STATUS OF TX-DOT'S TRAFFIC MANAGEMENT SYSTEM WORK IN THE FORT WORTH AREA

by

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I. INTRODUCTION

Tx-DOT's Fort Worth District has been involved with the design, installation, and limited operation of an Advanced Traffic Management System (TMS) since 1985. Now, eight years later, we are operating and maintaining this system with District personnel. This paper is an update of the status of this work in the Fort Worth District and a collection of comments, opinions, and speculation regarding plan development and implementation based upon lessons learned through experiences on many projects. Also discussed is the feasibility of a governmental agency attempting in-house design and maintenance of hi-tech electronic systems.

II. GETTING STARTED

We got started in the Traffic Management business in 1985. Several members of the District 2 Traffic Section worked with a local consultant to put together a 20 year plan to install electronic remote sensing equipment and motorist communication devices on most of the District's freeways. The plan was tied to the reconstruction schedule and sources of funding identified. It was submitted to our Austin Headquarters and then to the Federal Highway Administration (FHWA) for conceptual approval. A short time later the plan was approved and we started doing research and preparing plans.

The Plan

When the District's plan is fully implemented, we can monitor operating conditions on 260 miles of freeway and to initiate some form of corrective actions on 80 miles of this 260 mile network. We hope to expand our Motorist Assistance Patrol, or Courtesy Patrol as it is called in Texas, to cover all of the major freeways in Tarrant County.

When the Fort Worth Area system is fully operational in the year 2005, it will include:

- 7000 inductive loop detectors distributed over 260 miles.
- 207 ramps with metering equipment and "wrong way" entry detection capability.
- 95 traffic signal systems on freeway frontage roads will be computer controlled.
- 45 changeable message signs (CMS).
- 80 closed-circuit television surveillance cameras (CCTV) on fiber optic cable.
- 640 lane control signals (LCS) installed at 160 locations.
- 6 highway advisory radio (HAR) transmitters.
- 9 zone (satellite) computer sites and a Control Center

The Anticipated Benefits

Based on experiences in other states, when our system is fully operational area-wide, we anticipate a savings of at least 156,000 vehicle-hours of delay per day. We also anticipate a 12 to 20 percent increase in vehicles moved per hour, a 10 mile per hour increase in average travel speeds and 30 percent fewer accidents. More efficient freeways mean less time spent in traffic which Translates into a substantial savings of fuel, air pollution abatement, and available productive hours. The benefit-to-cost ratio of this program is approximately 11 to 1.

How It Works

The District's area-wide Traffic Management plan includes four interrelated functional systems: a remote sensing or surveillance component to monitor operational conditions on the freeways, an interactive control network to allow implementation of corrective actions as freeway conditions deteriorate, a Control Center to coordinate response measures, and an area-wide data communications network to link the other systems to the control center and the media.

System surveillance is accomplished through inductive loop detectors installed in slots sawed in the pavement of the freeway main lanes and ramps and strategically located closed-circuit television cameras. The detector loops will be used to constantly monitor traffic volumes and speed and to detect wrong way ramp entry. They can also be used to collect data for operational analysis, planning, and research purposes. CCTV cameras will be used to confirm potential problems identified by the loop detectors, locate accidents and disabled vehicles, and to monitor the effectiveness of corrective measures implemented from the control center. It may also be possible to correlate reports from aerial observers and freeway "spotters" with information provided by the surveillance systems.

The interactive control network will give system operators several options for dealing with problems on the freeways. Ramp metering can be used to regulate the volume of traffic entering the facility. CMS, HAR, and Citizen's Band Radio (CB) will warn motorists of upcoming delays and offer alternate routing information. LCS will allow for lane closures during incidents. A link to frontage road traffic signals can be used to modify timing to compensate for volume increases during freeway diversions.

System operators will have the option to dispatch the District's Courtesy Patrol or an Incident Management Team to assist motorists with stalled vehicles or help clear traffic accidents. It may also be possible to provide real-time traffic advisory information to the local commercial media, government agencies, and major employment centers, via the District's computerized public information network. Someday we may be able to give people direct access to live video feeds of conditions on selected highways and warnings of problem areas through cable television. This information would give them the opportunity to select routes that avoid congested areas.

The Control Center will probably be located somewhere on the District Headquarters complex near IH 20 and McCart street on the south side of Fort Worth. This is the most practical location since the State already owns the land and we will be can provide better security than if it is at a remote site. We already have a communications trunk line running into the complex and centralizing our activities at this location would reduce travel time for crews. It also would allow us to bring in additional personnel quickly in the event of a crisis. The zone processing (satellite) equipment locations in the field will be used as front-end processors, which will reduce the data load and partition the dependency of the entire system on the Control Center. They will be connected to the Central when opportunity and resources allow. Another reason to put in the Control Center toward the end of the project is that it provides the opportunity to use the latest technology to design and equip the "brains" of the system.

The area wide data communications system will use various communication technologies to gather data from the field and move it efficiently back and forth between the various system elements. We will use our own twisted wire cable or commercial telephone lines to connect the remote data gathering devices, such as inductive loops embedded in the pavement, to the main communication trunk lines and our control center. Some of these trunks are still 50-pair cable, but eventually, all will be fiber optic cable. The cable runs will contain both single and multi-mode fiber. This arrangement allows the flexibility to use new technology as it develops and has huge capacity, if multiplexing is used, to increase the load carrying capability. For isolated and remote locations, we will use microwave networks and video compression technology to bring back video and other data. We may also use radio systems, such as spread-spectrum and wireless modems to gather and return data to inaccessible locations.

The Diverse Team Concept

This work is expensive, complex, and tedious. It involves dealing with highly specialized digital electronic equipment provided by a host of small companies. The concepts may sound simple and translate easily into planning documents and scholarly papers, but the detailed design, field installation, operation, and maintenance of the system elements is a challenge.

System development started on a part-time basis in 1985 in the District's Traffic Engineering Section and remained a secondary priority until the District's organizational structure was changed in September 1992. The original design team was composed of a few civil engineers and engineering technicians working on a part time basis. When we started work on the project, we didn't realize that the "part time" situation would continue to exist for over six years. However, a scheduled reorganization of the District has provided several additional personnel who are assigned specifically to this task. We also now have an electrical engineer and are trying to expand our maintenance support organization.

Since reorganization, we have finally been able to concentrate full time on design, operation, and maintenance of the Traffic Management Systems. We now have nine people assigned to this work on a full time basis. These nine people do product research, conceptual design, prepare plans, operate the equipment, provide project field inspection and administration services, and maintain the system. The Department does not have functional job titles for personnel specializing in Traffic Management Systems or for electronics technicians, so all our people have other titles.

We have been able to keep up with the sizeable demands of this task by employing a "Diverse Team Concept". This simply means that most of our personnel are able to do many different tasks and we time-share to get by. For example, some of our design and maintenance personnel also stand operational watches in the Satellite Operations Center and sometimes assist with field inspection of construction activities. The team concept has given us the latitude to move people around to accommodate changes in the work load and has produced a flexible, well educated, highly motivated work force.

III. SYSTEM DESIGN ISSUES

Starting From Scratch

Some of our equipment, such as lane control signals over the main lanes of freeways, has not been widely used elsewhere in this country. Our limited Travel budget and official policies did not offer the opportunity for our entire design team to travel to other States that had experience with Traffic Management Systems. We were occasionally able to send a person on a short tour of systems in other states, but the opportunity to ask detailed design and technical questions was very limited. This lack of external input created a situation where we had to do a lot of research and experimentation. The Federal Highway Administration has been very helpful by organizing and hosting seminars and training sessions that brought outside experts into our area.

A "Plain Vanilla" Modular Design Philosophy

I have always believed in keeping things as simple as possible and trying to stay with proven, well-tested technologies. I am not opposed to trying new ideas, but I am always skeptical of manufacturer's inflated claims about the merits of their new products, especially if I find out that they really have no verifiable performance history outside their labs. The point is that we are spending the public's money, so we want to be sure that we spend it wisely. There is no need to purchase broadcast quality equipment if high-grade commercial quality will do the job.

I believe in interchangeability and modularity because it makes it easier to quickly isolate a problem and replace defective major assemblies. When you have an electronic problem that is serious enough that you have to go get the electrical diagrams and start tracing circuits with a logic probe or an oscilloscope, you probably are not going to find it quickly. The desirable approach is to have enough functional spare modules available so that you can quickly isolate the problem to a single chassis, card, or module by using a removal and replacement technique. When the system is operational again, you can take your time and troubleshoot the defective module down to the component level in the shop, or send it off to an expert to fix. This may offend some electronic purists, but the name of the game is to minimize equipment down time and repair costs. I also believe that quicker is better when considering the safety of our maintenance personnel. Remember that the troubleshooting process must often take place on catwalks or in bucket trucks hanging just a few feet over traffic going 65 miles per hour, so it is desirable to keep exposure to a minimum.

A Failure to Communicate

Our equipment installation schedule is tied to reconstruction of the existing highway system. This has proven to be both a benefit and a creator of problems. This arrangement results in equipment being installed on a series of projects. This schedule provides a rare opportunity to periodically reevaluate and improve specifications and make improvements between projects based upon feedback from our construction and maintenance personnel. The negative aspect of this staged implementation is that each project brings the chance that we will have a mixture of equipment from different manufacturers. This prevents standardization and complicates equipment repair and spare parts procurement.

