a legal entity which is funded by the four major agencies involved in the project.

Funding Summary - A capital budget summary and operating budget for 1995 is shown in **Table II - 19** and **Table II - 20**. Annual operating costs are approximately $1 million, with total capital expenses for the construction of the TMC approximately $13.4 million.

Implementation/Phasing Summary - The TMC is scheduled for completion in late 1995, with functions transferred from the interim center in early 1996. Various components of the system are now operational, with additional segments being added on an annual basis.

Los Angeles TMC

The California Department of Transportation (Caltrans) began implementing an Advanced Transportation Management System in 1971. The system monitors conditions on the areas 400 plus miles of freeways, and provides valuable traffic information to motorists.

Facilities and Equipment Summary - The TMC is housed in a State owned building that is shared with other divisions and departments of Caltrans. The ATMS system is composed of numerous loop detectors (in about 1200 locations) which provide occupancy and speed information, CCTV at 23 locations (400 planned for the future), changeable message signs (CMS) in 73 locations, one dozen highway advisory radio (HAR) transmitters, 798 metered ramps (with 1140 planned for the future), and a service patrol of approximately 200 trucks. Information is distributed to motorists using several media, including FAX, cable television Channel 35, Traffic Vision reports to subscribers, and via the Internet. Communications is currently provided over leased telephone lines, but a fiber trunk line is currently being installed which will replace the need for leased telephone lines.

Table II-19
Houston TranStar Capital Budget Summary
Austin Area-Wide ITS
Austin, Texas

Element	Current Element Cost	Original Budget Transportation	Original Budget Emergency Management	Original Combined Budget Total	Cost - Budget Difference Transportation	Cost - Budget Difference OEM	In Kind Non Reimbursable Services
DESIGN							
Preliminary Engr	244,202	244,202		244,202	0		
Final Design	664,139	528,927	39,788	568,715	95,424		
Const Design Support	140,000	115,000		115,000	25,000		
Subtotal	1,048,341	888,129	39,788	927,917	120,424	0	0
CONST					0		
Building Const	5,849,000	5,411,871	139,049	5,550,920	298,080		
Building Const Change Orders	161,695			0	161,695		
Building Contingency (5% of Bid minus existing change orders)	130,755			0	130,755		
Const Mgt	398,000	350,000		350,000	48,000		
Furniture	416,500	500,000	55,000	555,000	138,500		
OEM Op's Rm Work Station Redesign	70,000		43,500	43,500		26,500	
Site Clearing				0	0		13,167
Site Drainage				0	0		15,000

Table II-19 (continued)
Houston TranStar Capital Budget Summary
Austin Area-Wide ITS
Austin, Texas

Element	Current Element Cost	Original Budget Transportation	Original Budget Emergency Management	Original Combined Budget Total	Cost - Budget Difference Transportation	Cost - Budget Difference OEM	In Kind Non Reimbursable Services
Median Opening				0	0		23,000
Overflow Parking Lot				0	0		7,800
Radio Antenna Cables				0	0		20,000
Parking Lot Striping				0	0		3,000
Subtotal	7,025,950	6,261,871	237,549	6,499,420	500,030	26,500	81,967
PHONE SYSTEM					0		
Phone Switch/Sys Transportation	282 461	250 000		250,000	32,461		
Phone Switch/Sys OEM	107,039		7,600	7,600		99,439	
Phone, Data,CCTV Cables	100,000			0	100,000		
Subtotal	489,500	250,000	7,600	257,600	132,461	99,439	0
Computer Systems					0		
Computer Hardware	2,356 955	2 000 000		2 000 000	356,955		

Table II-19 (continued)
Houston TranStar Capital Budget Summary
Austin Area-Wide ITS
Austin, Texas

Element	Current Element Cost	Original Budget Transportation	Original Budget Emergency Management	Original Combined Budget Total	Cost - Budget Difference Transportation	Cost - Budget Difference OEM	In Kind Non Reimbursable Services
Systems Integration	1 750 000	1 750 000		1 750 000	0		
Systems Integration Unfunded Delivery 1	224 130			0	224,130		
Systems Integration Unfunded CMS	396,000			0	396,000		
Systems Integration CMS Satellites	163,000			0	163,000		
Subtotal	4,890,085	3,750,000	0	3,750,000	1,140,085	0	0
GRAND TOTAL FUNDED ELEMENTS	13 453,876	11 150,000	284,937	11 434 937	1,893,000	125,938	81 967

Table II - 20

Houston TranStar Operating Budget
Austin Area-Wide ITS
Austin, Texas

OPERATING BUDGET		
ITEM	FULL YEAR	FY 95\96
SUPPLIES/MATERIALS		
Maintenance Supplies	42,000.00	25,940.00
Office Supplies	32,000.00	19,745.00
Computer Supplies	25,500.00	15,735.00
Postage	4,000.00	2,470.00
Sm Tools/Minor Equip	15,000.00	18,500.00
Printing	30,000.00	39,596.00
Publications	5,000.00	5,000.00
Memberships	2,000.00	2,000.00
Training	1,000.00	1,000.00
Office Equip Rental	21,500.00	13,265.00
Computer Equip Rental	5,500.00	3,395.00
Misc Office Equip	3,000.00	3,000.00
Travel	18,000.00	18,000.00
SUBTOTAL	204,500.00	167,646.00
UTILITIES		
Electric	110,000.00	67,870.00
Gas	20,000.00	12,340.00
Water/Sewage	12,000.00	7,404.00
Communication(Telephone)	44,500.00	50,180.00
SUBTOTAL	186,500.00	137,794.00
MAINTENANCE SERVICES		
Building Cleaning	25,000.00	15,425.00

SOURCE: Houston TranStar, September 1995.

