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16. Abstract
This report documents the development of a comprehensive plan for implementation of Intelligent Transportation Systems in the Dallas area. Objectives, findings, and recommendations are summarized as follows:

1. Develop a Broadly Based Steering Committee
A committee was formed with representatives from various transportation-related agencies including ten cities, Texas Department of Transportation (TxDOT), Dallas County, Dallas Area Rapid Transit, North Central Texas Council of Governments, FHWA, universities, several consultants, and other private sector companies.

2. Assess Existing TMS and Potential ITS Technology
An inventory of existing traffic management systems and transportation facilities was compiled. Thirty of the cities in the study area were surveyed to determine incident management procedures and to identify particular problems or needs.

3. Identify Institutional Issues and Legal Barriers
A workshop was held to examine any potential institutional issues which might be barriers to area-wide traffic management. It was generally agreed that a regional concept was essential, but not necessarily as a regional control center. The cities still wanted to have control of traffic management within their particular jurisdiction but were open to cooperative operation for incident conditions across city limit lines. Under incident conditions, predetermined, jointly developed signal timing plans would be called for from a Dallas Area Transportation Management Center (DATMC).

4. Develop an Implementable, Area-Wide Multi-Jurisdictional ITS Plan
Projects are defined for both freeway and surface street systems. Included are ATMS, ATIS, APTS, AVSS (AVCS), and CVO elements and their interaction. The DATMC will be operated by TxDOT but with sharing of video images and traffic data among the various operating issues over a wide-area network. Since a communications backbone network will not be in place for some time, much of the CCTV system will initially be in compressed video format transmitted over leased ISDN lines. The recommended plan reflects both State and National Architecture efforts.

5. Develop Costs, Benefits, and an Implementation Plan
Costs, benefits, and a staged implementation plan were developed and emphasize near-term improvements to incident management procedures, mobility assistance patrol upgrades, and other ITS elements. A medium- and long-term implementation plan is specified. A benefit:cost ratio of 17:1 was estimated for the recommended plan.

17. Key Words
Intelligent Transportation Systems, ITS, ATMS, ATIS, APTS , AVSS (AVCS), CVO, ITS Architecture, Traffic Management Systems, Traffic Information Systems

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INTELLIGENT TRANSPORTATION SYSTEM PLAN

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IMPLEMENTATION STATEMENT

This project assessed existing Intelligent Transportation System (ITS) capabilities in the Dallas area, studied advanced ITS technology, and developed a comprehensive ITS plan for the Dallas Urban Area. Specific projects are delineated, and a phased implementation is provided.

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation, nor is it meant for construction, bidding, or permit purposes.

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LIST OF ABBREVIATIONS

AHAR: Automated Highway Advisory Radio
AHS: Automated Highway System
ATIS: Advanced Traffic Information Systems
ATMS: Advanced Traffic Management Systems
APTS: Advanced Public Transit Systems
AVI: Automatic Vehicle Identification
AVL: Automatic Vehicle Location
AVSS: Advanced Vehicle Safety Systems (formerly Advance Vehicle Control Systems)
CATV: Community Access Television (Cable Television)
CBD: Central Business District
CCTV: Closed Circuit Television
CMS: Changeable Message Signs
CV: Compressed Video
CVO: Commercial Vehicle Operations
DART: Dallas Area Rapid Transit
DATMC: Dallas Area Transportation Management Center
DBMS: Database Management Systems
EDP: Early Deployment Planning Projects
EMRS: Emergency Response Management Systems
EMS: Emergency Management Systems
ETTM: Electronic Toll and Traffic Management
FCC: Federal Communications Commission
FHWA: Federal Highway Administration
FOTs: Field Operational Tests
FTE: Full-Time Equivalent
GIS: Geographical Information Systems
GPS: Global Positioning Systems
HAR: Highway Advisory Radio
HAT: Highway Advisory Telephone
HAZMAT: Hazardous Materials
HDLC: High Level Link Data Control
HOV: High Occupancy Vehicles
IDR: Incident Detection and Response
IP: Internet Protocol
ISDN: Integrated Serviced Digital Network
ISO: International Organization for Standardization
ISP: Information Service Providers
ISTEA: Intermodal Surface Transportation Efficiency Act
ITMS: Integrated Transportation Management Systems
ITP: Incident Timing Plans
ITS: Intelligent Transportation Systems (formerly Intelligent Vehicle/Highway Systems)
LCS: Lane Control Signals

LCN: Local Communications Network
LOS: Level-of-Service
MAP: Mobility Assistance Patrols
ME: Medical Examiner
MOE: Measure of Effectiveness
MPO: Metropolitan Planning Organization
NCTCOG: North Central Texas Council of Governments
NEMA: National Electrical Manufacturers Association
NTCIP: National Traffic Control/Intelligent Transportation Systems Communications Protocol
OPAC: Optimization Policies for Adaptive Control
ORNL: Oak Ridge National Laboratory
PC: Personal Computer
PCS: Personalized Communications Devices
RF: Radio Frequency
ROW: Right-of-Way
RSS: Root of Squared Sums
SCAT: Sydney Co-ordinated Adaptive Traffic System
TBC: Time-Based Controller
TIPS: Trip Itinerary Planning Systems
TSO: Traffic Safety Officer
TTI: Texas Transportation Institute
VMS: Variable Message Signs
VIP: Video Imaging Processing
WAN: Wide Area Network
WIM: Weigh-in-Motion

SUMMARY

This report documents the development of a comprehensive plan for implementation of Intelligent Transportation Systems (ITS) in the Dallas Urban Area. The contract defined the objectives summarized below:

1. *Develop a Broadly Based Steering Committee*

   A committee was formed with representatives from various transportation-related agencies including ten cities, TxDOT, Dallas County, Dallas Area Rapid Transit, North Central Texas Council of Governments, FHWA, universities, several consultants, and other private sector companies.

2. *Assess Existing Transportation Management Systems and Potential ITS Technology*

   An inventory of existing traffic management systems and transportation facilities was compiled. Thirty of the cities in the study area were surveyed to determine incident management procedures and to identify particular problems or needs.

3. *Identify Institutional Issues and Legal Barriers*

   A workshop was held to examine any potential institutional issues which might be barriers to area-wide traffic management. It was generally agreed that a regional concept was essential, but not necessarily as a regional control center. The cities still wanted to have control of traffic management within their particular jurisdiction but were open to cooperative operation for incident conditions across city limit lines. Under incident conditions, predetermined, jointly developed signal timing plans would be called for from a Dallas Area Transportation Management Center (DATMC).

4. *Develop an Implementable, Area-Wide Multi-Jurisdictional ITS Plan*

   Projects are defined for both freeway and surface street systems. Included are ATMS, ATIS, APTS, CVO, and AVSS elements and their interaction. TxDOT will operate the DATMC and will share video images and traffic data with the various operating agencies over a wide-area network. Since a communications backbone network will not be in place for some time, much of the CCTV system will initially be in compressed video format transmitted over leased ISDN lines.

5. *Develop Costs, Benefits, and an Implementation Plan*

   Costs, benefits, and a staged implementation plan were developed and emphasize near term improvements to incident management procedures, mobility assistance patrol expansion, and other ITS elements. A medium and long-term implementation plan is specified.

1. INTRODUCTION

1. INTRODUCTION

With the completion of the interstate highway system, the attention of transportation officials at the federal level has shifted from constructing new roadways to achieving more efficient use from the existing transportation system. The passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) provides funding for state and local transportation agencies to begin developing and implementing Intelligent Transportation Systems (ITS). These systems, formerly known as Intelligent Vehicle Highway Systems (IVHS), use modern communication, computer, and control technologies to accomplish the following goals (1):

- Improve safety and mobility in the transportation network;
- Reduce the environmental impacts of transportation by reducing congestion and delay in the transportation network;
- Enhance economic productivity and viability by improving efficiency and operations of transportation in a region; and
- Provide new services to travelers that are designed to enhance travel on existing systems and encourage the use of alternative modes of transportation.

The FHWA has identified 29 potential ITS user services that can be implemented by state and local transportation agencies to achieve better utilization of the existing transportation network (2). Table 1-1 lists these user services.

1.1 Problem Statement

Traffic congestion and its associated problems of increased traveler delay, vehicle emissions, fuel consumption, and potential for traffic accidents are not challenges unique to this area, nor are they challenges. The Dallas Area-Wide Intelligent Transportation System Plan seeks to address those problems and to propose resources to mitigate them through means other than major construction projects. Working with the Steering Committee, the following goals were established for the Dallas area:

- Reduction of congestion caused by freeway incidents;
- Reduction of general congestion and the resultant delay, emissions, and fuel consumption;
- Deployment of seamless transportation systems;

- Promotion and support of multimodal transportation and of high occupancy vehicles; and

- Reduction of vehicle-miles traveled.

Table 1-2 presents problems facing the Dallas area, how they may have been addressed traditionally, and the user service areas proposed by the Dallas Area-Wide ITS Plan. A more comprehensive discussion relating transportation problems to ITS solutions is presented in Chapter 4 of this document.

Table 1-1. ITS User Services

Type of Service	Individual User Services
Public Transportation Management	• Public Transportation Management • En-Route Transit Information • Personalized Public Transit • Public Travel Security
Travel and Traffic Management	• Pre-Trip Travel Information • En-Route Driver Information • Route Guidance • Ride Matching and Reservation • Traveler Services Information • Traffic Control • Incident Management • Travel Demand Management • Emissions Testing and Mitigation
Electronic Payment	• Electronic Payment Services
Commercial Vehicle Operations	• Commercial Vehicle Electronic Clearance • Automated Roadside Safety Inspections • On-Board Safety Monitoring • Commercial Vehicle Administrative Processes • Hazardous Materials Incident Notification • Commercial Fleet Management
Emergency Management	• Emergency Notification and Personal Security • Emergency Vehicle Management
Advanced Vehicle Safety Systems	• Longitudinal Collision Avoidance • Lateral Collision Avoidance • Intersection Collision Avoidance • Vision Enhancement for Crash Avoidance • Safety Readiness • Pre-Crash Restraint Deployment • Automated Vehicle Operations

Table 1-2. Dallas Area Transportation Problems and User Service Solutions

Problem	Solution	Conventional Approach	ITS User Services
Traffic congestion	Increase roadway capacity (vehicular throughput)	• New roads • New lanes	• Traffic control • Incident management
	Increase passenger throughput	• HOV lanes • Car pooling • Fixed route transit	• En-route transit information • Public travel security
	Reduce demand	• Flex time programs	• Travel demand management
Traffic accidents, injuries, and fatalities	Improve safety	• Improve roadway geometry (increase radius of curvature, widen lanes, etc.) • Remove road obstacles to improve sight distances • Traffic signals, protected left hand turns at intersections • Fewer at-grade crossings • Driver training • Sobriety check points • Lighten dark roads to improve visibility / better lighting • Reduce speed limits and post warnings in areas prone to adverse conditions	• Emergency notification & personal security • Emergency vehicle management • Incident management
Lack of mobility and accessibility	Provide user friendly access to quality transportation services	• Expand fixed route transit and paratransit services • Radio and TV traffic reports	• Pre-trip travel information • En-route transit information • Public transportation management
Disconnected transportation modes	Improve intermodality	• Static inter-agency agreements	• Pre-trip travel information • En-route transit information
Transportation following emergencies	Improve disaster response plans	• Review and improve existing emergency plans	• Hazardous material incident notification
Vehicle-based air pollution and fuel consumption	Increase transportation system efficiency, reduce travel and fuel consumption	• More efficient conventional vehicles • Regulations	• Incident management

1.2 Background

Planning for the Dallas Area-Wide ITS Plan actually started long before the project was officially formalized. Two committees, the Transportation Management Team (TMT) and the Mobility Technical Committee (MTC), had been meeting monthly to address specific safety and operational problems in the Dallas area. Comprised of transportation professionals, both the TMT and MTC had an interest in the emerging ITS movement.

A subcommittee representing both groups was constituted for the purpose of becoming more informed about developments in ITS and to explore funding avenues to bring the Dallas area "up-to-speed" in advanced traffic management.

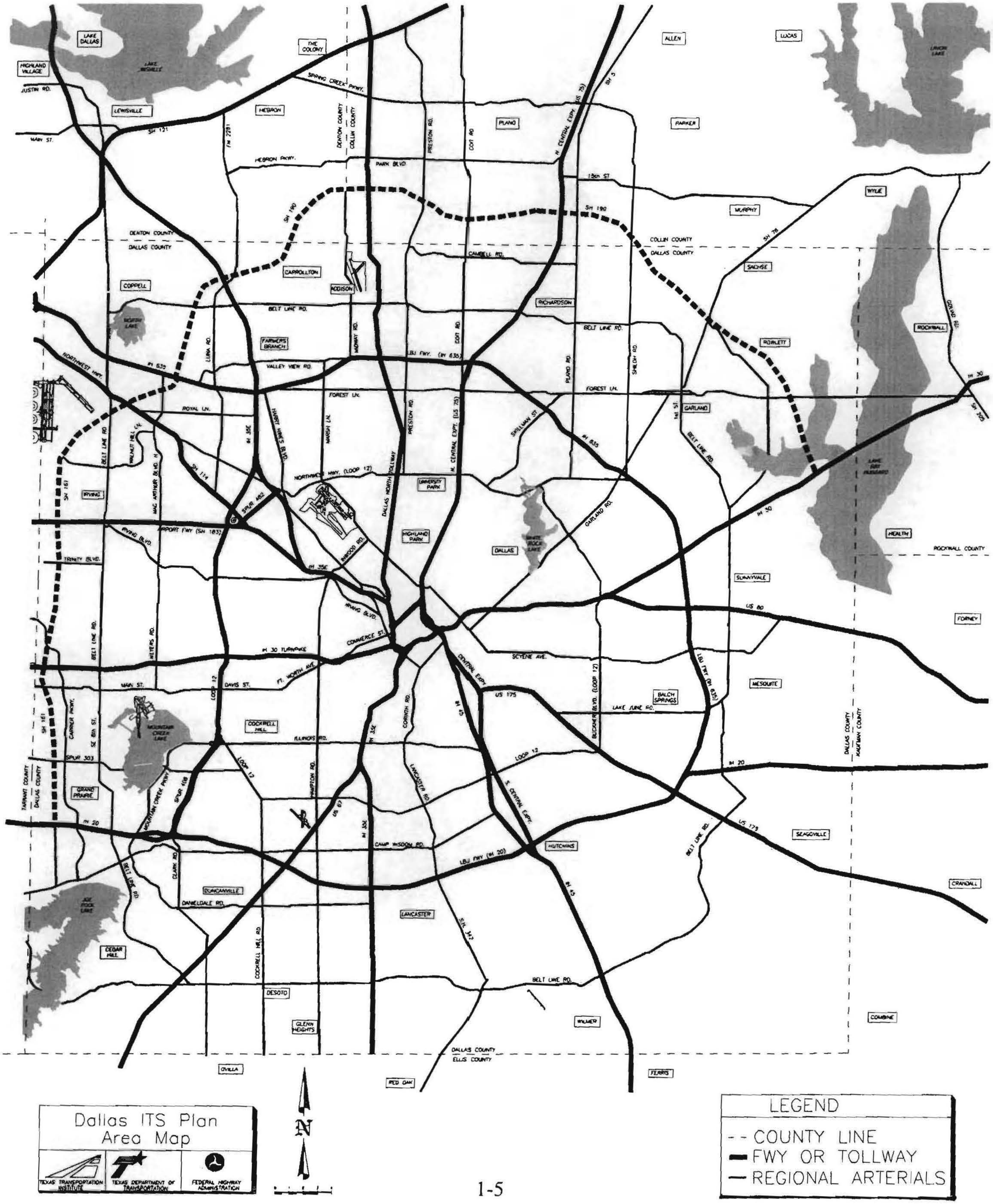
Some of the pioneering efforts in freeway management, control, and integration with surface streets had been implemented and tested in Dallas in the early '70s. For various reasons, including funding and reconstruction of major freeways, the area had not kept pace with large-scale integrated traffic management systems. Several of the cities had centrally managed traffic signal management systems, but area-wide management was not possible. When the opportunity for Federal Highway Administration's (FHWA) Early Deployment ITS planning funds appeared, the ITS subcommittee moved quickly to develop a proposal for the Dallas area. The proposal reflected the group's vision of the critical elements to be incorporated in the comprehensive planning study, thus the statement at the beginning of this section that planning began before the project was officially formalized. TTI has served as the performing agency for the plan development.

Although the Dallas area is not precisely defined and seems to be continually changing, for purposes of this project, the plan development area was taken to be Dallas County and the municipalities which directly abut the county to the north, south, and east of the county boundaries. Specifically, the Fort Worth urban area was excluded from this project principally because it is in a different highway district. However, the Dallas area-wide project planning staff has maintained close contact with Texas Department of Transportation (TxDOT) personnel in Fort Worth so that ITS efforts can be complementary. Currently, both the Dallas District and the Fort Worth District have plans for separate Transportation Management Centers; however, the two Transportation Management Centers will be interconnected, thus allowing for the exchange of data and video. Notably, the Dallas District and Fort Worth District have initiated a joint Intelligent Transportation System project on SH 183 that will be the first inter-District ITS effort in the State. The Dallas District has also implemented and designed several ITS related projects prior to or during the development of this plan. TxDOT staff have coordinated their work with this ITS Plan effort to ensure that these ITS projects are in accord with the plan being developed.

1.3 Plan Development Area Profile

The Dallas study area comprises approximately 2,600 square kilometers with a population exceeding two million. The City of Dallas itself has a population of approximately one million. There are 33 incorporated cities in Dallas County. The City of Dallas has contiguous boundaries with 15 of these cities, five of which have populations greater than 100,000 and three of which have populations between 50,000 and 100,000. There are nearly 500 kilometers of freeways in the Dallas Area-Wide ITS Plan study area, with approximately 200 kilometers in Dallas and the remaining mileage distributed among 24 other cities. Figure 1-1 shows the Dallas Area-Wide ITS Plan study area.

Figure 1-1. Dallas Area-Wide ITS Plan Study Area



1.4 Objectives of the Dallas Area-Wide ITS Plan Study

During the development of the proposal for this ITS Plan project, a committee representing TxDOT, Dallas County, area cities, and other transportation-related public agencies met to define goals and objectives of the ITS Plan. The stated objectives as defined in the proposal and included in the contract are:

1. Establish a broadly-based Steering Committee, including representatives of the responsible transportation agencies in the Dallas area, as well as transportation-oriented businesses, whether passenger, goods movement, or information services.

2. Assess the existing transportation management and communications linkages within the Dallas area, and investigate the potential of existing ITS technology to bring about improvements, both near-term and long-term.

3. Identify institutional and legal barriers to communication, cooperation, and coordination, and recommend the means to resolve them.

4. Under the guidance of the Steering Committee, produce an *implementable* integrated, area-wide, multimodal, multi-jurisdictional Intelligent Transportation System Plan, including the private sector as a partner, and maintain sufficient flexibility to incorporate emerging technologies.

5. Develop project evaluation criteria, estimated costs and benefits, priorities, and a staged implementation plan.

6. Define projects for implementation, prepare proposals, refine costs, and identify private and public funding sources.

1.5 Coalition Building

The Steering Committee consisted of representatives from various transportation-related agencies, including:

- City of Carrollton;
- City of Dallas;
- City of Farmers Branch;
- City of Garland;
- City of Grand Prairie;

- City of Irving;
- City of Mesquite;
- City of Plano;
- City of Richardson;
- Dallas Area Rapid Transit;
- Dallas County Public Works Department;
- Dallas Regional Mobility Coalition;
- Federal Highway Administration - Region 6 and Texas Division;
- North Central Texas Council of Governments;
- North Central Expressway Mobility Task Force;
- Texas Department of Transportation - Dallas District and Traffic Operations Division;
- Texas Transportation Institute; and
- University of Texas at Arlington.

In addition, several consultants and other private sector companies participated periodically. The committee met monthly to review project progress, to receive technical briefings, to give direction to the performing agency, Texas Transportation Institute (TTI), and to be advised of progress on other ITS projects in the area. Attendance was generally 25 to 35 persons. In addition, technical presentations from private sector suppliers of advanced ITS technology were given at the monthly meetings and at other specially called meetings. Four workshops were held during the course of the plan to address and to develop a consensus approach to specific issues:

- Institutional Issues - Traffic Signal Control During Incidents;
- Institutional Issues - On-Site Incident Management;
- Institutional Issues - Dallas Transportation Management Center Location; and
- Texas and Dallas National ITS Architecture Concerns.

Progress on development of the Plan was reported periodically at meetings of the Traffic Management Team, Mobility Technical Committee and the Dallas Regional Mobility Committee, as well as at local professional meetings so that agencies not on the Steering Committee could be informed.

In addition, the Steering Committee participated in several meetings regarding the National ITS Architecture Initiative. The Steering Committee also participated in development of all aspects of the plan and gave constructive feedback to the performing agency. Monthly notes of meetings were distributed to all participants as were detailed records of workshop proceedings and agreements reached.

1.6 Existing Dallas Area-Wide ITS Deployment

1.6.1 Traffic Signal Systems

There are approximately 2,200 signal locations within the study area with 55 percent (1,213 signal locations) in the City of Dallas. TxDOT maintains and operates approximately 210 signals in smaller cities. Many of these are located on freeway frontage roads. Of the existing traffic signals in the area, approximately 75 percent are in coordinated subsystems. Signal management by some form of central system (central computer or closed loop) is possible at approximately 45 percent of the signals in the area. Of the remaining coordinated signals, 601 were coordinated by local time based coordination (TBC) with 66 being coordinated by local masters. The cities of Addison, Carrollton, Farmers Branch, Garland, Irving, Plano, and Richardson have closed loop systems with central control by a personal computer, and Dallas has a central computer system.

1.6.2 Closed Circuit Television Monitoring

Three cities presently have the capability to monitor traffic with closed circuit television via their CATV systems:

- Richardson - 15 cameras; 15 more planned (including portable/mobile cameras) using a combination of microwave and the existing CATV system.

- Plano - 4 locations with 5 cameras; 7 more cameras planned.

- Garland - 4 locations with 7 cameras.

The following cities have committed funding to install surveillance cameras in the near future:

- Carrollton - 5 locations with 7 cameras utilizing microwave.
- Dallas - 4 cameras (Fair Park area).
- Farmers Branch - 7 cameras.
- Grand Prairie - 10 cameras (Trinity Park area).
- Mesquite - 2 cameras.

TxDOT has cameras planned for installation at 14 locations on North Central Expressway (US 75) to be installed as part of the US 75 reconstruction and at 10 to 12 locations on IH 635 north as part of the High Occupancy Vehicle (HOV) lanes construction.

1.6.3 Courtesy Patrols/Mobility Assistance Patrols

TxDOT presently operates five patrol vehicles on freeways countywide from 6:00 A.M. to 10:00 P.M., Monday through Friday. In addition, TxDOT also operates two patrol vehicles on freeways countywide on weekends from 4:00 P.M. to midnight. Figure 1-2 shows patrol routes currently covered by TxDOT (not all patrol routes are covered during all periods).

1.6.4 Changeable Message Signs

TxDOT currently operates 26 changeable message signs (CMS) on freeways or on major streets approaching freeways. Thirteen of these CMS are permanent, and the remainder are portable signs provided by the US 75 construction contractors. Three permanent CMS are to be installed on US 75 in the near future.

1.6.5 Control Centers

CMS are operated from the TxDOT's Dallas District Headquarters in Mesquite, and the courtesy/mobility assistance patrols are dispatched from the District as well. Control center hardware, including CCTV monitors and controls, will be installed in a Transportation Management Satellite building near the interchange of US 75 and IH 635 with CCTV and other equipment being installed as part of the US 75 reconstruction and the IH 635 HOV system. Ultimately, plans call for a Dallas Area Traffic Management Center (DATMC) for all freeway corridors to be installed and operated at a central site. Most of the cities with traffic signal management systems, as described previously, have an area devoted to central control and will establish communications links with TxDOT's Transportation Management Satellite and ultimately TxDOT's DATMC.

1.6.6 Summary

Figure 1-3 shows TxDOT's Dallas District ITS projects completed or currently under construction. Figure 1-4 shows TxDOT's Dallas District ITS projects in design.

Figure 1-2. Dallas Area Mobility Assistance Patrol Routes

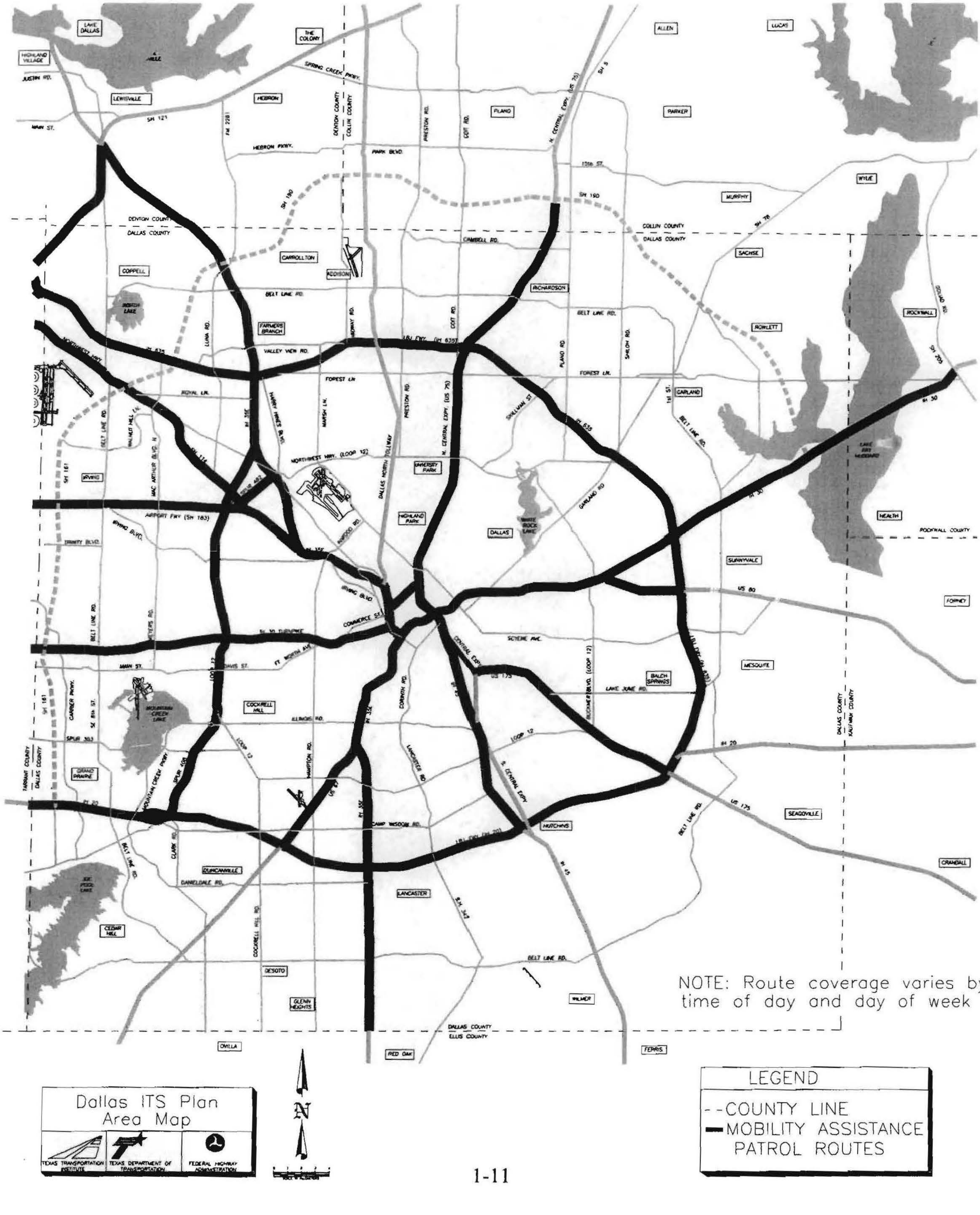


Figure 1-3. Dallas Area ITS Freeway Projects Completed or Under Construction

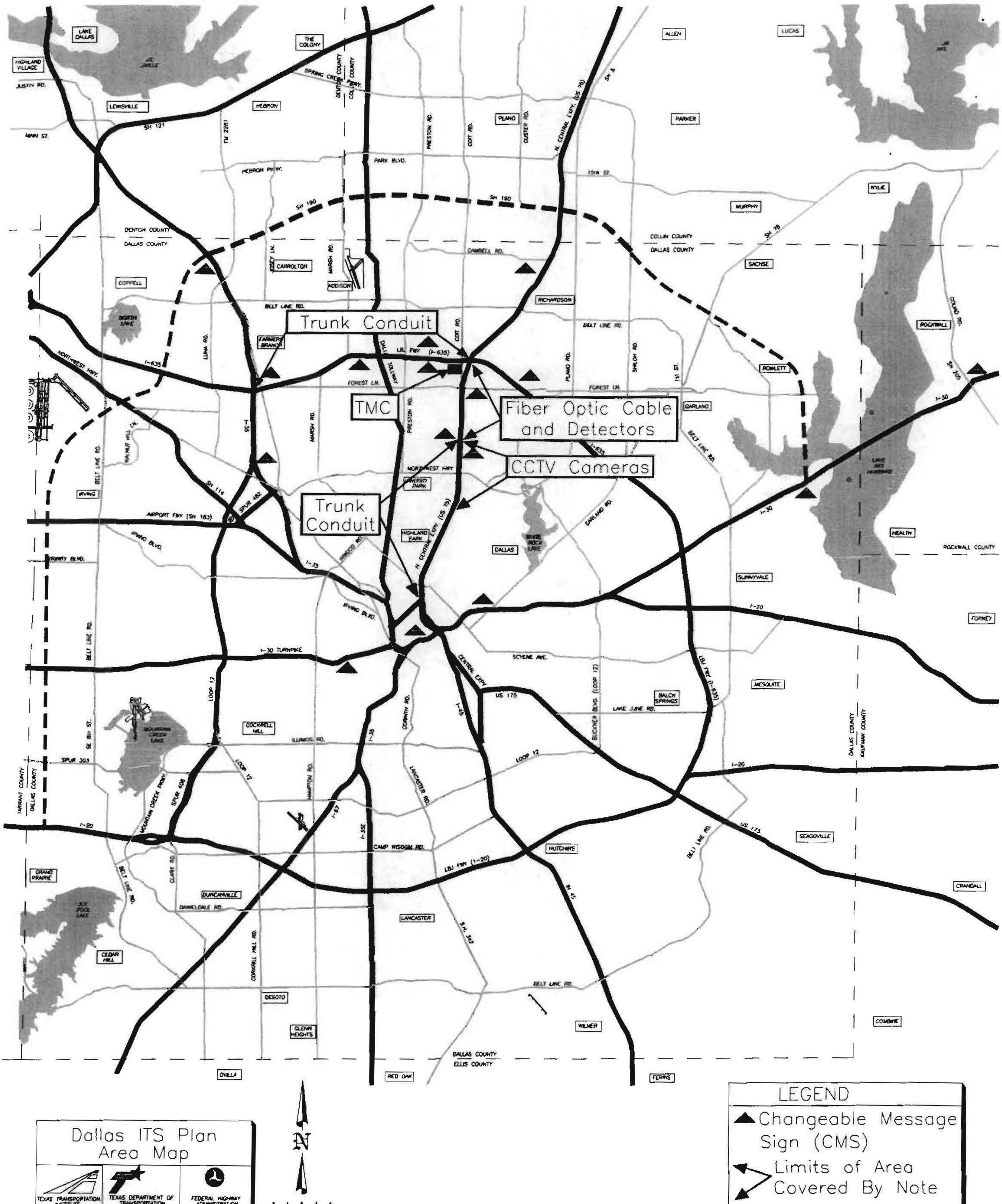
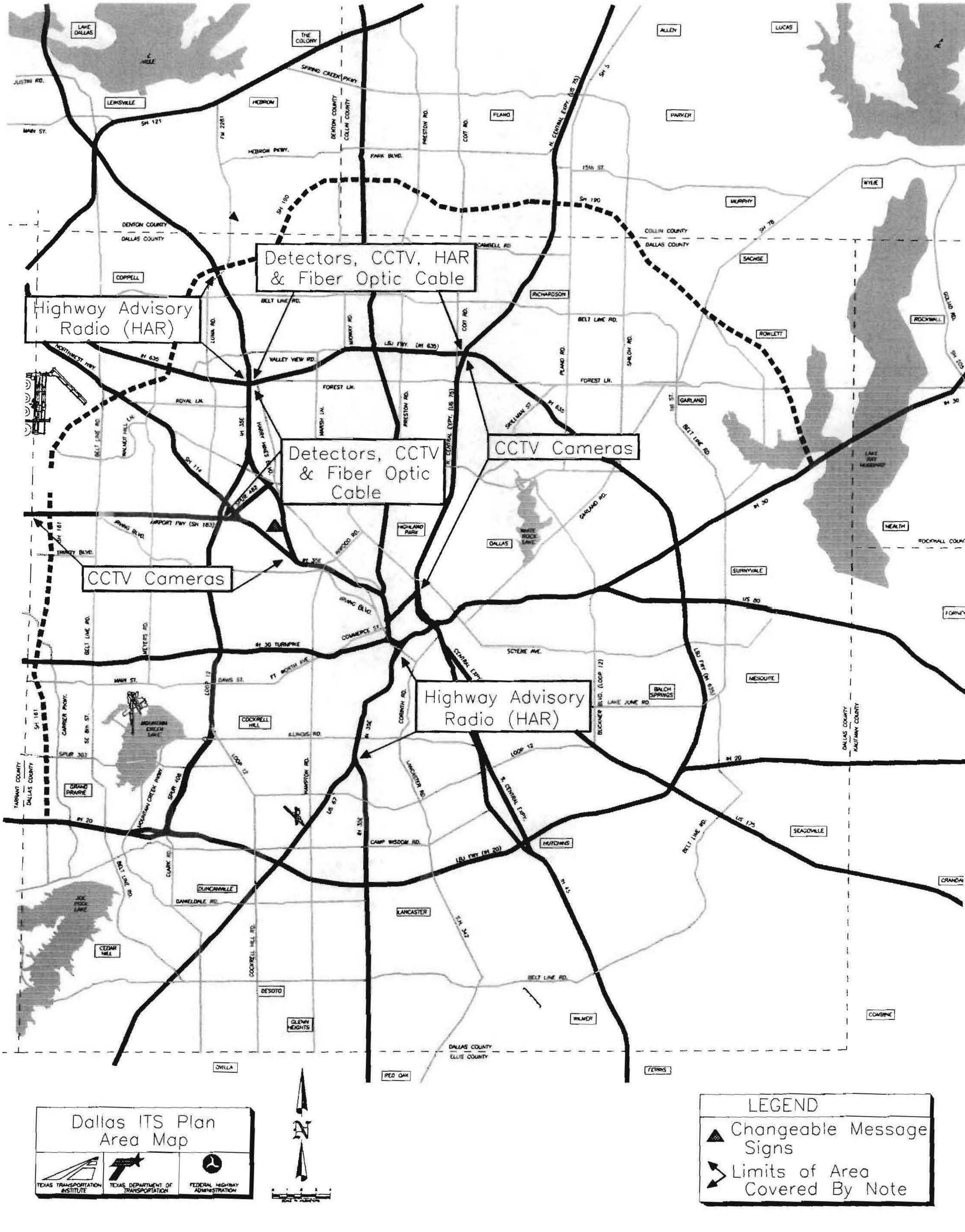


Figure 1-4. Dallas Area Freeway Projects in Design



1.7 Guide to the Dallas Area-Wide ITS Early Deployment Plan

This Dallas Area-Wide ITS Plan is arranged into six chapters. Chapter 1 provides an overview of the Plan, including a description of the objectives of the Early Deployment Planning process, a summary of the regional coalition building process and a profile of existing ITS deployment in the area.