The most serious disadvantage of staged implementation is not one of logistics; it is the issue of equipment incompatibility. For example, we have found that not only do the various makers of CMS not use compatible hardware, they also do not use the same data communications protocol and operating software. To make matters worse, some equipment suppliers consider this information to be a "trade secret" and have refused to give us the detailed technical information on the communications protocol needed to tie-in future equipment additions. You can specify that the equipment must be fully compatible with what you already have, but in reality this may not prove to be the case. In short, equipment from different suppliers or even from the same supplier may not be able to communicate with each other. If we are unable to integrate all equipment into one system, we will have to control each group of equipment separately. This is a highly undesirable situation and will degrade the efficiency of the system. Some sign suppliers want to solve this problem by installing their brand of sign controller in the other guy's equipment instead of developing a system that can talk to it directly.

This issue of incompatible equipment is a very serious problem and it can result in a patchwork array of mismatched equipment that cannot be integrated with successive layers of automation and is difficult to maintain. I believe it is not cost effective to always insist upon low-bid purchasing procedures for hi-tech electronics. This tact degrades overall system operation and will not allow the individual equipment items to be used to their full potential. There are cases where sole source purchase of proprietary equipment is essential and should be allowed.

What you see is not always What You Get

A designer's visualization of technical concepts does not always translate smoothly into functional equipment through lines on paper and written specifications. Most Roadway Contractors are use to dealing with highway construction and bridge activities and are not familiar with hi-tech electronics systems. They rely upon an electrical sub-contractor to qualify and provide the equipment.Some equipment suppliers will assure the sub-contractor that is responsible for providing the Traffic Management items that their standard product meets specifications. Later, after the bid has been accepted and the project has began, a detailed analysis of their technical literature may show that it does not meet the specs. Sometimes they are convincing enough to gain approval to ship the equipment to the job site. They then try to negotiate for concessions after the equipment is delivered and found to be deficient.

Sometimes, by the time we discover a better way to do something or that an error has been made on the specifications, several projects are in various stages of design and construction. If we are lucky and the problem is a little or no cost issue, we may be able to talk the manufacturer or contractor into changing it. However, if it is a major change we have to weigh the costs of doing it now with a field change, or waiting until later. You are outside the low bid option when you make field changes, so sometimes, it may be cheaper to wait and correct the problem on a maintenance contract or with our own personnel after the project is completed.

Reaching Out To Bring In Isolated Problem Areas

Most of our system is installed on IH 35W and IH 20 in southern Tarrant County. This is due to our dependence upon the District's freeway reconstruction schedule. We also wanted to localize and concentrate our resources to obtain an earlier return on investment and to provide a laboratory for experimentation. However, most of the District's severe freeway congestion problems are now in the northeast sector of the county. Projects that provide an opportunity to install the underground conduit and cabinets in that area are several years away. We need to get some incident detection resources into that area, even if it is temporary, so we have decided to install some isolated equipment "clusters" using remote sensing and limited advisory response. For example, we may install video cameras at congested interchanges and use compressed video techniques and commercial lease or dial-up lines to return the data to the temporary control center. We can then use the same type of communications scheme to remotely place warning messages on changeable message signs or activate ramp metering equipment in the cluster.

Funding Is Critical

The Intermodal Surface Transportation Act of 1991 (ISTEA) gave the local Metropolitan Planning Organizations (MPO), also called The Council of Governments (COG), has project selection authority over the expenditures of certain categories of highway funds. The Bill also tasked the MPOs with the development of plans for dealing with deteriorating air quality and increasing congestion. Dallas and Fort Worth are in moderate non-attainment areas for ozone. However, even though we are in an area that is definitely in need of ways to minimize delay on the freeways, we have been restricted to just one category of funding for Traffic Management projects. This category is called Congestion Mitigation and Air Quality (CMAQ) and it is controlled by the MPO. In this category, we must compete with traffic signal projects on city arterials, bicycle programs, and alternative fuel programs for funding. This is not logical because other areas of the State that are in compliance with air quality standards have access to some Federal and State funding categories, such as NHS-Category 3D, Traffic Management Systems, that we are not allowed to use in non-attainment areas.

We still are able to put equipment on the big roadway jobs, but due to the problems explained earlier in this paper, we prefer to use smaller projects to install the hi-tech equipment. The formulas used by the MPO to evaluate the benefits of various congestion mitigation options are not appropriate for Traffic Management projects that are going to be implemented in stages over a long period. The short term advantages of individual system elements, like CMS, HAR, LCS, and CCTV are very difficult to quantify. We must find a way to justify funding for these items in non-attainment areas by viewing them as essential components of an approved area wide plan. Putting all the equipment in on the big roadway jobs funded with Federal National Highway (NHS) money is not a desirable alternative.

III. OPERATIONAL AND TECHNICAL ISSUES

The incident detection algorithms for the inductive loop detectors have not been developed yet, so our primary means of finding problems is the television cameras and calls received from our maintenance personnel. The operators do have additional tasks to perform, such as logging incidents and keeping up with the regular posting schedule for the changeable message signs, but much time is spent sitting, watching, and waiting for something to happen. I am sure that the pace will pick up as additional sections of the system come on line and when additional operational software is developed.

Inadequate staffing has severely impacted our operational schedule. We are only able to operate out of the IH 35/IH 20 satellite operations center two days a week. We now have an operator in the center on Wednesdays and Fridays from 6 A.M. to 7 P.M., but we hope to be able to go to a five day week by next summer. We are available on a 24 hour basis for incidents that can be handled by putting up messages on the changeable message signs. We have personnel on-call at night with a lap top computer. They can communicate with the signs by accessing the master computer in the satellite via a dial-up modem. We also go to the satellite building when called to change the lane control signals and signs to support our incident management or maintenance personnel.

Inductive Loop Detectors

We have installed 6'x 6' inductive detector loops at approximate one-half mile spacing in the freeway mainlanes. We have a loop in each lane and alternate between arrays of single loops or detection and counting and double loop arrangements for vehicle speed measurement. We have worked with the TM folks in our Austin Operations Division, to validate information provided by the loops and to customize their graphics display software to meet our operational needs. The next step will be to develop incident detection algorithms and associated software.

Our design and maintenance personnel have done a considerable amount of research on various methods of vehicle detection, including evaluation of infrared, sonic, radar, and video detectors. We will use whatever technology works best for a particular location.

Lane Control Signals (LCS)

The fiber optic lane control signals (LCS) are a unique aspect of our system. To my knowledge, we are the only agency that is using lane control signals on the mainlanes of freeways for purposes other than traffic control in tunnels and reversible or high occupancy vehicle (HOV) lanes. Our signals are mounted on bridges or overhead sign structures positioned over each of the freeway mainlanes. The distance between signals varies with available support structures, but the goal is to keep several groups of signals in the driver's field of vision. This is not always possible for freeways with many grade variations and retaining walls.

We are using the LCS, which display 18 inch symbols, to close or open lanes to support incident management efforts. We are trying to educate the public on the intended purpose of the signals and of the meaning of the various symbols by using the four CMS on IH 35W. The following message is displayed on all four CMS when they are not being used for incident management or for ozone alert warnings:

Green Arrow - Lane open
Yellow X - Vacate lane
Red X - Lane closed

The local motorist's comprehension of the of the LCS appears to be increasing. We have observed that if drivers can see that there is indeed a reason to vacate a particular lane, they will do so. However, if they cannot see the incident or a traffic backup is starting to build, they will often move back into or continue to drive in the closed lane.

Changeable Message Signs (CMS)

CMS are dynamic electronic billboards that can display almost any brief message. The more sophisticated sign systems are computer-controlled and can be programmed to display a sequence of messages at a specific time and to maintain a log of the sign's activities. They can also monitor the performance of a group of signs and alert the operator if there is a failure.

We presently have 10 flip-disk type changeable message signs with three lines of 20 18-inch characters and nine more signs on order. The nine new signs will have fiber optic displays and 3 rows of 18 18-inch characters. We also plan to experiment with Light-Emissive Diode (LED) signs on a future job. We have not had many problems with most of the flip-disk signs, but we feel that they do not perform well on east-west routes because of morning and evening back lighting from the sun. We may improve message visibility by going to a light-emitting display design.

When we first got the changeable message signs, we were only going to use them for incident management. However, we have made a few exceptions over the years. Construction work zone messages are put up because the signs are sometimes included in the traffic control plan for the projects. We support District and City roadway lighting maintenance crews by warning of lane closures. During bad weather, we have displayed warnings of possible bridge icing conditions. We put up ozone alert warnings and associated ride share information because this seems a natural complement to our goal of optimizing available highway capacity by helping with demand management efforts. After all, Tx-DOT is also responsible for Public Transportation Programs and we work very closely with the local Transportation Authorities on programs that encourage motorists to share rides and help establish Park and Ride Lots. The local Metropolitan Planning Organization, the North Central Texas Council of Governments (NCTCOG), has approved use of FHWA CMAQ funds for one of our Traffic Management projects, so a lack of cooperation with their efforts toward improving the local air quality would not be appropriate.