Table II - 20 (continued)

Houston TranStar Operating Budget
Austin Area-Wide ITS
Austin, Texas

OPERATING BUDGET		
ITEM	FULL YEAR	FY 95\96
Landscape Maint	13,200.00	8,804.00
Building Maint	20,200.00	13,375.00
Office Equip Maint	2,000.00	1,340.00
Mechanical Maint	42,000.00	28,140.00
SUBTOTAL	102,400.00	67,084.00
COMPUTER HARDWARE MAINT		
	200,000.00	133,400.00
SUBTOTAL	200,000.00	133,400.00
COMPUTER SOFTWARE MAINT		
	181,000.00	120,727.00
SUBTOTAL	181,000.00	120,727.00
COMMUNICATIONS EQUIP		
Included in Hardware	0.00	
SUBTOTAL	0.00	0.00
VIDEO MAINTENANCE		
Included in Hardware	0.00	
SUBTOTAL	0.00	0.00
PERSONNEL		
Salaries(4 Positions)	277,550.00	268,905.00
SUBTOTAL	277,550.00	268,905.00
GRAND TOTAL	1,151,950.00	895,556.00

SOURCE: Houston TranStar, September 1995.

<u>Maintenance Summary</u> - Operations and maintenance costs average approximately $2.5 to $3 million per year. These costs include salaries for 30 personnel, leased phone line expenses, equipment, and maintenance contracts. The majority of the maintenance of the system is handled through contracts with private companies. In 1991, a service patrol was initiated between Caltrans and the California Highway Patrol (CHP). Private tow operators are contracted and assigned a beat to patrol. This service costs approximately $14 million per year to operate, including administration.

<u>Personnel Summary</u> - Approximately 30 persons are on the TMC staff, including traffic engineers, system operators, software technicians, and dispatchers. The center is operated 24-hours a day, seven days per week. Personnel are used on a rotating shift basis, with at least three staff members on duty at all times (one CHP officer, one Caltrans operator, and one Caltrans dispatcher).

<u>Funding Summary</u> - Cost and funding information is not well defined because of the "piecemeal" approach used in developing the system. Many system costs, such as the installation of loop detectors, were hidden within freeway reconstruction projects and are not known. However, estimates for the total system range from the hundreds of millions of dollars to one billion dollars, maximum. Current capital outlays for completion of the system are approximately $300 million.

<u>Implementation/Phasing Summary</u> - Caltrans began implementing an Advanced Transportation Management System (ATMS) in the Los Angeles area in 1971 with a relatively small 42 mile freeway loop. Between 1971 and 1990, using a "piecemeal" approach, the system was expanded to its current 400 miles. In 1990, state legislation provided funding for the ATMS, from which a ten year plan was developed for a future 550 mile system.

Minneapolis Traffic Management Center

The Minnesota Department of Transportation's Traffic Management Center (TMC) opened in 1972 and is the operations center for managing freeway traffic in the Twin Cities Metro Area. The TMC is also participating in a number of ITS operational tests, such as the Integrated Corridor Traffic Management (ICTM) project. The ICTM project is being implemented along a 7.9 mile segment of IH 494, with the main objective of improving the efficiency of traffic movement throughout the corridor on freeways and arterial streets. The freeway and arterial traffic control devices, such as traffic signals, are being integrated in an adaptive traffic control environment. In addition, the project will develop unified traffic control strategies through interjurisdictional cooperation, implement an incident management plan, and implement a comprehensive motorist information program. The communication media is fiber optic cable. The cable is also connected to transit and EMS users.

An evaluation of the system along IH 35W between downtown Minneapolis and Burnsville identified the following highway user benefits, which are typical of other large systems:

- Roadway capacity increased from 1800 to 2200 vehicles per hour per lane;
- Peak period speeds increased 35% from 34 to 46 mph;
- Peak period accidents decreased 27% from 421 to 308 per year;
- Peak period accident rates decreased 41% from 3.40 to 2.02 accidents per million vehicle miles traveled;
- Peak period fuel consumption was reduced by one million gallons per year;
- Peak period air pollutant emissions (carbon monoxide, hydrocarbons, and nitrogen oxides) were reduced by four million pounds per year; and,
- One million dollars a year in road user benefits are attributed to reduced accidents and congestion.

Facilities Summary - The TMC is housed in a building originally constructed in 1972, with a redesign completed in December 1992. The new design includes two independent operator work stations, a radio announcer station, an information officer station, computer graphics terminals, and a large screen map display. Each operator's workstation consists of 24 17-inch monitors and computer terminals with graphics capabilities to control the ramp meters and changeable message signs. A large computer generated map displays real-time traffic conditions on area freeways. The communication connection to other agencies reduces the urgency desire to move into one facility.

Equipment Summary - The traffic management system currently in operation in the Minneapolis/St. Paul area includes 380 ramp meters, 156 CCTV cameras, and 56 changeable message signs. The CCTV cameras located along IH 94 are mounted on tall buildings and communicate to the TMC via microwave signal. Other CCTV cameras communicate via fiber optic cable or coaxial cable, with the coaxial cable being replace with fiber optic cable within the next five years. Changeable message signs are of the six sided rotating drum type, but the MnDOT is currently evaluating new sign technologies.

Maintenance, Personnel and Funding Summary - Detail information on maintenance activities, personnel, and funding is not generally available at this time. However, information on personnel and funding is being compiled in a TMC Business Plan report, and should be available in the near future. The TMC personnel in peak periods includes 2 operators, 1 public information officer, 1 radio broadcaster, 1 TRILOGY System (Demonstration Project) operator broadcasting to vehicles, and 2 supervisory personnel for a total of 7 people. In off peak periods only 2 people are present. The hours of operation are from 6:00 am to 9:00 pm weekdays and 7:00 am to 8:00 pm on weekends.

Implementation/Phasing Summary - The traffic management system in the Minneapolis/St. Paul area was initiated in 1972 as part of the IH 35W Urban Corridor Demonstration Project, and has evolved into the system described in this section. The system is still being developed as new technologies are discovered, tested, and implemented.

Summary

The five agencies surveyed by Wilbur Smith Associates included two TMCs primarily designed for freeway surveillance (San Antonio TransGuide and Los Angeles TMC), one TMC primarily designed for operating a local traffic signal system (Montgomery County, Maryland), two TMC designed for operating both freeways and traffic signal systems (Houston TranStar) and (Minnesota DOT TMC).

All agencies surveyed stressed that a definite commitment of adequate financial resources, qualified personnel, fully integrated systems, and appropriate technology are available. Funding for operations and maintenance must be allocated from a dedicated source prior to beginning construction of the system. Staffing, training and funding must be available for construction, operations, and maintenance.