Chapter 2 focuses on incident management. This issue, incident management, was a driving force in launching the study and a significant incentive for regional coalition building. The chapter contains a number of recommendations for incident detection, response and clearance.

Chapter 3 identifies ITS deployment policies and guidelines. These policies and guidelines are recommendations for deploying ITS that are consistent with the regional ITS consensus, are feasible within the set of technological dependencies associated with ITS services and products, and are bounded by institutional considerations of funding, staffing, liability, and others.

Chapter 4 describes the recommended ITS Plan in the context of the national ITS enabling framework, statewide transportation policies, and the FHWA recommended ITS Early Deployment Process. This chapter also describes key attributes of the proposed Dallas Area-Wide ITS System technologies.

Chapter 5 outlines the proposed ITS Plan in the language of the National ITS Architecture deliverables. Since the FHWA sponsored National ITS Architecture Program is not complete, only a representative sampling of the Dallas Area-Wide ITS Plan is depicted from this perspective.

Finally, Chapter 6 summarizes the recommended ITS Deployment Plan for the study region and provides estimated benefits, costs and staging of projects.

1.8 References

1 *Intelligent Vehicles and Highway Systems.* Executive Summary of Mobility 2000. Texas Transportation Institute, Texas A&M University System, College Station, Texas. 1990.

2 Seminar on *Intelligent Vehicle Highway Systems.* U.S. Department of Transportation, Federal Highway Administration, Washington D.C., 1993.

2. INCIDENT MANAGEMENT

2. INCIDENT MANAGEMENT

Chapter 2 focuses on incident management. This issue, incident management, was a driving force in launching the study and a significant incentive for regional coalition building. This chapter contains a number of recommendations for incident detection, response and clearance.

2.1 Background

The Dallas area, like other urban areas, is striving to maintain mobility on a network of freeways and arterials which increasingly are over-capacity during peak periods. Added congestion caused by incidents on the network further restricts the capacity of the system. When these incidents occur during peak periods, the effect can be dramatically compounded by a network already under strain. In a recent study by the Texas Transportation Institute (1), Dallas area congestion costs, in terms of delay and fuel costs, exceed $1 billion per year, or about $590 per person per year. In contrast, the cost per person per year in New York is $430.

An "incident" is defined as any occurrence that reduces capacity on a freeway or arterial. Incidents can consist of ordinary occurrences such as a stalled vehicle on a shoulder, that impedes traffic flow, to traffic accidents and cargo spills that require police or emergency response, or even hazardous materials spills with direct area-wide impact and the potential to paralyze the transportation network. Adverse weather can constitute an incident; flooding, ice or snow generate major responses by transportation servers in the area. Special events drawing large crowds are also considered incidents and require detailed traffic management capabilities. The Federal Highway Administration (FHWA) estimates that incidents are the direct cause of 60% of all delay due to congestion; recurrent congestion due to over-capacity conditions on freeways accounts for the remaining 40% (2). Even minor incidents, such as stalled cars on the shoulder or minor accidents relocated off the roadway, can cause significant delay and queues when drivers' attention is drawn to the vehicles involved in the incident or response. Incidents impact the driving public due to the delays and associated costs, safety issues, driver frustration, lack of dependability of the transportation system, and the effect on alternate routes.

Loss of mobility is one aspect of incidents, but also important are the safety implications, which influence not only those involved in the incident but the traveling public that encounters them. One of the most serious impacts of incidents is that they can cause other incidents. One study estimated that 20% percent of all incidents were caused by previous incidents (3). These can, in turn, be minor or major in nature.

Even though improvements have been made in the detection, response, and clearance of incidents, the tools and techniques can continue to be improved. The Dallas area has, in the Early Deployment Planning process, identified some areas for improvement, increased scope and enhanced services. This builds upon the features already in place that address this critical concern. Incident management is an integral part of any ATMS plan because without it, the system only works when things happen as planned. The incident management aspect of planning for contingencies can and should be a part of any ITS plan.

Many of the various agencies responsible for transportation in the Dallas area have expressed regional cooperation and interest in the planning of a coordinated Incident Detection and Response program. By consensus, improved incident management has been identified as the key aspect of ITS that will serve a critical need, incur minimum expense, and allow implementation in the short term. As a part of the Plan study, over 20 Dallas area cities were interviewed to assess the existing incident management system and its problems as experienced by the emergency service providers in these cities. In addition, the National Incident Managment Coalition held a regional forum in Dallas in April 1993, which allowed discussion of the topic by high level community leaders throughout the area. Finally, through the monthly meeting process of the Project Steering Committee, a more thorough deliberation was possible on the local issues and technical problems. A special workshop on Incident Management was held with this group in July 1994, and some areas in which beneficial cooperative actions might be considered have come into focus.

2.2 The Existing Incident Management System

In 1994, there were 10,519 reported accidents on the nearly 500 freeway kilometers in the Dallas area. Eighty-nine involved fatalities, and 5,761 involved injuries. It is estimated that these accidents may have caused up to one-half of the delay due to incidents in the area. The remainder were caused by much less serious incidents, stalled cars, and minor accidents with no injuries, to which police don't respond. In 1991, TTI conducted a study of incident frequency on Dallas freeways on a few sample days and found that a rate of one incident per 40,000 vehicle kilometers is prevalent (4). Based on annual vehicle miles traveled on Dallas area freeways and annual reported accidents, this would suggest that minor incidents occur 50 times more frequently than major ones. Another result of the study was that incidents occur more frequently in areas of congestion, whether recurrent or due to an initial incident. In order to reduce the probability of secondary incidents, either accidents or vehicle breakdowns due to stop and go driving, it becomes imperative to clear the original cause quickly and to handle traffic affected by it.

The key to incident management lies, of course, in the timely and efficient response of police and fire department personnel. Their abilities to assess the situation, call forth resources, and monitor and re-evaluate changing needs in the field are key to the incident management process. Many times this effort is dangerous for the officer, and the lives of accident victims may hang in the balance. Emergency response personnel need to be involved at every step in the design of improved incident management procedures if the further public goals of clearing the roadway and restoring normal traffic flow are to be met. Without an adequate field response, it would be impossible to effectively manage major incidents, regardless of the sophistication of the ITS infrastructure and operational strategy.

Since major and minor incidents can be handled quite differently, the following discussion separates the two. During the interviews with the Dallas area cities, those interviews involving police and fire personnel focused primarily on major incidents.

2.2.1 Minor Incidents

TxDOT has undertaken two efforts in the area of minor incidents. In 1988, the Dallas District of TxDOT initiated a campaign which has attracted national interest, the "Move-It" campaign. Texas law states that driveable vehicles involved in an accident must be removed from the travel lanes, but many motorists were unaware of the law. The campaign went a long way toward educating motorists, but apparently many still believe it is illegal to move their vehicles until the police have come, or at least until the necessary identifications have been exchanged. In addition to further publicizing of the "Move-It" campaign, it may be worth exploring with insurance companies ways to publicize this law, since fear of losing insurance benefits is a primary reason motorists give for not moving their vehicles.

The second TxDOT effort has come through extension of its previously existing freeway service patrol. These vehicles, known as Courtesy Patrols or Mobility Assistance Patrols (MAP), are equipped with push bumpers to move a stopped vehicle out of a travel lane, gas to refuel vehicles as needed, air to help with flat tires, and cellular phones to call for wreckers if needed. Other supplies for basic traffic control assistance include traffic cones, flares, and an arrowboard. They can be summoned by the Dallas Police Department via Dallas police radio. A variety of small repairs can be handled quickly to get vehicles and traffic moving again. An evaluation of the MAP program is currently underway; a potential benefit-cost ratio estimate of 20:1 may be possible under peak traffic conditions, ranging down to 2:1 under conditions where freeway traffic is not affected by the incident, and the individual motorist being assisted is the only beneficiary.

Current operations include five patrols Monday through Friday from 6:00 A.M. to 2:00 P.M., four patrols from 2:00 P.M. to 10:00 P.M., and two weekend patrols from 4:00 P.M. to midnight. These patrols are now assisting 1,700 drivers per month, or an average of one assist per patrol hour. The public response has been overwhelmingly positive, with those people assisted expressing great appreciation.

2.2.2 Major Incidents: Police and Fire Perspective

Interviews were conducted with the people who do the work of clearing incidents to gain knowledge of their procedures and to get their suggestions for how coordinated efforts between agencies might improve things for them by speeding up the process and making it safer. Barton-Aschman Associates, a transportation consulting firm with an office in Dallas, also conducted an Incident Management study on arterials in six cities in the north Dallas area, and the two interview processes were coordinated.

2.2.2.1 Incident Reporting

Almost all freeway incidents are now reported by users of cellular phones. While this is a great boon in that they are reported almost instantly, it may present problems in locating the site. Callers dial 911, which is a free cellular call. If such a call were made from a home or business, the location would automatically be pinpointed; however, for a cellular phone, the call goes to the nearest system headquarters. This can result in the wrong city receiving the call and the need to transfer it. Additionally, the cellular facilities or, alarmingly, the 911 facilities can be severely overloaded.

Further, as the Dallas area is broken into numerous jurisdictions, drivers may be unable to identify in which city they are currently driving, much less exactly where they are, and the correct direction of travel for the accident site. Fortunately, an accident will be reported several times, and dispatchers sifting between conflicting bits of information may be able to zero in on the correct site. However, this can be a major problem where freeway access points are few, and missing the exact location or direction of travel can cause delays in emergency vehicles reaching a site by as many as ten critical minutes. Many cities mentioned pinpointing the location of the incident as a critical area for improvement. Consideration should be given to making the city boundaries more visible, to increasing the size and frequency of mile markers on the freeway to make drivers more aware of them and to beginning a campaign to increase awareness of location and the need for accuracy. Additionally, signs can be mounted on bridges identifying the cross-street name. The good news is obvious: people care, and they are willing to report an incident.

2.2.2.2 Dispatch

Most 911 calls typically go to the police dispatcher, hopefully to the right city. If it is a non-injury accident, the caller is notified that the police will not come, that driveable vehicles are to be removed from the freeway and insurance data taken by the individuals involved. (In some cities, however, police continue to respond to such accidents.) If the accident involves nondriveable vehicles, police will respond. If an injury is reported by the 911 call, the fire department is automatically notified as well. Police typically arrive on the scene within five minutes, and fire response time is typically also under five minutes. A high degree of cooperation exists between cities in that both respond to locations close to city boundaries. The first crew on the scene works the accident, regardless of the jurisdiction, but the "right" city assumes authority immediately upon arrival. If the accident is major, both cities may continue to work together.

2.2.2.3 Incident Clearance

When an injury is involved, the fire department usually commands the scene until victims are cared for, and they call additional ambulances, including helicopter ambulances, as needed. If there is a crime scene, the police command the scene as well, protecting it for collection of evidence. If a hazardous material spill is involved, it is again the fire department who commands the scene. No jurisdiction reported problems with knowing who was in charge at the scene at any given time.

Police in some cities are reluctant to push vehicles from the roadway due to liability concerns about vehicle damage or air bags accidentally inflating. Police call wreckers to remove vehicles from the roadway. At the time of the interviews, wreckers contracted by the City of Dallas served on a rotation priority system, which meant that the closest wrecker was often not the one called. Dallas, along with other cities, had a required response time ranging from 30 to 45 minutes with penalties assessed for failure to meet the response time requirement. However, some cities had exclusive wrecker contracts. Some assistance getting wreckers to the incident through heavy congestion would be welcomed. During the last state legislative session, a new law was passed allowing vehicle owners the right to call their own wrecker. This could increase delay in clearing an incident significantly.

Wrecker policy is again involved in the final clearance of an incident, which occurs when the debris is cleaned up and traffic is allowed to use the roadway again. The wrecker is generally charged with the responsibility of cleaning up the roadway and ensuring that driving can be safely resumed. Frequently, this is not done well enough, leaving street crews to finish up. Improvement in this procedure could save time in incident clearance. Further, if private wreckers are called, they will not be required to clear debris, and some other entity will have to assume responsibility; in the case of a freeway incident, this would probably be TxDOT.

If a gasoline or diesel fuel spill has occurred in the accident, special absorbent material is needed and is usually not readily available. Several cities suggested creation of joint-use special absorbent stockpiles with loaded trucks or trailers available for delivery to the site on short notice at any hour. TxDOT is now handling this responsibility, but the response time is slow due to the distances to be traveled, the congestion encountered, and the initial difficulty in reaching authorized people, especially after normal working hours.

2.2.2.4 Maintaining Mobility

Police handle the traffic control during incident clearance, and there is an almost universal feeling among them that officers could use more specialized training in this area. Safety at the scene is job number one for the accident victims, for the emergency personnel, and for the traveling public. This often translates to stopping the traffic altogether for several reasons. First, keeping traffic moving takes an extra officer, and staffing is very tight in many cities. Second, motorists moving in a slow queue may become impatient and drive down shoulders, causing further hazards. Third, those passing an accident scene may include gawkers, who sometimes run into equipment and personnel. Fourth, a fuel spill is very often associated with a major accident, and this creates a hazard until it is cleaned up. Spills may very well take a long time, since simply washing it off the roadway is not environmentally acceptable. Clearly, many police and fire officers currently feel it is not in the best interests of the victims or accident respondents to allow traffic past the scene. Education on the increased probability of accidents upstream may alter this perception.

One helpful element mentioned by several police departments is the frequent presence of the TxDOT MAP vehicles, who monitor police broadcasts and may arrive on scene to help. Equipped with arrowboards and traffic cones, they can provide assistance in traffic control as directed by the police.

Some police departments stated an interest in using changeable message signs in the vicinity (especially around construction sites) to provide information on accidents to motorists and to encourage diversion.

2.2.2.5 Special Problems

Loaded trucks provide a critical case. Although heavy duty wreckers are available, they cannot upright a loaded semi without the side walls of the trailer giving way. So this means the cargo must be off-loaded, which is sometimes a time consuming procedure. Many carriers have contracts with local representatives to handle this duty, and loads dumped on the roadway can be removed by TxDOT personnel. Some cities suggested the joint acquisition of an air bag system capable of uprighting a semi. One such system in the region could be used as needed by any jurisdiction, spreading the cost. There are also several wrecker services with air bag systems in Tarrant County, at least one of which is willing to upright trucks in Dallas.

Another example of joint cooperation suggested was the establishment of a region wide hazardous material team. The City of Dallas has one such team (a second was lost to budget cuts), and they are willing to respond to other cities when requested. A considerable problem exists in identification of the type of hazardous material, and the availability of the appropriate equipment. Private companies under contract to the city are called to do the actual cleanup after initial identification and site security are established.

The problem of fatalities at the scene of an accident is difficult, if infrequent. Typically, emergency medical personnel are not authorized to declare someone dead and will transport to the hospital when in doubt. However, when it is obvious that death has occurred on the scene, the county medical examiner (ME) must be called, and this can add 30 minutes to several hours to the accident clearance time during weekends or holidays. Further, only the ME can request transportation for the body, and this is often done after arrival at the scene, adding yet another 30 minutes. It was suggested that some improvement might be realized by bringing in the ME via helicopter for a major accident. Virtually every city stated that this is a problem. Also, the ME could call for transportation while en-route to the scene.

2.2.2.6 Other Suggestions

Using a common communication system between emergency vehicles (interjurisdictional or between police and fire) would help, and greater availability of cellular phones for the police could speed the clearance process.

Most cities favor the use of an emergency vehicle traffic signal preemption system, such as Opticom, but cost is a problem unless a source of funds could be identified.

2.3 Other Incident Management Systems

The commitment to provide increased mobility and safety through incident management programs has been ongoing in other locations, many of which have been building services and features for decades. Often there are ideas and elements worthy of consideration and inclusion in a Plan to be developed for Dallas. Although many programs of note exist, selected programs are highlighted below.

2.3.1 Illinois Department of Transportation

In Chicago, drivers are the beneficiaries of the many elements of the freeway traffic management plan, which consists of the freeway traffic surveillance and control system, the Emergency Traffic Patrol (the Minuteman service), motorist assistance cellular phone service, highway advisory radio with AM band local broadcasts, and a telephone hotline for taped reports and messages. The Minutemen respond to incidents that disrupt traffic and provide 24-hour mobile surveillance and motorist assistance with 35 patrol trucks (12 patrols), a staff of some 59 employees, wreckers, cranes and other special equipment. They assist over 100,000 motorists per year; the service is free to the motorists. The Minutemen have traffic handling duties, which include removing disabled vehicles from the roadway, establishing emergency detours with cones, barricades, flares, signs and lights, and helping at maintenance and construction sites. The motorist assistance cellular phone service fields more than 12,000 calls per month with a free cellular phone line, *999 (5).

2.3.2 Washington State Department of Transportation

The Seattle area incident management program also has as its objective quick response to incidents in order to provide traffic control assistance, cleanup, and prompt clearance. The system utilizes an incident response engineer and pre-event incident planning. A study conducted between 1987 and 1989 by the Washington State Department of Transportation (WSDOT) found that an accident on an urban freeway inbound into Seattle would incur an average commuting time delay cost of $2,700 per minute of accident duration. As one aspect of a comprehensive traffic management plan, incident management is considered to be a very visible service for which drivers can perceive direct and immediate benefit. WSDOT documents incident response costs, bills the responsible party, and has an almost perfect (near 100%) reimbursement rate. After an incident, the response is evaluated to determine the effectiveness of the response and any future enhancements. WSDOT response times for implementing traffic control assistance average just 15 minutes (6). WSDOT now estimates that the incident management program has allowed major incidents to be cleared an average of one to two hours quicker than before. Total freeway closures are now unusual, since traffic flow can often be maintained even at major incidents.

2.3.3 Los Angeles

The incident management program in Los Angeles is home to one of the largest service patrols. This service began in 1991, funded by a one-half cent sales tax, and consists of 88 tow trucks. These are privately owned and operate on a contractual basis with CALTRANS, the California Highway Patrol, and the County Transportation Commission. They assist over 700 vehicles per day (7).

2.4 Proposed Incident Management Enhancements for the Dallas Area

Some of the other ideas brought out in the consensus building process during the development of the ITS Early Deployment Plan include those shown in Table 2-1 and Table 2-2. Table 2-1 shows the proposed recommendations for detection, response, and clearance of incidents that are major in nature. Major incidents may be defined as those incidents which require the services of a police officer. Table 2-2 lists recommendations for minor incidents. Similar incident management requirements can be developed for arterial streets.

2.4.1 Management of Major Incidents

Relying heavily on the existing tendency of drivers to report problems with cellular 911 calls (sometimes to the extent of overloading the 911 lines), the incident management program hopes to implement a free dial-in service for reporting freeway incidents. Once an incident has been reported and its general location established, video surveillance cameras can be used, if available, for confirmation of precise location and assessment. Video cameras can help identify resources needed for response.

At one of its monthly meetings, the Steering Committee undertook an exercise using Delphi consensus building methods to assess the relative importance of various aspects of incident management, with reference to the benefits achievable to the public if the ultimate system could be implemented. At first, the opinions varied widely, but within a couple of iterations, consensus was obtained that between 40% and 50% of the total public benefits achievable would likely come from actually *clearing the freeway sooner*. This problem is viewed as the number one problem in the Dallas area, with respect to incident management. Due to the presently uncoordinated efforts of multiple jurisdictions and the view of many police officers that moving traffic is not a priority, accidents may tie up the freeway for hours. Better cooperation and a policy directed toward swift clearance could cut the time significantly, while still maintaining the safety of assisting officers and vehicles passing the scene.

Texas has an opportunity not available in many other states to reduce incident clearance times. In 1991, the Legislature of the State of Texas passed a law ("Removal of Obstructions." Section 1, Chapter 1, Title 116, Article 6673g, as amended by the State of Texas 72nd Legislature, 1991) that gives TxDOT the authority to *remove spilled cargo or personal property from the roadway without the owner's permission, if it is endangering public safety*. The Dallas District of TxDOT has accepted this authority and is developing policies for working with other jurisdictions to implement procedures for providing clearance of roadways as soon as possible after safety and investigation efforts are concluded. At the time of this writing, however, the City of Dallas' attorneys continue to maintain that the law does not protect the City from liability in the event of damage to property. Since the police command the accident scene, they may, and have, refused to allow TxDOT personnel the opportunity to clear the roadway. This issue must be resolved.

In order to take advantage of the ability to clear accidents more quickly and to reopen the freeway to traffic, it becomes imperative that TxDOT appoint a champion who will take the lead in resolving these conflicts and addressing other issues that hamper freeway clearance. This person, who in this report will be referred to as the Traffic Safety Officer (TSO), might well be a retired police officer, capable of relating to the police and fire officers and understanding the conflicting needs occurring at an accident scene. The TSO should be a person who facilitates the prompt clearance of an incident and who assures smooth, safe and efficient traffic handling during an incident. He should provide access for emergency equipment if that hasn't already been accomplished prior to his arrival at the scene. The TSO should implement freeway traffic control and assist with dispatching HazMat teams, sand trucks, front end loaders, air bags or semi-truck uprighting equipment. He should be a coordinator of resources and services and work in concert with the other response agencies at the incident scene. His role would be to assist in safely managing the traffic at the site, accessing TxDOT resources for clearance and being the point of communication for the Transportation Management Center. Two officers trained as TSOs would allow one person to be on duty and one to be on call if needed for a backup.

A suggested target might be 15 minutes from the time the TSO arrives at the scene until the traffic control is set up, for a major incident at any time of the day. Traffic control means getting traffic moving safely past the scene in as many lanes as possible.

Table 2-1. Incident Management Requirements for Major Incidents

Requirement	Proposed Recommendations
Detection: Immediate detection and notification	Allow free calls from cellular phones to Dallas Area Transportation Management Center (DATMC) 1. Develop a *999 service for freeway incidents 2. Provide improved location of incident reported a. Provide and publicize 0.1 mile markers on freeways, along with *999 b. Provide training for operators in obtaining precise location and direction of incident
	Video cameras for verification 1. Activate per *999 call 2. Determine appropriate responders and equipment needed
	Notify Police and/or Fire, if necessary
	Notify Traffic Safety Officer (TSO)
	Monitor freeway speeds upstream of incident, where detectors available
	Activate upstream cameras to monitor length of queue
	Provide notification on incident and preliminary conditions to traffic traveler services
Response: Immediate response of appropriate emergency teams	5 minute typical response time for police and fire, if location is correct
	TSO (or first arrival) secures access for emergency equipment
	Freeway traffic control instituted by TSO
	Coroner summoned by police immediately if fatalities occur
	Heavy equipment dispatched by DATMC or TSO
	Other equipment summoned by TSO including HazMat teams, sand trucks, front-end loader, and air-bag or other semi-truck uprighting equipment
Immediate response of appropriate Transportation Management Center and/or DATMC	Changeable Message Signs (CMS) for motorists upstream
	Lane Control Signals (LCS) and speed warnings upstream
	Continuous communication with other involved TMCs
	Initiate Highway Advisory Radio (HAR) messages
	Initiate in-vehicle, in-home, and in-business advisory
Clearance: Reroute traffic and handle it efficiently (DATMC)	1. Notify involved cities' transportation managers on duty 2. Electronically close lanes and ramps as necessary 3. Follow pre-determined action plan, after cities' OK 4. Monitor adaptive signals as needed 5. Monitor queue back up, adjust CMS as needed 6. Monitor site on video and via telephone with TSO or police
During clearance, reopen as many freeway lanes as safety permits	1. TSO on scene w/equipment: arrowboard, cones, flashers, cellular phone, access to off-site resources 2. TxDOT assumes responsibility for goods/loads removal 3. Movable vehicles moved to shoulder immediately 4. Set up screens around incident if possible 5. Open shoulder to traffic if feasible 6. Direct traffic slowly (50 km/hr) past scene, alternating lanes allowed to pass to eliminate queue jumping
After incident cleared, maintain safety	1. Check adequacy of debris clean up in blocked lanes 2. Move official vehicles from lanes as soon as emergency over 3. DATMC monitors scene to determine when lanes are reopened 4. DATMC notifies media, HAR, other TMCs 5. Continue monitoring queue, adjusting CMS, etc. until clear

2.4.2 Management of Minor Incidents

Table 2-2 lists recommended procedures for minor incidents. For incidents not considered major enough to bother reporting, some form of speed detectors will be helpful. However, with over 10% of the vehicles in Dallas equipped with cellular phones, any incident causing a detectable slowdown will most likely be reported if the call is free. Therefore, early funding should probably go to video surveillance rather than to detectors, because cameras provide more information on the type of incident involved.

Table 2-2. Incident Management Requirements for Minor Incidents

Requirement	Proposed Recommendations
Detection: Immediate detection and notification	Cellular free calls to *999 and Video Camera verification
	Detection by roving MAP vehicle
	Intensify MAP vehicles in recurrent congestion and construction zones
	Local area TMC notified by detecting unit
Response: Immediate response of appropriate service provider	Ten minute response time from MAP dispatch
	Thirty minute response from other equipment ordered
Immediate response of appropriate Transportation Management Center (TMC) and/or DATMC	Video check of incident
	Monitor queuing, activate advisory systems as needed
Clearance: Roadway clearance within 15 minutes after arrival	1. Secure safety with arrowboard, cones, flasher, if needed 2. Determine action needed and request help if needed 3. Implement action to clear roadway 4. TMC notes clearance, provides notification 5. Notifications via cellular phone as requested by the driver of the vehicle being assisted 6. Depart scene within twenty minutes, as a goal

Extremely minor incidents will continue to be found through MAP vehicles driving up on them. This service needs to be significantly expanded if it is to play a prominent role in minor incident clearance as well as support for major incident clearance. However, there has been an ongoing limitation on the number of Full-Time Equivalents (FTEs) who may be hired by TxDOT. This issue needs to be addressed, perhaps with the use of contractual patrol services to supplement existing service. In addition, factors such as the new wrecker policy, which allows motorists to summon the wrecker of their choice, may adversely impact clearance times if mitigation measures are not implemented. It should be the responsibility of the MAP to push disabled vehicles to the safety of the outside shoulder, from which a private service may be summoned, using the on-board cellular phone in the patrol vehicle.

However, if mobility on the freeway is the prime objective, as it would need to be to achieve the highest value to the public from the MAP, some prioritizing of level of assistance to individual motorists would be required at times. For instance, during peak hours if there are conflicting priorities for assistance, the MAP vehicles would be expected to concentrate on those activities that clear obstructions from freeway lanes, perhaps offering no more assistance than pushing vehicles to safety, as mentioned above, and summoning help for them, if they require more than changing a flat tire or adding water or fuel. In that case, each assist should take no more than fifteen minutes in order that the maximum number of assists could be performed where they would have the greatest benefits. Off peak, a more thorough level of individual attention could be given to each assist, as is the case now. Suggested target clearance times for a minor incident are 15 minutes to respond and 15 minutes to clear during a peak period, and one hour allowed outside of peak periods for detection, response and clearance.

2.5 Implementation

The Steering Committee established action items previously required to move toward improved incident management, along the lines of the ideals detailed previously in Table 2-1 and Table 2-2. These involve institutional issues of policy, cooperation, and education of responding agencies. Table 2-3 lists the steps believed to be required.

The first step is reaching policy makers who can establish swifter incident clearance as a priority, along with existing priorities at the accident scene. A local champion is needed, and it was believed that a search of benefits from programs elsewhere could establish the case in point. However, this data is largely anecdotal at this point. More research is needed on this subject, and research has been proposed to TxDOT to lay this foundation. At this time, there is justification only in rough estimates of the secondary accidents caused by queuing (20% of all freeway accidents) and in delay to motorists, including commercial vehicles by American Trucking Association, at $60 per vehicle hour.

A second step lies in educating police in the value of improved traffic handling in enhancing safety, both of the freeway traffic and of the respondents at the scene, as well as the victims of the accident. Several means have been suggested to implement this type of education, and these are listed below. Another ongoing educational opportunity is the increasing reliance on the MAP for traffic control set up. As these personal relationships are forged at accident scenes, it is hoped that further clearance measures will be allowed by the Scene Commander. And with a designated Traffic Safety Officer, dedicated to incident management, cooperation may be further enhanced.

Given TxDOT's limits on their number of FTEs, it is also suggested that TxDOT consider contracting with wreckers and other equipment service providers, extending to their contracting agencies the authority for freeway clearance.

Ongoing activities for the Steering Committee include the formation of a Subcommittee to further study police incident clearance procedures and to identify means of including the police in developing improvements. Also, the feasibility of obtaining the assistance of the Department of Public Safety (DPS) to handle accidents on the Dallas freeways will be determined.

Table 2-3. Implementation Issues

Implementation Issues	
Policy	Make incident management and clearance a priority for police at a policy level.
	Revise TxDOT maintenance agreements with cities to be consistent with TxDOT authority for clearing roadways.
	Secure authority for TxDOT to contract with wreckers and other services for property removal from roadway.
	Introduce TxDOT services in freeway clearance to local police, EMS, fire, streets and city management.
	Resolve legal issues regarding potential liability to the City of Dallas if TxDOT assumes authority to clear freeways.
Training	Offer Academy training session on incident management, with participation by local traffic engineers, TxDOT.
	Include incident management as a part of continuing education for police.
	Develop refresher training video for police roll call.
	Provide training for dispatchers in recognition of appropriate action and response.
Future Research	Further research impacts of incidents on secondary incidents.
	Review incident management procedures in top 10 urban areas.
	Estimate potential savings to local cities.

2.6 Traffic Management Actions During Incidents

The Dallas Area-Wide ITS Steering Committee developed an approach for designating actions that traffic management systems and other roadway operators would undertake in response to incidents. The approach recommends that various jurisdictions take independent but coordinated actions, depending on the status of incident scenarios. Figure 2-1 illustrates these Operations Plans to be scenario specific with regard to incident status, location, time of day and agency. In this figure, cities are categorized according to various attributes, including the number of traffic signals and the presence/absence of computerized traffic signal control and monitoring capability. The categories are labeled Tier 1, Tier 2, Tier 3 and Tier 4.