If a CMS always has a message on it, drivers tend to ignore it. To overcome this problem, we have installed two flashing yellow beacons on top of the sign that can be remotely activated. When we have an incident, such as an accident, or another short duration event that merits immediate action and a high level of message compliance, we turn on the flashers to get people's attention.

The CMS in Tarrant County provides an opportunity to get lane closure and incident information out to a lot of commuters in a short period of time. We combine the sign messages with newspaper and radio warnings in an attempt to "scare" motorists away from a location that is experiencing temporary congestion due to maintenance and construction activities. We have had a considerable amount of success with this approach.

We have several options for communicating with the CMS. We have some signs linked to the master computer in the temporary operations center via our own twisted-wire cable. The signs that are outside the range of the cable are accessed through commercial dial-up telephone lines. We originally used commercial lease lines for each sign, but the cost of lease lines was about 10 times more than for unconditioned dial-up lines. We lost the ability to monitor the signs for failure, but since the computer automatically "polls" or dials them up at frequent intervals, we still can keep track of what they are doing. At this stage of our System Implementation Plan, loss of a sign is inconvenient but not critical.

Closed-Circuit Television Systems (CCTV)

The CCTV color cameras are now our primary means of incident detection. Eventually, they will be used to confirm potential problems identified by the loop detectors, confirm the messages put on the CMS, and response of traffic to changes to the LCS.

When we first put up the cameras, some people thought that we were using them to monitor freeway speeds or watch for criminal activity on the frontage roads. One gentleman was concerned that we were monitoring activities at a nearby motel. We have worked with the media through various newspaper articles, stories on the Cable News Network (CNN), National Public Radio, and various technical papers to explain that we are mainly watching for traffic slow downs and accidents and really are not trying to intrude into people's personal lives. We hope eventually to be able to provide a video feed and real time traffic information to some local commercial television stations. I believe that when people see this, they will lose some of their concerns about the purpose of the cameras.

Our cameras are mounted on the side of the freeway on 40 or 60 foot steel poles. They are in a pressurized nitrogen-filled weatherproof housing and have pan, tilt, and zoom capability. They use a Charge-Coupled Device (CCD) imaging system, with motorized iris and white balance, and the optics have a 10 to 1 zoom capability. The cameras are spaced at one mile intervals and have over-lapping visual coverage. The video signal is returned to the control center on multi-mode fiber optic cable and the camera control functions are carried on twisted wire cable. Future installations will use T-1 drop inserts and multiplexing techniques to place both video and camera controls on the fiber system.

We have had very few problems with the CCTV equipment and almost no problems with the fiber optic system. Of course, the equipment is still new and some of it is still under warranty. However, we are confident that our people are can fix it when we do start having problems.

The cameras are usable at night, but the glare from vehicle headlights, roadway signs, and illumination reduces their sensitivity. This is a minor problem in the winter months when the days are short. It is not an issue for the rest of the year because we do not plan to staff the center on a 24-hour a day basis. If future traffic growth forces us to operate on a regular basis during darkness, we will modify the cameras to enhance their abilities.

Temporary Operations Center

We are presently operating out of the temporary control center at the IH 20/IH 35W interchange. This building is of pre-fabricated tilt-wall concrete construction and is surrounded by a 10 foot high steel mesh fence. We have 50-pair twisted-wire cable and both single and multi-mode fiber optic cable connections into the building. One wall is filled with a bank of 8 CCTV color monitors and the rear wall has equipment racks and a huge uninterruptible power supply unit (UPS). There are positions for at least two operators at a series of tables opposite the bank of monitors. The operators have access to commercial telephone lines, a radio link to the District's 24-hour dispatcher, citizens band radio, a scanner, and various computers with which to communicate with the field equipment.

The Temporary Control Center was originally designed to be a satellite or remote equipment shelter, but we made it a bit larger than originally planned so we could start operating as soon as possible. As the system grows, we will eventually have to move into a permanent control center. For now, this structure provides an opportunity to experiment with new ideas and equipment before we design the permanent center.

We view the IH 35W/IH 20 Satellite building as a training ground for future improvements. I believe in a reality-based design philosophy; i.e. you make improvements at frequent intervals based upon real-life field experiences, not academic theory. Lessons learned here will be used as the basis for the design of the Central Control and Monitoring Facility and to refine operational software and procedures. Much of the equipment in the satellite is sitting on top of tables. This affords us the opportunity to move the equipment around to optimize operator comfort and efficiency. Human factor issues, such as reach distances, monitor viewing angles, ease of access to controls, chair heights, and equipment mounting positions can be easily adjusted in this type of environment, prior to designing less flexible consoles.

Motorist Assistance Patrols and Major Incident Management

A disabled vehicle on the shoulder of a freeway may result in only minor traffic slowdowns during off-peak hours. The same occurrence during rush hour, when the freeway is approaching capacity, may result in lengthy backups due to "rubbernecking". Research has shown that an incident that results in the closure of just one lane in one direction of a three-lane freeway, can reduce the capacity of the entire freeway section by 50 percent.

The District's Motorist Assistance Patrol, or Courtesy Patrol as it is called in Texas, began operations in the Fort Worth area in 1973. The original purpose of the Patrol was to keep the freeways clear and running smoothly. It was charged with monitoring collision damage to state property and providing a quick response to occurrences, such as objects in the roadway, that could pose an immediate danger to the traveling public. This program minimized the need to call out District maintenance forces to handle minor problems. Helping stranded motorists was not the primary focus of the Patrol when it was started, but it seems to be now. It has been estimated that the Patrol assists approximately 3,650 disabled vehicles per year. They also helped the local police direct traffic at 730 accidents and logged 336,000 miles on their trucks last year.

The Courtesy Patrol trucks operate twenty-four hours a day, seven days a week. They patrol IH 820 (The Loop) around Fort Worth and all the state-maintained freeways within the Loop. Their usual schedule is as follows:

Monday through Friday - 2 trucks on from midnight to 8:00 A.M.
1 truck from 8:00 A.M. to 3:30 P.M.
2 trucks from 4:00 P.M. to midnight.

Saturday, Sunday & holidays - 2 trucks on 12 hour shifts.

The Patrol has 16 personnel, including 3 radio dispatchers. Two people are assigned to each truck because it has been determined that many incidents require at least two people to handle them safely and properly. For example, one person may be setting out flares while the other turns on the truck's electronic arrow board and starts to help a stalled motorist or sets up traffic control at an accident scene. Training for new personnel is conducted on the job. The usual practice is to assign novices to work with an experienced operator.

It costs approximately $100,000 to purchase, equip, operate, and maintain one Patrol pickup truck for a year. The trucks have a two-way radio to talk with their dispatcher, cellular phones, and a citizen's band radio to talk to motorists and commercial truckers. The trucks have push-bumpers and carry jumper cables, air tanks, water cans, gasoline, tools, traffic cones, and flares. The operators will push a stalled vehicle to safety, give a motorist a gallon of gasoline or try to help them repair their vehicle. They can use their two-way radio to ask the dispatcher to call a wrecker of the motorist's choice or someone to come get them.

Motorists are not charged for these services and the operators will not accept tips or donations. After helping a stalled motorist, the Courtesy Patrol operators will hand them a comment card and invite them to fill it out and mail it back to the District Headquarters. Approximately 75 percent of these cards are returned and the response is usually favorable.

Handling Major Incidents

The Courtesy Patrol is can handle most minor incidents, but specialized equipment and expertise is needed to deal with more serious problems. The District's two Safety Officers work with the police to clear major incidents, such as overturned trucks, spilled cargo, and hazardous materials.

In 1972, the Fort Worth District Engineer become concerned about the time it took to remove major incidents from the roadway and clean-up the debris. In the past, a roadway may have been blocked for hours, even days, while trucking companies hand-picked spilled cargo. State law seemed to imply that the Department had the authority to keep the roadways clear and assist with the removal of spilled cargo. The District Engineer felt that the authority was clear enough and that it was time to do something about the problem. He charged the District Safety Officer with establishing a working relationship with the local police and approved the use of state forces to hasten the removal of traffic obstructions.

The District, using the existing interpretation of legal authority, remained actively involved in the removal of wrecks and spilled cargo for almost 20 years. During that period, liability for damages was not a problem, though cargo was sometimes damaged during the removal process. In 1991, the State Legislature clarified their intent in this matter by passing specific supporting legislation. State Senate Bill 312 was signed by Governor Richards on May 22, 1991. This law authorizes the

Department of Transportation to remove spilled cargo and personal property from the roadway or right-of-way when the Department determines that the spillage is blocking the roadway or endangering the public safety. It specifies that Department employees will not be held liable for any damages or claims of damage to removed cargo or personal property unless the removal or disposal was carried out recklessly or in a grossly negligent manner.

The Safety Officers are on 24-hour call. Their vehicles bristle with antennas and emergency lights. They are crammed with radio equipment and cellular phones, linking them to the Courtesy Patrol, the District dispatcher and various other emergency agencies. They work directly with the local police and fire department personnel at the scene of an accident. If required, they will call in State personnel and heavy equipment to push the wrecked vehicles and spilled cargo off the road.