For TMC site visits to areas that would possibly be representative to the Austin area it is recommended that the agency staff visit the following cities: San Antonio and Houston, Texas; Los Angeles, Anaheim, and San Diego, California; Montgomery county, Maryland; and

Minneopolis, Minnesota. The Las Vegas, Nevada system should be carefully monitored during its expansion phase since Nevada DOT is proposing to utilize 2070's for their system upgrade.

Multi-Agency Traffic Management Center

The Multi Agency Traffic Management Center (TMC) is the core of an integrated traffic control system for multi agency utilization. The primary purpose of the TMC is to gather roadway and traffic data and information for use by numerous local agencies. The TMC should more accurately be called an Information Management Center (IMC) to help encourage the use of the facilities by non-transportation related agencies. The full benefits of a TMC cannot be realized until all of the governmental agencies in the Greater Austin Area become a part of the TMC.

The first step in establishing a multi-agency TMC is the formation of an operations management committee comprised of members of the various agencies most actively involved in its development. This organization should facilitate decision making in regards to the center. The committee should be comprised of, at a minimum, the following members:

- Texas Department of Transportation, Austin District;
- City of Austin (representing traffic, police, fire, and EMS functions);
- Capital Metro; and,
- Travis County.
- Research Enity; and,
- Private Sector Representation

Similar committee structures have provided the catalyst in the development of traffic management centers in cities around the nation, such as Las Vegas, Nevada and Houston, Texas. The committees should be advised by a Board of Directors comprised of one representative from each member agency. A manager or director with no current ties to any member agency manages the committee. This management structure will help to ensure that decisions made will benefit all of Greater Austin and not just one of the member agencies. Funding for the management structure should be provided by the member agencies.

There are two different approaches which could be utilized to develop a TMC for the Greater Austin Area: a centralized approach and a distributed approach. Both of these TMC designs are described in the following sections.

Centralized Traffic Management Center

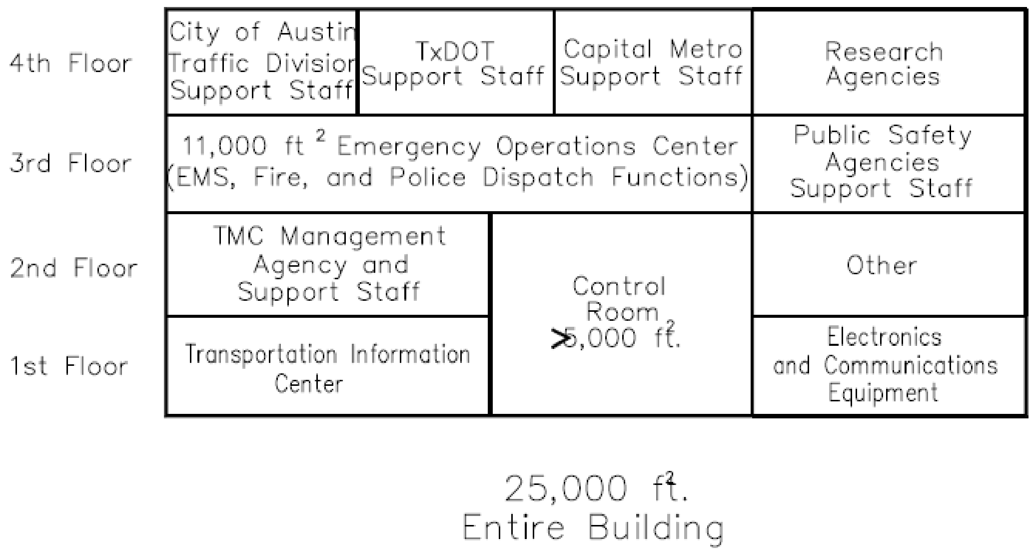
A centralized Traffic Management Center, as shown in **Figure II - 34**, consolidates all operations and dispatching functions of numerous agencies into one building at one location and provides the greatest opportunity for interagency coordination and multi agency cost sharing. The primary areas of coordination are within a few feet of each other and not only lends itself for field coordination but also provides local agency coordination in case of a major disaster. The functions and agencies involved are generally shown on Figure II - 34.

The Texas Department of Transportation, City of Austin, Travis County, Public Safety Agencies (PSA), and Capital Metro are primarily the current end users of a shared Multi Agency Traffic Control Center. This type of deployment enables the total coordination and immediate inter agency coordination within the building as well as the field. In the future, numerous other agencies or organizations, as identified in **Table II - 21**, may be involved in the TMC and may have a desire or need for one or more workstations within the center.

The news media will play a very important role in the development of the Centralized Traffic Management Center in that the news media will educate the public and help to disseminate traffic conditions throughout the Greater Austin Area. This function will also improve public relations and improve the likelihood of bond elections for sources of funding.

The 800 MHZ radio frequency trunking system, which should be a part of the Centralized Traffic Management Center, plays an extremely important role in the interagency coordination of the wider Greater Austin Area. This type of communication system facilitates coordination, especially during major disasters, and will preclude the coordination of a non-centralized traffic management system.

In this case, since the entire head end of the 800 MHz system is located at the Centralized TMC (where all of the coordination emanates), it is easy for all of the agencies to communicate via an 800 MHz radio frequency trunking system during major disasters. Major disasters may interrupt power or preclude the remote outlying areas from communicating over the standard fiber optics or standard telephone system. The 800 MHz trunking system can be highly effective in providing a communications system in times of disaster when electrical power is typically unavailable.