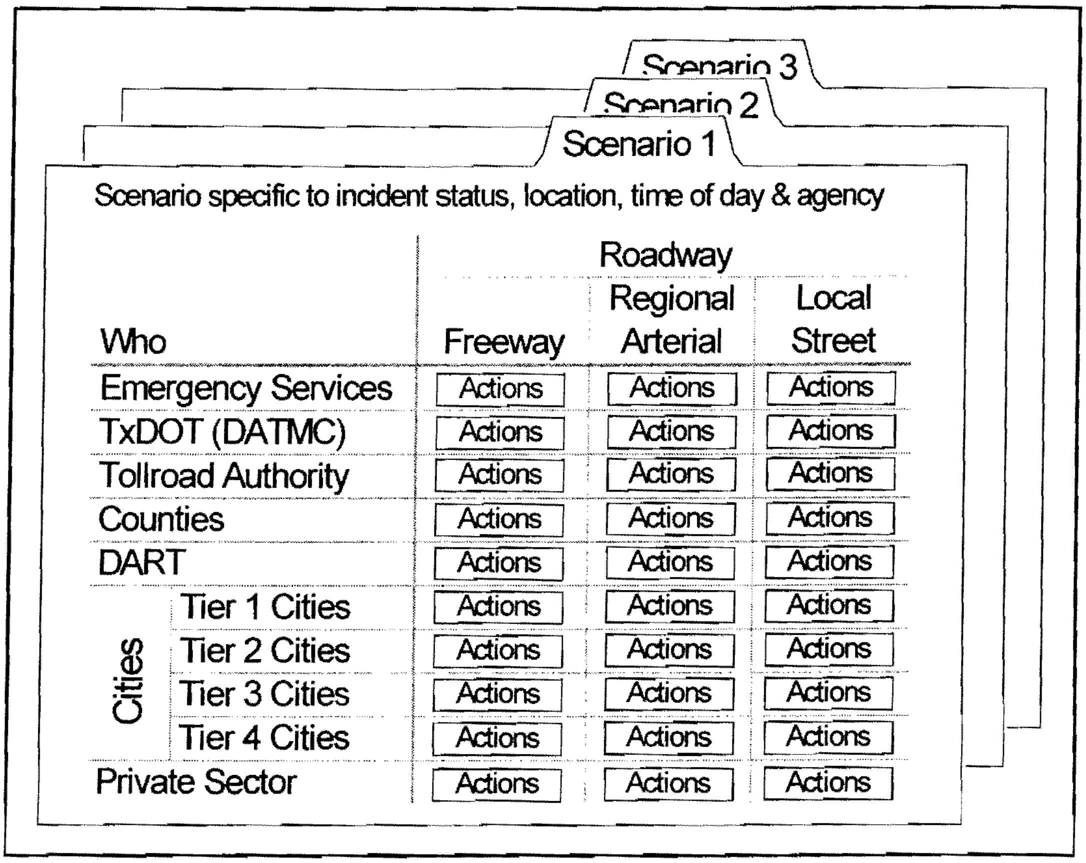


Figure 2-1. Operational Scenario Overview

Incident management action plans were developed for the various scenarios identified with regard to incident status, time of day (either primetime or non-primetime) and incident location. Seven scenarios are identified and numbered accordingly as shown in Table 2-4.

Table 2-4. Scenario Numbering

Incident Condition	Time	Incident Location		
		Freeway	Regional Arterial	Local Street
Incident	Primetime	#1	#2	#3
	Non-primetime	#4	#5	#6
Non-incident	All Times	#7		

In Table 2-4, *primetime* entails all weekday hours of the day that city operators are on duty, and *non-primetime* entails weekends and all weekday hours of the day that city operators are not on duty.

Tables 2-5 through 2-11 illustrate the general type of scenario specific incident management action plans appropriate for the seven scenarios identified in Table 2-4. The scenarios are fairly self-explanatory with actions under various situations delineated by agency. The Steering Committee, in a workshop setting, developed an approach that is responsive to signal operations during incidents but retains the autonomy for individual jurisdictions with coordinated signal systems to retain final determination of timing plans to be implemented. For liability and other reasons, the participants felt that the ultimate responsibility should remain with the individual city control systems. The following comments on each scenario address the traffic signal system operation during incident conditions (the use of *primetime* and *non-primetime* in the scenario descriptions, as well as in Table 2-5 through Table 2-11, again refers to when city TMC operators are and are not on duty, respectively):

- <u>Scenario 1: Incident Occurring on Freeway During Primetime</u>

  Upon verification of a freeway incident, the Dallas Area-Wide Transportation Management Center (DATMC) would recommend predetermined incident responsive signal timing plans to those cities that have the capability to implement plans remotely (Tier 1 cities). These cities would implement and operate the timing plans, predetermined and mutually developed, recommended by the DATMC in response to incident conditions. For cities without such capability, the DATMC would remotely command locally stored incident responsive signal timing plans at local intersections, primarily at frontage roads and crossing arterials.

- <u>Scenario 2: Incident Occurring on Regional Arterial During Primetime</u>

  The DATMC will serve as a communications transfer point to notify affected agencies when an incident has occurred. Cities with central control capability (Tier 1 cities) would operate their signals under their adopted city operational policies. If warranted, the DATMC would remotely command locally stored incident responsive signal timing plans at local intersections, primarily at frontage roads and crossing arterials.

- <u>Scenario 3: Incident Occurring on Local Street During Primetime</u>

  Signals would be operated under city operational policies.

- <u>Scenario 4: Incident Occurring on Freeway During Non-Primetime</u>

  Upon verification of an incident, the operator at the DATMC would determine if notifying the operators on call for affected cities is warranted. The operator on call could either implement incident condition timing plans from a remote terminal or at the city control center. Alternatively, as participants become more comfortable with multiple jurisdiction operation, DATMC operators could activate the required plan from the DATMC for the Tier 1 cities during non-primetime hours. As in Scenario 1, these plans would be predetermined and mutually developed, and the city signal system would implement them from their library of timing plans.

- Scenario 5: Incident Occurring on Regional Arterial During Non-Primetime

  The DATMC will serve as a communications transfer point to notify affected agencies. In accordance with city policies, an operator may enact timing adjustments from a remote terminal at his/her home or be dispatched to the city management center.

- Scenario 6: Incident Occurring on Local Street During Non-Primetime

  Signals would be operated under city operational policies.

- Scenario 7: No Incidents

  Standard operation by all agencies.

Table 2-5. Incident Management Action Plan #1

		Who	Incident Location: Freeway – Freeway	Incident Location: Freeway – Frontage Road	Incident Location: Regional – Alternate Routes	Incident Location: Regional – Other Arterials	Incident Location: Local Streets	Communications
Emergency Services		Police, Fire, Streets, EMS, Wreckers, HazMat	Incident Management Services	Incident Management Services	Incident Management Services	Incident Management Services	NA	Notify DATMC
Transportation Services	Other Agencies	TxDOT (DATMC)	MAP vehicles, CMS, ATIS, Ramp control, HAR, Incident Management Services	Rec Pat - Tier 1 Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Rec Pat - Tier 1 Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Rec Pat - Tier 1 Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	NA	Notify other agencies & private sector
	Other Agencies	Tollroad Authority	CMS, ATIS, Ramp control, HAR, Incident Management Services	NA	NA	NA	NA	Notify DATMC if incident located on Tollroad
	Other Agencies	Counties	NA	NA	NA	NA	NA	NA
	Other Agencies	DART (Dallas Area Rapid Transit)	Reroute	Reroute	Reroute	Reroute	Reroute	Notify passengers
	Tier 1 Cities	*Cities with central computer capability:* Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano, Farmers Branch	NA	Oper Pat	Oper Pat	Oper Pat	Norm Op	NA
	Tier 2 Cities	*Cities with >15 signals & w/o central capability:* Mesquite, Addison*, Duncanville, Park Cities, Lewisville, Desoto	NA	NA	NA	NA	Norm Op	NA
	Tier 3 Cities	*Cities with <15 signals & w/o central capability:* Balch Springs, Lancaster, Wylie*, Rockwall, Sunnyvale, Allen, Cedar Hill, Red Oak, Coppell, Sachse*, Cockrell Hill*	NA	NA	NA	NA	Norm Op	NA
	Tier 4 Cities	*Cities w/o signals:* Glen Heights, Seagoville, Wilmer, Hutchins, Rowlett*, Ferris, Buckingham*	NA	NA	NA	NA	NA	NA
		Private Sector	NA	NA	NA	NA	NA	Notify public & DATMC

Note: All data applies after incident detected
* = No freeway within corporate limits
NA = Not applicable
Rec Pat = Recommend incident pattern
Oper Pat = Operate incident pattern
Norm Op = Normal operations
DATMC = Dallas Area Transportation Management Center
MAP = Mobility Assistance Patrol

Scenario 1: Incident Occurring on Freeway During Primetime

Table 2-6. Incident Management Action Plan #2

Who			Incident Location: Freeway – Freeway	Incident Location: Freeway – Frontage Road	Incident Location: Regional – Alternate Routes	Incident Location: Regional – Other Arterials	Incident Location: Local Streets	Communications
Emergency Services		Police, Fire, Streets, EMS, Wreckers, HazMat	Norm Op	Norm Op	Incident Management Services	Incident Management Services	NA	Notify DATMC
Transportation Services	Other Agencies	TxDOT (DATMC)	CMS, ATIS, Ramp control, HAR	Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	NA	Notify other agencies & private sector
	Other Agencies	Tollroad Authority	CMS, ATIS, Ramp control, HAR	NA	NA	NA	NA	NA
	Other Agencies	Counties	NA	NA	NA	NA	NA	NA
	Other Agencies	DART (Dallas Area Rapid Transit)	Reroute	Reroute	Reroute	Reroute	Reroute	Notify passengers
	Tier 1 Cities	*Cities with central computer capability:* Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano, Farmers Branch	NA	Oper Pat	Oper Pat	Oper Pat	Norm Op	Notify DATMC if incident located in their city
	Tier 2 Cities	*Cities with >15 signals & w/o central capability:* Mesquite, Addison*, Duncanville, Park Cities, Lewisville, Desoto	NA	NA	NA	NA	Norm Op	Notify DATMC if incident located in their city
	Tier 3 Cities	*Cities with <15 signals & w/o central capability:* Balch Springs, Lancaster, Wylie*, Rockwall, Sunnyvale, Allen, Cedar Hill, Red Oak, Coppell, Sachse*, Rowlett*, Cockrell Hill*	NA	NA	NA	NA	Norm Op	Notify DATMC if incident located in their city
	Tier 4 Cities	*Cities w/o signals:* Glen Heights, Seagoville, Wilmer, Hutchins, Rowlett*, Ferris, Buckingham*	NA	NA	NA	NA	NA	NA
		Private Sector	NA	NA	NA	NA	NA	Notify public & DATMC

Note: All data applies after incident detected
* = No freeway within corporate limits
NA = Not applicable

Rec Pat = Recommend incident pattern
Oper Pat = Operate incident pattern
Norm Op = Normal operations

DATMC = Dallas Area Transportation Management Center
MAP = Mobility Assistance Patrol

Scenario 2: Incident Occurring on Regional Arterial During Primetime

Table 2-7. Incident Management Action Plan #3

		Who	Incident Location: Freeway – Freeway	Incident Location: Freeway – Frontage Road	Incident Location: Regional – Alternate Routes	Incident Location: Regional – Other Arterials	Incident Location: Local Streets	Communications
Emergency Services		Police, Fire, Streets, EMS, Wreckers, HazMat	Norm Op	Norm Op	Norm Op	Norm Op	Incident Management Services	Notify DATMC
Transportation Services	Other Agencies	TxDOT (DATMC)	Norm Op	Norm Op	Norm Op	Norm Op	NA	Notify private sector & DART
Transportation Services	Other Agencies	Tollroad Authority	Norm Op	NA	NA	NA	NA	NA
Transportation Services	Other Agencies	Counties	NA	NA	NA	NA	NA	NA
Transportation Services	Other Agencies	DART (Dallas Area Rapid Transit)	Norm Op	Norm Op	Reroute	Reroute	Reroute	Notify passengers
Transportation Services	Tier 1 Cities	*Cities with central computer capability:* Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano, Farmers Branch	NA	Oper Pat	Oper Pat	Oper Pat	Oper Pat	Notify DATMC if incident located in their city
Transportation Services	Tier 2 Cities	*Cities with >15 signals & w/o central capability:* Mesquite, Addison*, Duncanville, Park Cities, Lewisville, Desoto	NA	NA	NA	NA	Norm Op	Notify DATMC if incident located in their city
Transportation Services	Tier 3 Cities	*Cities with <15 signals & w/o central capability:* Balch Springs, Lancaster, Wylie*, Rockwall, Sunnyvale, Allen, Cedar Hill, Red Oak, Coppell, Sachse*, Rowlett*, Cockrell Hill*	NA	NA	NA	NA	Norm Op	Notify DATMC if incident located in their city
Transportation Services	Tier 4 Cities	*Cities w/o signals:* Glen Heights, Seagoville, Wilmer, Hutchins, Rowlett*, Ferris, Buckingham*	NA	NA	NA	NA	NA	NA
		Private Sector	NA	NA	NA	NA	NA	Notify public

Note: All data applies after incident detected
* = No freeway within corporate limits
NA = Not applicable
Rec Pat = Recommend incident pattern
Oper Pat = Operate incident pattern
Norm Op = Normal operations
DATMC = Dallas Area Transportation Management Center
MAP = Mobility Assistance Patrol

Scenario 3: Incident Occurring on Local Street During Primetime

Table 2-8. Incident Management Action Plan #4

Who			Incident Location: Freeway – Freeway	Incident Location: Freeway – Frontage Road	Incident Location: Regional – Alternate Routes	Incident Location: Regional – Other Arterials	Incident Location: Local Streets	Communications
Emergency Services		Police, Fire, Streets, EMS, Wreckers, HazMat	Incident Management Services	Incident Management Services	Incident Management Services	Incident Management Services	NA	Notify DATMC
Transportation Services	Other Agencies	TxDOT (DATMC)	MAP vehicles, CMS, ATIS, Ramp control, HAR, Incident Management Services	Act Pat - Tier 1 Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Act Pat - Tier 1 Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Act Pat - Tier 1 Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	NA	Notify other agencies & private sector
Transportation Services	Other Agencies	Tollroad Authority	CMS, ATIS, Ramp control, HAR, Incident Management Services	NA	NA	NA	NA	Notify DATMC if incident located on Tollroad
Transportation Services	Other Agencies	Counties	NA	NA	NA	NA	NA	NA
Transportation Services	Other Agencies	DART (Dallas Area Rapid Transit)	Reroute	Reroute	Reroute	Reroute	Reroute	Notify passengers
Transportation Services	Tier 1 Cities	*Cities with central computer capability:* Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano, Farmers Branch	NA	Oper Pat (automated system)	Oper Pat (automated system)	Oper Pat (automated system)	Norm Op	NA
Transportation Services	Tier 2 Cities	*Cities with >15 signals & w/o central capability:* Mesquite, Addison*, Duncanville, Park Cities, Lewisville, Desoto	NA	NA	NA	NA	Norm Op	NA
Transportation Services	Tier 3 Cities	*Cities with <15 signals & w/o central capability:* Balch Springs, Lancaster, Wylie*, Rockwall, Sunnyvale, Allen, Cedar Hill, Red Oak, Coppell, Sachse*, Rowlett*, Cockrell Hill*	NA	NA	NA	NA	Norm Op	NA
Transportation Services	Tier 4 Cities	*Cities w/o signals:* Glen Heights, Seagoville, Wilmer, Hutchins, Rowlett*, Ferris, Buckingham*	NA	NA	NA	NA	NA	NA
		Private Sector	NA	NA	NA	NA	NA	Notify public & DATMC

Note:
All data applies after incident detected
* = No freeway within corporate limits
NA = Not applicable
Rec Pat = Recommend incident pattern
Oper Pat = Operate incident pattern
Norm Op = Normal operations
Act Pat = Activate incident pattern
DATMC = Dallas Area Transportation Management Center
MAP = Mobility Assistance Patrol

Scenario 4: Incident Occurring on Freeway During Non-Primetime

Table 2-9. Incident Management Action Plan #5

Who			Incident Location: Freeway		Incident Location: Regional		Incident Location: Local Streets	Communications
			Freeway	Frontage Road	Alternate Routes	Other Arterials		
Emergency Services		Police, Fire, Streets, EMS, Wreckers, HazMat	Norm Op	Norm Op	Incident Management Services	Incident Management Services	NA	Notify DATMC
Transportation Services	Other Agencies	TxDOT (DATMC)	CMS, ATIS, Ramp control, HAR	Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	Oper Pat - Tier 2 Oper Pat - Tier 3 NA - Tier 4	NA	Notify other agencies & private sector
Transportation Services	Other Agencies	Tollroad Authority	CMS, ATIS, Ramp control, HAR	NA	NA	NA	NA	NA
Transportation Services	Other Agencies	Counties	NA	NA	NA	NA	NA	NA
Transportation Services	Other Agencies	DART (Dallas Area Rapid Transit)	Norm Op	Norm Op	Reroute	Reroute	Reroute	Notify passengers
Transportation Services	Tier 1 Cities	*Cities with central computer capability:* Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano, Farmers Branch	NA	Oper Pat (staff on-call)	Oper Pat (staff on-call)	Oper Pat (staff on-call)	Norm Op	NA
Transportation Services	Tier 2 Cities	*Cities with >15 signals & w/o central capability:* Mesquite, Addison*, Duncanville, Park Cities, Lewisville, Desoto	NA	NA	NA	NA	Norm Op	NA
Transportation Services	Tier 3 Cities	*Cities with <15 signals & w/o central capability:* Balch Springs, Lancaster, Wylie*, Rockwall, Sunnyvale, Allen, Cedar Hill, Red Oak, Coppell, Sachse*, Rowlett*, Cockrell Hill*	NA	NA	NA	NA	Norm Op	NA
Transportation Services	Tier 4 Cities	*Cities w/o signals:* Glen Heights, Seagoville, Wilmer, Hutchins, Rowlett*, Ferris, Buckingham*	NA	NA	NA	NA	NA	NA
		Private Sector	NA	NA	NA	NA	NA	Notify public & DATMC

Note: All data applies after incident detected
* = No freeway within corporate limits
NA = Not applicable
Rec Pat = Recommend incident pattern
Oper Pat = Operate incident pattern
Norm Op = Normal operations
DATMC = Dallas Area Transportation Management Center
MAP = Mobility Assistance Patrol

Scenario 5: Incident Occurring on Regional Arterial During Non-Primetime

Table 2-10. Incident Management Action Plan #6

Group	Subgroup	Who	Incident Location: Freeway – Freeway	Incident Location: Freeway – Frontage Road	Incident Location: Regional – Alternate Routes	Incident Location: Regional – Other Arterials	Incident Location: Local Streets	Communications
Emergency Services		Police, Fire, Streets, EMS, Wreckers, HazMat	Norm Op	Norm Op	Norm Op	Norm Op	Incident Management Services	Notify DATMC
Transportation Services	Other Agencies	TxDOT (DATMC)	Norm Op	Norm Op	Norm Op	Norm Op	NA	Notify private sector & DART
Transportation Services	Other Agencies	Tollroad Authority	Norm Op	NA	NA	NA	NA	NA
Transportation Services	Other Agencies	Counties	NA	NA	NA	NA	NA	NA
Transportation Services	Other Agencies	DART (Dallas Area Rapid Transit)	Norm Op	Norm Op	Norm Op	Norm Op	Reroute	Notify passengers
Transportation Services	Tier 1 Cities	*Cities with central computer capability:* Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano, Farmers Branch	Norm Op	Norm Op	Norm Op	Norm Op	Norm Op	NA
Transportation Services	Tier 2 Cities	*Cities with >15 signals & w/o central capability:* Mesquite, Addison*, Duncanville, Park Cities, Lewisville, Desoto	NA	NA	NA	NA	Norm Op	NA
Transportation Services	Tier 3 Cities	*Cities with <15 signals & w/o central capability:* Balch Springs, Lancaster, Wylie*, Rockwall, Sunnyvale, Allen, Cedar Hill, Red Oak, Coppell, Sachse*, Rowlett*, Cockrell Hill*	NA	NA	NA	NA	Norm Op	NA
Transportation Services	Tier 4 Cities	*Cities w/o signals:* Glen Heights, Seagoville, Wilmer, Hutchins, Rowlett*, Ferris, Buckingham*	NA	NA	NA	NA	NA	NA
		Private Sector	NA	NA	NA	NA	NA	Notify public & DATMC

Note: All data applies after incident detected
* = No freeway within corporate limits
NA = Not applicable

Rec Pat = Recommend incident pattern
Oper Pat = Operate incident pattern
Norm Op = Normal operations

DATMC = Dallas Area Transportation Management Center
MAP = Mobility Assistance Patrol

Scenario 6: Incident Occurring on Local Street During Non-Primetime

Table 2-11. Incident Management Action Plan #7

		Who	Incident Location					Communications
			Freeway		Regional		Local Streets	
			Freeway	Frontage Road	Alternate Routes	Other Arterials		
Emergency Services		Police, Fire, Streets, EMS, Wreckers, HazMat	Norm Op	Norm Op	Norm Op	Norm Op	Norm Op	NA
Transportation Services	Other Agencies	TxDOT (DATMC)	Norm Op	Norm Op	Norm Op	Norm Op	NA	NA
		Tollroad Authority	Norm Op	NA	NA	NA	NA	NA
		Counties	NA	NA	NA	NA	NA	NA
		DART (Dallas Area Rapid Transit)	Norm Op	Norm Op	Norm Op	Norm Op	Norm Op	NA
	Tier 1 Cities	*Cities with central computer capability:* Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano, Farmers Branch	NA	Norm Op	Norm Op	Norm Op	Norm Op	NA
	Tier 2 Cities	*Cities with >15 signals & w/o central capability:* Mesquite, Addison*, Duncanville, Park Cities, Lewisville, Desoto	NA	NA	NA	NA	Norm Op	NA
	Tier 3 Cities	*Cities with <15 signals & w/o central capability:* Balch Springs, Lancaster, Wylie*, Rockwall, Sunnyvale, Allen, Cedar Hill, Red Oak, Coppell, Sachse*, Rowlett*, Cockrell Hill*	NA	NA	NA	NA	Norm Op	NA
	Tier 4 Cities	*Cities w/o signals:* Glen Heights, Seagoville, Wilmer, Hutchins, Rowlett*, Ferris, Buckingham*	NA	NA	NA	NA	NA	NA
		Private Sector	NA	NA	NA	NA	NA	NA

Note: All data applies after incident detected
* = No freeway within corporate limits
NA = Not applicable

Rec Pat = Recommend incident pattern
Oper Pat = Operate incident pattern
Norm Op = Normal operations

DATMC = Dallas Area Transportation Management Center
MAP = Mobility Assistance Patrol

Scenario 7: Normal Operations with No Incidents, All Time Periods

2.7 References

1 T. Lomax, D. Schrank and S. Turner. *Urban Roadway Congestion - 1982 to 1992, Volumes 1 and 2.* Report No. FHWA/TX-94-1131-7. U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. and Texas Department of Transportation. July 1995.

2 *Incident Management Workshop; Relieving Traffic Congestion Through Incident Management.* U.S. Department of Transportation, Federal Highway Administration; Dallas, TX. February 1994.

3 *TRAC Research Review, "Projects Aim to Improve Incident Management Effectiveness, Increase Safety."* July 1995.

4 *Dallas Areawide Freeway Motorist Assistance Study.* Prepared for TxDOT and DRMC by TTI. July 1991.

5 Reiss, Robert and Walter Dunn. *Freeway Incident Management Handbook.* Appendix C, "Illinois Department of Transportation Emergency Traffic Patrol," July 1991.

6 Berg, David, Bill Legg and Lloyd Showalter. "Seattle Area Incident Management Program," Institute of Transportation Engineers; A Special Issue Focusing on Incident Management. March 1992.

7 Judycki, Dennis and James Robinson. "Managing Traffic During Nonrecurring Congestion," Institute of Transportation Engineers; A Special Issue Focusing on Incident Management. March 1992.

3. DALLAS AREA-WIDE ITS DEPLOYMENT GUIDELINES

3. DALLAS AREA-WIDE ITS DEPLOYMENT GUIDELINES

Chapter 3 identifies ITS deployment guidelines. These guidelines are recommendations for deploying ITS that are consistent with the regional ITS consensus, are feasible within the set of technological dependencies associated with ITS services and products, and are bounded by institutional considerations of funding, staffing, liability, and others. Chapter 3 also presents a consensus model for ATMS deployment that addresses the existing interjurisdictional considerations for the Dallas area.

3.1 Compliance with State and National ITS Deployment Policies

The Dallas Area-Wide Plan should be consistent with existing transportation policies in the State of Texas and with the existing national ITS policy framework. For the State of Texas, the TxDOT 1995 Transportation Plan serves as a guiding policy reference. At the national level, the 1995 National Program Plan for ITS serves as a guiding policy reference. Although these documents have different focuses, they have objectives that are related to each other and to the Dallas Area-Wide ITS Plan. The following two sections describe these associations.

3.1.1 TxDOT Transportation Policies

Table 3-1 lists objectives included in TxDOT's 1995 Transportation Plan that have some relevance to ITS.

Table 3-1. TxDOT Transportation Plan Categories

TxDOT Transportation Plan Categories Pertinent to ITS
1. Focus policies, strategies and actions on the Texas Multimodal Transportation System
2. Maximize personal mobility using a full range of transportation solutions
3. Maximize the efficiency and effectiveness of freight transportation
4. Utilize technology to increase transportation mobility
5. Maintain and enhance essential transportation infrastructure and services in rural Texas
8. Balance expansion and preservation of transportation modes and corridors
9. Encourage cost-effective private sector participation in transportation solutions
10. Maintain up-to-date information for transp. planning, programming and decision-making
12. Maximize connections between all transportation modes
13. Coordinate statewide transportation and economic development policies
14. Ensure adequate transportation capacity to meet international trade-related demands
15. Develop environmentally sound transportation infrastructure, facilities and programs
16. Minimize risk from transportation of hazardous materials
17. Ensure transportation system capacity during emergencies and disasters
18. Maximize the safety of all transportation modes
19. Expedite the project development process
22. Optimize the use of existing funding sources
26. Provide a transportation revenue structure that ensures cost responsibility
28. Monitor and address emerging issues

Within these objectives, the following strategies are pertinent to ITS.

Table 3-2. TxDOT Plan Strategies Pertinent to ITS

TxDOT Transportation Plan Strategies Pertinent to ITS	
1.1	Adopt and further describe the Texas multimodal transportation system
2.2	Implement transp. demand management strategies and promote ridesharing and carpooling
3.2	Identify bottlenecks in the freight transp. system and implement prioritized improvements
4.1	Develop and encourage widespread and cost-effective applications of Intelligent Transportation Systems technology
5.1	Adopt intermodal transportation infrastructure and facilities serving rural Texas as priority elements of the statewide multimodal transportation system
8.1	Implement market-based incentives and pricing mechanisms to promote more efficient travel behavior and mode choice decisions
9.1	Promote public-private transportation partnerships
9.2	Preserve transportation infrastructure through increased inspections and enforcement
10.1	Implement fully the management systems
12.1	Implement investments needed to maximize linkages between transportation modes
12.2	Improve intermodal access and facilities at ports, airports, and rail facilities
12.3	Increase public access to current, accurate information regarding intermodal transportation
13.1	Develop a statewide economic development plan linked to state transportation policies
14.1	Designate international trade corridors of statewide significance
14.2	Re-engineer border-clearance procedures and relocate border-related processing activities
14.3	Increase cooperation and coordination between state, federal, local, and Mexican jurisdictions
14.4	Establish and maintain international trade databases
15.1	Support the Texas Plan for Alternative Fuels and adopt State Implementation Plan transportation control measures in air quality
16.1	Designate routes for hazardous materials transportation, including (those) destined for cross-border trade
17.1	Designate emergency evacuation routes for priority maintenance and funding
18.2	Enhance enforcement of transportation safety regulations and laws
18.3	Improve transportation safety public education programs
19.2	Broaden advance planning to ensure multimodal collaboration in project planning, design, ROW designation and acquisition
22.1	Focus on projects with the greatest return on investment
26.1	Internalize the true costs of the transportation decisions of all users to the extent possible
28.1	Address emerging issues and funding opportunities

3.1.2 Dallas Area-Wide Deployment Guidelines and Their Relationship to State and National Policies

Table 3-3 identifies relationships between the Dallas Area-Wide Plan and both the TxDOT Transportation Plan and National ITS Program Plan. It also includes a reference to the Dallas Area-Wide Plan document for further information regarding the recommended deployment policies or technologies. Section 4.3 describes the prioritization of ITS user services and identifies those services not included in the Dallas Area Wide Plan (like intersection collision avoidance).

Table 3-3. Dallas Area-Wide Guideline: Responsiveness to National and State Policies

Key Deployment Guideline Recommendation	*Dallas Area-Wide Plan Reference*	*TxDOT Transportation Plan*	*National Program Plan*

Incident Management
• Designate a Traffic Safety Officer for Incident Management
  • TxDOT should designate a Traffic Safety Officer to coordinate resources and services related to incidents.
• Traffic Management Infrastructure Providers
  • During incidents, transportation infrastructure providers should take independent but coordinated actions depending on the status of incident scenarios.
• Mobility Assistance Program
  • TxDOT should continue to operate the Mobility Assistance Program and expand its coverage.
• Cellular Telephone Incident Reporting "Hot-Line"
  • TxDOT should implement an easy to remember "hot-line" number, such as *999, for motorists to report freeway incidents via free cellular telephone calls.
• Incident Management Training for Police and Fire Personnel
  • TxDOT and NCTCOG should develop and provide an Incident Management Training Course for Dallas area Police and Fire personnel.
	Chapter 2	Ensure transportation system capacity during emergencies and disasters.	Improve service level by improving incident management.
			Improve service level by improving the ability to respond to HAZMAT incidents.

Traditional Operational Roles
• Infrastructure providers will retain operational responsibility for facilities that are traditionally within their purview
  • Traffic signal operations remain the responsibility of cities.
  • Freeway facility operations (e.g., ramp meters, changeable message signs) remain the responsibility of TxDOT.
  • Tollroad operations remain the responsibility of the Texas Turnpike Authority.
  • Transit operations, including operation of HOV lanes, remain the responsibility of DART.
	Chapter 4	NA	NA

Table 3-3. Dallas Area-Wide Guideline: Responsiveness to National and State Policies - continued

Key Deployment Guideline Recommendation .... *Dallas Area-Wide Plan Reference*	*TxDOT Transportation Plan*	*National Program Plan*

Traffic Control .... Chapter 4
• The Dallas Area-Wide Traffic Control System should be deployed using a distributed computer processing model.
    • TxDOT should operate a Dallas Area Traffic Management Center (DATMC) that will serve as the operational center for the area's freeway system. It should also serve as the focal point for private sector information exchange and for coordination of response actions during incidents.
    • Both data and delivery of transportation services will be located in geographically distinct operational sites.
    • Deployment should be evolutionary in nature and contain the following communications elements throughout the implementation time frame (e.g., Internet, wide-area networking, fiber backbone along freeways).
    • Emergency Services like Police and Fire will interface with the TxDOT DATMC.
	Utilize technology to increase transportation mobility.	Enhance productivity by reducing delay associated with congestion.
		Improve mobility by improving traffic information.

Table 3-3. Dallas Area-Wide Guideline: Responsiveness to National and State Policies - continued

Pre-Trip Travel & En-Route Driver Information .... Chapter 4
• Information flow to the public regarding traffic flow is a joint responsibility of the public sector and the private sector.
• TxDOT is the primary contact for infrastructure based transportation information for private sector ATIS providers.
• Cities, the Texas Turnpike Authority and DART will provide TxDOT access to their transportation infrastructure information for subsequent delivery to the private sector.
• Changeable Message Signs
  • Transportation infrastructure providers should limit deployment of public sector changeable message signs and other ATIS services that compete with the private sector.
  • TxDOT-owned CMS should be placed primarily at strategic locations (e.g., freeway to freeway) and not placed at regular, repeated intervals along the freeway.
  • Arterial and intersection CMS should be a component of the Dallas Area-Wide ITS Plan. However, it will be an intermediate-term element for traffic generators.
• Highway Advisory Radio
  • Highway advisory radio should be implemented for all freeway segments.
	Encourage cost-effective private sector participation in transportation solutions.
	Maximize connections between transportation modes.
	Optimize the use of existing funding sources.
	Utilize technology to increase transportation mobility.
		Improve service level by improving transit information.
		Improve service level by improving incident information to drivers.
		Improve mobility by improving traffic information.

Electronic Toll and Traffic Management (ETTM) .... Chapter 4 • The region should advocate a single standard for ETTM transponders that can be used on various roadways (e.g., DNT, SH 190, D/FW Airport) and for various purposes (roadway user fees, parking payment and congestion pricing). • Anonymous ETTM data should be shared in real-time with TxDOT for the purpose of freeway management.	Utilize technology to increase transportation mobility.	Improve service level by improving convenience of transportation payment.

Table 3-3. Dallas Area-Wide Guideline: Responsiveness to National and State Policies - continued

Key Deployment Guideline Recommendation ... *Dallas Area-Wide Plan Reference*	*TxDOT Transportation Plan*	*National Program Plan*

Network Surveillance ... Chapter 4
• Roadway Detection
  • Use of loop detectors should be a near-term deployment strategy for measurement of traffic flow and for incident management.
  • Video based detection systems, microwave / radar detectors, probe vehicle flow data collection, and other non-intrusive technologies should be the primary methods of freeway traffic flow measurement. These technologies will be implemented as products mature and as adaptive traffic control technologies are implemented.
• Closed Circuit Television (CCTV)
  • Freeway CCTV should be implemented for all freeway segments.
  • Arterial and intersection based CCTV will be a component of the Dallas Area-Wide ITS Plan.
  • CCTV images should be shared in real-time with other operating agencies and the news media.
	Utilize technology to increase transportation mobility.	Improve mobility by improving traffic information.
		Improve mobility by increasing the monitoring of transportation facilities.

Freeway Ramp Metering ... Chapter 4 • Freeway ramp metering should be implemented for all freeway segments where recurring congestion can not be mitigated through capacity improvements, HOV implementation, mode shifts, or other means.	Utilize technology to increase transportation mobility.	Enhance productivity by reducing delay associated with congestion.
DART ... Chapter 4 • High Occupancy Vehicle lanes should be programmed and implemented for all freeway segments where they can be effective. • Traffic flow information gathered through the transit vehicle locator system should be shared in real-time with TxDOT for the purpose of freeway management. • Where possible, intelligent, priority treatment for transit vehicles should be implemented, at intersections with available capacity, on freeway ramps with significant congestion, and at metered freeway ramps.	Maximize mobility using a full range of transportation solutions.	Enhance productivity by reducing delay associated with congestion.