Through the years, the District's Safety Officers have dealt with many types of spilled cargo. Among these have been hundreds of gallons of sticky molasses, produce of all kinds, terrified cattle, computers, soft drinks, beer, and even a truck load of Ion's Irish Cream. If hazardous materials, such as gasoline or caustic chemicals are involved, they will call in local experts and specialized equipment to handle the cleanup. They also have the option to call in heavy-duty wreckers and ion specialists to upright and haul away overturned trucks. An accident on IH 20 a few years ago resulted in them enlisting the equipment of a nearby roadway contractor to remove a bridge that had been knocked down when a large water trailer came loose from the truck hauling it and struck a support column.

The District bills the trucking companies for the cost of removal and cleanup of major incidents and we have an 80 percent recovery rate. It costs the District approximately $35,000.00 a year to support that portion of the Safety Officers time and vehicles used for incident management. When they aren't working wrecks, these gentlemen teach driver's training classes, monitor employee driving behavior, recommend remedial action for poor driving performance, and patrol the District's highways looking for unsafe conditions.

<u>Problems with local government police authority for incidents</u>

One problem associated with developing an effective Regional Incident Management plan in Texas is the way that police authority is assigned in our state. In other states, such as California, responsibility for handling wrecks on the freeways is clearly the responsibility of the State Police agency, the California Highway Patrol (CHP) in this example. In Texas, our State Police Agency, the Department of Public Safety (DPS), has discretionary enforcement authority everywhere on the State highway system, but they concentrate their efforts in the smaller cities and rural areas. This means that city police are usually responsible for enforcement activities on the freeways within their corporate limits and that they can assign their own priorities and time limitations for clearing a wreck. Most cities have their own wrecker contract and some call off a rotating list of wrecker companies. The end result is often unnecessary delays and inconsistent policies and procedures. I am not proposing that this be changed; I am just mentioning it as an explanation for why it is difficult to development regional incident management plans in an area with many small cities and fragmented police authority.

Another example of problems with the development of programs that transcend the boundaries of several cities or counties is the construction and operation of high occupancy vehicle (HOV) lanes in the Dallas-Fort Worth area. To be effective, HOV lane auto occupancy criteria must be enforced. This enforcement must be by certified city or Transportation Authority Police Officers. This is possible in Dallas because the HOV lanes are located within the service area of the Dallas Area Rapid Transit Authority (DART). However, in Tarrant county, the Fort Worth Transportation Authority (FWTA) services just the City of Fort Worth and a few other small cities. For HOV lanes to be practical from downtown Fort Worth to The Dallas County line, the voters of several small cities would have to approve a local sales tax so that the FWTA can extend their service area to include the HOV lanes. This is unlikely since the HOV lanes would be mostly carrying commuters that neither live or shop in the small cities that they are passing through. TX-DOT lacks enforcement powers, so the District would be unable to operate the lanes with State forces.

IV. CONSTRUCTION ISSUES

Our Traffic Management Maintenance Section is also responsible for the inspection of Traffic Management equipment installation in the field. This is difficult on roadway jobs because we do not have any real authority on those jobs. We have worked with our Construction Resident Engineers to allow us to verify that the equipment meets specifications, but field installation is supervised by the District Construction Section. A discussion of the problems caused by this arrangement is presented below:

Just A Minor Annoyance On The Big Jobs

The General Contractors on the big roadway jobs seem to look upon the Traffic Management equipment as an undesirable but necessary burden that they must accept to get the high-dollar roadway and bridge items. We have had some real bad experiences with low-bid sub-contractors working under General Contractors. After dealing with bonding companies and bankruptcy regulations, the quality of some equipment and work obtained was very poor. The Traffic Section lacks legitimate authority on the jobs and has to rely upon the District's project personnel for permission to verify that the equipment provided by the General Contractor meets our specifications. In the early projects, the General Contractors, our Resident Engineers, and project inspection personnel were not familiar with this type of equipment or the challenges of installing it properly. Many of these items, such as conduit for fiber optic cable, have very tight installation tolerances. We were finally able to establish a precedent for the Traffic Section to inspect and approve the Traffic Management items on the projects, but we still lack real authority to reject sub-standard work or equipment that really did not satisfy the specifications. This situation has resulted in some problems that we are still trying to resolve.

Our equipment is usually installed toward the end of a roadway reconstruction project. There is a lot of pressure on us to hurry up and approve the equipment so that the General Contractor will not run out of time and can be released from the responsibility of maintaining the already completed roadway items. Some equipment has a lengthy test period that due to late delivery, will exceed the number of days allowed for the contractor to complete the job without penalty. The usual policy in this situation is for the State Resident Engineer to allow the contractor to go ahead and "sell" the roadway items and allow the Traffic Management equipment test period to continue. It is difficult to get the General Contractor back out to fix malfunctioning equipment after they have moved on to another job. Also, by that time the State Resident Engineer has moved on to other work and really does not have time to spend on these problems.

Don't Pay Until You Verify

We must keep a close watch on equipment delivery schedules. It is vitally important to do a detailed inspection and specification compliance check on items like changeable message signs before the contractor is allowed to install the equipment in the field. We have found that once the manufacturer ships the equipment from the factory to the installing sub-contractor and material-on-hand payments have been made by project personnel, it is not going to be possible to reject it based on a failure to meet specifications. If you allow the contractor to go ahead and install the equipment in the field before it has been proven conclusively that it satisfies the intent of the specifications and is fully functional, you have lost most of the leverage to enforce requests for major corrections. It is much safer to address this potential problem in the project documents and require that the contractor provides a local testing and evaluation facility, such as a warehouse. This arrangement affords the time and opportunity for the purchasing agency to conduct a thorough inspection and evaluation of the equipment provided in a fully operational environment. Inspection is much more difficult once the unit is mounted over the highway. A warehouse also provides a secure, all-weather place were the equipment can be conveniently disassembled, modified, or repaired before installation in the field.

Another option for inspecting the supplier's equipment before it is delivered to the job site would be for us to send an inspection team to the suppliers plant. There are pros and cons to this approach. The advantage is that the supplier and the installing contractor would not have to pay shipping and local warehouse costs for an item that may not meet specifications. This approach also would be more convenient for the supplier if the equipment requires major modifications. The disadvantages are that the inspection team would have to be very small due to travel expenses. Many of these suppliers are in other States and even other countries. We would not be able to take the equipment and number of people that we would normally use to detail strip and inspect a large item, such as a CMS. We sometimes require the contractor to pull all the modules out of a sign so that we can inspect the wiring and workmanship. I believe that the supplier and installing contractor should be responsible for insuring that the equipment meets specifications before it is shipped. Our role is to verify that it meets specs before we allow them to install the equipment in the field.

Out Of Sight, Out Of Mind

Equipment warranties are always a problem when the equipment is installed on big roadway jobs. The equipment is usually purchased and installed by an electrical sub-contractor. The equipment manufacturer looks upon that sub as the customer and does not pay much attention to our complaints or requests for quick warranty service. We had one contractor who argued that our specified "no cost to the state" one year warranty was not the arrangement that he had with the bankrupt electrical sub-contractor's bonding company. We had anticipated receiving the manufacturer's usual one year on-site parts and labor warranty. However, we were told that they expected us to troubleshoot the problem with our own forces and ship the defective component to their factory in another state at our expense. We finally got this issue resolved, but it is typical of the type of misunderstandings and problems that can arise from situations where there is a series of contractors between the equipment manufacturer and the end user.
Another problem is documentation. You usually get the equipment technical manuals, but you do not get the purchase receipts. These receipts are essential for proving when and by who the equipment was purchased.

Our approach now is to include items, like underground conduit, inductive loops, cabinets, and buildings on large roadway reconstruction projects. This is essential for projects that involve backfill supported retaining walls, because the conduit must go in below the layers of galvanized steel straps. We then come back later and put in the hi-tech specialty items, such as fiber optic cable, data communications systems, computers, and closed-circuit television equipment, on smaller projects were the bidding will be by contractors familiar and experienced with this type of work. In the end, we get better prices and final product.

Working Behind Retaining Walls

We have always been concerned about what would happen if we were ever forced to have to work in areas behind backfill supported retaining walls. We were afraid that if we had to trench or drill behind these structures, we could get into the retaining straps and jeopardize the structural integrity of the walls. Well, on a recent job, we were forced to trench for fiber optic cable conduit and install pull boxes behind a series of fill supported walls on IH 20. We discovered that if you are not going too deep and are careful, it can be done. We were lucky, there were no drilled shafts that had to go behind the walls. One way to minimize the problems associated with working behind this type of retaining walls on staged reconstruction projects is to look ahead and anticipate where camera pole foundations and other items that would conflict with the straps and go ahead and put in the foundations when the walls are constructed or "block out" a location for future use.

V. MAINTENANCE ISSUES

The District had planned from the start to maintain the Traffic Management Systems with State forces. We have always believed that we can maintain the equipment cheaper and more efficiently with our own people. Our logic was, that since we designed and regularly operated the systems, we would be more familiar with the equipment than would an outside contractor. This has proven to be a valid assumption.

Fix What You Can And Contract Out The Rest

Our approach is to fix whatever we can ourselves and request assistance from the Traffic Management Section in our Austin offices or a specialized contractor if we get into something that we can't handle. For example, we will troubleshoot the initial problem, remove and replace defective assemblies or components, and repair what we can on the removed items. If the problem is determined to be in a proprietary card or assembly, we will ship it to a specialized commercial service center or to the manufacturer.