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HOUSTON, TEXAS

NORTH AMERICAN CONTROLS CORPORATION
ADVANCED TRAFFIC ENGINEERING
KESSMANN & ASSOCIATES

Possible Centralized TMC Building Arrangement
Austin Area–Wide ITS
Austin, Texas

Figure II–34

Table II - 21

Agencies and Organizations to be Potentially Involved in the Austin TMC
Austin Area-Wide ITS
Austin, Texas

Texas Department of Transportation
City of Austin Traffic Division
City of Austin EMS
City of Austin Police Department
City of Austin Fire Department
Capital Metro
Texas Department of Public Safety
University of Texas Police Department
Travis County Sheriffs Office
Metro Police
Courtesy Patrol
National Weather Service
Federal Highway Administration
Federal Transit Administration
Federal Aviation Administration

NAFTA Weigh-in-Motion Monitoring
HAZMAT Monitoring
News Media
Commercial Traffic Reporting Services
Commercial Vehicle Operations
City of Round Rock
City of Pflugerville
City of West Lake Hills
City of Del Valle
City of Rollingwood
City of Sunset Valley
City of Cedar Park
City of Oak Hill
City of Jollyville

Advantages - A Centralized Traffic Management Center (TMC) will provide unified traffic management and traveler information for the metropolitan area. This type of deployment will provide the following advantages:

- A centralized TMC will bring together traffic management and public transportation personnel from the City of Austin, TxDOT, Capital Metro, and other agencies. This includes the freeway traffic management and traffic signal system personnel who will be able to work together in developing corridor and area wide traffic management plans for recurring and non-recurring events. This is especially important as traffic volumes grow due to increasing population and freight movement. Communications between all agencies/entities will become much easier with the ability to "walk across the room" and discuss an incident or procedure resulting in faster resolution;

- Only one large "hub" communication node will be necessary with a central TMC, thereby minimizing initial construction and later expansion costs. A communication component will be necessary for each major connection into the primary fiberoptic network.

- A central TMC will provide facilities consolidation, with only one physical site needed to operate and maintain;

- A heightened sense of a "TEAM" is formed when all agencies/entities are in one location. Efforts are focused upon providing a unified response. Obstacles produced by the "them vs. us" syndrome are decreased as members become better acquainted with each entities's capabilities, resources, procedures, and personnel;

- A central TMC will also permit intermodal integration through the coordination of traffic management and public transportation. Transit operations could be carried out through a separate computer which would be interconnected with the other traffic management and freeway HOV computers. Being in one location, however, personnel can work more closely in developing strategies for encouraging transit operations (e.g. bus and rail priority operations, improved communications with the public and the media);

- A centralized TMC will permit the Public Safety Agencies, Public Transportation and Traffic Management personnel to work together and to provide one focal point for working with surrounding cities and other agencies (public works, maintenance, Metropolitan Planning Organization);

- A centralized TMC will improve efficiency in overall traffic management and implementation of Intelligent Transportation Systems (ITS). This includes applications for reducing vehicle emissions and increasing HOV and public transit ridership;

- A centralized TMC will also provide one focal point for gathering, analyzing, and disseminating information to the public and commercial media stations. This will permit more accurate and timely information than if information must come from many agencies within the region;
- The development of a central TMC will reduce overall costs to each agency by combining space and communication utilization and by reducing overall operation maintenance costs; and,
- A central TMC will permit the traffic management agencies to have one manager or director (as is being done in Las Vegas and Houston) to coordinate operations and work with the administrators of various agencies.

Disadvantages - Despite the numerous advantages, the Centralized TMC deployment approach provides the following disadvantages:

- The primary disadvantage of the Centralized Traffic Management Center is the possibility of failure in a major disaster. Acts of terrorism and major disasters may interrupt the primary functions of the Centralized Traffic Management Center. Good security measures would include a screening reception area fairly well isolated from the operations and controls areas of the Centralized Traffic Management Center. Finding a location that meets the security needs of all participants as well as operating needs of all participants may be very difficult, costly, and not easily accessible to communications medium.
- A large amount of land will be required in one location for the TMC building and parking areas. Also, each agency has desired needs which makes it more difficult to find a suitable site.
- Initial Facilities Start-up Costs - the initial building costs of constructing a facility to house all agencies/entities would exceed the costs of implementing a Distributed Traffic Management Center that utilizes some or most of the existing facilities.

Facilities Summary - A centralized TMC would require all agencies participating in the center to relocate operational functions and possibly additional support staff to one location. A possible building arrangement was previously shown . The two-story control room would eventually contain approximately 40 workstations to accommodate all of the potential agencies and organizations and large rear-projection screens and/or a video wall at the front of the room. The workstations are the primary operations consoles that are used to verify, detect and provide verification of the type of incident that occurs throughout any part of the Greater Austin Area.

The control room can provide the video verification as well as traffic load conditions, for the Emergency Safety Center located on the third floor. All dispatching functions for Police, Fire, and EMS would be located on the third floor, with a facility of approximately twice the size of the current City of Austin EOC or ESC. The location of the ESC in the same building as the management center is extremely useful during major incidents involving hazardous materials, fire, or terrorism activity. Travis County and other PSA's would also be located in the facility.

The Transportation Information Center (TIC) would also be located on the first floor, with large windows overlooking the control room. The TIC is a gathering room for the media, commercial vehicle operators, and other groups desiring real-time traffic information.

The electronics and communications equipment room contains racks of equipment which can support the intent of the Operations Center but also includes spares for future growth. Equipment contained in the electronics and communications equipment room is identified in **Table II - 22**. A common area for all electronics racks which provides communications, video switch gear controller, controller electronics for the traffic signal control systems, as well as TxDOT computer controls, and PSA electronics racks for all 800 MHz trunking and all support console electronics would be concentrated in this area.

This area should be sized for a 100% spare growth for the next 20 years. The type of equipment that can be utilized by the control Center as well as all of the PSA and 911 call outs can be listed under the Equipment Room Equipment Racks as indicated in Table II - 22.

The control center would be overlooked by a planning coordination room. A good design should include windows for the planning coordination room, as well as windows for the hall, Director's room, and the halls adjacent to the control room areas. The typical second floor configuration would provide office space for the Director, secretary, and support personnel, including break room, and storage room.

Even with one TMC, there could be two operations control rooms adjacent to each other, if desired. One control room would provide for the PSA personnel and the second for the Traffic Management, Capital Metro and Traffic Information Center personnel. The two control rooms could be separated by a glass partition.