Table 3-3. Dallas Area-Wide Guideline: Responsiveness to National and State Policies - continued

Key Deployment Guideline Recommendation .... *Dallas Area-Wide Plan Reference*	*TxDOT Transportation Plan*	*National Program Plan*

Standards .... Chapter 5
• National Architecture Standards
  • The region will work closely with national ITS architecture efforts to ensure that deployment of vehicle-roadside communications is consistent with the national goals of a seamless ITS system.
• NTCIP
  • Infrastructure "application data" (like traffic signal information) should be formatted to correspond to the NEMA NTCIP standard.
• GIS
  • GIS information should be based on a regional standard (like ARCInfo and GDS products).
	Utilize technology to increase transportation mobility.	Improve mobility by improving transportation affordability.

3.2 Guidelines for the Dallas Area-Wide ATMS Design

A number of non-technical institutional issues had an impact on the Dallas Area-Wide Plan guidelines. Primary among those are the following interjurisdictional issues that influence each operating agency:

- fund ITS on a regional basis;
- identify a common definition of transportation related services on a regional basis;
- participate in transit activities (not all regional cities participate in the funding of the regional transit authority);
- relinquish "control" of traffic signal system operations; and
- interact with adjacent cities at boundary locations for mutually beneficial roadway operations.

The Dallas region has been actively involved in arranging for compatible traffic signal operations at boundary locations for many years. This has occurred through the Transportation Management Team, the Mobility Technical Council and programs such as a Dallas County funded traffic signal upgrade and timing project. However, existing investments in ATMS infrastructure, user expectations, anticipated funding opportunities and agency policies meant that a regional, single site, single agency solution would not be a candidate ATMS alternative for the Dallas Area. Therefore, a multiple site ATMS was quickly established as a design objective.

With a multiple site solution, there is still a question of how and where data is stored. It could be stored at a centralized site, it could be decentralized and stored at individual agency sites (with little sharing of data), or it could be distributed throughout the region with significant sharing of data. The following sections describe these alternatives in more detail. The recommended model is the distributed alternative where data is a shared resource and application processing may require data from other sites. Please note that this discussion does not focus on the type of traffic signal control, e.g. once per second, time based.

3.2.1 Centralized Model

A centralized ATMS design involves storing data needed throughout the region in a central database management system (DBMS). In this design, various transportation management centers would access data through PCs and other devices using a communications network. The data gathered from the central DBMS would be used locally at city facilities for control, monitoring and ITS user service tasks. Reciprocally, as data is gathered from the field, it would be stored in the central DBMS.

Using this centralized architecture, each jurisdiction would be able to accomplish its responsibilities. For instance, a Tier 1 ATMS would keep traffic signal timing and phasing data at the TxDOT Dallas Area Transportation Management Center and download that data to the regional Tier 1 traffic signal control computer for implementation. This regional computer would use the data to control and monitor traffic signals through the use of field masters or exercise these functions directly without field masters (depending on the regional implementation). Figure 3-1 illustrates a conceptual, centralized ATMS architecture. It does not show all the complexity or interactions in the implementation of a centralized architecture. However, it does illustrate the data flows typical of this scheme.

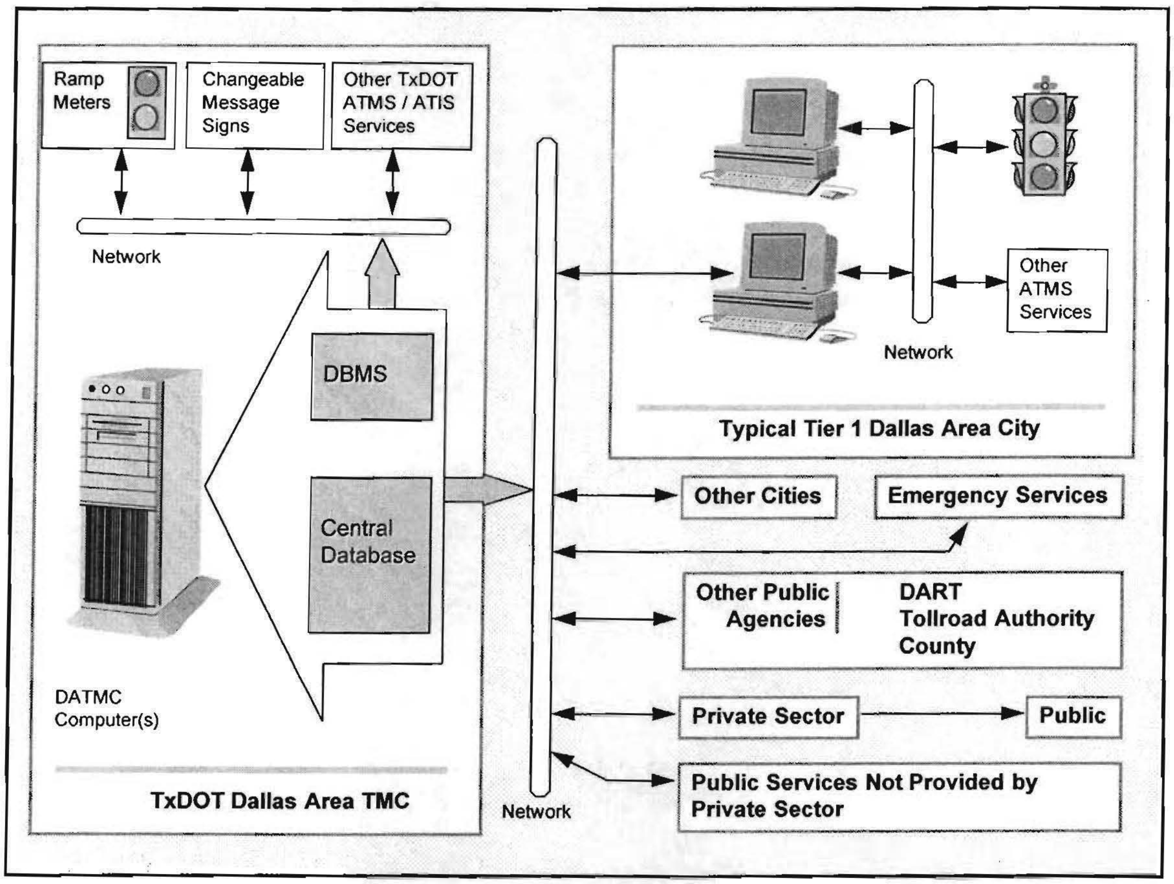


Figure 3-1. Centralized Dallas Area-Wide ATMS Model

There are shortcomings associated with a centralized ATMS architecture given the geographically dispersed configuration of field equipment, the multi-jurisdictional nature of the region and the functionality of the Dallas Area-Wide ITS ATMS Operations Plan. These shortcomings include the following:

- Dependence on communications integrity and central system performance

  Failure of either the communications system or the central computer system has a significant impact on total system performance, since essential data is stored at one location. To compensate for this risk, the system would probably be built with redundant communications paths and fail-safe computer equipment.

- Requirement for significant communications capacity

  Both data required for field implementation (e.g., traffic signal timings) and surveillance and control data gathered from the field (e.g., traffic MOEs) would be transmitted to and from the central database at the TxDOT DATMC. This communications load requires a significant communications infrastructure investment to produce an appropriate capacity.

- Adaptive control strategy

  Adaptive traffic signal control strategies are being formulated under the guidance of FHWA with the premise that traffic signals can exchange data with each other in real-time and jointly formulate optimized signal timings. Because of communications delays and computer processing requirements, the prevailing strategy to implement adaptive control has focused on processing the data in the field after exchanging data between intersections. The centralized model doesn't support this kind of processing.

- Incompatibility with existing Dallas Area-Wide ITS Plan ATMS deployment

  Existing ATMS deployment in Tier 1 cities (Dallas, Irving, Richardson, Garland, Carrollton, Grand Prairie, Plano and Farmers Branch) is based on each agency maintaining its own databases. Using the TxDOT DATMC as an exclusive repository of database information is not compatible with their existing deployment.

3.2.2 Decentralized Model

A decentralized model has both data and delivery of services located in geographically distinct sites. An important concept of this model is that data is not a shared resource in all cases. Each site maintains its data locally and regularly updates a central database. The sites can share data, but typically do not because they lack the resources in equipment and/or software. Figure 3-2 illustrates the decentralized model.

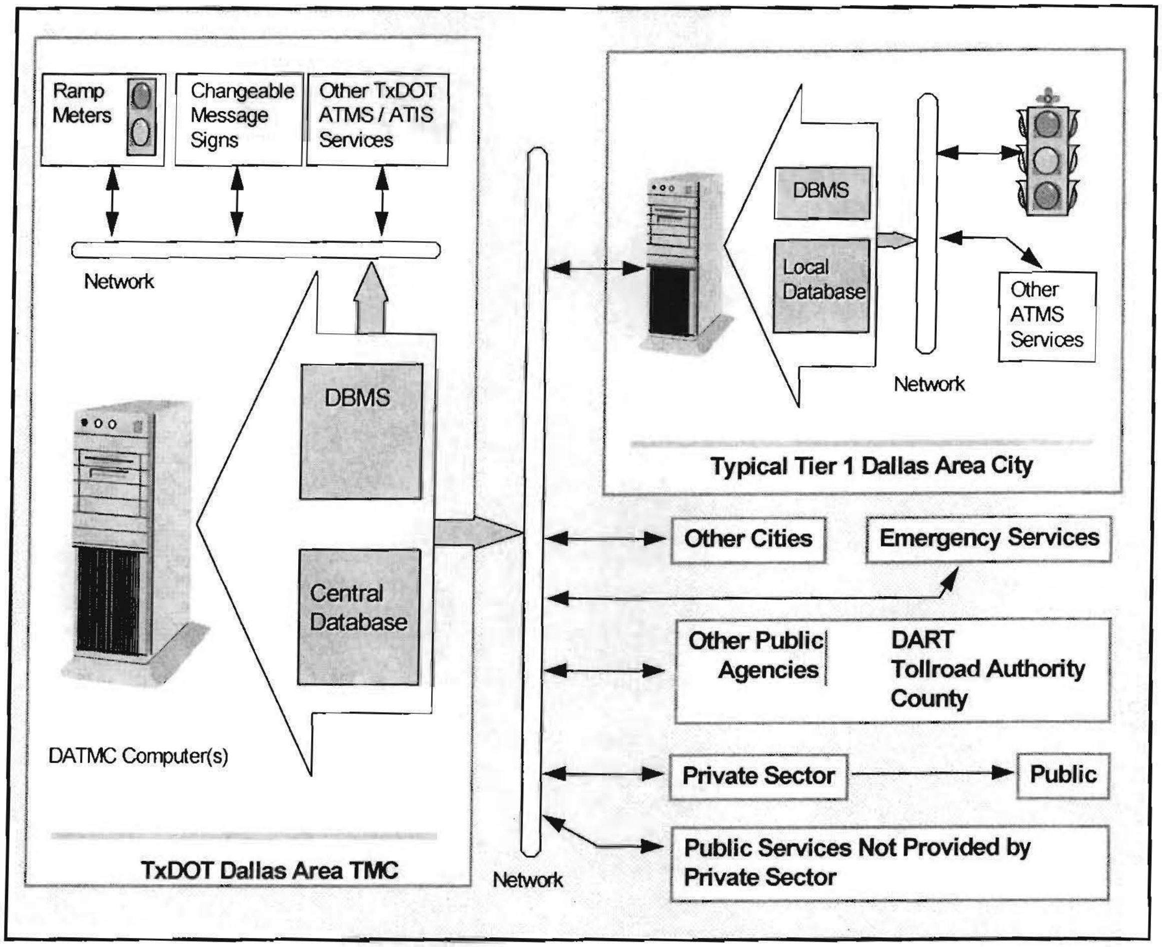


Figure 3-2. Decentralized Dallas Area-Wide ATMS Model

This model is more appropriate for the Dallas Area-Wide ITS Plan than the centralized concept. It is consistent with existing deployment and could provide a deployment path toward a distributed architecture (discussed in the next section) because of its communications requirements. However, it is not best suited for providing significant communications between agencies (video, for instance) and for implementing adaptive traffic signal control strategies.

3.2.3 Distributed Model

A distributed model is based upon the following concepts:

- data is a shared resource;
- significant communications can occur between sites; and
- application processing may require data from any of the sites.

These concepts are integral to the success of the Dallas Area-Wide Operations Plan. Some data is desired by all organizations (e.g., incident related video, traffic signal timings). There will be significant communications between non-TxDOT sites (especially when two adjoining Tier 1 cities are managing an incident during prime time). Data for a specific application may be gathered from multiple sites (e.g., traffic MOE data for adaptive traffic signal control strategies). Figure 3-3 illustrates the distributed model.

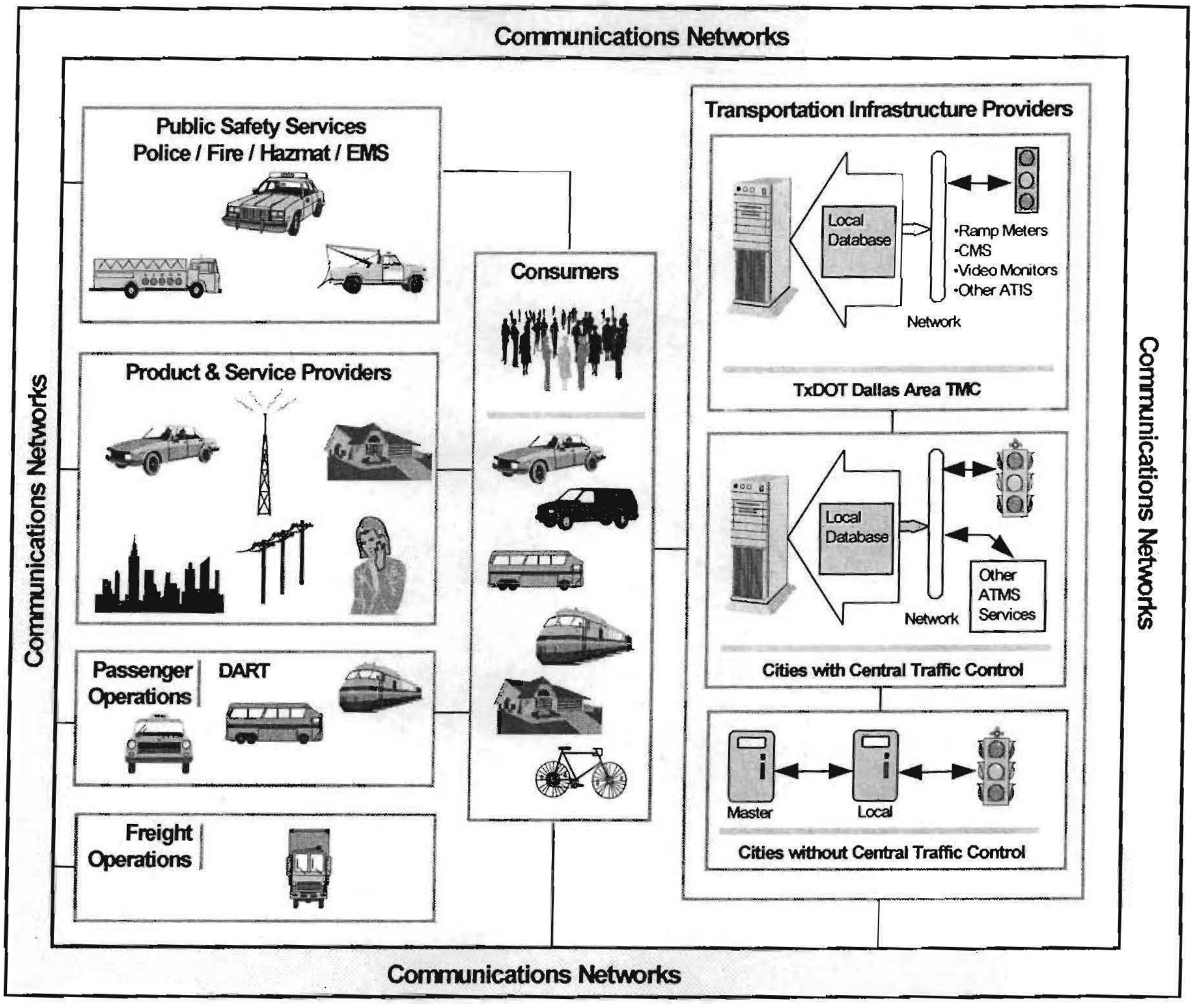


Figure 3-3. Distributed Dallas Area-Wide ATMS Model

4. DALLAS AREA-WIDE ITS SERVICE PLAN

4. DALLAS AREA-WIDE ITS SERVICE PLAN

This chapter begins with a description of ITS User Services, which are products of the enabling ITS framework. These User Services define the scope and diversity of ITS as identified prior to the National ITS Architecture Project sponsored by the FHWA.

The text then defines extensions to the concept of User Services that were developed as an outcome of the National ITS Architecture Project. Section 4.3 describes the Dallas Area-Wide ITS agency deployment priorities based upon the informed guidance of the Regional Steering Committee.

Building on the priorities of the region, beginning in Section 4.4, the text describes key attributes of the Dallas Area-Wide ITS System. These attributes are grouped according to ITS functional areas (ATMS in Section 4.4, ATIS in Section 4.5, Advanced Public Transit Systems in Section 4.6, Commercial Vehicle Operations in Section 4.7, Advanced Vehicle Safety Systems in Section 4.8, and Advanced Rural Transportation Systems in Section 4.9).

Finally, Section 4.10 identifies the key ITS Equipment Packages relevant to the Dallas Area-Wide ITS Plan.

4.1 ITS Planning

The Dallas area faces the transportation problems typical of a large urban area: traffic congestion, lack of mobility, disconnections between transportation modes, budgetary constraints, traffic accidents, traffic injuries, traffic fatalities and vehicle generated air pollution. Conventional solution approaches to these problems have typically been based on capacity enhancements (e.g., adding new lane miles of highway) and mode shift inducements (e.g., providing ride matching for car pooling). However, with the completion of the interstate highway system, the attention of transportation officials at the federal level has shifted from constructing new roadways to achieving better and more efficient use from the existing transportation system. In addition, because of the density of existing property development, large urban regions like the Dallas area have few moderately priced right-of-way choices on which to construct new roadways and thereby to increase highway capacity.

The passage of the Intermodal Surface Transportation Efficiency Act (ISTEA) provided funding for state and local transportation agencies to begin developing and implementing Intelligent Transportation Systems that can mitigate transportation problems within the constraints of existing roadway infrastructure. In the spring of 1993, the FHWA published a guide entitled "IVHS Planning and Project Deployment Process" to serve as a guide for the planning efforts of ITS early deployment planning projects (EDPs). Figure 4-1 is a representation of the steps involved in the 1993 ITS planning process. The EDP process is summarized as follows:

- Problem identification (Step #1 in Figure 4-1);
- Formation of coalitions to jointly resolve the problems (Step #1 in Figure 4-1);
- Selection of user services as the menu of solutions, known as a "User Service Plan" (Step #3 in Figure 4-1);
- Identification of a systems architecture to support deployment of user services (Step #6 in Figure 4-1);
- General technology alternative analyses (Step #7 in Figure 4-1); and
- Listing of proposed projects that address the originally identified problems, known as a "Strategic Deployment Plan" (Step #8 in Figure 4-1).

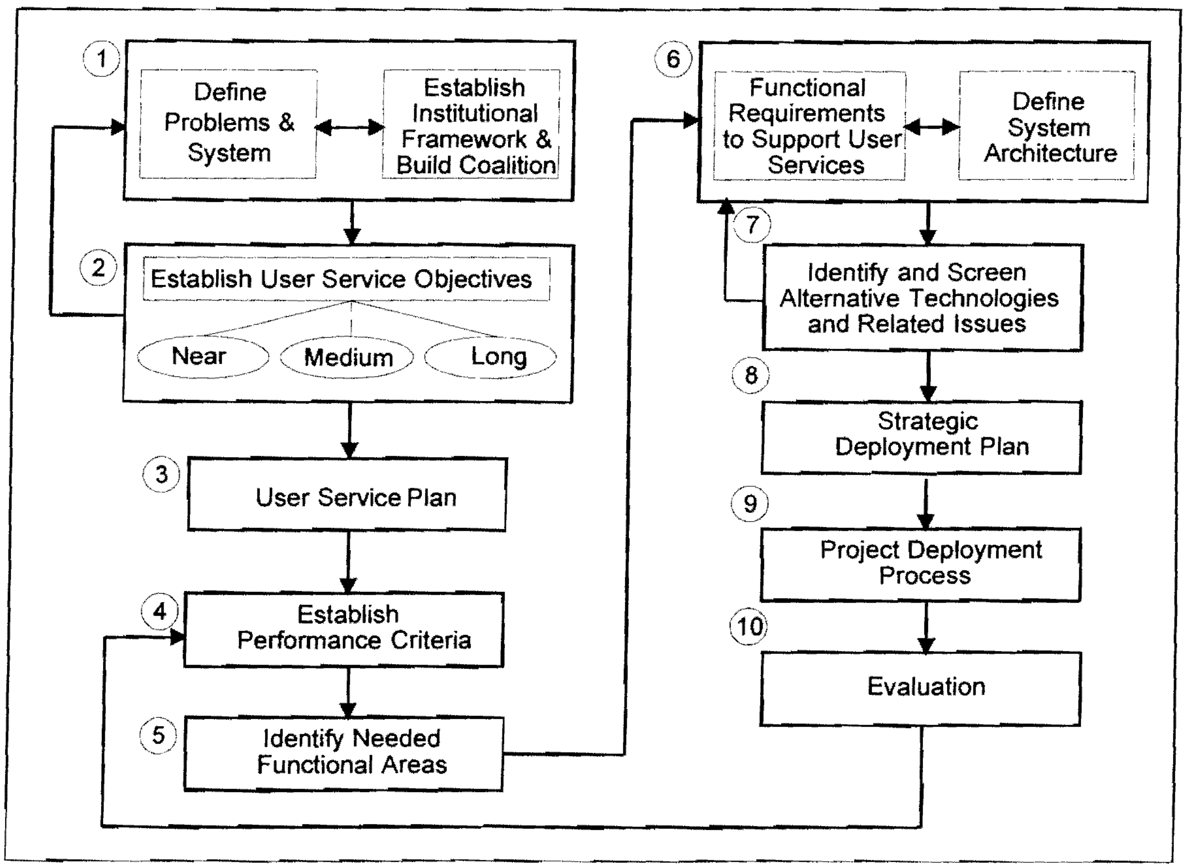


Figure 4-1. ITS Planning Guidance as Defined in 1993

However, ITS is a rapidly evolving discipline, and this EDP process has been enhanced in order to incorporate the work of the ITS National Architecture Project, FHWA's emphasis on deployment of Intelligent Transportation Infrastructure, ITI, (derived from the 1995 concept of Core Infrastructure) and the results of federally sponsored Field Operational Tests (FOTs). Figure 4-2 is adapted from *ITS Architecture, Implementation Plan* (1). TTI originally submitted the figure in the October 1995 *ITS Architecture, Implementation Plan* to the National Architecture Teams. It is a representation of a process that could be used by regions like Dallas to develop ITS Deployment Plans using the products of the National ITS Architecture, ITI and FOTs. Figure 4-2 retains the essential techniques and components of the 1993 FHWA guidelines, but incorporates the results of the National Architecture Project work.

Specifically, the Dallas Area-Wide EDP process uses documents produced from the National Architecture work (e.g., *Vision Document* (2), *Theory of Operations* (3), *Implementation Plan* (4)) to influence the Dallas Area-Wide ITS Plan's three major products: Dallas Area-Wide ITS Service Plan, Dallas Area-Wide ITS Architecture, and the Dallas Area-Wide ITS Strategic Deployment Plan.

- The Dallas Area-Wide ITS Service Plan is very similar to the FHWA's "User Service Plan." However, instead of selecting user services as the menu of solutions, it uses ITS Market Packages as the menu of choices to resolve transportation problems in the Dallas Area. Market packages are a National ITS Architecture concept that identify "units of deployment for user services." The Dallas Area-Wide ITS Service Plan is a consensus built, policy compliant, problem/solution oriented description of the ITS Plan. The ITS Service Plan incorporates Steps #1 - #3 and #7 of the 1993 EDP process shown in Figure 4-1.

- The Dallas Area-Wide ITS Architecture is essentially a series of National Architecture renditions of the regional ITS architecture. It uses the same framework of subsystems, market packages and data flows contained in the National ITS Architecture work. The Dallas Area-Wide ITS Architecture incorporates Steps #3 - #6 of the 1993 EDP process shown in Figure 4-1.

- The Dallas Area-Wide ITS Strategic Deployment Plan is directly analogous the FHWA Strategic Deployment Plan, Step #8 in Figure 4-1. It lists potential projects applicable to the region that will further the deployment of ITS while mitigating the region's transportation problems.

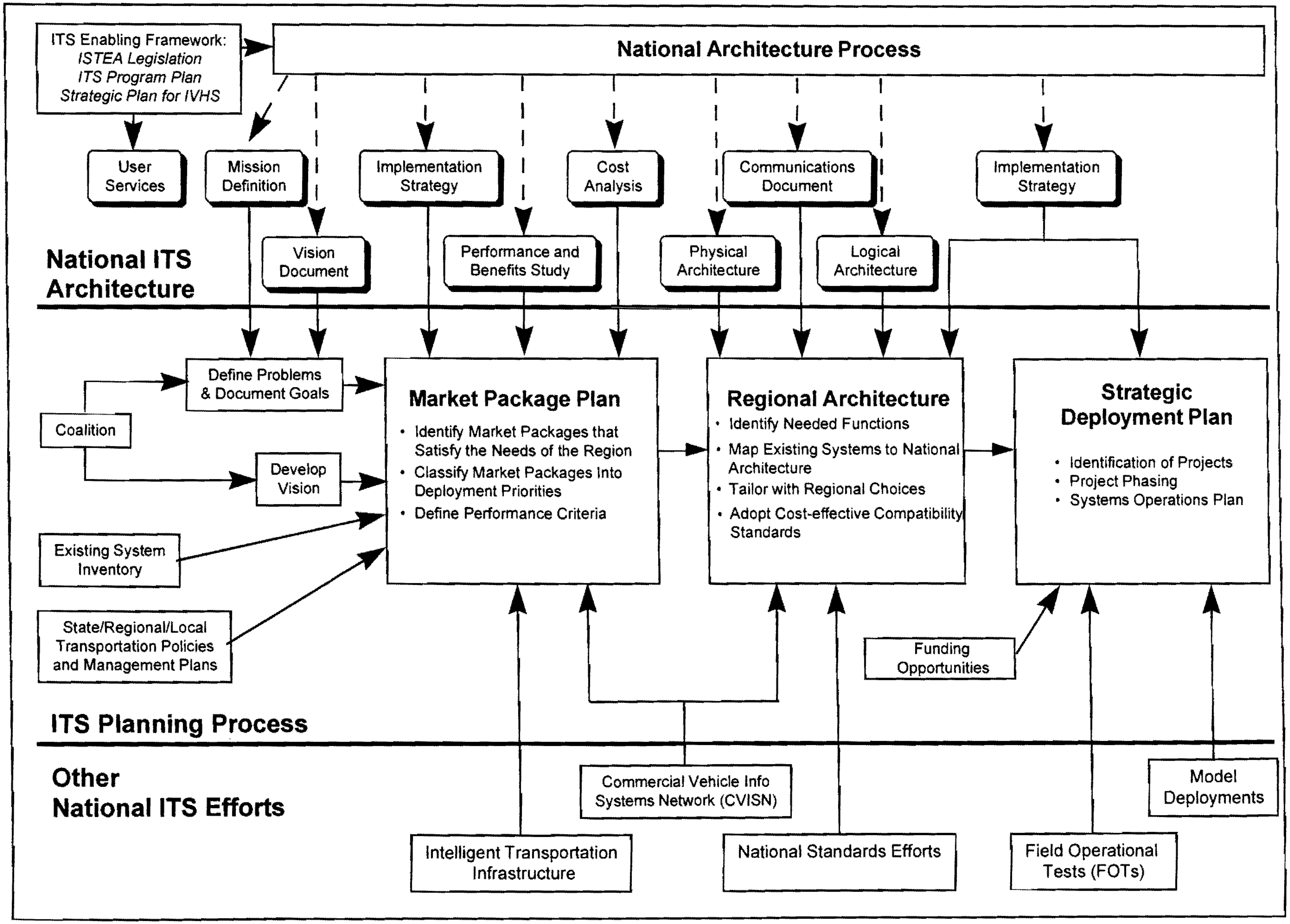


Figure 4-2. Updated ITS Planning Process

4.2 ITS Problems, Solutions, User Services and Market Packages

The FHWA identified 29 potential ITS user services that can be implemented by state and local transportation agencies to achieve better utilization of the existing transportation network (5). These User Services were defined to provide ITS solution descriptions for the problems confronting a region deploying ITS. Table 4-1 lists the user services.

Table 4-1. ITS User Services

Type of Service	User Services
Public Transportation Management	• Public Transportation Management • En-Route Transit Information • Personalized Public Transit • Public Travel Security
Travel and Traffic Management	• Pre-Trip Travel Information • En-Route Driver Information • Route Guidance • Ride Matching and Reservation • Traveler Services Information • Traffic Control • Incident Management • Travel Demand Management • Emissions Testing and Mitigation
Electronic Payment	• Electronic Payment Services
Commercial Vehicle Operations	• Commercial Vehicle Electronic Clearance • Automated Roadside Safety Inspections • On-Board Safety Monitoring • Commercial Vehicle Administrative Processes • Hazardous Materials Incident Notification • Commercial Fleet Management
Emergency Management	• Emergency Notification and Personal Security • Emergency Vehicle Management
Advanced Vehicle Safety Systems	• Longitudinal Collision Avoidance • Lateral Collision Avoidance • Intersection Collision Avoidance • Vision Enhancement for Crash Avoidance • Safety Readiness • Pre-Crash Restraint Deployment • Automated Vehicle Operations

Table 4-2 identifies both ITS and non-ITS candidate solutions to transportation associated problems. It is adapted from the National Architecture documents and identifies some of the relationship between problems, solutions, user services and market packages (6). The October 1995 *ITS Architecture Implementation Plan* summary from which Table 4-2 was derived did not specifically designate user services as candidate advanced systems to solve problems. The focus of the *Implementation Plan* summary were on market packages as the menu of choices to solve transportation problems. However, the Dallas area began the ITS Planning Process before the concept of Market Packages was developed. Consequently, consensus work and regional training regarding ITS were based on the concept of user services. Therefore, a solutions menu that connects problems, user services and market packages holds significant value for the Dallas area coalition. TTI has provided the National ITS Architecture Teams with a copy of Table 4-2 and asked them to include such a table with user service designations as a part of their final 1996 deliverables.

Column one in Table 4-2 highlights the problems of traffic congestion, lack of mobility, disconnections between transportation modes, budgetary constraints, traffic accidents, traffic injuries, traffic fatalities and vehicle generated air pollution. Conventional solution approaches to these problems are illustrated in the third column, typically based on capacity enhancements (e.g., adding new lane miles of highway) and mode shift inducements (e.g., providing ride matching for car pooling). Column four lists advanced solutions to column one problems. ITS user services are identified as underlined entries in column four, "Advanced Systems Approach." The column identified as "Representative Supporting Market Packages" names some of the market packages associated with the user services listed in the "Advanced Systems Approach" column. It is significant to note that a number of market packages may be required to support a user service and that a market package may be used in more than one user service.