This "fix what you can" approach is dependent upon having good electronics technicians, test equipment capable of isolating and analyzing typical malfunctions and a large enough stock of working spare parts to last until defective assemblies can be repaired and returned. Unfortunately, some of our specialized proprietary equipment, like lane control signal controllers, were designed and manufactured by small low-bid contractors that did the work for a General Contractor and now refuse to make any more of them. This leaves us with the problem of a dwindling supply of replaceable assemblies. The low bid process over a period of several projects, complicates this problem further by resulting in several incompatible versions of the same device. Our only solution to this problem will be for state-wide standardization of as many devices as possible and standard interface and communications protocols.

We have suffered from a lack of resources ever since we started this work in 1985. We have managed to stay operational by taking other District's leftovers and being willing to work under adverse conditions. We used the people available in the Traffic Engineering Section to do the work, borrowed test equipment before we could get our own, scrounged vehicles from other District's reject lists, fixed up old buildings, and funded the maintenance from our small allocation from the District Maintenance Engineers's budget. I attribute our success to the "team concept" and the feeling of significant individual contribution and "pride in ownership" that people get when they are working as part of a group. Everyone has a voice in the design and most major decisions are made with group agreement.

Existing Utilities Drawings

We have recognized the importance of having some group within the District prepare plan sheets showing all existing utilities at a particular location. We became aware of this problem recently when we spotted a landscaping contractor trenching for sprinkler pipe and digging holes for trees in an interchange that had a considerable amount of underground surveillance and roadway lighting conduit. The landscaping project plans had been prepared by a consultant and did not have any information on existing utilities. This information is particularly important for fiber optic cable, because it cannot be located with a metal detector. We need someone who is responsible for reviewing the as built plans for all projects that have taken place at a particular location and preparing a composite drawing that shows all known existing utilities.

We plan to make it easier to find fiber optic cable by running a wire inside the conduit. This will give us a way to trace the cable by connecting a small transmitter to one end of the wire and monitoring signal strength with a receiver.

Can We Design And Maintain This Equipment Ourselves?

In my opinion, an agency considering getting into the Traffic Management business should ask themselves several very important questions before they start:

(1) Is top management fully aware of the total cost of building and supporting a statewide program of this magnitude? Are they willing to direct the rest of the organization to cooperate with the implementation process?

(2) Are there enough Federal, State, and local construction dollars available in the years ahead to fully implement a successful statewide Traffic Management program?

If our funding must be approved by the local MPO, are they receptive to funding these items and are they willing to fund maintenance and operations costs?

(3) Are we willing and able to provide the dedicated budget and specialized personnel necessary to make this a successful venture?

(4) Are we willing to exert the leadership and support needed to insure standardization of equipment among all users in the organization?

(5) Are we willing to work to structure our State's laws to make it feasible for local and state agencies to clear incidents from the highway (i.e.,- protection from tort liability claims for damages)?

If the answer to any of these questions is no, then my advice is not to get involved!

You Have to Have The Right Tools

If an agency plans to try to maintain this type of equipment with their forces, they must invest in some very sophisticated, expensive test equipment. A few examples are:

Fiber optics fusion splicer and accessory kit
Optical time domain reflectometer (OTDR)
Dual trace Oscilloscope
Digital Multimeters

Power supplies
Logic probes and pulsers
Signal generator
EPROM programmer and eraser.
Chip and component testers
Good quality desoldering and soldering equipment
System -specific test equipment (Spectrum analyizer, signal generators, etc.)
Lap-top computer with communications software.
Plus a good stock of spare modules for all equipment
Plus training on how to use these items
Plus Electronics Technicians to maintain the equipment

VI. BUDGET, STAFFING, AND FUNDING ISSUES

We are still hampered by the lack of a dedicated operations budget. We have been able to obtain some funds for maintenance of the Traffic Management equipment as part of the District Maintenance Engineer's Budget. We need a predictable dedicated budget for Traffic Management so that we can plan for spare part purchases, equipment replacements and upgrades over a period of several years. As it is now, the money can be reduced or taken away anytime during the year. It is very difficult to do any meaningful long range planning in this type of environment.

You need someone with a four year, or possibly a two year, technical degree in electronics and with a considerable amount of military or commercial electronic maintenance experience to maintain this equipment.

The Austin Connection

When we began our design efforts in 1985, there was no support group in our Austin Headquarters who specialized in Traffic Management activities. This situation was corrected a few years ago when a Traffic Management Section was formed in the Maintenance and Operations Division. One of the real bright spots in our work has been the quality of the technical support provided by this group. They have helped with plans reviews, hardware and software design for field interface equipment, and the computer equipment in our temporary control center. They have also provided on-site field support on a regular basis. It would not have been possible for us to have come as far and fast as we have without their assistance.

VII. PROGRESS

We estimate that approximately 24 percent of the system shown on our original plan has been completed. The exact percentage is difficult to estimate because of the problem of what to use for a criteria. We have approximately nine million dollars worth of work in the ground at this time and another three million is under construction. Based on the 1985 approved plan, we are on time and on schedule.

VIII. SUMMARY

Advanced Traffic Management Systems have the potential to help relieve the crippling effects of urban congestion. If the equipment is well designed, correctly installed, professionally operated, and properly maintained, it can make a difference. However, equipment on the road is just one part of the solution. This effort must be complemented by aggressive Incident and Demand Management programs. But don't forget the roads themselves! We have a tremendous investment in highway infrastructure in this country. Highways must be maintained and they must periodically be rebuilt. It does not do any good to install millions of dollars worth of electronic equipment on highways suffering from terminal inadequate capacity and crumbling pavement.

If an agency is trying to decide whether to get into the Traffic Management business or not, they should first determine the willingness of top management to commit the resources to make it work. The capital investment is just the starting point. The systems must be designed, installed, operated, and maintained. This requires additional people and money.

If the decision is made to proceed with the project, my advice is to get good people, insist upon a team approach, keep the design simple and modular, stay with well known brands and off-the-shelf equipment, and try to do as much of the work in-house as possible.

15 Oct 93
W. E. Ewell
TMSYSTAT.WPF

ITEMIZD.WK3

ITEMIZED DESCRIPTION OF TRAFFIC MANAGEMENT SYSTEM PROJECTS

District 02, Fort Worth   Report Date: 11-Oct-93

1985 to 1993

Percent Complete: 23.58%

LEGEND: TR=Trunk Line, LP=Loops, 50=50 Pair, CMS=Changeable Message Sign, LCS=Lane Control Signal, CS=Count Station, GB=Ground Boxes, BC=Bridge Conduit, TV=CCTV, FO=Fiber optic communications system, SAT=Satellite Building, CVCS=VIDEO COMPRESSION SYSTEM, MW=MICROWAVE COMMUNICATIONS

PROJECT NUMBER	PROJECT DESCRIPTION	LENGTH (MILES)	SURVEILLANCE ITEMS	COMPLETION DATE	CMS	LOOPS	LCS	CCTV	SAT BLDG	INSTALLATION COSTS	FEDERAL-AID PROJECT NUMBER	CONTRACTOR
1	I-35W/I-20 INTERCHANGE	2.665	TR,LP,SAT	31-Dec-91	0	177	0	0	1	$219,160.00	MA-IR 20-4(195)438	AUSTIN BRIDGE
2	I-20: CAMPUS TO LP-496	3.601	TR,LP	11-Apr-89	0	145	0	0	0	$688,000.00	MA-IR 20-4(193)439	ZACHRY
3	I-35W: HATTIE TO FELIX(INSIDE)	4.236	TR,LP,50,CMS,LCS	24-May-89	4	123	57	0	0	$784,858.00	I-35W-5(103)417	BROWN & BLAKNEY
4	I-30: WESTRIDGE TO PENTICOST	1.618	TR,LP	12-May-89	0	52	0	0	0	$294,520.00	I-IR 30-4(63)009	ZACHRY
5	I-30: PENTICOST TO UNIVERSITY	1.925	TR,LP,LCS	05-Apr-90	0	79	26	0	0	$394,736.00	I-30-4(66)010	MARTIN K. EBY
6	SH-360: ABRAM TO I-20	3.826	TR,LP,CMS,50	18-Jun-89	1	55	0	0	0	$1,030,773.00	C-2266-2-64	SOUTHWESTERN
7	I-20: McCART TO HEMPHILL	1.965	TR,LP,CMS,LCS	30-Jul-92	5	77	17	0	0	$1,095,625.00	IR-20-4(204)435	J.D. ABRAMS
8	I-30/I-820 INTERCHANGE	1.573	TR,LP	22-Feb-91	0	127	0	0	0	$652,672.00	IR-820-4(207)476	ZACHRY
9	I-35W:HATTIE TO FELIX(OUTSIDE)	4.409	TR,LP	12-May-87	0	20	0	0	0	$310,820.00	I-35W-5(89)417	SUNMOUNT
10	SH-360 @ SP-303	2.236	TR,LP	31-Dec-92	0	29	0	0	0	$316,589.00	MA-F 1128(12)	AUSTIN BRIDGE
11	I-35W/I-30 (NORTH INCREMENT)	0.606	TR,LP	29-Aug-88	0	33	0	0	0	$196,581.00	I-35W-5(97)422	J.D. ABRAMS
12	SH-183/SH-360 INTERCHANGE	2.167	8-CS	23-Sep-89	0	33	0	0	0	$25,500.00	MA-F 634(36)	ALLAN CONSTRUCTION
13	SH-121/SH-183 INTERCHANGE	4.412	6-CS	16-Apr-88	0	20	0	0	0	$25,000.00	MA-F 1120(21)	GRANITE CONSTRUCTION
14	SH-360/SH-183 TO SH-121	6.966	BC,GB	01-Jun-92	0	0	0	0	0	$95,705.00	F 1128(10)	AUSTIN BRIDGE
15	IH-20:SH-183 TO McCART	2.466	TR,LP,50,CMS,LCS	01-Mar-95	2	89	23	0	0	$1,157,319.00	IR 20-4(211)432	GRANITE CONSTRUCTION
16	IH-35W:HATTIE TO I-35/I-20 INT	4.715	TV,FO	28-Jul-92	0	0	0	8	0	$664,446.00	IR 35W-5(112)417	MICA CORPORATION
17	I-20 EAST: IH-35W TO LOOP 496	7.885	CMS,LCS,GB,BC,TV,FO	30-Nov-94	6	0	45	7	0	$2,629,867.00	CM 93(1)I	MICA CORPORATION
18	I-30/I-35W EAST INCR. (BROWN)	1.000	CMS,TV,LCS,LP,CVCS,MW	30-Jul-97	1	53	15	2	0	$1,631,328.50	I 35W-5(116)422	J.D. ABRAMS
19												
	TOTALS	58.271			19	1112	183	17	1	$12,213,499.50		