Table II - 22

Electronics and Communications Equipment Room
Austin Area-Wide ITS
Austin, Texas

	Rack Number	Description
Communications	1 -6	T1, DS3 Equipment
	7 - 8	Fiber Optic Termination
	9 - 10	800 MHZ Trunking
Video Switchgear controls	1 - 4	Video Switching & workstation
	4 - 8	Termination & Test Equipment
	9 - 10	Spare
Traffic Management Computers	1 - 3	City Traffic Computers
	4 - 8	TxDOT Freeway Traffic Computers
	9 - 10	Interface Cabinet*
	11	CMS Computers*
PSA Equipment**	1 - 3	Police Department
	4 - 6	Fire Department
	7 - 9	Other PSA Departments
	10	800 MHZ Trunking

* The CMS Cabinet is the network server for all CMS field controllers as well as the clients in the TMC.

** The generic equipment for each PSA would include 800 Mhz I/F's , dispatch connects, T1 interfaces, fiber optic interface, telephone PBX connects, 800 Mhz call, did group manager unit.

It may be desirable to locate the TMC/PSA control room and computers below ground for purposes of security. Discussions to date have involved the construction of a new facility, but it may be possible to lease, lease to buy or buy a building that will meet the central TMC/PSA needs in lieu of constructing a new building.

Equipment Summary - A centralized TMC approach consolidates all equipment into one facility, including hardware, software, and communication needs. The equipment needed for a centralized TMC is summarized in the following sections:

- *Hardware* - Hardware used in the operation of a centralized TMC is identical to the hardware recommended in previous chapters for the Traffic Signal System (TSS), the Freeway Traffic Management System (FTMS) and Incident Management, Verification, and Response. The required hardware is summarized as follows:

  - TSS Local Intersection Controller/FTMS Local Control Unit (2070/ATC)
  - Vehicle Detectors (Inductive Loops, Video Image Processing, Microwave Detectors, and Infrared Detectors)
  - Surveillance Equipment (CCTV)
  - TSS Central System/FTMS Computer Unit (Networked Pentium-type PC workstations with bi-directional links to Police/Fire/EMS CAD System)

- *Software* - Software used in the operation of a centralized TMC is similar to the software recommended in previous sections for the Traffic Signal System (TSS), the Freeway Traffic Management System (FTMS) and Incident Management, Verification, and Response. There is a need to have separate software operating in a windows or similar environment such that the entire package will not have to be rewritten if changes or made to one package. Each type of operating package has a unique task to perform and can be tailored to perform that task efficiently while operating under the primary operating system. Updates can be made to each individual package as needed or as available without upgrading the entire system. The required software is summarized as follows:

  - Traffic Signal System Controller Software
  - Central Traffic Signal Software
  - Freeway Management System Controller Software
  - Freeway Management System Central Software
  - Incident Detection Software - Incident Detection Software for the Local Controller that provides incident alarms to the TSS/FTMS Central/Computer Unit. These alarms are calculated by measuring parameters i.e. volume, speed, and occupancy at each vehicle detector location (upstream and downstream). An incident is detected based upon any of these parameters exceeding threshold limits. When an alarm occurs, CCTV could be used at the TSS/FTMS to verify the incident. A message could then be sent to the Police/Fire/EMS CAD system once verification is complete. The other software previously referenced (i.e. ramp metering, signal coordination, emergency vehicle pre-emption, changeable

message signs with diversionary route information, routing alternatives, etc.) could then be initiated by the TSS/FTMS system.

- Linkage Software for Bi-Directional Communications between the TSS, FTMS, and Police/Fire/EMS CAD System - The linkage software allows the field equipment to notify the TMC of an incident or pre-emption and the PSA know the location of their vehicles in the field. The TMC could then communicate to their field units. Software that will allow messages to be sent between the TSS, FTMS and Police/Fire/EMS CAD System should be implemented so that all agencies are notified of incidents. The TSS and FTMS should be notified of all incidents that might have an effect on traffic flow. The TSS and FTMS could be utilized to improve response to the incident and increase safety.

· *Communications* - The primary communications equipment can consist of standard Public Exchange (PBX) telephone communications system as well as the primary fiber optics Freeway Traffic Management System, GAATN Fiber Optic Ring Telecommunications System, and the 800 MHZ radio frequency common carrier trunking system, as well as the cellular telephone service area. These types of communications systems are all related in one way or another to the common shared objectives of the Centralized Traffic Management Center.

In the case of a major disaster where power is unavailable in different areas throughout the Austin Area, the 800 MHZ system can be a tremendous asset for the operations of the Centralized Traffic Management Center. Vice versa, when the 800 MHZ system does not function well in a rather hidden area in a certain point of the Greater Austin Area, either a cellular phone or a fiber optic communications drop can be made accessible by utilizing the GAATN, or the common Freeway Traffic Management System fiber optics major communications trunkline. The communications equipment summary and estimated cost is shown in **Table II - 23**.

The communications concerns for the centralized TMC approach (which carry all data, voice and video communications) offer the best alternative to a multi-agency cost sharing system for TxDOT, City of Austin, Travis County, and PSA. In addition, Capital Metro, news media, courtesy patrols, and signal shop maintenance can utilize this common multi-agency communications system.

A centralized TMC would provide a common communications system with a multi-agency cost sharing which will in the end provide the most cost effective communications system. This would be true for the onset of the initial projects cost and long term operations and maintenance of the system. The commonality of the communications system throughout the entire area enhances the common electronics packages that are available for the different agencies.

Table II - 23

Communications Equipment Needs and Cost
for Centralized Traffic Management Center
Austin Area-Wide ITS
Austin, Texas

Item	Estimated Cost
DS3 Carrier - 4 Shelves	$ 120,000
T1 Carrier - 20 Shelves	240,000
Fiber Optic Termination - 2 cabinets	30,000
Interface Drivers - 1 Cabinet*	50,000
800 MHZ Trunking System**	991,600
TMC Building Communications	
Control Room - 40 Workstations	40,000
PSA Room - 50 Workstations	50,000
PBX interconnects - 80 Lines	5,600
Total	**$ 1,527,200**

* Interface drives include the following:
- Video equipment
- Data equipment/management system
- Voice equipment

** A detail study to determine this cost is currently being conducted by PSA.

Maintenance Summary - Operating and maintenance costs for TMCs operating in other cities average approximately $2.1 million per year. Average manintenance costs can be estimated during the planning stages at approximately 10 percent of the construction cost of a TMC. Annual maintenance costs typically range from 5 to 20 percent of TMC construction costs and will vary depending on the number of field units needing maintenance (such as loop detectors) and the type of communication system installed.