Table 4-2. Connecting Problems, Solutions, User Services and Market Packages

Problem	Solution	Conventional Approach	Advanced Systems Approach	Representative Supporting Market Packages

Traffic Congestion	Increase roadway capacity (vehicular throughput)	• New roads
		• New lanes
			• Advanced traffic control
			• Incident management
			• Electronic toll collection (electronic payment services)
			• Corridor management
			• Advanced systems to reduce vehicle headway
			• Commercial vehicle electronic clearance
			• Commercial vehicle administrative processes
			• Efficient fleet routing (commercial fleet management)
			• Efficient vehicle routing through:
			  • en-route driver information
			  • electronic yellow pages (traveler services information),
			  • route guidance
			• Automated vehicle operation
				• Surface street control
				• Advanced coordinated /integrated traffic control
				• Freeway control
				• Probe surveillance
				• Incident dispatch/coordination
				• Dynamic toll/parking fee management
				• Automated highway system
				• Advanced vehicle longitudinal control
				• Weigh-in-motion
				• Electronic clearance
				• International border electronic clearance
				• Fleet administration
				• Broadcast based ATIS
				• Interactive ATIS with driver & traveler information
				• Interactive ATIS with infrastructure route selection
				• Interactive ATIS with infrastructure yellow pages & reservation
				• Route guidance
				• In vehicle signing

	Increase passenger throughput	• HOV lanes • Car pooling • Fixed route transit	• Ride matching and reservation • Integrate transit and feeder services • Flexible route transit (personalized public transit) • En-route transit information • Public travel security	• Dynamic ridesharing • Multi-modal coordination • HOV & reversible lane management • Demand responsive transit operations • Multi-modal coordination • Interactive ATIS with driver & traveler information • Transit vehicle tracking • Transit security
	Reduce demand	• Flex time programs	• Travel demand management • Telecommuting • Transportation pricing	• Dynamic toll / parking fee management • HOV & reversible lane management

Note: ITS User Services are underlined in the column labeled "Advanced Systems Approach"

Table 4-2. Connecting Problems, Solutions, User Services and Market Packages - continued

Problem	Solution	Conventional Approach	Advanced Systems Approach	Representative Supporting Market Packages
Lack of Mobility and Accessibility	Provide user friendly access to quality transportation services	• Expand fixed route transit and paratransit services • Radio and TV traffic reports	• Multi-modal pre-trip travel information • En-route transit information • Respond dynamically to changing demand (public transportation management) • Personalized public transit • Common, enhanced fare card (electronic payment services)	• Interactive ATIS with driver & traveler information • Demand responsive transit operations • Transit passenger and fare management • Transit vehicle tracking • Dynamic toll / fee parking management
Disconnected Transportation Modes	Improve intermodality	• Static inter-agency agreements	• Pre-trip travel information • En-route transit information • Regional transportation management systems • Regional transportation information clearinghouse	• Advanced coordinated / integrated traffic control • Multi-modal coordination • Interactive ATIS with driver & traveler information • Interactive ATIS with infrastructure yellow pages & reservation
Severe Budgetary Constraints	Use existing funding efficiently	• Existing funding authorizations & selection processes	• Privatize ITS market packages • Public-private partnerships • Barter right-of-way • Advanced maintenance strategies	• Traffic system maintenance • Transit maintenance
	Leverage new funding sources		• Increased emphasis on fee-for-use services	• Dynamic toll / fee parking management
Transportation Following Emergencies	Improve disaster response plans	• Review and improve existing emergency plans	• Establish emergency response center (ERC) • Internetwork ERC with law enforcement, emergency units, traffic management, transit, ... • Hazardous material incident notification	• Emergency response • Incident dispatch / coordination

Note: ITS User Services are underlined in the column labeled "Advanced Systems Approach"

Table 4-2. Connecting Problems, Solutions, User Services and Market Packages - continued

Problem	Solution	Conventional Approach	Advanced Systems Approach	Representative Supporting Market Packages
Traffic Accidents, Injuries, and Fatalities	Improve safety	• Improve roadway geometry (increase radius of curvature, widen lanes,...) • Remove road obstacles to improve sight distances • Traffic signals, protected left hand turns at intersections • Fewer at-grade crossings • Driver training • Sobriety check points • Lighten dark roads to improve visibility / better lighting • Reduce speed limits and post warnings in areas prone to adverse conditions	• Partially and fully automated vehicle control systems • Intersection collision avoidance • Automated warning systems • Vehicle condition monitoring • Driver condition monitoring • Vision enhancement for crash avoidance • Automated detection of adverse weather and road conditions, vehicle warning, and road crew notification • Monitoring of commercial vehicles (on-board safety monitoring) • Automated roadside safety inspection • Longitudinal collision avoidance • Lateral collision avoidance • Monitoring of driver, vehicle & roadway infrastructure (safety readiness) • Pre-crash restraint deployment • Emergency notification & personal security • Emergency vehicle management • Automated vehicle operation	• Intersection collision avoidance • Vehicle safety monitoring • Driver safety monitoring • Driver visibility improvement • Network surveillance • Traffic information dissemination • In vehicle signing • Intersection safety warning • Pre-crash restraint deployment • Advanced vehicle lateral control • Advanced vehicle longitudinal control • Mayday support
Vehicle-Based Air Pollution	Increase transportation system efficiency, reduce travel and fuel consumption	• More efficient conventional vehicles • Regulations	• Advanced traffic management to smooth flows • Multi-modal pre-trip information • Telecommuting • Transportation Pricing • Alternative fuel vehicles • Emissions testing and mitigation	• Surface street control • Freeway control • Advanced coordinated/ integrated traffic control • Interactive ATIS • Dynamic toll / parking fee management

Note: ITS User Services are underlined in the column labeled "Advanced Systems Approach"

As noted earlier in this chapter, market packages are a National ITS Architecture concept that identify "units of deployment for user services." Table 4-3 defines the relationships between user services and market packages. This table is excerpted from the National ITS Architecture *Implementation Plan* (7). For example, the user service "public transportation management" has a number of market package deployment options, which collectively define the notion of public transportation management. These deployment market package options are:

- transit vehicle tracking;
- transit fixed route operations;
- paratransit operations;
- transit passenger and fare management;
- transit security;
- transit maintenance; and
- multi-modal coordination.

Table 4-3. Deployment of ITS User Services Through Market Packages

User Services	Market Packages																																																				
	Transit Vehicle Tracking	Transit Fixed-Route Operations	Paratransit Operations	Transit Passenger and Fare Management	Transit Security	Transit Maintenance	Multi-modal Coordination	Broadcast Based ATIS	Interactive ATIS with Driver and Traveler Info	Interactive ATIS with Infra Route Selection	Interactive ATIS with Yellow Pages&Reserv	Interactive ATIS with Dynamic Ridesharing	Mayday Support	Network Surveillance	Advanced Integrated Signal/Route Control	Dynamic Toll/Parking Fee Management	Traffic System Maintenance	Virtual TMC and Smart Probe Data	Probe Surveillance	Basic Signal Control	Advanced Coordinated/Integrated Signal Control	HOV and Reversible Lane Management	Incident Detection System	Incident Dispatch Coordination/Comm System	Traffic Information Dissemination	Traffic Network Performance Evaluation	Freight Administration	Material Tracking and Response	HAZMAT Management	Emergency Routing	Emergency Response	E-911 Interface	ITS Planning	Route Guidance	In Vehicle Signing	On-board CVO Safety	Emissions Sensing	Vehicle Safety Monitoring	Intersection Collision Avoidance	Automated Highway System	Fleet Administration	Driver Safety Monitoring	Longitudinal Safety Warning	Lateral Safety Warning	Intersection Safety Warning	Pre-Crash Restraint Deployment	Driver Visibility Improvement	Advanced Vehicle Longitudinal Control	Advanced Vehicle Lateral Control	Vehicle Tracking and Dispatch	Electronic Clearance	International Border Electronic Clearance	Weigh-In-Motion	Roadside CVO Safety
Pre-Trip Travel Information								x	x	x	x	x																																										
Traffic Control														x	x		x	x	x	x	x	x			x	x																												
Incident Management																		x	x				x	x																														
Travel Demand Management																x						x																																
Public Transportation Management	x	x	x	x	x	x	x																																															
En-Route Transit Information		x	x				x		x	x		x																					x																					
Public Travel Security	x			x	x							x																		x	x																							
Hazardous Material Incident Notification																											x	x	x	x	x																							
Emergency Notification & Personal Security													x																			x																						
Emergency Vehicle Management																														x	x																							
En-Route Driver Information								x	x	x	x	x																						x	x																			
Ride Matching & Reservation												x																																										
Electronic Payment Services				x					x	x	x	x				x																																						
On-Board Safety Monitoring																																				x																		
Emissions Testing & Mitigation																																					x																	
Traveler Services Information											x																																											
Route Guidance										x																								x																				
Personalized Public Transit	x		x	x																																																		
Automated Roadside Safety Inspection																																																						x
Commercial Vehicle Admin. Processes																																																			x	x		
Commercial Vehicle Electronic Clearance																																																			x	x	x	
Commercial Fleet Management																																									x									x				
Longitudinal Collision Avoidance																																											x					x						
Lateral Collision Avoidance																																												x					x					
Intersection Collision Avoidance																																							x						x									
Vision Enhancement For Crash Avoidance																																															x							
Safety Readiness																																						x				x	x											
Pre-Crash Restraint Deployment																																														x								
Automated Vehicle Operation																																								x														

4.3 Prioritization of ITS User Services

At the beginning of the Dallas Area-Wide ITS Planning Project, professionals from agencies within the region began meeting on a periodic basis to address incident management and emerging ITS opportunities. These transportation, safety and planning professionals formed an ITS Steering Committee that supplemented their meetings with educational presentations from industry and academia. In addition, the Steering Committee reviewed pertinent literature reviews, existing infrastructure assessments and operational practices.

Based on the Steering Group's assessment of regional transportation problems (primarily traffic congestion, lack of mobility and accessibility, disconnected transportation modes, transportation following emergencies and traffic accidents/injuries/fatalities), technology maturity and institutional considerations, they assigned each of the ITS user services a deployment priority. The deployment categories were classifications of high, medium and low. This categorization technique is consistent with the ITS planning guidelines identified in Section 4.1 and was made considering the technology assessment presented to the Steering Group. Table 4-4 summarizes the ranking of the user services and identifies the region's assessment of technology and institutional responsibilities. The table also contains a column designating whether the user service is a part of the recently announced Intelligent Transportation Infrastructure (ITI).

The technology considerations included the categories of surveillance and sensors, location identification, communications, algorithms and control. The National ITS Architecture document entitled *Evolutionary Deployment Strategy*, contains a more detailed summarization of these technology risks (8). For instance, surveillance and sensor technology is divided into the categories of traffic, vehicle status, environment, vehicle monitoring, driver monitoring, cargo monitoring, obstacle ranging, lane tracking and security. The technologies are classified as mature, emerging or immature. Some user services received a low ranking for area-wide near term deployment, even though they are important to the region. For instance, the user service "emissions testing and mitigation" received a low ranking for near-term deployment because enforcement application technologies that monitor emissions for specific vehicles are not yet mature and because existing enforcement of individual vehicle emissions is currently done on a statewide basis.

Table 4-4. Dallas Area Assessment of ITS User Services Prioritization

User Services	Technology					Institutional				ITI	Ranking
	Sur	Loc	Com	Alg	Con	Reg	Stat	Fed	Priv	ITI	Ranking
Pre-Trip Travel Information	M	M	M	E		X				Yes	High
Traffic Control	M		M	E	M	X				Yes	High
Incident Management	M	M	M	E		X				Yes	High
Travel Demand Management		M	M	E	M	X				Yes	High
Public Transportation Management		M	M			X				Yes	High
En-Route Transit Information		M	M	E		X				Yes	High
Public Travel Security		M	M			X				Yes	High
Hazardous Material Incident Response		M	M	E		X				No	High
Emergency Notification & Personal Security		M	M			X				No	High
Emergency Vehicle Management	M	M	M	E		X				No	High
En-Route Driver Information	M	M	M	E		X			X	Yes	Medium
Ride Matching And Reservation	M		M			X				No	Medium
Electronic Payment Services		M	M	E		X			X	Yes	Medium
On-Board Safety Monitoring	M			E					X	Yes	Medium
Route Guidance	M	M	M	E					X	No	Low
Traveler Services Information	M	M	M	E					X	No	Low
Emissions Testing And Mitigation	E		M	E			X			No	Low
Personalized Public Transit		M	M			X				Yes	Low
Commercial Vehicle Electronic Clearance					M		X			No	Low
Automated Roadside Safety Inspection	M		M	E	M		X			No	Low
Commercial Vehicle Administration Processes					M			X		No	Low
Commercial Fleet Management		M	M	E					X	No	Low
Longitudinal Collision Avoidance	I			E					X	No	Low
Lateral Collision Avoidance	I			E					X	No	Low
Intersection Collision Avoidance	I		M	E	M	X				No	Low
Vision Enhancement For Crash Avoidance	I								X	No	Low
Safety Readiness	E			E		X				No	Low
Pre-Crash Restraint Deployment	I			E					X	No	Low
Automated Vehicle Operation	E	M	M	E	M			X		No	Low

Key:

Sur = surveillance & sensor
Loc = location ID
Com = communications
Alg = algorithms
Con = control

X = primary institutional responsibility
Reg = primarily regional responsibility
Stat = primarily a statewide responsibility
Fed = primarily a federal responsibility
Priv = primarily a private responsibility

ITI =Intelligent Transportation Infrastructure

Based on this prioritization, the following table defines the prioritized relationship between user services and market packages for the Dallas Area-Wide ITS Plan.

Table 4-5. Ranking of Market Packages Based on User Service Ranking

Market Packages — High Priority (part 1)

User Services	Transit Vehicle Tracking	Transit Fixed-Route Operations	Paratransit Operations	Transit Passenger and Fare Management	Transit Security	Transit Maintenance	Multi-modal Coordination	Broadcast Based ATIS	Interactive ATIS with Driver and Traveler Info	Interactive ATIS with Infra Route Selection	Interactive ATIS with Yellow Pages&Reserv	Interactive ATIS with Dynamic Ridesharing	Mayday Support	Network Surveillance	Advanced Integrated Signal/Route Control	Dynamic Toll/Parking Fee Management
Pre-Trip Travel Information								X	X	X	X	X				
Traffic Control														X	X	
Incident Management																
Travel Demand Management																X
Public Transportation Management	X	X	X	X	X	X	X									
En-Route Transit Information		X	X				X		X	X		X				
Public Travel Security	X			X	X							X				
Hazardous Material Incident Notification																
Emergency Notification & Personal Security													X			
Emergency Vehicle Management																
En-Route Driver Information								X	X	X	X	X				
Ride Matching & Reservation												X				
Electronic Payment Services				X					X	X	X	X				X
On-Board Safety Monitoring																
Emissions Testing & Mitigation																
Traveler Services Information											X					
Route Guidance										X						
Personalized Public Transit	X		X	X												
Automated Roadside Safety Inspection																
Commercial Vehicle Admin. Processes																
Commercial Vehicle Electronic Clearance																
Commercial Fleet Management																
Longitudinal Collision Avoidance																
Lateral Collision Avoidance																
Intersection Collision Avoidance																
Vision Enhancement For Crash Avoidance																
Safety Readiness																
Pre-Crash Restraint Deployment																
Automated Vehicle Operation																

Market Packages — High Priority (part 2)

User Services	Traffic System Maintenance	Virtual TMC and Smart Probe Data	Probe Surveillance	Basic Signal Control	Advanced Coordinated/Integrated Signal Control	HOV and Reversible Lane Management	Incident Detection System	Incident Dispatch Coordination/Comm System	Traffic Information Dissemination	Traffic Network Performance Evaluation	Freight Administration	Material Tracking and Response	HAZMAT Management	Emergency Routing	Emergency Response	E-911 Interface	ITS Planning
Pre-Trip Travel Information																	
Traffic Control	X	X	X	X	X	X			X	X							
Incident Management		X	X				X	X									
Travel Demand Management						X											
Public Transportation Management																	
En-Route Transit Information																	X
Public Travel Security														X	X		
Hazardous Material Incident Notification											X	X	X	X	X		
Emergency Notification & Personal Security																X	
Emergency Vehicle Management														X	X		
En-Route Driver Information																	
Ride Matching & Reservation																	
Electronic Payment Services																	
On-Board Safety Monitoring																	
Emissions Testing & Mitigation																	
Traveler Services Information																	
Route Guidance																	
Personalized Public Transit																	
Automated Roadside Safety Inspection																	
Commercial Vehicle Admin. Processes																	
Commercial Vehicle Electronic Clearance																	
Commercial Fleet Management																	
Longitudinal Collision Avoidance																	
Lateral Collision Avoidance																	
Intersection Collision Avoidance																	
Vision Enhancement For Crash Avoidance																	
Safety Readiness																	
Pre-Crash Restraint Deployment																	
Automated Vehicle Operation																	

Market Packages — Medium Priority and Low Priority

User Services	Route Guidance (Medium)	In Vehicle Signing (Medium)	On-board CVO Safety (Medium)	Emissions Sensing	Vehicle Safety Monitoring	Intersection Collision Avoidance	Automated Highway System	Fleet Administration	Driver Safety Monitoring	Longitudinal Safety Warning	Lateral Safety Warning	Intersection Safety Warning	Pre-Crash Restraint Deployment	Driver Visibility Improvement	Advanced Vehicle Longitudinal Control	Advanced Vehicle Lateral Control	Vehicle Tracking and Dispatch	Electronic Clearance	International Border Electronic Clearance	Weigh-In-Motion	Roadside CVO Safety
Pre-Trip Travel Information																					
Traffic Control																					
Incident Management																					
Travel Demand Management																					
Public Transportation Management																					
En-Route Transit Information																					
Public Travel Security																					
Hazardous Material Incident Notification																					
Emergency Notification & Personal Security																					
Emergency Vehicle Management																					
En-Route Driver Information	X	X																			
Ride Matching & Reservation																					
Electronic Payment Services																					
On-Board Safety Monitoring			X																		
Emissions Testing & Mitigation				X																	
Traveler Services Information																					
Route Guidance	X																				
Personalized Public Transit																					
Automated Roadside Safety Inspection																					X
Commercial Vehicle Admin. Processes																		X	X		
Commercial Vehicle Electronic Clearance																		X	X	X	
Commercial Fleet Management								X									X				
Longitudinal Collision Avoidance										X					X						
Lateral Collision Avoidance											X					X					
Intersection Collision Avoidance						X						X									
Vision Enhancement For Crash Avoidance														X							
Safety Readiness					X				X	X											
Pre-Crash Restraint Deployment													X								
Automated Vehicle Operation							X														

Based on the prioritization of ITS user services, Table 4-6 defines the ITS user services and links them to the problems they solve. This table is similar to Table 4-2. Connecting Problems, Solutions, User Services and Market Packages, but Table 4-6 only contains the user services ranked high priority by the Steering Group and does not contain other non-ITS advanced solutions to the transportation problems.

Table 4-6. ITS User Services For Dallas Area Problems

Problem	Solution	Conventional Approach	ITS User Services
Traffic Congestion	Increase roadway capacity (vehicular throughput)	• New roads • New lanes	• Advanced traffic control • Incident management
	Increase passenger throughput	• HOV lanes • Car pooling • Fixed route transit	• En-route transit information • Public travel security
	Reduce demand	• Flex time programs	• Travel demand management
Traffic Accidents, Injuries, and Fatalities	Improve safety	• Improve roadway geometry (increase radius of curvature, widen lanes,...) • Remove road obstacles to improve sight distances • Traffic signals, protected left hand turns at intersections • Fewer at-grade crossings • Driver training • Sobriety check points • Lighten dark roads to improve visibility/better lighting • Reduce speed limits and post warnings in areas prone to adverse conditions	• Emergency notification & personal security • Emergency vehicle management • Incident Management
Lack of Mobility and Accessibility	Provide user friendly access to quality transportation services	• Expand Fixed Route Transit and Paratransit Services • Radio and TV Traffic Reports	• Multi-modal pre-trip travel information • En-route transit information • Respond dynamically to changing demand (public transportation management)
Disconnected Transportation Modes	Improve intermodality	• Static inter-agency agreements	• Pre-trip travel information • En-route transit information
Transportation following emergencies	Improve disaster response plans	• Review and improve existing emergency plans	• Hazardous material incident notification
Vehicle-Based Air Pollution and Fuel Consumption	Increase transportation system efficiency, reduce travel and fuel consumption	• More efficient conventional vehicles • Regulations	• Advanced traffic management to smooth flows • Multi-modal pre-trip information • Telecommuting • Transportation pricing • Alternative fuel vehicles

4.4 Advanced Traffic Management Systems

The primary function of Advanced Traffic Management Systems (ATMS) is the real-time management of both recurrent and non-recurrent (incident) congestion. Via detection and surveillance systems, ATMSs monitor transportation networks for congested traffic conditions, either recurrent or non-recurrent. In response to congested traffic conditions, ATMSs implement operational control strategies, as well as incident management plans, to maximize mobility and safety throughout the transportation network. Components typically associated with regional ATMSs include Traffic Management Centers (freeways and arterials), Transit Management Centers, communications media integrating various agencies, roadway detection and surveillance equipment, various control strategies (ramp meters, freeway lane control signals, coordinated/adaptive traffic signals, etc.), and incident detection and response plans.

4.4.1 Dallas Area Transportation Management Center

4.4.1.1 Facility Needs

The structure of the Dallas Area-Wide Intelligent Transportation System Plan calls for a Dallas Area Transportation Management Center (DATMC), which would accommodate the TxDOT regional freeway management center and serve as the data information transfer point for traffic data and video sharing among local public agencies. A Wide Area Network (WAN) would facilitate the sharing of traffic data and traveler information between multiple agencies. Several locations are under consideration for location of this facility including:

- TxDOT's Dallas District headquarters;
- IH 635 and IH 35E interchange;
- Downtown Dallas below elevated freeway structures;
- DART Park and Ride Site (Coit Road and Churchill Way); and
- Regional location (Dallas/Fort Worth).

All of the above sites would utilize TxDOT right-of-way.

The DATMC will house CCTV monitors, control consoles, high resolution projectors for map displays, control computers, information databases, communications hardware, and other related equipment, as well as staff offices and equipment maintenance areas. Sizes of freeway TMCs across the country vary greatly. For planning purposes of this study, 2,500 sq. meters DATMC with expansion capability up to 5,000 sq. meters will be assumed. Although TxDOT personnel will be the primary occupants, other agencies, such as DART and the Texas Turnpike Authority, as well as city police personnel, may also be represented. Representatives from City traffic departments may also be accommodated in the DATMC.

4.4.1.2 Hardware/Software

System hardware and software will be a major development for the freeway management, monitoring, and data transfer required for this system concept. Early implementation and testing of the Transportation Management Satellite system software could reasonably provide a basis for expansion to other corridors, resulting in time and capital savings. Also, TxDOT has developed similar software for other systems, which might be applied here. The development of the open protocol NTCIP controller (field processor) and its support by TxDOT will complement this effort.

4.4.1.3 Staffing Requirements

Typically, a Transportation Management Center is staffed from 12 to 24 hours a day, depending on functions and availability of personnel. The DATMC, assuming a 24-hour operation with a fully deployed system, may require as many as 27 personnel including a manager, operations and system engineers, control room supervisors, operators, maintenance technicians, public information/traffic information specialists, and clerical personnel.

Recommended 24- hour staffing for the DATMC for the Dallas area ultimate ITS deployment is as follows:

First Shift (AM)

Job Description	Staff
DATMC Manager	1
Operations Engineer	1
Systems Engineer (communications/hardware/software)	1
Control Room Supervisor	1
System Operators	2
Clerical Support	1
Public Information Officers/Traffic Information Specialists	2
System Maintenance Personnel (detectors, cameras, etc.)	2
Traffic Safety Officer (TSO)	1
Mobility Assistance Patrol Dispatcher	1
*999 Telephone Operators	2
Total First Shift Staff:	**15**

Second Shift (PM)

Job Description	Staff
Control Room Supervisor	1
System Operators	2
Clerical Support	1
Public Information Officers/Traffic Information Specialists	2
Traffic Safety Officer (TSO)	1
Mobility Assistance Patrol Dispatcher	1
*999 Telephone Operators	2
Total Second Shift Staff:	**10**

Third Shift (Deep Night)

Job Description	Staff
System Operator	1
*999 Telephone Operator	1
Total Third Shift Staff:	**2**

Hours corresponding with the three shifts will be staggered so that the first shift covers the entire AM peak traffic period and the second shift covers the entire PM peak traffic period (changing of shift personnel will not occur during peak periods). The staffing size discrepancy between the first and second shifts is the result of the personnel required to manage and maintain the DATMC/system all being assigned to the first shift; these personnel would be on call during the second and third shifts should an emergency situation needing their expertise arise, but typical working hours would be during the AM shift (first shift). The actual number of operations personnel (control room supervisors, operators, dispatchers, TSO officers, and *999 operators) for the first and second shifts is the same. The Dallas area system will be implemented incrementally, and DATMC operating staff would correspondingly build up over time. Initial staffing at the Transportation Management Satellite will include two persons.

4.4.1.4 Interagency Communications

The DATMC, as conceived in this plan, requires extensive communication and data exchange among participants. Personal communications channels must be open for participating agencies to discuss issues and reach consensus. On another level, communication in the form of shared video feeds and other electronic operational data will be received, processed, and transmitted as specific operating agencies require. A reliable and high capacity data transmission system is essential in an advanced system such as this. Owned or leased lines or a combination of owned and leased lines may be appropriate. Leasing bandwidth can preserve capital for deploying other essential ITS elements.

4.4.2 Communications Backbone

Typically, an integrated traffic management system is designed around a "backbone" or "core" communications cable topology. Communication drops or taps allow for the transmission of data such as CCTV images and freeway detection data back to a central management facility. The backbone also carries control commands and other information from the central site to field equipment. Modern freeway management systems have most recently used fiber optic cable for the backbone because of its greater capacity for carrying both video and digital data, as well as transmission efficiency.

The communications portion of any advanced traffic management and control system is often the single most costly item in a system implementation. The cost of conduit installation far outweighs the cost of the cable and the field communications equipment. In the Dallas Area-Wide ITS Plan study area, there are nearly 300 miles of freeways, which, if instrumented in a single project with a fiber optic cable backbone, would require an enormous amount of construction funds. Obviously, the backbone fiber would have to be staged. This delays introduction of ITS services by delaying communications access to the roadside and diverts capital investments from control and instrumentation to communications as well.

The approach developed with the Steering Committee is to primarily install conduit for communications cable in conjunction with planned freeway construction/reconstruction projects, as opposed to projects with the sole purpose being conduit installation. This approach will preserve capital funds for other ITS elements. A combination of leased ISDN lines and compressed video technology offers an attractive alternative to the tremendous capital outlay for cable installation. Furthermore, much of the field and monitoring equipment can be reused in a fiber network when it is extended. Finally, an incremental approach does not tie the total system to one technology, which may be replaced by a better, more economical technology in the future. The development of communications technology can arguably be called the fastest growing technology in the marketplace. In fact, the National Architecture Team in their June 1995 Interim Program submission document "Theory of Operations" indicates that the cost of access and use of private data networks will drop significantly. Pricing will influence most infrastructure operators and designers to use commercial data networks instead of private data networks in the near to intermediate term.

4.4.3 Detection and Surveillance Technologies

Accurate, real-time information regarding roadway and travel conditions (freeways and arterials) is the cornerstone of improving traffic flow on the transportation network. With accurate information, traffic management centers can implement control strategies, detect and manage traffic during incident conditions, and activate motorist information systems that will improve the quality of operations in the traffic network. Numerous detection and surveillance technologies exist, and many more are currently being developed that will improve both the quantity and quality of traffic and travel information. The Dallas Area-Wide ITS Plan provides for deployment of a combination of the following surveillance and detection technologies throughout the Dallas area-wide transportation network: vehicle detectors, CCTV, a cellular phone incident reporting "hotline," and vehicle probes.

4.4.3.1 Vehicle Detectors

It is recommended that vehicle detectors be installed on all strategic freeway mainlanes and ramps, and on North Central Texas Council of Governments (NCTCOG) designated regional arterials. Types of information that will be obtained from the vehicle detectors include vehicle speeds, volumes, lane occupancies, as well as potential incident warnings. Recommended types of vehicle detectors to be used include inductive loop detectors, radar/microwave detectors, and video image processing systems (VIPs).

Recommended typical spacings between freeway detectors is .8 kilometer (9). Approximate .8 kilometer spacings will allow incident detection algorithms to operate without too many false incident warnings and still allow operators to precisely pinpoint where congestion/incidents on freeways are occurring. "Spacings of less than .8 kilometer will be required on freeways with entrance/exit ramps located close together. To the extent possible, "non-intrusive" (radar/microwave or machine vision) detectors will be installed on existing freeway structures, signs, and bridges.

4.4.3.1.1 Inductive Loop Detectors

The inductive loop is the most common form of vehicle detection used for traffic management purposes. The actual cost of this "proven" technology and the equipment associated with inductive loop detectors is relatively low; however, the cost of installing and maintaining inductive loops, especially on operating freeway mainlanes, can be very high, particularly when the delay cost to motorists is included. Improvements to inductive loop detector technologies, such as pre-formed loops and better sealants, have reduced maintenance requirements; however, the installation costs associated with inductive loops remain high. A more favorable time to install loop detectors is during the construction or reconstruction of freeways.

The Dallas Area-Wide ITS Plan recommends freeway inductive loop detectors be installed only in conjunction with other planned freeway construction or reconstruction projects such as US 75 and SH 190.

It is envisioned that loop detectors will be the primary or sole source of incident/system detection for regional arterials in most cities for the near term. (Other "non-intrusive" detectors, such as radar/microwave and machine vision, will require additional maintenance expertise and manpower, as well as capital funds, which will deter their deployment in most cities.) Installation of loop detectors on regional arterials should be done during off-peak hours to minimize disruption to traffic.

4.4.3.1.2 Radar/Microwave Detectors

Using "non-intrusive" detectors, such as radar and/or microwave detectors, allows installation and maintenance activities to be performed with little or no disruption to traffic. While radar/microwave detectors are not quite as accurate as inductive loop detectors, their accuracy is more than adequate for incident detection purposes. The one major disadvantage of radar/microwave detectors is the limited availability of freeway installation locations. Radar/microwave detectors are located either to the side or above the roadway (optimum placement is directly over the roadway), which requires an overhead structure. Since it is not cost effective to install separate support structures, the spacings for freeway radar/microwave detector installations will often be determined by the locations of existing bridges and sign structures.

The Dallas Area-Wide ITS Plan recommends "non-intrusive" radar/microwave detectors be installed on all strategic freeways (freeways experiencing LOS E-F and/or high incident rates) where the opportunity to install loop detectors concurrently with freeway construction/reconstruction activities does not exist.

It is recommended that cities with sufficient maintenance expertise and manpower to handle the periodic maintenance (minor adjustments) required by radar/microwave detectors explore deployment opportunities using "non-intrusive" detectors; prime candidates for use of radar/microwave detectors include arterial construction zones where loop detection is not possible, or as temporary installations, until bad loops are replaced.

4.4.3.1.3 Video Image Processing Systems

Similar to conventional vehicle detectors, Video Image Processing (VIP) systems are capable of detecting vehicle speeds, volumes, and lane occupancies, as well as potential incidents. While nominally more expensive than other "non-intrusive" detectors, such as radar and microwave, CCTV surveillance cameras equipped with VIP capability give operators the added capability to immediately verify incident warning messages. If an incident has occurred, operators may switch the VIP from the video imagery mode to a standard CCTV mode and monitor nearby incidents via pan/tilt/zoom controls. Once the camera is zoomed, tilted, or panned, the VIPs' pre-set detection zones are lost and must be reset prior to switching back to the video imagery monitoring mode. In the past, resetting the detection zones has been a cumbersome task; however, several VIP manufacturers have stated that they are close to solving this problem. Although VIPs are close to becoming "proven" surveillance and monitoring technologies, there are still slight concerns regarding VIPs' ability to detect occupancies, as well as overall detection capabilities, during night/poor lighted conditions and inclement weather conditions.

Video imaging is a rapidly evolving technology. As video detectors and CCTV surveillance cameras equipped with VIP capability become "proven" surveillance technologies, it is envisioned they most likely will replace other "non-intrusive" freeway detectors, such as radar and microwave. It is recommended that TxDOT deploy both video imaging detectors and CCTVs equipped with VIP capability at a limited number of test locations. If and when VIP technology is demonstrated successful in terms of data accuracy and maintenance costs, the number of VIP detectors and CCTV surveillance cameras equipped with VIP capability deployed should increase accordingly. TxDOT has already purchased video imaging detectors and plans on installing them in conjunction with the IH 635 HOV system project. This project will serve as a valuable demonstration project to determine future deployment of video imaging detectors on other freeways in the Dallas area.

Similar to radar/microwave detectors, it is envisioned that only Tier 1 cities (cities with central computer capability) will have the maintenance expertise and/or manpower to maintain VIP detectors or CCTV cameras equipped with VIP capability. It is recommended that Tier 1 cities deploy VIP demonstration/test installations. Should these early deployment VIP demonstration projects be demonstrated successful in terms of capital and O&M costs and data collection, deployment would be increased accordingly in Tier 1 cities, as well as other cities, as they upgrade their existing systems (communication mediums/central computer capability).

4.4.3.2 CCTV Cameras

Although CCTV cameras can be used for monitoring purposes, the primary purposes of CCTV cameras are incident verification and incident management. CCTV cameras give operators/engineers the opportunity to survey existing traffic conditions before implementing traffic management/control strategies. Public information officers/traffic information specialists will also use the CCTV cameras to verify incidents, thus insuring that accurate, real-time information is being disseminated to the public, and media, as well as to other information outputs. Further, CCTV cameras will be useful in monitoring the clearance activities of an incident, including detection of secondary incidents, and in determining when the freeway is fully open again to traffic.

Table 3-3. Dallas Area-Wide Guideline: Responsiveness to National and State Policies - continued

Pre-Trip Travel & En-Route Driver Information .... Chapter 4
• Information flow to the public regarding traffic flow is a joint responsibility of the public sector and the private sector.
• TxDOT is the primary contact for infrastructure based transportation information for private sector ATIS providers.
• Cities, the Texas Turnpike Authority and DART will provide TxDOT access to their transportation infrastructure information for subsequent delivery to the private sector.
• Changeable Message Signs
  • Transportation infrastructure providers should limit deployment of public sector changeable message signs and other ATIS services that compete with the private sector.
  • TxDOT-owned CMS should be placed primarily at strategic locations (e.g., freeway to freeway) and not placed at regular, repeated intervals along the freeway.
  • Arterial and intersection CMS should be a component of the Dallas Area-Wide ITS Plan. However, it will be an intermediate-term element for traffic generators.
• Highway Advisory Radio
  • Highway advisory radio should be implemented for all freeway segments.
	Encourage cost-effective private sector participation in transportation solutions.
	Maximize connections between transportation modes.
	Optimize the use of existing funding sources.
	Utilize technology to increase transportation mobility.
		Improve service level by improving transit information.
		Improve service level by improving incident information to drivers.
		Improve mobility by improving traffic information.

Electronic Toll and Traffic Management (ETTM) .... Chapter 4 • The region should advocate a single standard for ETTM transponders that can be used on various roadways (e.g., DNT, SH 190, D/FW Airport) and for various purposes (roadway user fees, parking payment and congestion pricing). • Anonymous ETTM data should be shared in real-time with TxDOT for the purpose of freeway management.	Utilize technology to increase transportation mobility.	Improve service level by improving convenience of transportation payment.