COST%.WK3

PERCENTAGE SURVEILLANCE COST VS. ROADWAY RECONSTRUCTION COST
DISTRICT 02, FORT WORTH
1985 - 1993

Construction cost per mile: $8,525,393.27
Surveillance cost per mile: $209,735.54

As Of: 11-Oct-93

FTM: Changeable Message Signs
Lane Control Signals
CCTV, Satellite Building
SD/C: Conduit/Ground Box System
50 pair cable, Fiber Optic cable
Cabinets
Loops

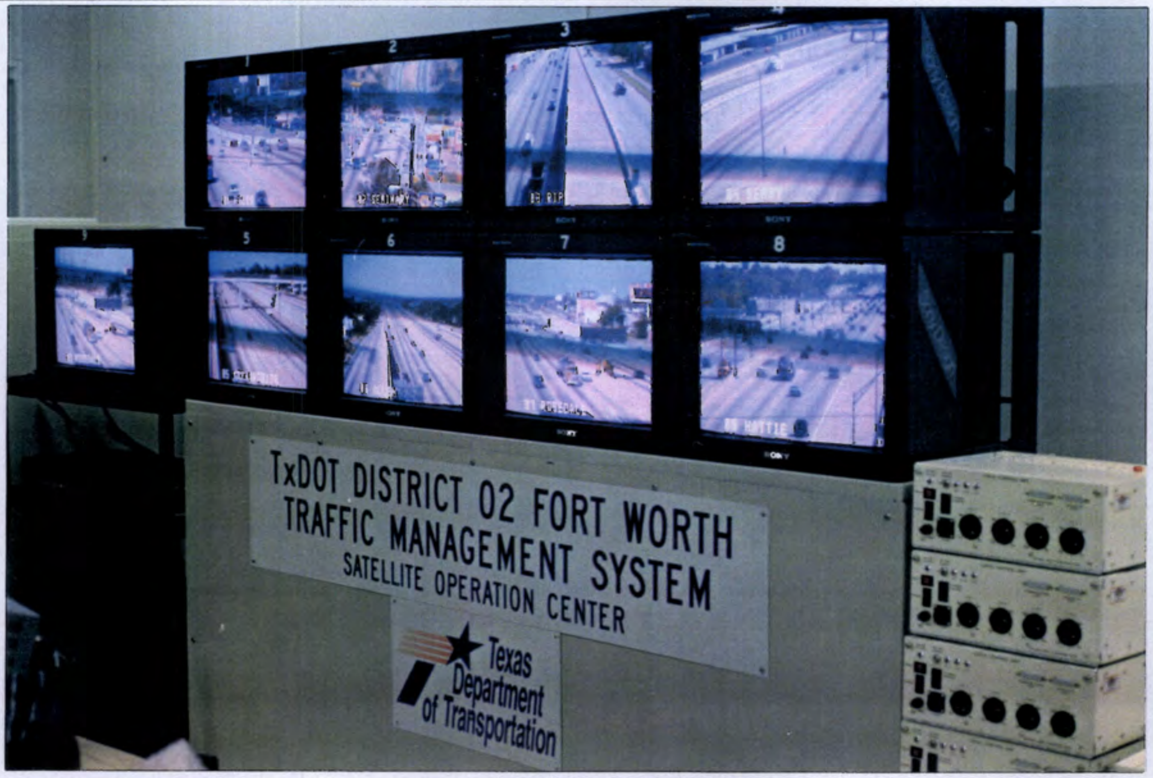
PROJECT NO.	PROJECTS	LENGTH (MILES)	ACTUAL CONST. COST	FTM COSTS	SD&C COSTS	ACTUAL SURV. COST	FTM PER MILE	SD&C PER MILE	% = SURV. /CONST.
1	I-35W/I-20 INTERCHANGE	2.665	$68,868,145.00	$0.00	$219,160.00	$219,160.00	$0.00	$82,236.40	0.32%
2	I-20:CAMPUS TO LOOP 496	3.601	$50,416,647.00	$0.00	$688,000.00	$688,000.00	$0.00	$191,058.04	1.36%
3	I-35W:HATTIE TO FELIX INSIDE	4.236	$12,447,778.00	$424,000.00	$360,858.00	$784,858.00	$100,094.43	$85,188.39	6.31%
4	I-30:WESTRIDGE TO PENTICOST	1.618	$39,956,481.00	$0.00	$294,520.00	$294,520.00	$0.00	$182,027.19	0.74%
5	I-30:PENTICOST TO UNIVERSITY	1.925	$33,913,085.00	$119,900.00	$274,836.00	$394,736.00	$62,285.71	$142,771.95	1.16%
6	SH-360:ABRAM TO I-20	3.826	$6,145,581.00	$122,690.00	$916,083.00	$1,038,773.00	$32,067.43	$239,436.23	16.90%
7	I-20:MCCART TO HEMPHILL	1.965	$29,333,178.00	$399,997.00	$695,628.00	$1,095,625.00	$203,560.81	$354,009.16	3.74%
8	I-30/I-20 INTERCHANGE	1.573	$27,738,445.00	$0.00	$652,672.00	$652,672.00	$0.00	$414,921.81	2.35%
9	I-35W:HATTIE TO FELIX-OUTSIDE	4.409	$50,933,044.00	$0.00	$310,820.00	$310,820.00	$0.00	$70,496.71	0.61%
10	SH-360 @ SPUR 303	2.236	$9,794,409.00	$0.00	$316,589.00	$316,589.00	$0.00	$141,587.21	3.23%
11	I-35W/I-30 (N. INCREMENT)	0.606	$19,262,499.00	$0.00	$196,581.00	$196,581.00	$0.00	$324,391.09	1.02%
12	SH-183/SH-360 INTERCHANGE	2.167	$31,693,814.00	$0.00	$25,500.00	$25,500.00	$0.00	$11,767.42	0.08%
13	SH-121/SH-183 INTERCHANGE	4.412	$19,593,369.00	$0.00	$25,000.00	$25,000.00	$0.00	$5,666.36	0.13%
14	SH-360:SH-183 TO SH-121	6.966	$30,012,363.00	$0.00	$95,705.00	$95,705.00	$0.00	$13,738.87	0.32%
15	I-20:SH-183 TO McCART	2.466	$43,958,758.00	$400,000.00	$757,319.00	$1,157,319.00	$162,206.00	$307,104.22	2.63%
16	I-35W:HATTIE TO I-35/I-20 INT	4.715	$664,446.00	$418,876.00	$245,570.00	$664,446.00	$88,839.02	$52,082.71	100.00%
17	I-20 EAST: IH-35W TO LOOP 496	7.885	$2,629,867.00	$1,165,500.00	$1,464,367.00	$2,629,867.00	$147,812.30	$185,715.54	100.00%
18	I-30/I-35W EAST INCR. (BROWN)	1.000	$19,421,282.00	$647,100.00	$984,228.50	$1,631,328.50	$647,100.00	$984,228.50	8.40%
	TOTALS	58.271	$496,783,191.00	$3,698,063.00	$8,523,436.50	$12,221,499.50	$63,463.18	$146,272.36	2.46%

IH35W/IH20 Satellite Operations Center

Location:	**On the northwest frontage road of the IH35W/IH20 Interchange, Adddress: 5520 South Freeway**
Size:	**16' W x 26' L x 9' H**
Construction:	**Prefabricated tilt wall unit.**
Weight:	**Approximately 92,000 lbs.**
Air Conditioner:	**MARVAIRE AVP 60ACA (62,500 BTU)**
Parking Lot:	**48' W x 42' L x 4" HMAC parking lot, with an 18' W x 40' L driveway.**
Fence:	**A 10' H chainlink security fence with a 20' double gate, enclosing the 108' x 70' property.**
Miscellaneous:	**Building was designed for a 110 MPH windload. Building has one 100W high pressure sodium vapor security light mounted on each exterior corner, two pole mounted luminaires & an external Security/ Surveillance camera.**
Function:	**To provide Environmental protection and Security for equipment installed in the Satellite Operations Center.**

As of Sept. 01, 1993

Satellite Operations Center Number One



Location:	**IH-35W/IH-20.**
Coverage:	**IH-35W - Hattie to Alta Mesa** **IH-20 - SH183 to US287**
Provisions:	**Houses the Closed Circuit Television controller, switcher and monitors, 7.5 KVA Uninterruptible Power Supply. Houses the Master controller for the Changeable Message Sign System and provides the termination and distribution units for the Fiber Optic and Twisted Wire Pair cable networks. Also includes the Freeway Traffic Management work station containing the System Control Unit interface to Local Control Units in the field, and remote control of the Lane Control Signals.** **The center also has a radio scanner, State radio and CB for additional monitoring of freeway conditions. Accidents are tracked manually on a wall map.**
Function:	**The interim center for Traffic Management System operates 6 am to 7 pm. These operations began on November 6, 1992. Some operational capabilities are extended 24 hours by using Stand-by personnel and Lap-top computers with modems.**

As of Sept. 01, 1993

Loop Detectors

Location: At 2000 foot intervals on main lanes and ramps with alternating locations having two loops per lane (Speed Loops).