Maintenance personnel requirements include a staff of trained personnel to perform communications maintenance, general equipment maintenance, and software maintenance. The size of this staff is dependent upon the type and size of TMC that is implemented in the Austin area, but is estimated at approximately one software maintenance person, one communications maintenance person, and two equipment maintenance persons present during all TMC operational hours. Operations personnel requirements are discussed in the Personnel Summary section.

Personnel Summary - The number of personnel needed by TxDOT and the City of Austin to operate a centralized traffic management center is identical to the staff needed regardless of their location, as previously identified in the Traffic Signal, Freeway Traffic Management sections. The only additional personnel needed to operate the center will be part of the operating committee, including the director or manager, 1 or 2 assistant directors, 4 support and secretarial staff, software manager, communition manager and a 24-hour security staff. The operating the Emergency Safety Center would be similar to the existing staffing level currently working as dispatchers in other locations. A 24 hour operation would require additional operational support staff. Staff needed by other agencies, such as Capital Metro. A 24-hour operation would require a minimum of 1 staff person per agency per shift for full operation. However, with some cross training in off-peak periods, the number of staff could be halved.

Funding Summary - The cost of developing a centralized TMC primarily consist of the cost of constructing or leasing a building and installing all hardware, software, and communications. The total cost is summarized in **Table II - 24**, and includes estimates for the building, software, workstations, and internal communications. The costs of installation of all field equipment and communications to field locations is summarized in previous chapters. Software costs are estimated based on the recommended design of a PC based system. If a Unix/windows based system is chosen, costs for software alone can be expected to increase to $15 to 20 million. If the

Table II - 24

Estimated Cost of Centralized TMC
Austin Area-Wide ITS
Austin, Texas

Item	**Estimated Cost**
TMC Building	$ 3 to 6 million
Internal Communications (see Table II-23)	$ 1.6 million
Hardware	
40 Workstations @ $ 10,000 (includes 4 video monitors, controls, console, and CPU)	$ 400,000
4 Servers @ $20,000	80,000
Software	
Non-proprietary, PC based system	$ 3 to 5 million
Total	**$ 8 to 13 million**

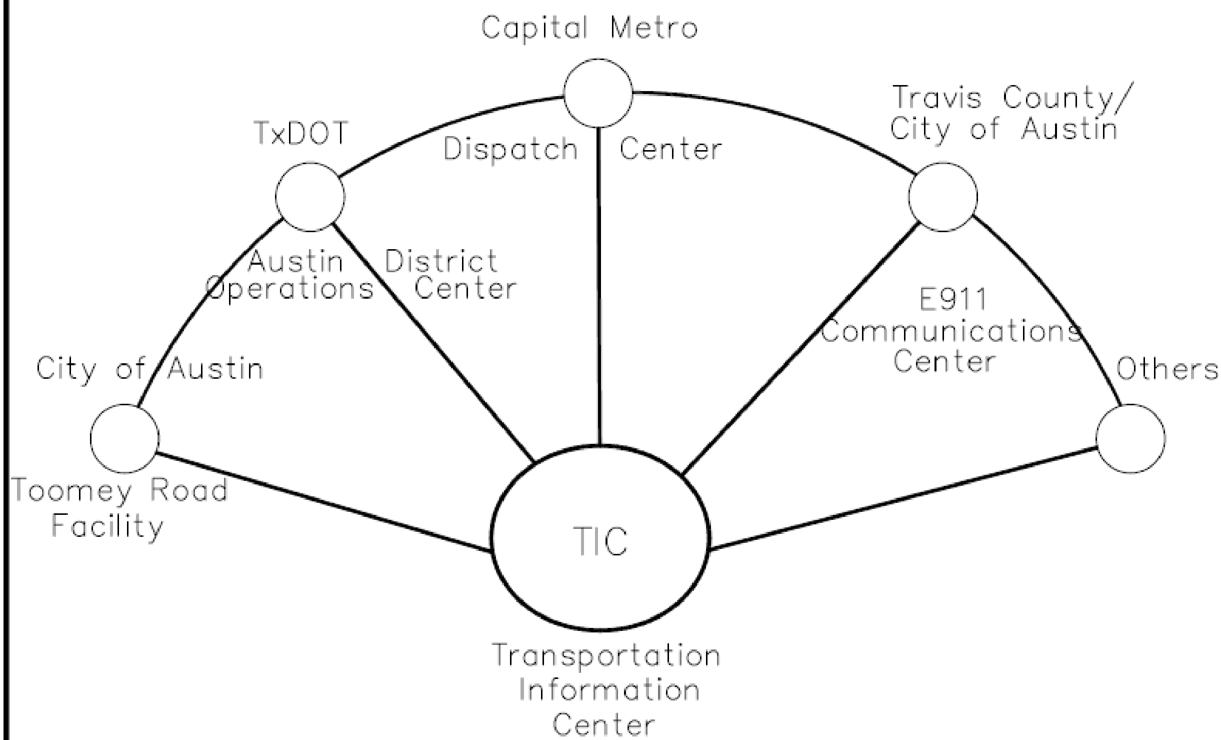
system is automated for many portions of the central system software, an additional $3 million would be needed for system integration. The automation portions could include what happens when a type of incident occurs in a specified section of the area. The agencies that provided input to the study are included in the cost estimates. The cost estimate does not include a major video display wall or press visitor rooms. The software allows each system to function separately and then communicate between agencies.

Funding could be through bond funds and Federal funds. It may be possible to rent a building temporarily, although the purchase/build concept would be preferable. A lease/purchase plan may also be possible.

Implementation/Phasing Summary - The implementation of a centralized traffic management center should be the long range goal of the Greater Austin Area. Separate traffic control centers will probably be needed initially due to limited funding resources. It may be that TxDOT and Capital Metro will have separate traffic control centers for their own systems initially and that all agencies could come together in one Operations Center (TMC) when the city's EMS and traffic control facilities are built as a result of a combined bond package. The Houston Area system should be "guideline" for the Austin Area. The Houston Area has a series of interlocal government agreements that allow joint operations, and maintenance. The governmental groups include TxDOT, Harris County, the City of Houston, and METRO.