The Dallas Area-Wide ITS Plan recommends that CCTV cameras be deployed on freeways located within strategic corridors at approximate 1.6 kilometer spacings (if possible, at freeway/cross street interchanges) as well as other key locations throughout the Dallas area freeway system, such as freeway-to-freeway interchanges. The Plan also recommends the deployment of CCTV cameras at regional arterial intersections. Existing buildings adjacent to freeways or major intersections, as well as intersection traffic signals, poles, freeway sign structures, and high mast illumination structures all provide possible locations to mount CCTV cameras; if no existing structures or buildings are available, 14 meter camera poles can also be utilized. In addition, the Dallas District currently operates a portable video surveillance trailer (two more video trailers are on order) with an extendible 12 meter mast with the ability to transmit video images over temporary telephone lines.

Two video formats will be provided from the CCTV cameras, full motion video and compressed video:

- <u>Full Motion Video</u>

  Full motion video consists of approximately 30 frames/second (speed variations for ranges greater than 20 frames/second are usually not detectable by the human eye) and is of television broadcast quality. Due to the large communications bandwidth required for full motion video, it will only be provided by CCTV cameras located along freeways with a fiber optic backbone in place. Regional arterial deployment locations will use full motion video where city cable franchises allow use of cable systems to transmit CCTV video; with the large number of private companies currently installing fiber in the various cities, opportunities for cities to obtain dedicated fibers from these companies should be explored.

- <u>Compressed Video</u>

  Compressed video consists of approximately 7-8 frames/second. Although compressed video is not of television broadcast quality, it is more than adequate for incident detection or verification purposes. Using compression algorithms, the video bandwidth requirements will be reduced and sent over leased Integrated Services Digital Network (ISDN) telephone lines. In addition to the compressed video, other ATMS components (vehicle detector data, ramp metering controls, CCTV camera controls, etc.) will exchange information via the ISDN telephone lines as well. The Dallas Area-Wide ITS Plan provides for compressed video to be used for CCTV camera stations located on freeways not supported by a permanent fiber optic backbone. It is also recommended that compressed video be utilized for regional arterial deployment locations where cable systems are not available for city use.

In addition to the permanent CCTV camera stations, it is also recommended that the Mobility Assistance Patrols (MAP) be provided access to mobile/portable CCTV camera stations. Portable CCTV camera stations will be used to monitor major incidents or scheduled special events/freeway maintenance activities. Possible communications media between the DATMC and the portable CCTV camera stations include a combination of wireless techniques (short haul microwave, spread spectrum) and leased land lines.

4.4.3.3 Cellular Telephone Incident Reporting Program

The rapidly increasing population of cellular mobile phones currently provides a vast resource for incident detection. Several urban areas throughout the country have implemented incident reporting "hot-line" numbers operated by trained telephone operators; upon receiving information on a reported incident, the operators refer the calls to the appropriate agencies (Mobility Assistance Patrols, corresponding police agencies, etc.). A cellular telephone incident reporting program will not only provide incident detection, but it will also allow motorists with cellular telephones to obtain assistance for themselves or for other freeway motorists in need of assistance. Two types of programs utilizing motorists with cellular telephones to report freeway incidents can be implemented.

The first program involves the recruitment of motorists who frequently drive the area freeways to volunteer as "incident" reporters. As an enticement, volunteers who are selected are given free cellular telephones with their basic monthly service fees paid (motorists are responsible for their own personal cellular phone usage; calls to the designated incident "hot-line" number are free). In return, motorists agree to report any minor/major freeway incidents they see to a designated cellular incident "hot-line" number. An advantage to the "recruitment" type program is that motorists reporting freeway incidents have been instructed on how to report incidents, thus ensuring all incidents are accurately reported; however, some public agencies offering this type of program have experienced problems with volunteers maintaining their agreement to pay for their own personal monthly cellular telephone usage charges.

The second type of "incident reporting" program targets all motorists with cellular mobile telephones. Through an extensive advertising campaign, motorists with cellular mobile telephones are encouraged to call and report freeway incidents to an incident "hot-line" number. The incident "hot-line" number is usually an easy to remember phone number, such as *999. The incident hot-line number will only be accessible from cellular telephones. Area-wide implemented *999 incident reporting numbers offer extensive coverage of freeway networks; however, by targeting all cellular telephone users, the accuracy and content (motorists reporting non-freeway/non-traffic related information) of the reports will diminish (10).

The Dallas Area-Wide ITS Plan recommends that the latter of the above mentioned cellular telephone incident reporting programs be implemented for the Dallas area freeways. A *999 program will provide extensive coverage for the Dallas area freeways during peak traffic hours, as well as off peak traffic hours. To prevent telephone operators from being overloaded, it is recommended that the "hot-line" number be advertised as a *freeway* incident reporting number only; however, incidents reported pertaining to arterials will be taken by the telephone operators and directed to the appropriate city agencies (local police, city traffic department., etc.). Implementing a *999 program will require an extensive initial and ongoing media campaign (notices could be billed to cellular mobile phone customers with their monthly bills), informational signage along freeways, as well as additional DATMC staff (minimum of two telephone operators per the first and second shifts).

4.4.3.4 Vehicles Probe (AVL/AVI)

Automatic Vehicle Locating (AVL) or Automatic Vehicle Identification (AVI) technologies can determine a vehicle's instantaneous position as it travels through a roadway network. By tracking vehicle "probes" throughout the roadway network at regular intervals, real-time travel information can be provided for the various travel links traversed.

While AVI systems typically provide more accurate real-time travel information than AVL systems, information provided by AVI systems is limited to roadways equipped with "readers," whereas AVL systems can provide coverage for the entire roadway network. The Dallas Area-Wide ITS Plan provides for implementation of a combination of AVL and AVI system technologies utilizing vehicle "probes" as sources of real-time travel information. Existing resources in the Dallas area that can be utilized include toll tags, cellular mobile phones, and DART's GPS system, as well as commercial AVL system service providers.

4.4.3.4.1 AVL

AVL systems monitor the approximate locations of vehicles equipped with "transponders" as they progress through roadway networks. These transponders transmit radio-frequency (RF) signals to a central monitoring location at regular intervals. Various types of AVL systems include Dead-Reckoning and Map Matching, Ground-Based Radio-Navigation, Loran-C, Global Positioning System (GPS), Differential GPS and Cellular Telephone Based (direction finding systems).

Emergency service agencies use AVL systems extensively to aid in dispatching emergency vehicles, and transit agencies use AVL systems to monitor operations. An evolving technology is the use of AVL systems as a means of obtaining real-time travel information from vehicles traveling throughout transportation networks.

4.4.3.4.1.1 GPS

DART's existing Global Positioning System (GPS), which will be used to monitor their buses as well as their operations vehicles, will also serve as a cost efficient means of obtaining real-time travel information for area freeways; however, due to the frequent number of DART bus stops (picking up and dropping off passengers) on surface streets, accurate, meaningful real-time travel information for regional arterials will be limited.

4.4.3.4.1.2 Cellular Telephones

Using RF receivers and triangulation techniques, it is possible to determine a vehicle's location by measuring signals resulting from cellular phone usage within the vehicle (cellular phones must be in use to allow tracking). In conjunction with map matching algorithms, vehicles (cellular "probes") can be tracked as they traverse area freeways and surface streets. A test project using cellular "probes" to obtain real-time travel information is currently underway in the Washington, D.C., area (11).

If the Washington, D.C., project successfully demonstrates that cellular "probes" can obtain real-time travel information, it is recommended that a similar system be installed for the Dallas area. A cellular "probe" traffic surveillance system will provide complete coverage for the Dallas area, including freeways as well as surface streets. Due to the experimental nature of cellular "probe" traffic surveillance systems, cost data is limited.

4.4.3.4.2 AVI

Automatic Vehicle Identification (AVI) systems uniquely identify individual vehicles as they pass through a detection area. Although there are several different types of AVI systems, they all operate using the same general principles. A roadside communication unit (reader) broadcasts an interrogation signal from its antenna. When an AVI-equipped vehicle comes within range of the antenna, a transponder (or tag) in the vehicle returns that vehicle's identification number to the antenna. The information is then transmitted to a central computer where it is processed. In most systems, the transponder and reader/antenna technology is independent of the computer system used to manage and process the vehicle identification information (12).

Currently, the most common application of AVI technology is for automated toll collections, such as on Dallas North Tollway; however, AVI technologies have recently been implemented for the purpose of collecting travel time information along roadways. In Houston, AVI systems have been installed to monitor traffic operations on main lanes and high-occupancy vehicle (HOV) lanes on area major freeways. Vehicles equipped with transponders are used as probes to collect current travel time information; this information is then used to alert freeway operators of potential incidents and congestion on both the main lanes and the HOV facility (12).

4.4.3.4.2.1 Toll Tags

The use of toll tags for automated toll collections on Dallas North Tollway (DNT) has been very successful. In addition to collecting tolls, the DNT toll tags can also be used as vehicle "probes." Utilizing the existing toll tag vehicle population, overhead toll tag "readers" can be installed on the DNT cross street bridges to provide real-time travel information for DNT. The Central Dallas Association (CDA) is currently developing a system that would make use of the same type toll tag used on DNT. These tags will allow entry into private parking garages, and the parkers accounts will be automatically debited as is done on DNT. Currently, six major downtown garages have committed to the program. The CDA is also exploring the use of the system at other locations, such as DFW Airport and Love Field. As described subsequently, the CDA, in cooperation with TxDOT, plans a number of kiosks located in the downtown area to inform travelers of traffic conditions. The CDA is also considering the installation of toll tag readers at critical locations on radial freeways to provide traffic condition information for display on downtown kiosks. Field studies show that a sufficient toll tag vehicle "probe" population exists on other Dallas area freeways. Expansion of toll tag readers to other outlying freeways would provide information area-wide. Installation of toll tags on regional arterials and/or freeway diversion routes with significant toll tag populations will provide additional surface street travel time information as well; the City of Farmers Branch has preliminary plans to install toll tag readers on Valley View Lane (diversion route for IH 635).

4.4.3.4.2.2 Private Sector Probes

Several commercial companies offering AVL services in the Dallas area are in operation. These companies use their AVL systems mainly to provide dispatching/fleet management services for commercial delivery related companies. There is potential for public/private partnerships between TxDOT and these commercial AVL providers. Having access to commercial AVL providers' vehicle "probe" data will allow TxDOT to obtain real-time travel information for area freeways and surface streets; in return, TxDOT can supply the commercial AVL providers travel information (congested traffic conditions), which they can use to better their fleet management capabilities. Due to privacy concerns, commercial providers have been hesitant in the past to supply public agencies with their vehicle "probe" data.

4.4.4 Control Strategies

In addition to collecting real-time traffic condition information, another primary function of ATMS is the implementation of control strategies to manage both recurrent and non-recurrent (incident) congestion. Improved levels of communication between the infrastructure and the vehicle and enhanced ability to obtain better and more timely information about traffic conditions in the transportation network will result from the deployment of ITS technologies. The deployment of ITS Technologies will enhance greatly transportation agencies' ability to implement control strategies to help control demand and ensure travel safety and mobility in the transportation network. These control strategies are focused at improving mobility and enhancing safety on the entire transportation network, including both the freeways and the surface streets. The Dallas Area-Wide ITS Plan recommends various forms of the control strategies summarized in the following sections be implemented throughout the Dallas area roadway network.

4.4.4.1 Ramp Meters

Ramp metering involves the use of traffic signals to regulate the number of vehicles entering freeways at entrance ramps. Ramp metering controls the flow of entering traffic so that the combined freeway and ramp traffic does not exceed the capacity of the freeway. Ramp metering promotes smoother operations on the freeway main lanes by reducing the impact of merging entrance ramp traffic on the freeway mainlane traffic.

Several different timing strategies have been developed for ramp metering systems (13). Pre-timed metering, where the ramp signal operates with a constant cycle, is the simplest strategy. With a pre-timed metering strategy, the ramp signal can be timed to permit either one vehicle only or a small platoon of vehicles to enter the freeway during each green interval. In contrast to pre-timed metering, traffic responsive metering is directly influenced by the mainline and ramp traffic conditions during the metering period. The metering rates are selected on the basis of real-time measurements of traffic variables indicating the current relationship between upstream demand and downstream capacity. Common strategies employed with traffic responsive ramp metering involve balancing upstream volumes with downstream capacities (demand-capacity control) and metering based on current occupancy levels (occupancy control).

Ramp metering systems have been installed and have operated successfully in numerous locations in the United States. The Texas Department of

Transportation is making provisions for ramp metering systems for most of the surveillance and control systems in the major metropolitan areas in Texas; ramp metering infrastructure (conduits and pull boxes) is being installed as part of US 75's reconstruction, which will allow ramp meters to be easily installed should ramp metering on US 75 become warranted in the future. The Dallas Area-Wide ITS Plan recommends ramp metering on freeway entrance ramps located within strategic corridors that meet minimum geometric requirements for ramp metering, such as adequate acceleration lanes and storage room. Strong support from local enforcement agencies and judicial systems is pivotal to the success of ramp metering.

4.4.4.2 Ramp Closures

Another strategy for improving traffic flow, particularly on freeways that operate at or near capacity, is to close selected entrance or exit ramps. Weaving areas caused by traffic entering and exiting the freeway can create turbulence in the main lanes of the freeway, which in turn reduce the capacity of the freeway. Closing specific ramps and making provisions for directing traffic to other ramps and surface streets helps maintain traffic flow on the freeway. However, because of its restrictive nature, closing freeway entrance and exit ramps can be controversial, meeting with considerable public opposition in some cases.

The Dallas Area-Wide ITS Plan recommends closing a freeway ramp only when other control strategies, such as ramp metering, have failed to maintain the desired quality of flow on the freeway. Two prime conditions where closing a ramp may prove to be beneficial include the following:

- When adequate storage is not available at an entrance ramp to prevent queues of vehicles waiting to enter the freeway from interfering with surface street traffic; and

- When traffic demand on the freeway immediately upstream of an entrance ramp is at capacity, but there is adequate capacity on adjacent alternate routes.

In both cases, closing the ramp forces traffic demand to other locations. Careful analysis would be required to ensure that alternative ramps and arterial streets can accommodate diverted traffic demands.

4.4.4.3 Lane Control Signals

Closing a lane on a freeway can also be used as a control strategy for improving traffic flow. The most common use of lane control signals (LCS) is as an advance warning of a blockage (either caused by an incident or a scheduled maintenance activity).

Lane control signals for the purpose of incident management are currently being utilized and evaluated in the Fort Worth District. The Dallas Area-Wide ITS Plan provides for deployment of LCS on strategic freeways. Deployment locations of the LCS will primarily consist of overhead cross street bridges. In addition to non-recurrent congestion, LCS can also be used to mitigate recurrent congestion. Recurrent congestion locations where freeway LCS can improve freeway mainlane operations include entrance ramps with heavy volumes, freeway merges, and freeway-to-freeway direct ramps.

The City of Dallas is currently using overhead lane control signals to operate reversible lanes on roadways in east Dallas (Live Oak Street and Ross Avenue) experiencing unbalanced peak hour traffic flows; to mitigate congestion and increase capacity, the City of Dallas uses LCS to reverse a lane during peak hours, thus giving the peak direction an extra lane of capacity. It is recommended that cities explore opportunities to increase capacity and mitigate congestion through the use of LCS on regional arterials experiencing unbalanced peak hour traffic flows.

It is also recommended that dynamic lane assignment signs be used to maximize approach capacities at intersections experiencing changing traffic patterns throughout the day. The City of Arlington operates with much success dynamic lane assignment signs at an intersection near the BallPark in Arlington; intersection approach lane assignments are changed throughout the day (before and after Rangers' baseball games) to account for predominant movements. Cities should explore opportunities to use dynamic lane assignment signs at intersection approaches with changing traffic patterns throughout the day. Prime candidates for dynamic lane assignment installations include intersection approaches on freeway service roads and freeway diversion routes. Other intersection approaches locations that should be considered are those located near major traffic generators, such as Fair Park, Reunion Arena, or high density employment areas.

4.4.4.4 HOV Lanes/Restrictions

The primary purpose of High Occupancy Vehicle (HOV) facilities is to increase the people-moving (as opposed to the vehicle-moving) capacity of a roadway. HOV facilities are exclusive lanes or facilities dedicated to the movement of vehicles carrying a high number of occupants. Since use of the lane is restricted to vehicles with high occupancy levels, HOV facilities are generally less congested than a typical freeway. Because of their time savings and greater reliability over regular lanes of traffic, HOV facilities are often attractive alternatives to many commuters traveling in peak periods. Traditionally, occupancy levels of 3 or more people per vehicle are defined as high-occupancy vehicles; however, some locations (Houston, Dallas, and Washington D.C.) permit vehicles carrying as few as two occupants to use their HOV facilities.

Several types of HOV facilities can be implemented on freeways or arterial streets, including the following (14):

- An exclusive facility in a separate right-of-way and dedicated for the full-time use of high-occupancy vehicles;

- An exclusive facility dedicated for the full-time use of high-occupancy vehicles, but contained within the right-of-way;

- A concurrent flow lane where a normal freeway lane is dedicated for the use of high-occupancy vehicles for at least a portion of the day (usually the peak period); and

- A contraflow lane where for a portion of the day a normal travel lane in the *off-peak direction* is dedicated for the use of high-occupancy vehicles traveling in the opposite direction (peak direction). The lane is typically separated from the off-peak direction travel lanes by insertable plastic posts or pylons, or a moveable barrier such as the one currently being operated on IH 30 in Dallas.

It is recommended that TxDOT and DART continue their partnering efforts to implement HOV facilities on candidate freeways throughout the Dallas area. In addition to the HOV lanes on IH 30, HOV lanes are also being constructed on IH 35E and IH 635. NCTCOG's Mobility 2010 Plan Update will serve as a guide for future HOV systems.

4.4.4.5 Arterial Traffic Signals

Improving the level of progression and control of traffic on the arterial street network can improve significantly mobility, air quality, and fuel savings. A significant portion of the traffic signals in the United States are in need of major improvements to both the equipment and signal timings (15). Therefore, providing better traffic signal control and modernizing equipment can reduce significantly the level of congestion on arterial streets. Fortunately, in the Dallas urban area, significant improvements in signal operations have been achieved through TxDOT's oil overcharge funding, ISTEA and the Dallas County bond program for signal improvements.

A number of basic improvement strategies that can produce significant improvements to traffic flow on the arterial street system are as follows (14):

- Timing Plan Improvements: Retiming traffic signals so that the timings correspond to current traffic flows and patterns can reduce unnecessary delays and congestion at some locations.

- Interconnecting Signals: Interconnecting two or more traffic signals can improve progression in an arterial or network of arterials. Traffic signal systems can be designed to provide pre-timed control (in situations where traffic patterns remain relatively constant) or adaptive control (in situations where traffic demands are constantly changing).

- Equipment Upgrades: Upgrading or modernizing existing traffic signal equipment, as well as routine maintenance on loop detectors, would permit more advanced traffic signal timing and control strategies to be implemented at particular intersections.

- Removal of Traffic Signals: Removing unwarranted and/or unneeded traffic signals can reduce vehicle delays and prevent unnecessary stops. However, if the unwarranted signal is located in a progressive/coordinated system, an unwarranted signal may be better than a two-way or all-way stop (depending on the direction of the progression).

With ITS, the degree to which these basic traffic signal engineering improvements will enhance traffic operations and safety will expand. As computer technology improves, sophisticated traffic controllers that provide improved control features can be implemented as intersections are upgraded. With improved controllers, better and more efficient timing plans and control strategies can be implemented. Advanced communication systems will greatly enhance a traffic management agency's capability to provide coordination between isolated intersections.

In addition to these basic improvements, implementing more advanced control strategies can further improve operations and flow on the arterial street system. With improved communications and computer technology, traffic signal systems that are adaptive to current traffic patterns can be implemented (16). Adaptive control systems use real-time data collected by advanced sensor and surveillance systems to perform short-term estimates of traffic flow conditions. Using these estimates, traffic signal timings are developed and implemented (in real-time) that will improve overall efficiency in the transportation network. Fully adaptive traffic signal systems may produce the greatest benefits in locations where congestion is high and where flow patterns are complex and vary by time of day. Two examples of real-time adaptive signal control techniques are OPAC and SCATS.

4.4.4.5.1 OPAC

Optimization Polices for Adaptive Control (OPAC) is a traffic signal control concept that determines whether or not to extend a phase by examination of a delay-based control function (17). The optimization technique used to achieve this goal is to minimize total intersection delay by minimizing the area between the cumulative arrival and the cumulative departure curves (18). This technique has been evaluated through a private sector contract to FHWA (19) and is currently being field tested in the following locations:

- New Jersey along Route 18 near New Brunswick at 16 interconnected signals; and
- Seattle, Washington, at two separate isolated intersections.

4.4.4.5.2 SCATS

SCATS is an acronym for the Sydney (Australia) Co-Ordinated Adaptive Traffic System. The objective of the master controller is to select the phase splits that most closely match demand, to select the cycle length that maximizes the efficiency of the intersection and to select appropriate offsets (20). The strategies used to achieve this set of objectives are:

- When demand is heavy, maximize throughput (vehs/hr) to avoid queue build-up;
- When demand is moderate, minimize delay within the system while avoiding excessive delay; and
- When demand is low, minimize the number of stops in the system.

In regards to traffic signals, the Dallas Area-Wide ITS Plan recommends that all traffic signals throughout the area have some type of central computer capability (either closed loop or central computer system). Traffic signals with central monitoring and control capability will allow incident detection (via incident/system detectors) on arterials and appropriate incident response timing plans to be activated from a central location in response to detected arterial of freeway incidents. Tier 1 cities will monitor and control their systems autonomously; in the near-term, it is envisioned that cities without central computer capability (non-Tier 1 cities) will have their signals monitored and controlled from the DATMC.

It is also recommended that cities reevaluate existing timing plans (particularly on regional arterials) on an annual basis, making any needed timing adjustments to account for changing traffic patterns at a minimum of every three years.

Regarding evolving real-time, traffic adaptive control strategies (OPAC, SCATS), it is recommended that further observation and evaluation of actual real-time, traffic adaptive projects is needed. The actual merits/benefits of real-time, traffic adaptive signal control strategies have yet to be "proven" or to be demonstrated as successful in an actual signal system. Furthermore, a decision to implement real-time traffic control strategies in the future should be made as a region, as opposed to an individual city; while an individual city operating real-time, traffic adaptive control strategies might benefit locally from improved traffic operation, if adjacent cities are not using traffic adaptive control strategies as well, the regional traffic operations will suffer as a result.

4.4.5 ATMS Summary

The primary function of ATMSs is the real-time management of both recurrent and non-recurrent (incident) congestion. Via detection and surveillance systems, ATMSs monitor transportation networks for congested traffic conditions, either recurrent or non-recurrent. In response to congested traffic conditions, ATMSs implement operational control strategies, as well as incident management plans, to maximize mobility and safety throughout the transportation network. The primary component from the proposed Dallas area ATMS is the Dallas Area Transportation Management Center (DATMC). The proposed DATMC will serve as the Dallas area regional freeway management center, as well as the data information transfer point for traffic data and video sharing among local public agencies. The proposed ATMS provides for implementation of a combination of various detection and surveillance technologies including vehicle detectors, CCTV, a cellular phone incident reporting "hotline," and vehicle probes; proposed ATMS operational control strategies to be implemented include ramp metering and ramp closures, lane control signals, HOV facilities, as well as various arterial traffic signal improvements.

4.5 Advanced Traveler Information Systems

The primary function of Advanced Traveler Information Systems (ATIS) is disseminating traveler information regarding traffic conditions on transportation networks, as well as information regarding the availability and accessibility of alternate routes and/or travel modes to the traveling public. ATISs, in conjunction with Advanced Public Transportation Systems (APTS), assist travelers with decisions regarding route planning, travel mode, and the time of day to travel. Accurate and timely traffic information will provide benefits to travelers in the form of time and money savings, as well as benefit regional mobility, which in turn will lead to a reduction in vehicle fuel emissions. Travel information that will be of interest to travelers includes:

- Congestion levels on the transportation network;
- Location and extent of congestion;
- Cause of congestion (is the congestion resulting from incidents, such as road construction or maintenance work, accidents, special events, etc., or is the congestion resulting from everyday normal recurring traffic conditions?);
- Expected duration of congestion;
- Estimated delays to travelers (travel time estimates);
- Available alternate routes;
- Alternate route travel time estimates;
- Available alternate travel modes;
- Transit schedules and routes;
- Transit schedule adherence (e.g., on-time or behind schedule);
- Weather information;
- Recommended speed/safety advisories; and
- Scheduled construction and maintenance lane closures.

The key to a successful ATIS is providing travelers with *accurate* and *timely* traffic information. Information disseminated by ATISs can be categorized as either pre-trip or en-route travel information.

4.5.1 Pre-Trip Travel Information

Generally, the public accesses pre-trip travel information from their homes and/or workplace, and they use pre-trip travel information to help *plan* travel routes, travel modes, and/or travel departure times. Recommended technologies to disseminate pre-trip travel information to the public in the Dallas area include: a dial-in telephone system, kiosks, and the Internet.

4.5.1.1 Dial-In Telephone System

Dial-in telephone systems, also known as Highway Advisory Telephone (HAT) systems, provide a cost-efficient means of disseminating real-time traffic operations information to travelers via touch-tone telephones. Two local cellular carriers serving the Dallas urban area currently provide limited traffic information to their customers on a call in basis. Using telephone push buttons to make menu selections, trip planners or motorists can access information of their particular interest. Various types of information that can be made available include: real-time traffic conditions, incident locations and available alternate routes, real-time corridor specific estimated travel times, lane closures due to scheduled construction or maintenance work, mass transit travel information, special events information, and weather information.

TxDOT currently operates a dial-in telephone "hotline" system (374-4100). The existing "hotline" number evolved from the "Widen75" telephone system; callers can access the existing "hotline" by dialing "Widen75" (943-3675) or "374-4100". TxDOT's "hotline" number provides static/pre-recorded information such as daily area freeway lane closures, the status of area freeway and transit construction projects, and TxDOT employment opportunities. The Dallas Area-Wide ITS Plan provides for expansion of TxDOT's existing dial-in telephone system to include dynamic real-time, location specific, travel information for the Dallas area freeways (HOV lanes included) and transit information such as schedules, routes, and schedule adherence. Through the use of voice processing techniques, it is possible to automate the dissemination of dynamic real-time information by tying the dial-in telephone system into the regional information database; however, with existing technologies, a fully automated dial-in system will not provide as accurate or as specific information as a manually operated system. Manually operated real-time information dissemination systems allow operators/public information officers to verify existing conditions before they disseminate the information, thus ensuring accuracy. It is recommended that the dial-in telephone system initially utilize public information officers/traffic information specialists to input manually real-time traffic information messages. A dial-in phone system with real-time information capability, in addition to static/pre-recorded messages similar to those currently being provided by TxDOT's "hotline" number, will require additional staff (public information officers/traffic information specialists) to operate. In order to reduce operating staff requirements, other ATIS technologies, such as Highway Advisory Radio (HAR), can be interfaced with the dial-in telephone system, since both will be broadcasting many of the same real-time informational messages.

4.5.1.2 Kiosks

A kiosk is simply a combination video monitor/computer or LED matrix display mounted in a stand-alone cabinet, which allows travelers to interact and retrieve requested information via user-friendly touch screens or keyboards/pads. Kiosks are usually installed in high density areas, such as mass transit stations, airports, shopping centers, major sporting or entertainment event locations, and high density employment locations. Kiosks can provide static (pre-programmed) and dynamic information (assuming the kiosk is tied into the regional information database). Types of information that can be disseminated from kiosks include real-time traffic and road conditions, incident locations, primary and alternate route travel time estimates, mass transit schedules, transit schedule adherence, and scheduled construction and maintenance related lane closures. Kiosks located in high density employment areas can also be used to promote ride-sharing by maintaining an informational database of potential car-poolers with similar origins and destinations.

It is recommended that public/private partnership opportunities be explored to provide kiosks at high density employment areas (Dallas Central Business District, Texas Instruments, etc.), area shopping malls and large special event centers (Fair Park, Reunion Arena, etc.). Proposed partnerships call for the private sector to finance the deployment of the kiosks. In return, TxDOT will provide available real-time traffic congestion information. Private sector kiosk providers will likely recoup their capital expenditures by using the kiosks for other non-transportation uses, such as commercial advertising for area restaurants, shops, etc. The proposed public/private partnerships will benefit regional transportation infrastructure providers by reducing congestion on the area transportation network; private sector participants benefit by having a valuable service (real-time traffic/travel information) to offer their tenants, employees or customers.

Section 4.6.1.5 discusses a partnership between TxDOT and DART to install kiosks in downtown Dallas.

4.5.1.3 Internet

The Internet world wide computer network provides a very cost efficient means of disseminating traffic information to the public. Access to the Internet is available to any personal computer user with an Internet connection. Traditionally, educational institutions or employers have provided Internet connections; however, local Internet providers can now obtain dial-up connections for home-use for a minimal monthly fee. Home and office based Internet usage is increasing at an explosive rate.

Many public agencies across the country are currently using the Internet to disseminate real-time traveler information (textual, graphical, and/or photographs). A few of the cities across the country currently providing real-time information via the Internet include San Diego, Los Angeles (Orange County), and Houston. Various types of traveler information being disseminated on the Internet include graphical representations of freeway networks depicting real-time speeds, real-time "snapshots" showing existing traffic conditions taken from CCTVs, real-time weather conditions, incident locations, scheduled construction and maintenance roadway closures, and mass transit schedules (as well as mass transit schedule adherence).

It is recommended that the Dallas Area-Wide ITS Plan take advantage of the Internet's rapidly growing popularity by deploying a Dallas Area-Wide Transportation Information "homepage." Providing traveler information via the Internet would require a connection to the Internet, access to a server, and a leased ISDN or voice grade communications line. Once the "homepage" is constructed, the staffing necessary to maintain it will be minimal. Real-time information disseminated over the Internet can be automated by tying into the regional information database. Direct links to other Dallas area "homepages" (Dallas area weather forecasts, as well as DART and other regional cities as they develop "homepages") could also be provided. Static/pre-recorded information, such as daily scheduled lane closures, will have to be input manually.

4.5.2 En-Route Travel Information

En-route travel information entails all information received by motorists during their trips. Types of en-route travel information typically disseminated to motorists include travel advisories alerting motorists to potentially hazardous or congested travel conditions, as well as available alternate routes. Recommended technologies to disseminate en-route travel information to motorists in the Dallas area include Highway Advisory Radio systems and Changeable Message Signs.

4.5.2.1 Changeable Message Signs

Changeable Message Signs (CMS), also referred to as Variable Messages Signs, have been utilized to communicate with motorists for over 30 years (21). Transportation agencies frequently use them for warning, regulation, routing, and traffic management purposes. The CMS is the primary real-time device used by transportation agencies to communicate directly to motorists in many urban areas. CMSs have several advantages for communicating with motorists in real-time. The technology is proven and is being utilized extensively nationwide. Also, CMS operations are generally incorporated into the overall traffic management system of the freeway, corridor, or roadway network, thus giving transportation agencies direct control over the amount and accuracy of information presented to motorists.

However, CMSs also suffer from several limitations. The location of the devices is generally fixed, which limits where and when motorists are able to access information. Also, the visibility of CMSs can be affected by external conditions, such as weather or a high percentage of trucks. Furthermore, motorists can see any given sign for only a short amount of time, which constricts the amount of information that can be presented to the motorist. Due to the limited amount of traveler information CMSs can convey, they are often supplemented with Highway Advisory Radio (HAR) systems. CMSs should be located upstream of high accident or bottleneck locations to allow motorists to divert to alternate routes during congested traffic conditions. CMSs are usually deployed 1-2 miles in advance of major decision points, such as freeway-to-freeway interchanges or exit/entrance ramps for surface cross streets, which may be used for traffic diversion.

Within the last few years, TxDOT has begun deploying permanent CMSs strategically located on Dallas area freeways. The Dallas Area-Wide ITS Plan provides for TxDOT to continue installing CMSs at other strategic locations on Dallas area freeways; it is also recommended that TxDOT, in a joint partnership with the Texas Turnpike Authority, deploy permanent CMSs on Dallas North Tollway and SH 190 Tollway. Communication media between the DATMC and the CMSs will vary depending on the availability of owned fiber for the different freeways. Area freeways with a fiber optic backbone in place will utilize fiber; if fiber is not available, a direct telephone line or cellular phone link can provide communications.

In addition to the permanent CMSs, it is recommended that TxDOT have portable CMSs readily accessible to Mobility Assistance Patrols and maintenance crews. The portable CMSs used by the Mobility Assistance Patrols could be stand alone signs or they could be mounted on patrol vehicles. Portable CMSs can be used to provide en-route travel information pertaining to congested freeways due to incidents or maintenance activities on freeway segments not covered by the permanent CMSs. Other uses of portable CMSs include special event signing/routing and advising potential freeway users (surface street traffic) of major freeway incidents and recommending alternate routes. Portable CMSs will have the capability of being controlled manually on site or from the DATMC via a cellular phone link.

It is also recommended that TxDOT continue its policy of requiring construction contractors to supply portable CMSs for large freeway construction/reconstruction projects. The portable CMSs currently being used on the US 75 reconstruction project have been very successful in notifying the general public, usually several days in advance, of upcoming mainlane closures, ramp closures, etc.