ROADWAY:	# Loops:
IH-35W	176
IH-30	131
	53 (const.)
IH-20	222
	89 (const.)
SH-360	84
SH-121/SH-183 Int.	20
SH-183/SH-360 Int.	33
IH-30/IH-820 Int.	127
IH-35W/IH-20 Int.	177
Total	1112

Size: 6X6 ft.

Construction: 3 Turns 14 AWG with shelf mount 913-SS Amplifiers , Data is returned to the Satellite Operations Center via Local Control Units and the Systems Control Unit.

Function: To provide volume , speed, occupancy, density & % trucks, data for the Traffic Management System .

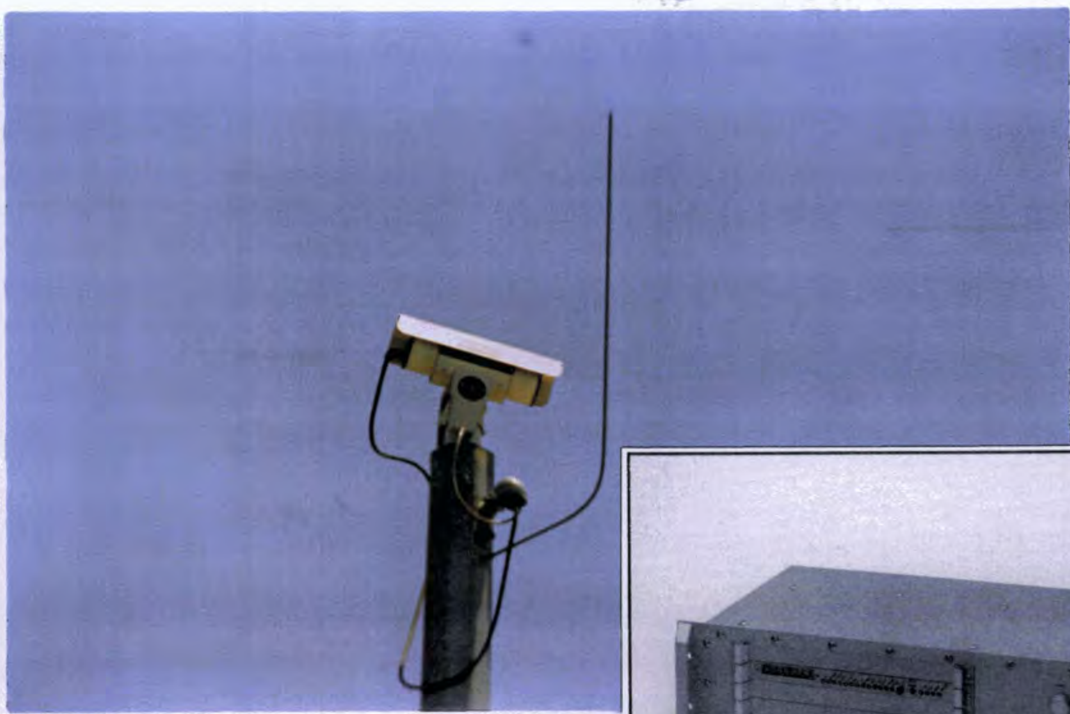
As of Oct. 13, 1993

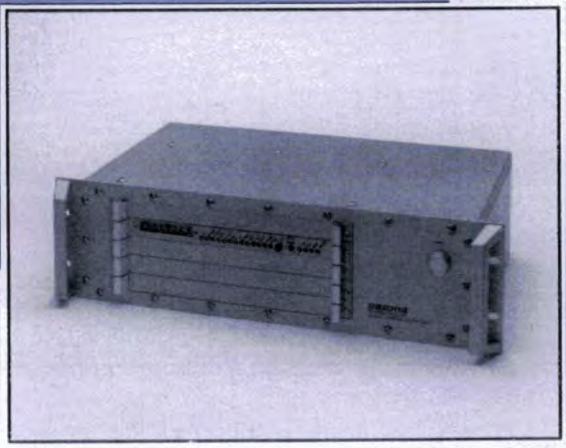
CCTV Installation

Location:	**At diamond intersections (approximately 1 mile spacing)** **On IH-35W: 8 cameras (installed)** **On IH-20 : 7 cameras (contract)** **On IH-35W: 1 camera (contract)**
Construction:	**COHU 1/2" CCD camera in a nitrogen pressurized environmental enclosure mounted on a Vicon pan/tilt unit, atop a 40' or 60' pole. Camera output is coax converted to Fiber Optics.**
CCTV Installation:	**Includes: camera, pan/tilt unit, pole, cabinet, fiber optics, and modems.**
Function:	**To provide visual verification of traffic conditions for the Traffic Management System.**

As of Sept. 01 , 1993

Alternate CCTV Installation
Color Video Compression System (CVCS)





Location: IH-30 @ US 287
1 color video compression system.

Conctruction: COHU 1/2" CCD camera w/environmental enclosure & Vicon pan/tilt unit, mounted on a 60' pole. Video signals are digitized and encoded (to a user selectable encode rate 300 bps to 10 Mbps) data stream. Video data stream will be transmitted to the decoder at the satellite on a commercial T-1 (1.54 Mbps) lease line.

CCTV Installation: Includes: color camera, environmental housing, pan/tilt unit, cabinet, 60' pole, encoder/decoder, modems and a T-1 lease line.

Function: To provide visual verification of traffic conditions for the Traffic Management System, and to monitor reconstruction of the I-30/I-35W interchange.

Under contract as of Sept. 01 , 1993

Alternate CCTV Installation
(Microwave)

Location:	**Renaissance Plaza (1600 Throckmorton)**
	1 Microwave Video System (under construction)
Construction:	**COHU 1/2" CCD camera w/environmental enclosure & Vicon pan/tilt unit. Transmitting video via 23 GHz short haul microwave link. Camera control signals transmitted via full duplex 9600 bps microwave data channel.**
CCTV Installation:	**Includes: color camera, environmental housing, pan/tilt unit, cabinet, microwave receiver/transmitter, fiber optic transmitter/receiver and 2' dia. dish, mounted on a non-penetrating roof mount structure.**
Function:	**To provide visual verification of traffic conditions for the Traffic Management System, and to monitor reconstruction of the I-30/I-35W interchange.**

Under contract as of Sept. 01 , 1993

Local Control Unit

Location: Two LCU's are installed in the surveillance cabinet at each diamond intersection (1 inbound and 1 outbound).

IH-35W	-	16 LCU
IH-20	-	2 LCU
IH-20	-	44 Contract
IH-30	-	4 Contract

Size: 11" W x 14" L x 5 1/2" H

Weight: 20 lbs.

Construction: LCU is composed of modular printed circuit boards, housed in an STD bus enclosure. The CPU board is based on a Z80 microprocessor. The LCU front panel is fitted for MS connectors, providing 196 I/O ports. Design provided by the Traffic Operations Division - Traffic Management Section.

Function: Currently provides systems communication for loops and LCS, with provisions for future ramp metering, signal interconnect, dynamic signs and barrier gates. LCU also provides limited front end processing for loop data.

As of Sept. 01, 1993

Changeable Message Signs

Location:	Roadway	Limits	# Signs
	IH-35W	Between IH-30 and IH-20	4
		@ Alta Mesa	2 contract
	SH 360	@ Parkrow	1
	IH-20	@ Bowman Springs	1
		@ Winscott-Plover	1
		@ Aledo	1
		@ James St.	2
		IH35W to Loop496	3 contract
		@ Grandbury Rd.	2 contract
	IH-820	@ Sun Valley	1 contract
	IH-30	@ Beach St.	1 contract

Construction:
1.)Flip-Disk Character Matrix signs: (Ferranti-Packard/TELESPOT)
2.)Flip -Disk FiberOptic /Hybrid Modified Character Matrix (TELESPOT)

Size: 31' W x 7' H x 16" Deep

Weight: 3300 lbs.