Distributed Traffic Management Center

The second approach in developing a traffic management center for the Greater Austin Area is a distributed deployment system. **Figure II - 35** illustrates a distributed TMC system architecture which involves the City of Austin, TxDOT, PSA, and Capital Metro operations to remain in their existing facilities, with improved communication systems connecting their operations together. This communications system includes data, voice, and video and is shared in order to unify all those entities into a complete traffic management system. In addition, a Transportation Information Center (TIC) or Incident Management Center (IMC) facility would be operated at a separate facility and staffed by one or two persons from each member agency. This facility would gather data from agencies and disseminate that information to the public.



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Possible Distributed TMC Approach

Austin Area-wide ITS
Austin, Texas

Figure II-35

Advantages - A distributed TMC approach provides for the following advantages:

- There is no single point of failure in any of the locations throughout the communications chain. That is to say, if the TxDOT location were to have a disaster, the other entities would continue to service the Greater Austin Area without interruption.

- It should be easier to find a location for each traffic control center with a decentralized system, since many agencies already have facilities in existence. For example, both TxDOT and the City of Austin have facilities available at present for traffic management.

- A distributed TMC approach could be quickly implemented at a lower cost than a centralized TMC approach. This type of a center could be implemented quickly as existing facilities could be used. Minimal modifications would need to be made to implement the recommended systems with the major efforts being focused on communications medium.

- With a distributed TMC approach, each agency could continue to operate as they currently do utilizing their existing management structure. Each agency could provide the level of services that they desire or their funding provides.

Disadvantages - Despite these advantages, the distributed TMC deployment approach provides the following disadvantages:

- The primary disadvantages to the distributed TMC approach is that cost effectiveness is lost because each location has to retrieve data, video, and voice communications instead of a shared common communications architecture as in a Centralized Traffic Management Center. Each agency has to be put on a network system throughout the entire Greater Austin Area. For example the City of Austin Transportation, which now has a small traffic management center, would be sampling the data throughout the Greater Austin Area. The communications system has to be configured so that TxDOT, EMS, Travis County, the Fire Department, and the Police Department, could utilize a portion of that telecommunications system. This type of architecture requires that the City Traffic Control System has to have its own communications architecture. TxDOT and all other agencies would have to acquire compatible communications architecture.

- Another disadvantage is that this type of distributed traffic management center provides for difficult coordination in case of a disaster where remote location communications is cut off to different parts of the city. If a power failure occurs in two to three parts of the city, or in a major area, this could cripple communications between TxDOT and the City of Austin Traffic Division and County agencies. This is what makes the centralized TMC approach very attractive in that all of the agencies are located within a common shared area and can effectively communicate either by telephone or directly face-to-face within the Traffic Management Center.

- Due to the commuincation logistics, a distributed TMC concept normally does not provide as many services as the centralized approach.
- There is less opportunity for personnel to work together and interact with each other. It is easier to work in your own world and not be as concerned with the overall picture in a decentralized system.
- The reduced opportunity for personnel to interact with each other can reduce efficiency of operations in reducing recurring and non-recurring congestion. Due to the distribution of personnel, communications between agencies may not be as rudimentary as in a centralized TMC approach.
- A decentralized system could also reduce fulfillment of benefits in multimodal operations. There would not be as much opportunity to develop a coordinated system design and application for public transportation and HOV operations and to develop a program for reducing vehicle emissions.
- The implementation of ITS user services will be more difficult to implement on a regional basis under a distributed system. This would be due to reduced communications, coordination, and cooperation.
- A distributed TMC approach also lacks a "TEAM" Image, because distribution of multiple agency operations could diminish the ability to build a unified support team.

Facilities Summary - The primary benefit of a distributed TMC approach is that each agency can utilize their existing facility, which reduces inital capital costs. The City of Austin could continue to utilize their existing facility at Toomey Road, while TxDOT could enhance their current operations at the Austin District Headquarters. Each agency's control center would need approximately 1300 square feet of total floor space, with about 700 square feet needed for operations activities and 600 square feet needed for the equipment room. The composite configuration of the distributed TMC approach operating as a single entity may require *six times* the resources previously identified for a centralized TMC. The major increase in space for a distributed system is the need for separate communications equipment at each facility, instead of consolidating the equipment into a centralized TMC. The major connection interface points or nodes are the expensive elements in distributed systems. Each location would eventually become a mini-TMC.

Equipment Summary - The majority of the equipment needed for a distributed TMC is identical to the equipment needed for a centralized TMC except the equipment is now distributed over several locations. In theory, hardware and software needs are identical, except that video conferencing capabilities should be added to the PC network to expedite communications between agencies. However, practically, there will be some redundancy in equipment and software in a distrubuted system. In a central system there will also be satellite offices or terminals. Video conferencing in a distributed TMC approach would permit each agency to better coordinate activities during times of emergencies.

Communications equipment needed by each agency in a distributed TMC approach is identified in **Table II - 25**. Since the 800 MHZ system is not shared with other agencies, the cost of the 800 MHZ trunking system will increase due to the fact that each location will require a digital controller, antenna tower, and other equipment necessary to integrate mobile talk groups.

Maintenance Summary - Operating and maintenance costs for TMCs operating in other cities average approximately $2.1 million per year, as identified previously. Average maintenance costs for the distributed TMC approach will be slightly higher than for the centralized TMC approach because of the additional facilities and communications equipment needed to operated this type of system.

Maintenance personnel requirements for the distributed approach are also similar to the centralized TMC approach and could include one trained staff of maintenance personnel that is responsible for maintaining all facilities in the TMC network. This staff would be slightly larger than for a centralized TMC and would be funded jointly by each participating agency. Operating personnel are discussed in the Personnel Summary section.

Personnel Summary - The number of personnel needed for a distributed system should be the same as for a centralized system. An overall center manager or director employed by the newly created legal entity is still needed to coordinate city and state operations, but his responsibilities and authority might be more difficult to achieve and maintain with a decentralized system. In addition, the TIC (which will coordinate all data gathering and the dissemination of the data to the public) will require at least one staff person from each agency during peak hours. However, these personnel are not necessarily additional staff members since they are probably already part of the existing staff. Additional personnel to operate and maintain the TIC, including the center director and support staff, are identical to those needed for the centralized TMC approach.