4.5.2.2 HAR

Local-area broadcast, more commonly referred to as Highway Advisory Radio (HAR), provides public agencies with the ability to disseminate local traveler information to motorists via the AM radio receivers in their vehicles; roadside or overhead signs instruct motorists to tune their vehicle radios to a specific frequency. HAR systems can broadcast live messages, pre-recorded messages or synthesized messages. Broadcasting synthesized messages will require the HAR systems to be tied into the regional information database. Types of information generally broadcast over HAR systems include severe weather information, construction or maintenance activities, routing to and from special events, incident information and available alternate routes.

HAR systems have an advantage over CMSs in that they are able to disseminate longer messages and can thus provide more specific information to motorists. HAR broadcasts have an advantage over commercial radio broadcast in that they provide more specific and immediate traffic information to motorists. Due to the limited output power (10-watt transmitter) permitted by the Federal Communications Commission (FCC), the signal broadcast quality provided by HAR broadcasts is not as high of quality as commercial radio broadcasts; however, the reduced quality broadcasts provided by HAR systems are more than adequate to serve their purpose of providing travel related advisories and messages to motorists. One of the primary disadvantages of this type system is that drivers must tune their car radios manually to the HAR frequency. However, efforts are underway to develop an automated HAR (AHAR) system. With AHAR, the radio monitors for special transmissions and automatically tunes to the AHAR frequency and mutes the car radio for the duration of the AHAR message.

The Dallas Area-Wide ITS Plan provides for deployment of permanent HAR systems in strategic corridors (corridors with freeways operating with peak hour LOS E-F and/or experiencing high incident rates). A basic HAR system station consists of a 10-watt radio transmitter, recorder/player, and an antenna. Freeway signage (static signs and CMSs) instructing motorists when to tune to a specified HAR frequency must supplment HAR systems. Communication mediums between the DATMC and the HAR system stations will vary depending on availability of owned fiber for the different freeways. Area freeways with a fiber optic backbone in place will utilize fiber. If fiber is not available, either a direct telephone or a cellular phone link can provide communications. Antenna locations are a critical factor in the coverage and quality provided by a HAR system. The approximate radial area coverage for a vertical whip antenna is approximately 8 kilometers. Actual coverage is dependent upon the level of interference from radio stations, power lines, and physical obstructions. A good ground system is also critical to obtaining desired efficiency (22). For the purpose of calculating quantities and cost estimates for this report, a deployment density of one HAR system station per strategic corridor will be assumed (actual deployment locations and densities will be controlled by field conditions).

In addition to deploying permanent HAR systems in strategic corridors, it is recommended that TxDOT Mobility Assistance Patrols be equipped with portable HAR stations with cellular phone link control capability. Portable HAR stations will allow traveler information regarding incidents/accidents/special events to be disseminated to motorists on freeways not covered by the permanent HAR systems.

4.5.3 ATIS Summary

The primary function of ATIS is disseminating traveler information regarding traffic conditions on transportation networks, as well as information regarding the availability and accessibility of alternate routes and/or travel modes to the traveling public. Using available information, travelers will make more informed decisions regarding route planning, travel mode, and the time of day to travel, thus reducing congestion on the overall transportation network. The key to a successful ATIS for the Dallas area is providing travelers with *accurate* and *timely* traffic information. The Dallas Area-Wide ITS Plan provides for pre-trip travel information dissemination via a dial-in telephone system, kiosks, and the Internet; en-route travel information will be provided via CMSs and HAR.

4.6 Advanced Public Transportation Systems

Public transportation systems can utilize many of the ITS technologies. Additional applications are being considered, and research and development activities are examining the use of new and emerging technologies with all types of transit services. These efforts are focusing on enhancing customer information, improving the delivery of transit services, and enhancing the efficient provision of these services through ITS technologies.

Advanced Public Transportation Systems (APTS), which focus on the use of advanced technologies to improve the delivery of transit services and to enhance the cost-effective and efficient provision of these services, is one of the six ITS categories. Transit systems may benefit from the Advanced Traffic Management Systems (ATMS), which include the development and operation of advanced transportation surveillance and monitoring systems to provide detection, communications, and control functions in major travel corridors. Transit can also benefit from the Advanced Traveler Information Systems (ATIS), which include the provision of pre-trip and in-vehicle information to motorists on current traffic and other conditions and real-time guidance on route information. A number of the user services also relate to public transportation, including pre-trip travel information, traveler services information, ride matching and reservation, travel demand management, public transportation management, personalized public transit, and public travel security.

The "Strategic Plan for IVHS in the United States" suggests that the following be considered:

- On-board transit vehicles: automated next and current stop information;
- At transit access points: changeable message signs with scheduled arrival times;
- In homes and offices: static transit schedule information and route displays via TV, cable TV, telephone and personal computers;
- Electronic billing through smart cards for limited transit costs;
- Automatic vehicle location (AVL) systems for fleet tracking; and
- Automated fleet maintenance tracking.

4.6.1 DART ITS Projects Already Underway or Planned

Dallas Area Rapid Transit (DART) has been developing ITS projects for a number of years. The following sections provide a brief description of these projects.

4.6.1.1 Integrated Radio System/Automatic Vehicle Location (AVL)

DART is in acceptance testing of an integrated radio system that includes automatic vehicle location on all of its transit buses and supervisory and support vehicles. The system utilizes the Global Positioning System (GPS) to generate the vehicle location information.

4.6.1.2 Personal Public Transportation

Building on the capability provided by the integrated radio system, DART is also scheduled to test the possibility of "route deviation" service or "personal public transportation." This operational test will evaluate the possibility of picking up off-route passengers based on scheduling allowances and convenience of point of pick-up using the AVL system in combination with a Geographic Information System (GIS) package and an off-the-shelf software package to provide the real-time rerouting. The University of Texas at Arlington and Texas Southern University will be assisting DART with the "personal public transportation" operational test. The primary objective of the test will be to evaluate the increases in ridership using advanced technologies to replace a traditional fixed-route transit service with a combination fixed-route/demand-responsive flexible transit service.

4.6.1.3 Automated High Occupancy Vehicle (HOV) Lane Enforcement

DART, working with TxDOT and TTI, is developing a program of enforcement for the IH 30 (East R.L. Thornton) HOV lane. The technology to verify occupancy of vehicles traveling in the HOV lane is being investigated for possible installation in that corridor; AVI tags and the potential use of imaging technologies are being considered to help enforcement of the minimum occupancy requirements in the IH 30 HOV lanes. As other HOV lanes are implemented, the technologies will be considered for those as well.

4.6.1.4 Automated Fleet Maintenance System

A reliable and accurate functioning Vehicle Maintenance System is one of the most important elements in a transit system's operations. DART has recently installed an automated system for monitoring fluids, mileage and tire tracking. Automatic recording and capture of mileage data is accomplished through a hub-mounted trip recorder installed on each of the DART buses. Each time a DART bus is serviced, its vehicle number and current life-to-date mileage is transmitted from the trip recorder installed on the bus to the fixed mount receivers installed in each service lane. Fluids dispensed to the bus are automatically recorded, and a complete record with vehicle number, mileage, and fuel and oil dispensed is stored on a computer controller at that division (a controller is located in each of the five operating divisions). Once each day, the computers transfer the data to the DART network server. Each controller has the capacity for interface to a tank monitoring system in anticipation of future upgrades to the tank monitoring equipment. The files also include tire tracking information.

4.6.1.5 Enhanced Customer Information Systems

DART has developed a GIS system that includes bus routes, bus stop locations, and landmarks. This GIS system will initially be used to provide the capability for automated trip planning by the DART Customer Assistance Representatives. Initial testing of the trip planning system (Trip Itinerary Planning System - TIPS) is set to begin in mid-September 1995 to January 1996, with introduction of the system for the Customer Assistance Center personnel in February 1996. It is planned that TIPS will later be available at the downtown DART Retail Sales Center as well. A number of other improvements are planned for the retail center that include new LED information boards and video updates on DART activities, integrating the telephone system with the main system, and utilizing voice mail to assist with lost and found calls. A new database for student and senior citizen photo identification cards, similar to the database recently developed for the disabled photo identification cards, will also be developed.

DART is also working closely with the Central Dallas Association's Transportation Management Association and TxDOT in developing five kiosks to be located in the downtown Dallas underground system. The kiosks will include information devices to provide information about DART routes and schedules, as well as updates on TxDOT construction planned and underway. The devices, featuring full matrix color LED signs, will accommodate user interaction.

4.6.1.6 Integrated Transportation Management Systems (ITMS)

Transit systems can benefit from inclusion in ITMS through the provision of real-time information on roadway conditions, travel times, incidents and accidents, and any other special conditions. This information can be used to better manage all types of transit services by diverting vehicles around trouble spots, and thus improving on-time performance, schedule adherence, and service efficiency. In addition, transit vehicles equipped with AVL or advanced radio systems can provide information on traffic conditions on arterial streets to the ITMS. Further, providing the real-time traffic and transit information generated by these systems to commuters may help encourage greater use of transit modes. State departments of transportation and local cities traditionally have been involved in the implementation of transportation management systems and centers. As mentioned elsewhere, the Cities of Dallas, Garland, Plano and Richardson have traffic control centers, and TxDOT is developing a Transportation Management Satellite to manage traffic operations for US 75 and IH 635, as well as other facilities, until the DATMC is implemented. DART has a control center where its AVL system provides data on fleet movement.

The incorporation of some DART operations at TxDOT's Transportation Management Satellite and the use of DART generated information from the DART control center are both planned. DART now intends to operate the IH 35E/IH 635 HOV system from TxDOT's Transportation Management Satellite.

DART will also benefit from the improvements to the arterial street traffic signal system that is underway throughout Dallas County. Improving the timing or phasing of traffic signals can help ensure that buses and other vehicles can maintain a constant speed, thus reducing delays.

4.6.2 Suggested Public Transit ITS Improvements

DART will be considering advanced technologies in the coming years to improve its own efficiency and to attract and maintain a greater customer base. Many of the advances provided by ITS result in greatly increased information and become exponentially beneficial to all citizens of a region when that information is shared among the various governmental institutions. The traveler and the taxpayer are the ultimate beneficiaries of an integrated, "user-friendly" system of transport. Below is an initial listing of proposed ITS projects to be considered.

4.6.2.1 System Management Projects

As the Transportation Management Satellite, and eventually the DATMC, are developed, DART should continue its involvement in the planning and ongoing operations of the centers. DART brings with it a wealth of information about the daily operations of the transportation system that is obtainable from the more than 1,000 vehicles it has driving the streets and freeways of the region daily. In turn, DART will gain the ability for its operations to respond to information processed there. It will be able to reroute, or adjust in other ways, to this information. DART will continue to operate its own Operations Center, but will exchange traffic operations information with the DATMC.

4.6.2.2 Surveillance and Monitoring

As mentioned above, DART has more than 1,000 vehicles driving the transportation system of the Dallas area daily. Its vehicles can be utilized as "probes" in the region, providing information on incidents, indicating travel times, and making other observations--both in an automated fashion through the AVL system and through direct communications with the vehicle operators and system supervisors via the radio system. At the present time, most paratransit vehicles (Handiride) are not equipped with tracking equipment. Vehicles with special needs occupants, whether DART or privately contracted, may require special attention. Furthermore, since these vehicles do not adhere to a fixed route, it may be important to have vehicle location capability. It is recommended that these vehicles be equipped so that their locations can be monitored for security, schedule adherence, and arrival/departure times.

The agency may also use the information generated by the AVL system and other components of the area-wide surveillance and monitoring program to enhance its route scheduling and planning functions.

DART has considered the use of surveillance cameras onboard the DART vehicles. Technological advances have been very rapid in the area of miniaturized video cameras for use in such applications. Use of the information provided by such on-board cameras will be primarily in the area of safety and security--two issues very important to operators and passengers.

4.6.2.3 Information Delivery

DART and the region are developing tools that will enhance delivery of information about the system. The transit agency has a GIS program, which will be the basis for building future information programs. DART should consider the use of the Internet, either through its own homepage or as a part of the TxDOT Homepage. If there are separate homepages developed, each can very easily be written to quickly connect, or lead, to the other. A poll by the Office of Survey Research at the University of Texas indicated that more than 41 percent of Texas households have home computers. The survey conducted in August 1995 shows that 29 percent of those home computers are connected to an on-line service, with that number rapidly increasing. The ability of individuals to receive real-time information on traffic flow and available public transit is no longer a "Star Wars" idea, but a project that could be implemented today. For those without home or office computers that can access the Internet, public libraries and kiosks (public or commercial) at employment and recreational centers can provide Internet access.

It is also suggested that DART take advantage of its own information (provided by the AVL system) to provide real-time information about bus arrival and departure times at major transfer points or other high density areas. Kiosks or personal computer terminals could provide system schedules, scheduled arrival times, and actual arrival times as determined from the tracking system. Such information should also be available at light rail stations.

As mentioned previously, DART is in the process of updating the services provided to customers and potential customers who telephone the agency for information. The agency is enhancing the ability of the customer assistance personnel by providing automated trip information. These systems should continue to be enhanced and improved. DART and other participating agencies should also continue to enhance the Ridestar system of computerized rideshare matching. The possibility for real-time rideshare matching should also be considered.

4.6.2.4 Electronic Fare Collection

ITS technologies provide the opportunity to integrate the payment methods for multiple modes, as well as for other goods and services, making the transit system much more convenient in the process. Smart cards, using a method such as a pre-paid electronic card, can be a convenience to the user and the transit agency. Technology is already available and in use elsewhere and is continuing to be refined. At the least, the smart card could be utilized for both the light rail and bus system. It could also be developed, in coordination with other public agencies and private concerns, to be used for other purchases. Other benefits to be enjoyed by the agency, other than relieving the agency of dealing with currency and coins, could include valuable information to be used in planning and scheduling. In fact, some transit systems have begun to accept regular bankcards (Mastercard and Visa) at the fare box.

4.6.2.5 Interagency Communications

As mentioned in other parts of this plan, one of the main benefits of an area-wide ITS program is the sharing of video and traffic data among the various agencies for the purpose of coordinated, integrated transportation management, particularly under incident conditions. As suggested elsewhere, ultimately a Wide Area Network (WAN) may provide interagency communications. Initially, interagency communications can be by telephone and through an Internet homepage. DART should be a participant in the development of these systems.

4.6.2.6 Future Public Transit Service Adaptations

As DART completes studies and demonstration projects testing ITS technologies, the agency should consider making service changes that respond to customer desires. As an example, should the demonstration project that is testing the possibility of deviating from fixed route service to pick-up and deliver passengers prove to be successful, implementation of flexible routing should be considered. It has the potential to be more cost effective and more convenient for passengers, a win-win situation for the agency and the region.

4.6.3 APTS Summary

Cooperation among the various agencies responsible for the transportation system and application of ITS technologies will greatly enhance travel in the area. All modes, including transit, should realize greater operating efficiencies and improved effectiveness. The provision of real-time information on traffic conditions through an integrated system will allow DART to respond to accidents and incidents in a proactive manner by rerouting and rescheduling buses. Providing real-time information on traffic and transit to individuals will allow them to make more informed travel choices and will result in increased transit ridership.

4.7 Commercial Vehicle Operations

Intelligent Transportation Systems address the needs of a wide range of vehicles, drivers, and travelers. However, commercial vehicle operations present a unique set of requirements to achieve the desired benefits outlined for motor carriers and regulatory agencies involved in commerce. Automating existing manual procedures, electronically capturing and reporting data, and improving the flow of information between carriers and regulatory agencies and between operators and dispatchers will increase the efficiency of traffic management and administration by transit agencies, state, and local governments.

The need for efficient transport of goods and materials has a significant impact on both public and private sectors. This has led to an increased interest in ITS for commercial operations. ITS technologies expedite commercial vehicle movements helping to reduce delays and enhance the movement of people and goods. These elements include the automation of a number of administrative and operational activities involving commercial vehicles, including trucks, intercity buses, and other commercial fleets. While the potential benefits from a comprehensive ITS program in CVO are broad-based, the primary goals are to be found in enhanced efficiency, productivity, customer service, and safety in transport of cargo.

CVO technologies include:

- Electronic Weigh-in-Motion (WIM) stations;
- Automatic Vehicle Location (AVL) tracking;
- In-vehicle navigation and communications; and
- Automatic Vehicle Identification (AVI).

4.7.1 Electronic Weigh-in Motion (WIM)

Weight information for large trucks traveling at highway speeds can be measured without stopping the truck, which would eliminate the delay associated with weigh stations. The weight data would be used to determine if the vehicle is traveling legally and for planning data purposes. Exceptions and violations would be brought to the attention of enforcement officials.

4.7.2 Automatic Vehicle Location (AVL) Tracking

Automatic vehicle location technologies are used to identify vehicle locations within an information network. Real-time information regarding vehicles' locations and progress may be utilized to track schedule adherence of transit and commercial vehicle fleets. This information could then be used to improve vehicle response times, to provide transit information to passengers, to indicate roadway conditions, and to improve safety of personnel and cargo (using automated MAYDAY alarms). The technology could also be applied to tracking and identifying of hazardous cargo.

4.7.3 In-vehicle Navigation and Communications

Much of the information ITS can provide is useful to all drivers, but CVO drivers, because of their vehicles, may need more specialized data. Trucks, for example, cannot be operated on all roads for a variety of reasons such as restrictive geometry and substandard bridges. Operators of these vehicles must have accurate, detailed information about any proposed alternatives to the routes they normally travel. Vehicles carrying hazardous materials have similar kinds of unique information needs.

4.7.4 Automated Vehicle Identification (AVI)

Automatic vehicle identification (AVI) provides electronic reading and recording of a vehicle's identity as it passes specific points, without any action by the driver or an observer. Information that identifies a vehicle is encoded onto a vehicle-mounted transponder or toll tag. As the vehicle passes a site with an AVI antenna, the tag is activated to transmit the coded data to the antenna and then to an adjacent roadside reader or processor. The primary applications for AVI are to automate toll collections, to enforce regulation and to collect commercial vehicle revenue. These tags can be read at highway speeds, thus allowing vehicle credentials and appropriate certifications to be identified without stopping the vehicle. By matching codes between scanner sites, link travel time and link information can be developed, and origin destination can be improved for planners.

4.7.5 Applications of Technology

4.7.5.1 Information Exchange

The most significant gain from ITS technologies for CVO applications is the use of electronic information exchanges using AVI tags. Information needed at weigh stations and border crossings can be sent electronically, therefore, reducing the number of stops required of the vehicle. Also, standardized automated toll collection will eliminate the need for multiple toll tags and delays at toll collection sites. This will be done with electronic permitting, which will enable a motor carrier to obtain and pay electronically for all required licenses, registrations, and permits on a just-in-time basis. An electronic record of the vehicle's credentials would be sent to the motor carrier's headquarters or other desired location. A supporting database would contain information about these transactions for access by appropriate governmental authorities.

By expanding the information collected, carriers can obtain essential information for managing their fleets, and governmental agencies can obtain information for planning purposes. Electronic systems will reduce the expense and effort on a motor carrier to comply with State licensing and reporting requirements. The States will likewise benefit through more efficient program administration, better enforcement of State requirements, and a higher incidence of carrier compliance with State requirements.

Another benefit is the simplification of governmental agencies tracking and monitoring the identity and condition of sensitive cargo in their area. Components of such a system would include electronic hazardous material shipment identification and tracking using AVI and AVL technologies. Early detection of cargo problems would allow time for the driver to respond and possibly to prevent a serious accident. Electronic placarding data would provide enforcement and incident response teams with timely, accurate data on cargo, enabling them to properly react in an efficient manner (23).

4.7.5.2 Equipment and Communication Standards

While equipment and communication standards are important to the ITS marketplace, they are critical to CVO. Large vehicle fleets demand equipment standardization in order to reduce the training and maintenance costs associated with parts proliferation. Standards for AVI are crucial given the essential role of AVI in so many CVO applications. Electronic vehicle equipment interface standards are essential if vehicle manufacturers are to be able to integrate add-on devices efficiently. Trucks that travel nationwide need to receive traffic information broadcasts anywhere without having to carry several different kinds of receivers. They also require electronic map databases that cover the entire nation. Guidance or standardization will be necessary at the national level to ensure compatibility issues are resolved (23).

4.7.5.3 Public/Private Partnership

The nature of CVO deployment to date has been a cooperative effort of the trucking industry and State agencies. Programs such as Help/Crescent and Advantage I-75 are examples of this cooperative public-private partnership. In-vehicle equipment, by its autonomous nature, is outside the scope of the public sector, but the governmental agencies must be prepared to support the real-time information needs of such equipment. Because of the necessary cooperation for successful CVO deployment, federal, state and local governments, and truck and bus companies need to play a more active role in decisions affecting the CVO ITS policies being developed.

4.7.5.4 Privacy Issues

The technology and information that will generate productivity improvements also raise sensitive privacy issues. The deployment of AVI and AVL technologies can provide almost constant information on a commercial vehicle and, accordingly, a driver's location and status of cargo. Such information can be extremely sensitive in the competitive CVO marketplace. Safeguards by both government agencies and commercial carriers must be considered (23).

4.7.5.5 Human Factors

While some research is underway, additional effort should focus on the way drivers interact with more complex on-board computer capabilities. Technology can give drivers the opportunity to obtain real-time highway and vehicular system information. The optimum way to display the information should be determined so that a commercial driver is not overloaded and can react in a safe, predictable manner (23).

4.7.6 Summary

Most of ITS elements applicable to Commercial Vehicle Operations will have application on a statewide or national level rather than within an urban area such as Dallas, as they apply to vehicle operation or fleet management. Any improvements made in ATIS or ATMS will of course accrue to CVO as a part of the traffic stream. Tracking or identifying technology such as AVI or AVL has the potential to provide useful travel data to ATMS, but privacy issues must be resolved. Commercial vehicle operators will probably only be willing to participate in ITS if there is a direct measurable economic benefit to offset their investment.

4.8 Advanced Vehicle Safety Systems

The purpose of Advanced Vehicle Safety Systems (AVSS), formerly known as Advanced Vehicle Control Systems (AVCS), is to enhance capacity and traffic flow on roadways and to improve traveler safety by averting accidents. AVSS include technologies that automatically control the driving tasks, as well as those that assist in the motorist's perception and reaction to roadway hazards. This divides AVSS into driver assistance advancements and vehicle-to-roadside control technologies.

4.8.1 Driver Assistance

Driver assistance advancements provide passive and active functions. The passive side of AVSS enhances the driver's ability to take preventative actions. Examples of passive functions are collision detection sensors used to alert drivers to impending blindspot collisions (side-to-side and reverse). Active functions control the vehicle's speed or direction to help prevent driving conflicts. The anti-lock braking systems currently standard in most new automobiles are examples of active functions.

4.8.2 Vehicle-to-Roadside Control

The next step in AVSS technologies is the infrastructure based systems that would rely on the roadway for information and control. Real-time information is shared between the vehicle and the roadway in a way that benefits both safety and mobility.

The following long term advances will be vehicle-oriented in nature:

- Automated braking systems for collision avoidance;
- Automated vehicle guidance systems;

- Platooning;
- Advanced in-vehicle information; and
- Transmitting in-vehicle vision systems.

For example, information concerning roadway conditions would be sent to the vehicle, and the control system would respond accordingly. Another aspect of vehicle to roadside communication is the use of collision detection sensors in conjunction with vehicle control. This automated vehicle guidance system provides immediate control that would steer the car to avoid a potential accident. This reduces the driver's perception and reaction time needed. Also, collision detection sensors can improve roadway capacity by enabling closer vehicle headways and eliminating speed differentials between vehicles traveling in the same lane. These systems will have added benefits of reduced fuel consumption and travel delays.

4.8.3 Implementation

AVSS is still in the experimental stages of development. The public sector needs to support and monitor on-going research efforts. This will prepare the public sector for the needs of AVSS. These needs will include dedicated lanes for automatic vehicle platooning and continuous vehicle-to-roadway-to-traffic management center communications and tracking.

The architecture for AVSS will need to focus on the following:

- Vehicle to infrastructure communications bandwidth and protocols to support the required exchange of information;
- Performance of sensors compatible with the millisecond reaction times of vehicle AVSS components; and
- Data processing capabilities of the ITS infrastructure is adequate to support the higher density and higher speed of traffic that will occur when AVSS is implemented.

The public sector will also need to design communications with an open architecture to ensure compatibility with systems provided by various vendors of in-vehicle products.

4.8.4 Summary

AVSS still requires a significant amount of research and development. AVSS is contingent on the successful reliability and implementation of the communications links and the control components, both from the system infrastructure and the software and hardware in the vehicles' sensors. Once implementation is possible, driver trust and liability for a car under automatic control will become a growing concern. These systems will likely be expensive and not available for retrofit into older cars, thus delaying AVSS implementation even longer. A better idea of the feasibility and benefits of AVSS will be seen once testing and implementation show these systems to be reliable.

Currently, AVSS research requires extensive participation from the private sector. The FHWA has shown interest in AVSS and will be providing additional funding in the future. Since the benefits of AVSS in the near-term to medium-term horizon are limited, they will most likely not affect current ITS implementation.

4.9 Advanced Rural Transportation Systems

The focus of the Dallas Area-Wide ITS Plan has been on the urban area. During the course of the plan development, FHWA identified Advanced Rural Transportation Systems (ARTS). The following paragraphs give a brief overview of some ARTS elements.

4.9.1 Introduction

Although the major emphasis of ITS has been congestion management in urban areas, ITS has also identified needs for rural travelers. Nationally, approximately 80% of roadway mileage is considered rural. While only 40% of vehicle miles traveled occurs on rural roads, 75% of heavy trucks and 80% of tourist travel occur there. While 30% of traffic accidents occur on rural roads, 60% of traffic fatalities occur there. Due to these statistics, several state DOTs have developed programs in rural ITS.

Studies have found that transportation-related issues for rural corridors, while sometimes similar, are most often quite different from urban corridors. The dynamics of rural travel are characterized by long distances, unfamiliar territories, varying environments, and higher speeds. The precise definition of "rural" is not universally agreed upon, but is a function of:

- Roadway classification;
- Traffic volumes;
- Population density;
- Land use; and
- Travel characteristics.

Many components of ITS can be adapted for both rural and urban settings. However, safety and information services are the prime needs for rural locations. These services include the following:

- Information services:
    - Pre-trip information including weather and road conditions;
    - Information relating locations of construction zones or rest areas;
    - Information targeted to tourists within the area; and
    - Roadside call boxes and information kiosks.
- Safety services:
    - Mayday systems;
    - Railroad crossing warning systems; and
    - Locations of emergency services.

4.9.2 Mayday

In a survey conducted under sponsorship of FHWA (24), rural travelers expressed two prime concerns. Rural travelers identified the ability to transmit a Mayday signal when in distress as the highest priority need. The National Highway Traffic Safety Administration (NHTSA) estimated that during 1991, over 6 million single-vehicle crashes were reported to police and other law enforcement agencies. These crashes resulted in the loss of almost 42,000 lives. It is widely understood that the biggest factor in reducing the number of casualties is the time required for notification and response. Data has shown that the crash notification time in rural areas is almost twice the notification time in urban areas.

A vehicle equipped with the Mayday system will have a built-in crash sensor and global positioning system (GPS). A signal will be sent either when the crash sensor is triggered or when the driver sends the signal manually. The GPS will determine the vehicle's location, and this information will be sent via a cellular system to the appropriate response center.

A large-scale operational test of an ITS Mayday emergency dispatch system has been launched in Colorado under the sponsorship of FHWA. This Mayday operational test is evaluating the use of GPS location technology and cellular phone two-way communications to provide assistance to travelers in an emergency dispatch area.

4.9.3 Pre-Trip Information

Pre-trip information was rated as the second highest priority to rural travelers. Primary information needs are related to advisory, safety, and warning. They include obtaining information on weather and road conditions with sufficient advanced warning to avoid adverse impacts. Weather sensors are being used in several rural areas, for example, the Texas Panhandle, to give early warning of adverse roadway conditions. There are also concerns about regulations and other restrictions en-route. These users view ATIS applications as potential tools that can assist them in traveling safely and efficiently.

Because of the extent of the rural roadway system and the lack of infrastructure to support ATMS and ATIS functions, a cooperative effort of highway and law enforcement agencies, economic development and tourism departments, county governments, the National Park Service, and other interest groups will be required.

4.9.4 Summary

Safety services and traveler information in rural areas are desired, and these areas can benefit from ITS applications. TxDOT currently has a work task for investigation of potential rural applications in the Dallas District.

4.10 ITS Market Package Characterization

Based on the recommendations of Chapter 4, Table 4-7 identifies the Market Packages pertinent to the Dallas Area-Wide Plan in the near term (i.e., ranked "high" by the Steering Group). These components of the National ITS Architecture provide an architecture based description of the Dallas Area-Wide ITS Plan.

Table 4-7. Dallas Area-Wide Market Packages

Market Packages
Transit Vehicle Tracking
Transit Fixed-Route Operations
Paratransit Operations
Transit Passenger and Fare Management
Transit Security
Transit Maintenance
Multi-modal Coordination
Broadcast Based ATIS
Interactive ATIS with Driver and Traveler Information
Interactive ATIS with Infra Route Selection
Interactive ATIS with Yellow Pages & Reserv
Interactive ATIS with Dynamic Ridesharing
Mayday Support
Network Surveillance
Advanced Integrated Signal/Route Control
Dynamic Toll/Parking Fee Management
Traffic System Maintenance
Virtual TMC and Smart Probe Data
Probe Surveillance
Basic Signal Control
Advanced Coordinated/Integrated Signal Control
HOV and Reversible Lane Management
Incident Detection System
Incident Dispatch Coordination/Comm System
Traffic Information Dissemination
Traffic Network Performance Evaluation
Freight Administration
Material Tracking and Response
HAZMAT Management
Emergency Routing
Emergency Response
E-911 Interface
ITS Planning

The National ITS Architecture documents define the association between market packages and specific equipment packages (25, 26). The ITS National Architecture defines an equipment package as "a set of equipment/capabilities which are likely to be purchased by an end-user to achieve a desired capability" (27). As such, they represent deployment options that are candidates for deployment in the Dallas area. Table 4-8 identifies the equipment packages associated with near-term deployment of the Dallas Area-Wide ITS Plan for ITS advanced public transit systems. Table 4-9 identifies the equipment packages associated with near-term deployment of the Dallas Area-Wide ITS Plan for ITS advanced traveler information systems. Table 4-10 identifies the equipment packages associated with near-term deployment of the Dallas Area-Wide ITS Plan for ITS advanced traffic management systems. Table 4-11 identifies the equipment packages associated with near-term deployment of the Dallas Area-Wide ITS Plan for ITS commercial vehicle systems. Finally, Table 4-12 identifies the equipment packages associated with near-term deployment of ITS emergency management systems.

Table 4-8. Advanced Public Transit Systems Equipment Packages

Market Packages	Equipment Packages
Transit Vehicle Tracking	Basic Information Broadcast
	Transit Center Tracking & Dispatch
	On-board Trip Monitoring System
Transit Fixed-Route Operations	Interactive Infrastructure Information
	Transit Center Fixed Route Operations
	Vehicle Dispatch Support
Paratransit Operations	Infrastructure Provided Dynamic Ridesharing
	Personal Interactive Information Reception
	Remote Interactive Information Reception
	Transit Center Paratransit Operations
	On-board Transit Driver Interface
Transit Passenger and Fare Management	Interactive Infrastructure Information
	Remote Transit Fare Management
	Transit Center Fare & Load Management
	On-board Transit Fare & Load Management
Transit Security	Emergency Response Management
	Remote Transit Security Interface
	Transit Center Security
	On-board Transit Security
Transit Maintenance	Fleet Maintenance Management
	On-board Maintenance
Multi-modal Coordination	Interactive Infrastructure Information
	Roadside Signal Priority
	TMC Multi-modal Coordination
	Transit Center Multi-modal Coordination
	On-board Signal Coordination

Table 4-9. Advanced Traveler Information Systems Equipment Packages

Market Packages	Equipment Packages
Broadcast Based ATIS	Basic Information Broadcast
	Personal Basic Information Reception
	Remote Basic Information Reception
	Basic Vehicle Reception
Interactive ATIS with Driver and Traveler Info	Interactive Infrastructure Information
	Personal Interactive Information Reception
	Remote Interactive Information Reception
	Interactive Vehicle Reception
Interactive ATIS with Infra Route Selection	Infrastructure Provided Route Selection
	Personal Interactive Information Reception
	Interactive Vehicle Reception
Interactive ATIS with Yellow Pages & Reserv	Infrastructure Provided Yellow Pages & Reservation
	Personal Interactive Information Reception
Interactive ATIS with Dynamic Ridesharing	Infrastructure Provided Dynamic Ridesharing
	Personal Interactive Information Reception
	Ridesharing
Mayday Support	Emergency Mayday & E-911 Interface
	Personal Mayday Interface
	Remote Mayday Interface
	Vehicle Mayday Interface

Table 4-10. Advanced Traffic Management Systems

Market Packages	Equipment Packages
Network Surveillance	Roadway Basic Surveillance
	Collect Traffic Surveillance
Advanced Integrated Signal/Route Control	ISP Advanced Integrated Control Support
	TMC Advanced Integrated Control
Dynamic Toll/Parking Fee Management	Parking Management
	Toll Administration
	Toll Plaza Toll Collection
	TMC/Toll Parking Coordination
	Vehicle/Toll Parking Interface
Traffic System Maintenance	Roadside Fault Reporting
	Traffic Maintenance
Virtual TMC and Smart Probe Data	Automated Road Signing
	Distributed Road Management
	Smart Probe
Probe Surveillance	ISP Probe Information Collection
	Probe Data Via Toll Collection
	TMC Probe Information Collection
	Probe Vehicle Software
Basic Signal Control: Surface Street Control	Roadway Basic Signal Control
	TMC Basic Signal Control
Basic Signal Control: Freeway Control	Roadside Support for Freeway Control
	TMC Incident Detection
Advanced Coordinated/Integrated Signal Control	Roadway Advanced Signal Controls
	TMC Advanced Signal Control
HOV and Reversible Lane Management	Roadway HOV Lane Usage
	TMC/HOV Lane Management
Incident Detection System	Roadway Incident Detection
	TMC Incident Detection
Incident Dispatch Coordination/Comm System	Emergency Response Management
	TMC Incident Dispatch Coordination/Communication
Traffic Information Dissemination	Roadway Traffic Information Dissemination
	TMC Traffic Information Dissemination
Traffic Network Performance Evaluation	TMC Traffic Network Performance Evaluation

Table 4-11. Commercial Vehicle Operations

Market Packages	Equipment Packages
Freight Administration	On-board Cargo Monitoring
	Freight Administration & Management
HAZMAT Management	CV Safety Administration
	On-board CV Electronic Data
	Fleet HAZMAT Management
	TMC Incident Dispatch Coordination / Communication

Table 4-12. Emergency Management

Market Packages	Equipment Packages
Emergency Routing	Emergency Vehicle Routing & Communications
	On-board Trip Monitoring System
	ERMS Route Plan Information Dissemination
	TMC Multi-modal Coordination
Emergency Response	Emergency Response Management
	On-board EV Safety
	ERMS Route Plan Information Dissemination
E-911 Interface	Emergency Mayday & E-911 Interface
ITS Planning	Data Collection and ITS Planning

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5. DALLAS AREA-WIDE ITS ARCHITECTURE

5. DALLAS AREA-WIDE ITS ARCHITECTURE

5.1 National Transportation Architecture

The National ITS Architecture uses a reference model that contains three layers: communications, transportation and socioeconomic. The transportation layer consists of nineteen interconnected subsystems. These subsystems align closely with existing jurisdictional and physical boundaries that characterize the operation and maintenance of existing transportation systems. Figure 5-1 illustrates the transportation and communication layers of the architecture by depicting both the subsystems (transportation layer elements) and the major communications interconnects (communication layer elements) required to support ITS services. The figure represents a fully deployed architecture in the twenty year time frame.