Function:
-Inform motorists of roadway and traffic conditions ahead.
-To advise alternate routes available.
-To notify of scheduled activities, allowing the motorist to plan schedules and routes to avoid delay.
-To warn of Ozone alerts for Demand Management.

As of Sept. 01, 1993

Lane Control Signals

Location: Cross-street bridges and sign bridges on:

IH-35W	-	57 heads
IH-30	-	26 heads
IH-20	-	17 heads
		23 heads (contract)
IH-20 EAST		45 heads (contract)
Total		**168**

Size: 22" square

Construction:
1.) Matec Fiberoptics Inc.
2.) Telespot Inc.

Weight: 62 lbs

Function:
Green ↓ : Lane available to motorists
Yellow X : Prepare to vacate lane
Red X : Lane not available to motorists
First extensive mainlane usage in the United States.

As of Sept. 01, 1993

Courtesy Patrol

Location: IH-820 and IH-30 / IH-35 within the loop (IH-820).

Composition: Three - Two man crews in half-ton pickups. Each truck is equipped with an arrow board, gas cans, water, flares and other equipment to assist stranded motorists.

Function: To provide 24 hour motorist assistance and limited incident management under the supervision of the District's Safety Coordinators.

As of Sept. 01, 1993

The Fort Worth

VISION

Vehicular
Information and
Surveillance on an
Intelligent Highway
Optical
Network

Texas Department of Transportation

District 02

Traffic Engineering

PRESENTATION OF THE FORT WORTH FREEWAY TRAFFIC MANAGEMENT SYSTEM

VISION

"Vehicular Information and Surveillance on an Intelligent highway Optical Network"

May 24, 1993

By: Tai Nguyen,
Steve Connell and
Scott Friend

The History:

The Fort Worth traffic management concept was approved November 20, 1984 by Highway Commission Minute Order 82421. Gaining Commission approval paved the way for publishing the Fort Worth Traffic Management Concept book in December, 1985. The concept book provided the basic design foundation for our system.

The concept became reality in June, 1984 when the IH-35W: Hattie to Felix - outside lanes project went to contract. The first IH-35W project was followed immediately by the IH-35W: Hattie to Felix - Inside Lanes project, April 1987, which placed our first Changeable Message Signs (CMS), loop detectors (Loops) and Lane Control Signal Heads (LCS). The CMS' became functional in August 1988 and were used for traffic control for the remainder of the project.

The System:

Our system has grown to include:

More than 56 miles of conduit,
10 CMS in operation,
8 CMS under construction,
1059 Loops installed,
123 LCS in operation,
45 LCS under construction,
8 Closed Circuit Television (CCTV) cameras in operation,
7 CCTV cameras under construction,
1 Remote Satellite Operations Center in operation,

The cost of the system installed to date is $8,000,000 and the price bid for the project under construction is $2,700,000.

The Concept:

The three essential elements of the Fort Worth Traffic Management System are: Surveillance (Detection/Verification), Communication and Information/Control.

Surveillance:

The Fort Worth system uses 6' X 6' three turn inductive loops for vehicle detection. These loops are embedded in all freeway lanes, entrance and exit ramps, at approximately 2000' intervals. The basic function of these loops are detection of vehicle presence, percent occupancy and collection of volume data, however, alternate detector stations, primarily at entrance ramps, are configured with two loops per lane for speed detection. Verification of the detector data is by color Closed Circuit Television, at one mile intervals.

Other detection systems being investigated include Ice Detection for bridges and multi-level interchanges, Sonic Vehicle Detectors, Microwave Vehicle Detectors and Laser Vehicle Detectors.

Communications:

The Fort Worth system is designed with a three level redundancy concept.

Level 1:

The first level consists of the detection, verification, information and control elements installed in the field. These elements, such as Loops, Cameras, Lane Control Signals and Changeable Message Signs, are distributed around Surveillance Cabinets which are usually located at diamond interchanges. The Surveillance Cabinet provides the first control point in the system. At the Surveillance Cabinet we are able to collect loop data, control and view output from the CCTV cameras, manipulate the Lane Control Signals and display messages on the Changeable Message Signs. The Surveillance Cabinets are aligned in surveillance corridors, with one side designated as the communications trunk. The first level elements are connected to the communications trunk via Local Control Units (LCU's) developed by the Department's Division of Safety and Maintenance Operations - Traffic Management Group (D-18TM).

Level 2:

The second level, the Satellite Operations Centers, are typically located at the intersection of two surveillance corridors, usually a multi-level directional interchange. A Satellite Operations Center houses a Freeway Traffic Management (FTM) workstation for each surveillance corridor and other equipment required for independent control of the CCTV and CMS systems. The FTM workstation, also developed by D-18TM, contains a Satellite Control Unit (SCU) and a System Manager Unit (MANAGER). The MANAGER is the operator level control software which allows remote operation of the field elements and collection and analysis of the field data. The SCU is an interface unit connecting the MANAGER unit to the LCUs in the field via the data communications systems. The LCU's process and transmit field data to the satellite, while distributing satellite commands to the field elements.

Level 3:

The highest level of control is the proposed TxDOT Freeway Traffic Management Center. This center will be located at the District headquarters complex and will communicate with all Satellite Operations Centers via a single mode Fiber Optics communication network. An operator in this center will be able to collect data from any loop, and send commands to any element, anywhere in the system. The hardware, software and final concepts for this center are under consideration now with design scheduled for 1995.

Data communications for the Fort Worth system is, currently, by shielded 50 pair twisted wire cables. The project under construction includes sub-rate T1 transmission, on Fiber Optic cables, for data communications. All future projects will use Fiber Optic data communications. Video transmission is, and will be, by multimode Fiber Optic cable.

The Information:

The elements currently available,in the Fort Worth system, for motorist information are Changeable Message Signs (CMS) and Lane Control Signals (LCS).

CMS:

We currently have ten refelective flip=disk CMS installed. These signs use two dedicated twisted pair (six signs) or dial up phone lines (four signs) for communications. Control for these signs is provided by an 80386 PC, under QNX, an UNIX based operating system. The Master Controller (primary control) is in the Satellite Operations Center, with Remote Controllers located in the Traffic Engineering section and the Freeway Traffic Management Maintenance Section. The project under contract will require Fiber Optic CMS and a DOS operating system.

LCS:

The LCS are fiber optic indicator heads, centered over each freeway lane, designed to inform the motorist of the availability of that lane to traffic. The indications provided are a red X, a yellow X and a green arrow. Some heads were provided with an additional yellow arrow indication, however, the yellow arrow is not supported by The Manual On Uniform Traffic Control Devices at this time. The intended meaning of each indication is:

Red X: Lane obstructed, unavailable to traffic
Yellow X: Caution, be prepared to vacate lane
Green Arrow: Lane available to traffic

The LCS are, typically, spaced at one mile intervals and controlled from the Satellite.

Other information systems being investigated are Highway Advisory Radio , In-car Navigation Systems and Broadcast Media Links.

The Control:

Proposed control systems include Interactive Predictive Ramp Metering, Frontage Road Signal Interconnection and Incident Response Teams. Other control systems being investigated include Ramp Closure Systems and Variable Lane Assignments at diamond intersections.

The Plan:

We are ending the ninth year of our twenty year plan. The last nine years have produced tremendous results, however, many challenges still lay ahead. The vision for our system, outlined in the Concept approved by the Highway Commission in 1984, includes the following:

260 miles of freeway under the Freeway Traffic Management System
including 80 miles of system containing all active elements of the Freeway Traffic Management System Concept,
7000 Inductive Loop Detectors,
207 Ramp Metering/Wrong Way Detection installations,
95 Frontage Road Signal Interconnection systems controlled by Central,
45 Changeable Message Signs,
80 Closed Circuit Television cameras,
640 Lane Control Signal Heads,
6 Highway Advisory Radio installations,
9 Satellite Operations Centers and
1 Freeway Traffic Management Control Center.

The projected cost of the total system is $53,000,000 (1985 dollars).

Our efforts are being rewarded with an efficient, functional system and the future of our system is exciting. The exact shape of that future is still being molded, by emerging technologies, by new Federal emphasis and by our own continuing experiences in design, operation and maintenance.

THE OPERATIONS:

On November 6, 1992, the Fort Worth System moved to the next level with initiation of regular operations from the first functional Satellite Operations Center in Texas. The Operations schedule began with one Operations day (6 AM to 7 PM) every other week. By January 1, 1993 the Satellite was being operated every Friday. On May 8, 1993 personnel from TxDOT's Division of Maintenance and Safety Operations, the Traffic Management Group, delivered and installed the Satellite Control Unit software, enabling centralized collection of detector data and control of LCS in the IH-35W corridor. This software installation added Wednesdays to the regular Operations schedule. The Operations schedule will increase gradually to Monday through Friday, by September 1, 1993.

The Benefits:

Implementation of an effective traffic management system provides a means of extending the functional life of an existing roadway facility. As capacities are exceeded or safety and operational problems occur, it provides the capability to recognize and respond in an appropriate and timely manner. This precludes or lessens the impact of congestion by reducing pollution, decreasing accidents, and increasing or maintaining mobility and acceptable levels of service. These benefits demonstrate the importance of the transportation system as a key element in a viable urban economy. Implementation of such a system, built efficiently in stages, will provide the flexibility before the problems far exceed available capabilities and resources.