Table II - 25

Communications Equipment Needs and Cost for Each Agency in a Distributed Traffic Management Center

Austin Area-Wide ITS

Austin, Texas

Cabinet	Description	Estimated Cost
1	DS3 - 2 Shelves	$60,000
2	T1 Carrier Cabinet	20,000
3	Fiber Optic Cabinet	15,000
4	800 MHZ Trunking	250,000
5	Video Switchgear	40,000
6	Test Equipment	30,000
7	PBX Switch	15,000
8	PBX Interconnects	2,500
		$432,500

Funding Summary - Hardware and software costs for the distributed and centralized TMC approaches are considered to be identical, as shown in **Table II - 26**. However, facility and communications costs for the distributed approach differ from the centralized approach. Facility costs for the distributed approach will be greatly less than the $3 to 6 million estimated for construction of the TMC because the distributed approach will greatly utilize existing facilities. Facility costs of approximately $1 to 2 million will be needed for construction of the TIC, including office space for the center director and support staff.

Communications costs will be considerably higher than costs estimated for the centralized TMC approach because separate equipment is needed at each facility instead of consolidating the equipment in a single location. Communications equipment for each agency will cost over $430,000, as itemized previously in Table II - 25. Thus, with a minimum of five locations assumed to be part of the distributed system, communications equipment will cost over $2,150,000.

Implementation/Phasing Summary - As described previously, the distributed TMC approach should be utilized as an interim measure, while a centralized TMC for the Greater Austin Area is being designed and constructed. The first step in establishing a TMC in Austin is to create an organization to develop, operate, and maintain the center.

TMC Summary

A distributed system allows existing facilities and staff to be fully utilized. With a distributed system, a new building (TMC) would not have to be constructed (facility costs are hidden). A major communication mode would have to be constructed at each agency and/or office location for a distributed system. A centralized TMC should have fewer communication links if every manager does not require a full connection to the system. A centralized TMC generates synergy by having employees working side by side.

Table II - 26

Estimated Cost of Distributed TMC
Austin Area-Wide ITS
Austin, Texas

Item	**Estimated Cost**
TMC or TIC Building	$ 1 to 2 million
Internal Communications (see Table II-25)	$ 2.1 million
Hardware	
40 Workstations @ $ 10,000 (includes 4 video monitors, controls, console, and CPU)	$ 400,000
4 Servers @ $20,000	80,000
Software	
Non-proprietary, PC based system	$ 3 to 5 million
Total	**$ 6.5 to 9.5 million**

Generalized Costs

In costing an Advanced Traffic Management System, it is very difficult to provide specific costs until an implementation plan is developed. The plan would include system and agency functions and a schematic system design, operation, and maintenance plan. The plan would define funding opportunities and simplementation schedule. Generalized costs are illustrated on **Table II-27.** Specific costs would be provided in the implementation plan communications needs.

The City of Austin and TxDOT requested an estimation be made of possible bandwidth needs for an Austin Area-wide traffic signal system. The bandwidth allocation is shown on **Table II-28.** The proposed bandwidth allocation provides for present intersection controls and 100% growth capacity.

Table II-27
Unit Costs of Core Infrastructure
for Advanced Traffic Management System
Austin Area-Wide ITS
Austin, Texas

Item	**Unit Capital Cost ($K/unit)**	**Unit Operating and Maintenance Cost ($K/unit)**
SURVEILLANCE		
Inductance Loop Detectors	0.80	0.04
CCTV Cameras 20.00	1.00	
HOV Lane Control & Monitoring	250.00	12.50
TRAVELER INFORMATION		
Fixed Changeable Message Signs & Controllers	200.00	10.00
Fixed Highway Advisory Radio & Controllers	20.00	1.00
COMMUNICATION		
Fiber Optic Cable (per mile)	240.00	12.00
Signal Communication (per intersection)	10.00	0.50
TRAFFIC MANAGEMENT CENTER		
Computers and Hardware	680.00	34.00
Software	220.00	11.00
Facilities and Communication	4,000.00	200.00
Operating and Maintenance Personnel	0.00	50.00
TRAVELER INFORMATION CENTER		
Computers and Hardware	102.00	5.10
Software	300.00	15.00
Facilities and Communication	4,000.00	200.00
Kiosks	30.00	10.00
Operating and Maintenance Personnel	0.00	50.00
INCIDENT MANAGEMENT EQUIPMENT		
Vehicles	50.00	2.50
Portable Highway Advisory Radio	50.00	2.50
Portable Changeable Message Signs	30.00	1.50
Operating and Maintenance Personnel	0.00	50.00
SYSTEM DESIGN AND INTEGRATION	5,400.00	0.00

SOURCE: Texas Department of Transportation, Intelligent Transportation Systems Draft Implementation Strategy

Table II-28
Bandwidth Allocation
Austin Area-Wide ITS
Austin, Texas

City of Austin

Total Number of Existing Intersections = 600

Proposed Number of Cameras - Every 13 intersections, roughly 50 cameras

Digital Data Bandwidth:

30 Communications City Segments plus additional 30 segments for future

- **60 Segments @ 1.152 MB/second Total Bandwidth**

Maintenance Voice Bandwidth:

- **60 Segments @ 3.84 MB/second Total Bandwidth**

CCTV Bandwidth:

- 150 Video cameras (50 present + 50 special events + 50 furture)
- 60 Communications Segments @ 3 cameras/segment
- **900 MHZ total Video Bandwidth**

Composite Raw Bandwidth:		Digital Data 1.152 MB/second
		Voice 3.84 MB/second
	(Non compressed)	Video 900.000 MHz/second
		904.992 MHz/second

TxDOT

FTM = Projected 100 miles of Freeways

Video: 100 miles x 1 camera/mile = 100 cameras

Bandwidth = 100 cameras x 5 MHz/second = 500 MHz/second

Data & Voice: 100 miles/10 miles/section = 10 freeway sections

10 sections x 1.554 Mhz + 15.54 = 515.54 Mhz

FTM total Bandwidth = 500 MHz + 15.54 Mhz = 515.54 MHz