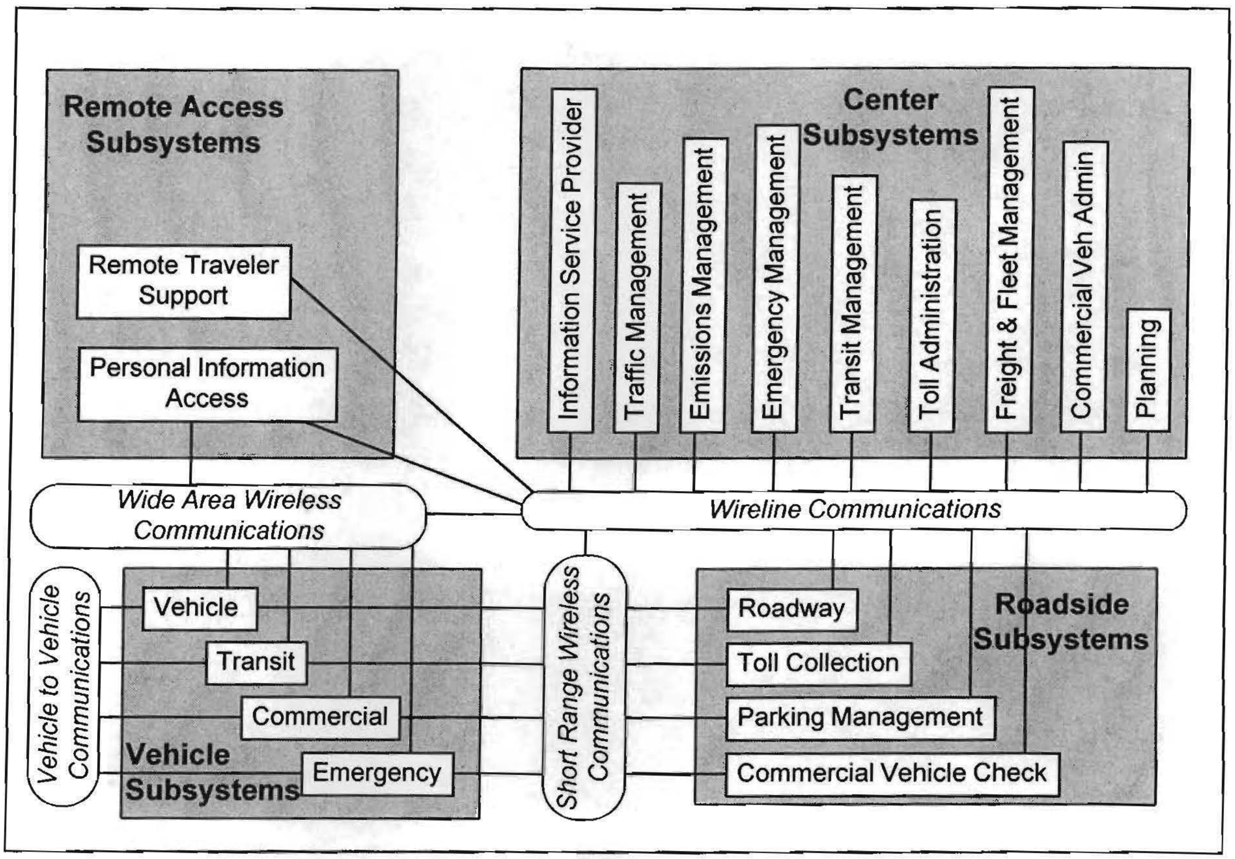

Figure 5-1. Twenty Year National Architecture

As illustrated in Figure 5-1, the ITS architecture subsystems may be grouped into four subsystem classes that share basic functional, deployment, and institutional characteristics. These classes (Center, Roadside, Vehicle, and Remote Access) are used to organize the following descriptions of ITS subsystems. The brief descriptions are summaries of more comprehensive treatments supplied to the FHWA at the June 1995 National Architecture Interim Program Review.

Center Subsystems

The center subsystems provide management, administration, and support functions for the transportation system.

- Commercial Vehicle Administration Subsystem

  The Commercial Vehicle Administration Subsystem will operate at one or more fixed locations within a region. This subsystem performs administrative functions supporting credentials, tax, and safety regulations.

- Emergency Management Subsystem

  The Emergency Management Subsystem operates in various emergency centers supporting public safety including police and fire stations, search and rescue special detachments, and HAZMAT response teams.

- Emissions Management Subsystem

  This subsystem provides the capabilities for air quality managers to monitor and manage air quality.

- Fleet Management Subsystem

  The Fleet Management Subsystem provides the capability for commercial drivers and dispatchers to receive real-time routing information and access databases containing vehicle and cargo locations as well as carrier, vehicle, cargo, and driver information.

- Information Service Provider Subsystem

  This subsystem provides the capabilities to collect, process, store, and disseminate traveler information to subscribers and the public at large. It is likely that this subsystem will be deployed in various manifestations, some private and focused on specific services and market segments, others public and directed towards general public information delivery.

- Traffic Management Subsystem

  This subsystem communicates with the Roadway Subsystem to monitor and manage traffic flow.

- Toll Administration Subsystem

  The Toll Administration Subsystem provides general payment administration capabilities to support electronic assessment of tolls and other transportation usage fees.

- Transit Management Subsystem

  The Transit Management Subsystem provides the capability for determining accurate ridership levels and implementing corresponding fare structures.

<u>Roadside Subsystems</u>

These infrastructure subsystems provide the direct interface to vehicles traveling on the roadway network.

- Commercial Vehicle Inspection Subsystem

  The Commercial Vehicle Inspection Subsystem supports automated vehicle identification at mainline speeds for credential checking, roadside safety inspections, and weigh-in-motion.

- Parking Subsystem

  The Parking Subsystem provides the capability to provide parking availability and parking fee information, to allow for parking payment without the use of cash with a multiple use medium, and to support the detection, classification, and control of vehicles seeking parking.

- Roadway Subsystem

  This subsystem includes the equipment distributed on and along the roadway that monitors and controls traffic.

- Toll Collection Subsystem

  Using pricing structures for locally determined needs, including the capability to implement various road pricing policies, the Toll Collection Subsystem provides the capability for vehicle operators to pay tolls without stopping their vehicles.

Vehicle Subsystems

These subsystems are all vehicle-based and contain driver information, vehicle navigation, and advanced safety systems functions.

- Personal Vehicle Subsystem

  This subsystem resides in an automobile and provides the sensory, processing, storage, and communications functions necessary to support efficient, safe, and convenient travel by personal automobile.

- Commercial Vehicle Subsystem

  This subsystem resides in a commercial vehicle and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient freight movement.

- Emergency Vehicle Subsystem

  This subsystem resides in an emergency vehicle and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient emergency response.

- Transit Vehicle Subsystem

  This subsystem resides in a transit vehicle and provides the sensory, processing, storage, and communications functions necessary to support safe and efficient movement of passengers.

Remote Access Subsystems

The traveler subsystems include the equipment that is used by the traveler to gather information and to access other traveler services prior to a trip and while en-route.

- Personal Information Access Subsystem

  This subsystem accesses traveler information at home, at work, and other locations frequented by the traveler using personal fixed and portable devices over multiple types of electronic media.

- Remote Traveler Support Subsystem

  This subsystem provides access to traveler information at transit stations, transit stops, other fixed sites along travel routes, and at major trip generation locations, such as special event centers, hotels, office complexes, amusement parks, and theaters.

5.2 Communication Layer Architecture

Figure 5-1 presents the relationship between the Communication Layer and the Transportation Layer. The communication architecture has two components: one wireless and one wireline. The applicable communications technologies are as follows.

- Wide Area Wireless Communications
  These systems are cell-based wireless infrastructures supporting wide-area information transfer (most data flows). The cell-based airlink, from a mobile terminal to one of a set of base stations, provides connections between mobile users or between mobile and fixed network-connected users (e.g., those connected to the telephone network). It is typified by the current cellular telephone network, the larger cells of Specialized Mobile Radio, and PCS.

- Short Range Wireless Communications
  Short-range airlink used for close-proximity (less than 15-30 meters) transmissions between a mobile user and a base station, typified by transfers of vehicle identification numbers at toll booths.

- Vehicle to Vehicle Communications
  Dedicated wireless system handling high data rate, with a low probability of error, line of sight transmission, and Automated Highway System (AHS)-related data flows, such as vehicle to vehicle transceiver radio systems.

- Wireline Communications
  Information transfer between two fixed entities. Typically, this interface will use one of the many alternative existing public or private networks that may physically include wireless (e.g., microwave) as well as wireline infrastructure. This infrastructure is typified by fixed (as compared to mobile) transmission sites.

5.3 Equipment Packages and Subsystems

Section 4.10 identified the National Architecture equipment packages relevant to the Dallas Area. The equipment package tables provided in that section of the document were selected based on the Steering Group prioritization of ITS user services. Those tables organized the equipment packages based on broad "functional" categories of ITS service (ATIS, APTS, ATMS, AVSS, CVO, EM and ITS). These same equipment packages can be aggregated by subsystem as well. Table 5-1 enumerates the relationships between equipment packages and the subsystems identified in Section 5.1.

These equipment package subsystem affiliations will be used in Section 5.4 to assist with describing architecture based deployment descriptions of ITS in the Dallas area.

Table 5-1. Dallas Area Equipment Packages Organized by Subsystem

Equipment Package	Subsystem
CV Safety Administration	Commercial Vehicle Administration
On-board Cargo Monitoring	Commercial Vehicle Subsystem
On-board CV Electronic Data	
Emergency Mayday & E-911 Interface	Emergency Management
Emergency Response Management	
Emergency Vehicle Routing & Communications	
On-board EV Safety	Emergency Vehicle Subsystem
On-board Trip Monitoring System	
Freight Administration & Management	Freight & Fleet Management
Fleet HAZMAT Management	
Basic Information Broadcast	Information Service Provider
ERMS Route Plan Information Dissemination	
Infrastructure Provided Dynamic Ridesharing	
Infrastructure Provided Route Selection	
Infrastructure Provided Yellow Pages & Reservation	
Interactive Infrastructure Information	
ISP Advanced Integrated Control Support	
ISP Probe Information Collection	
Parking Management	Parking Management
Personal Basic Information Reception	Personal Information Access
Personal Interactive Information Reception	
Personal Mayday Interface	
Data Collection and ITS Planning	Planning Subsystem
Remote Basic Information Reception	Remote Traveler Support
Remote Interactive Information Reception	
Remote Mayday Interface	
Remote Transit Fare Management	
Remote Transit Security Interface	
Transit Center Security	
Automated Road Signing	Roadway Subsystem
Roadside Fault Reporting	
Roadside Signal Priority	
Roadside Support for Freeway Control	
Roadway Advanced Signal Controls	
Roadway Basic Signal Control	
Roadway Basic Surveillance	
Roadway HOV Lane Usage	
Roadway Incident Detection	
Roadway Traffic Information Dissemination	
Probe Data Via Toll Collection	Toll Administration
Toll Administration	
Toll Plaza Toll Collection	Toll Collection

Table 5-1. Dallas Area Equipment Packages Organized by Subsystem - continued

Equipment Package	Subsystem
Collect Traffic Surveillance	Traffic Management
Distributed Road Management	
TMC / HOV Lane Management	
TMC / Toll Parking Coordination	
TMC Advanced Integrated Control	
TMC Advanced Signal Control	
TMC Basic Signal Control	
TMC Incident Detection	
TMC Incident Dispatch Coordination / Communication	
TMC Multi-modal Coordination	
TMC Probe Information Collection	
TMC Traffic Information Dissemination	
TMC Traffic Network Performance Evaluation	
Traffic Maintenance	
Fleet Maintenance Management	Transit Management
Transit Center Fare and Load Management	
Transit Center Fixed Route Operations	
Transit Center Multi-modal Coordination	
Transit Center Paratransit Operations	
Transit Center Tracking & Dispatch	
On-board Maintenance	Transit Vehicle Subsystem
On-board Signal Coordination	
On-board Transit Driver Interface	
On-board Transit Fare & Load Management	
On-board Transit Security	
On-board Trip Monitoring System	
Vehicle Dispatch Support	
Basic Vehicle Reception	Vehicle
Interactive Vehicle Reception	
Probe Vehicle Software	
Ridesharing	
Smart Probe	
Vehicle / Toll Parking Interface	
Vehicle Mayday Interface	

5.4 Architecture Representations of Dallas Area-Wide Deployment

The National Architecture development process is developing a common set of definitions, subsystems and data flows from which to describe ITS systems. As part of their work effort, the Teams are forming a representation of each ITS Service and each subsystem based upon these uniform definitions and upon the perspective of a twenty year build out (full ITS deployment). However, the Dallas Area-Wide Plan focuses on a near term deployment of ITS based upon Steering Group prioritization of ITS user services. In the near term, not all subsystems will be deployed. Initial emphasis will be placed on construction of core ATMS infrastructure, utilization of existing transit investments and integration of toll capabilities. Existing deployment might be characterized from an architectural subsystem and communications perspective as shown in Figure 5-2.

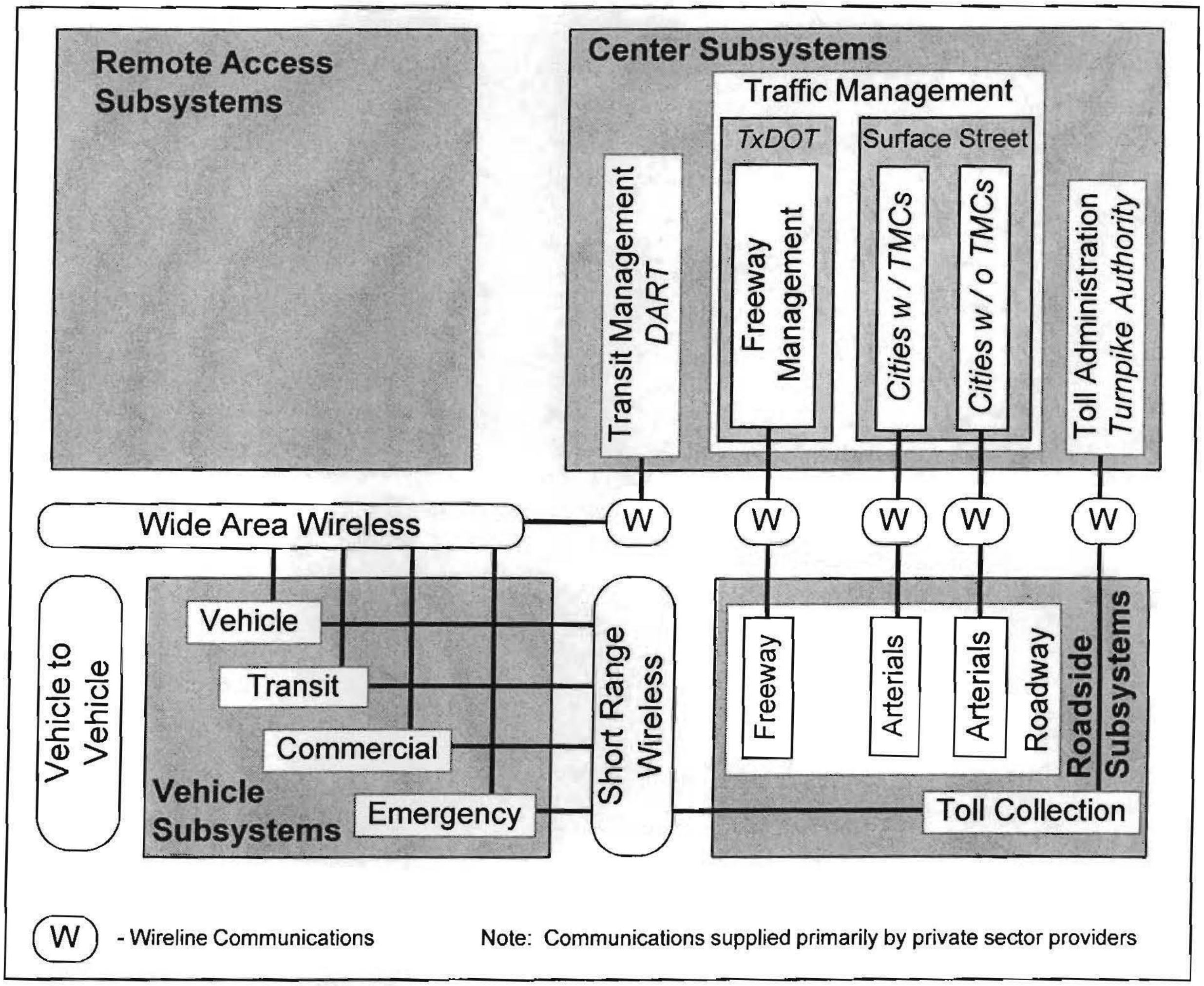

Figure 5-2. Existing Architecture in Terms of Subsystems and Communications

Figure 5-2 depicts the lack of interconnection between subsystems. It illustrates the dedicated subsystem to infrastructure communications that are currently deployed. Figure 5-3 illustrates the near term ITS deployment in the Dallas area and identifies agencies involved (those shown in italics).

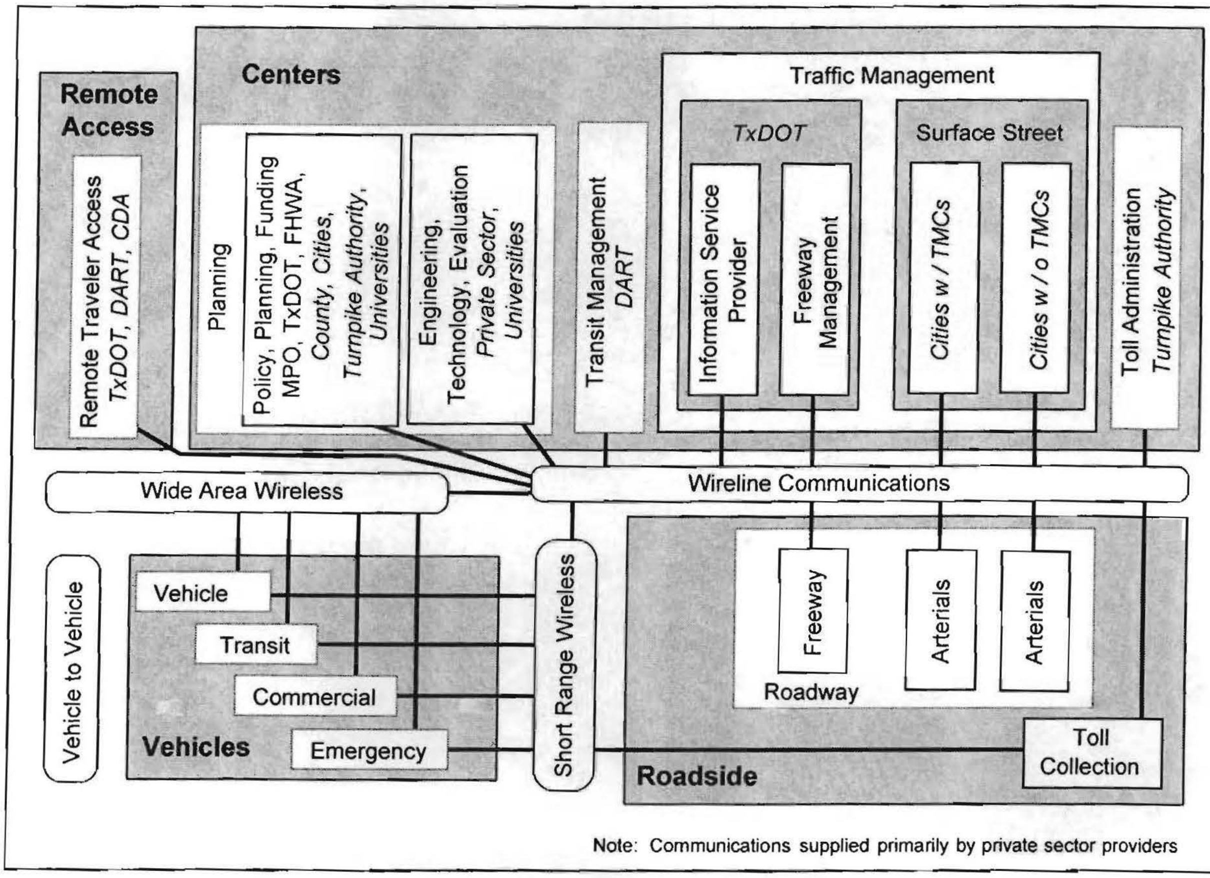

Figure 5-3. Near-Term Dallas ITS Architecture

The following two sections illustrate how these architecture concepts might be tailored to the Dallas area. The first section focuses on Traffic Management and the second on Incident Management. Each section contains a figure illustrating the applicable subsystems and the information flows between subsystems. Following each illustration is a description of the information flows cross-referenced to the numerically designated information flows on the diagrams. These diagrams were derived from National ITS Architecture document generalized user service block diagrams (1).

5.4.1 Traffic Management

Figure 5-4 illustrates the Traffic Control User Service as potentially deployed in the Dallas Area.

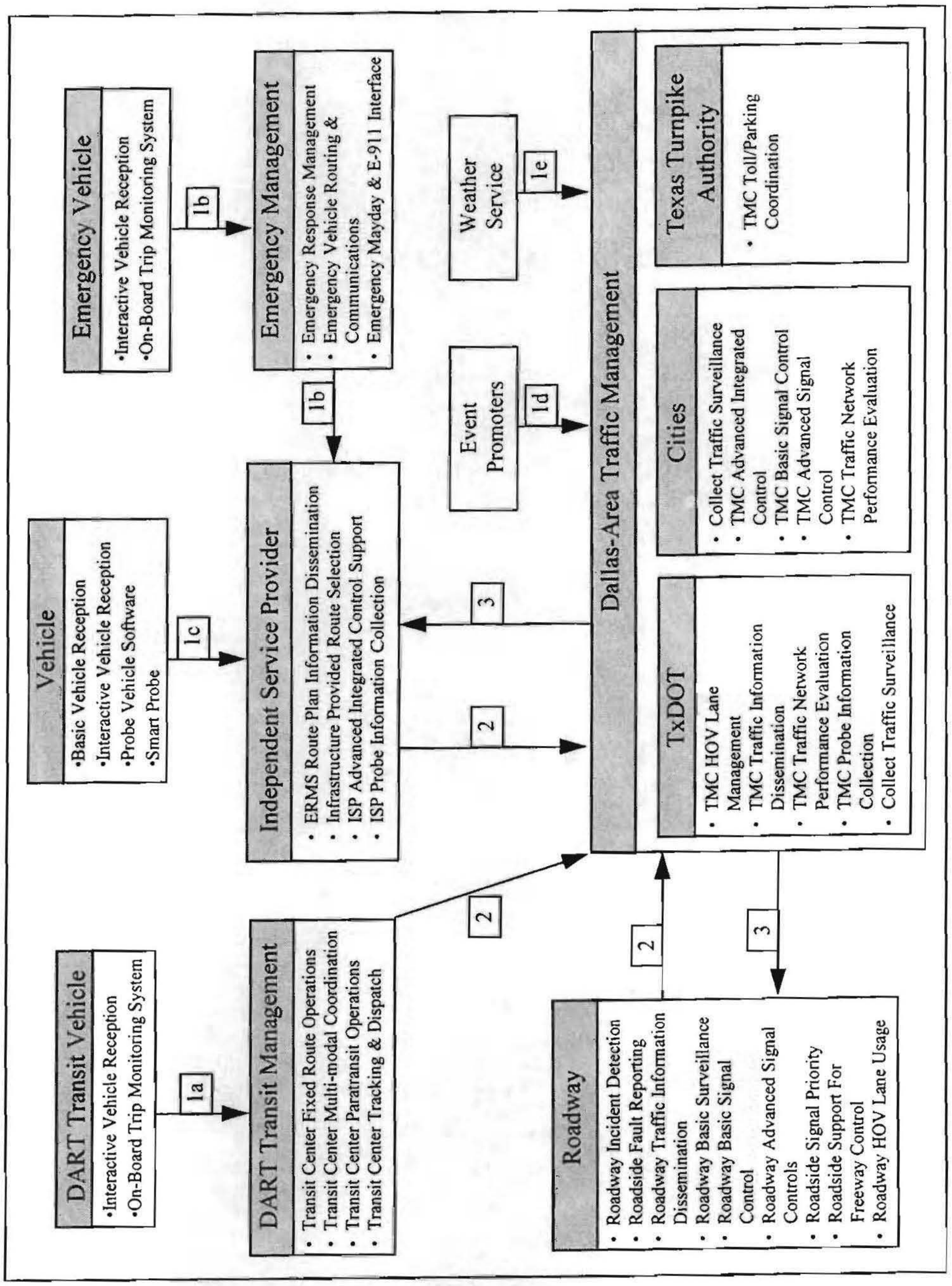

Figure 5-4. Dallas Area Traffic Control Architecture Representation

In this figure TxDOT will initially perform the Independent Service Provider (ISP) function. The information flows depicted in Figure 5-4 are summarized as follows.

1. Various vehicle traffic management service requirements are collected:

    a. DART Transit vehicles report their status (including location, a timestamp and occupancy) to the Dallas-Area Transit Management subsystem. The Transit Management subsystem processes this data to determine general transit vehicle priority needs as well an individual transit vehicle priority needs.

    b. Similarly, Emergency Vehicles report their current position and selected routes to an Emergency Management Center (EM) which forwards this information (message 1b) to the ISP.

    c. Other vehicles communicate their selected routes and updated locations to the ISP.

    d. Event promoters report "Event Info" to the TM for large traffic generators.

    e. Weather Service "Current and Predicted Weather" is delivered to the TM.

2. The DART Transit Management and the Information Service Provider subsystems send current position and expected routes and occupancies of vehicles to the Dallas Area-Wide Traffic Management subsystem. Roadway based surveillance data is also sent to the TM. Along with traditional surveillance data are messages about emergency vehicle preemption requests received directly from those vehicles at specific roadway locations. Also, field retrieved travel data generated from ETTM tags will be delivered to the TM.

3. The Dallas Area-Wide Traffic Management Center simultaneously processes the real-time routes required by emergency, DART, and other participating vehicles; determines an appropriate signal coordination strategy and sends this to the Roadway subsystems; updates its predicted traffic model; and sends this to the ISP.

5.4.2 Incident Management

Figure 5-5 illustrates the Incident Management User Service as potentially deployed in the Dallas area.

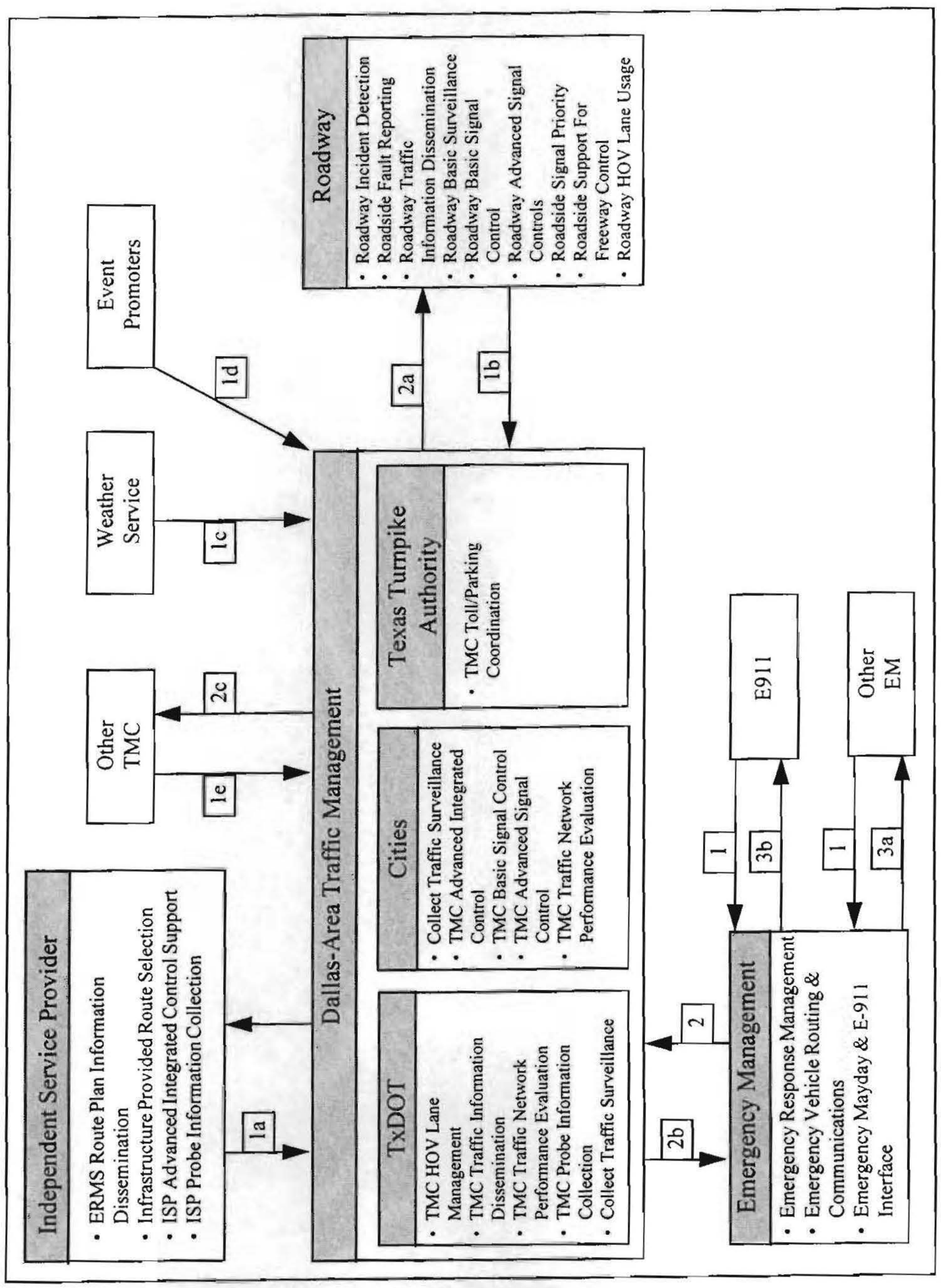

Figure 5-5. Dallas Area Incident Management Architecture Representation

In this figure the Independent Service Provider (ISP) function will initially be performed by TxDOT. The information flows depicted in Figure 5-5 are summarized as follows.

1. The TM continuously collects data from:

    a. ISP;

    b. Traffic sensors;

    c. Weather service data;

    d. Event promoter data about upcoming events; and

    e. Incident alerts from other TMs.

2. When an incident is verified, an appropriate incident response is prepared and messages are sent to:

    a. Roadway subsystems to set VMS and actuators;

    b. EMs to alert them to the incident and begin an incident clearance operation; and

    c. Other TMs to alert them to the incident and to participate in the incident clearance.

3. On receipt of a TM Incident Alert message, the EMs will notify with an Incident Alert message:

    a. Other EMs; and

    b. E-911 system.

5.5 Standards

Figure 5-6 was prepared in conjunction with the Rockwell International ITS Architecture Team. The drawing recommends standards for economies of scale between the centers that will be operating in the Dallas area. It suggests standards from the center subsystems to the roadside devices in order to facilitate regional interoperability. Finally, it identifies the adoption of standards from vehicles to roadside systems or to centers in order to achieve national interoperability.

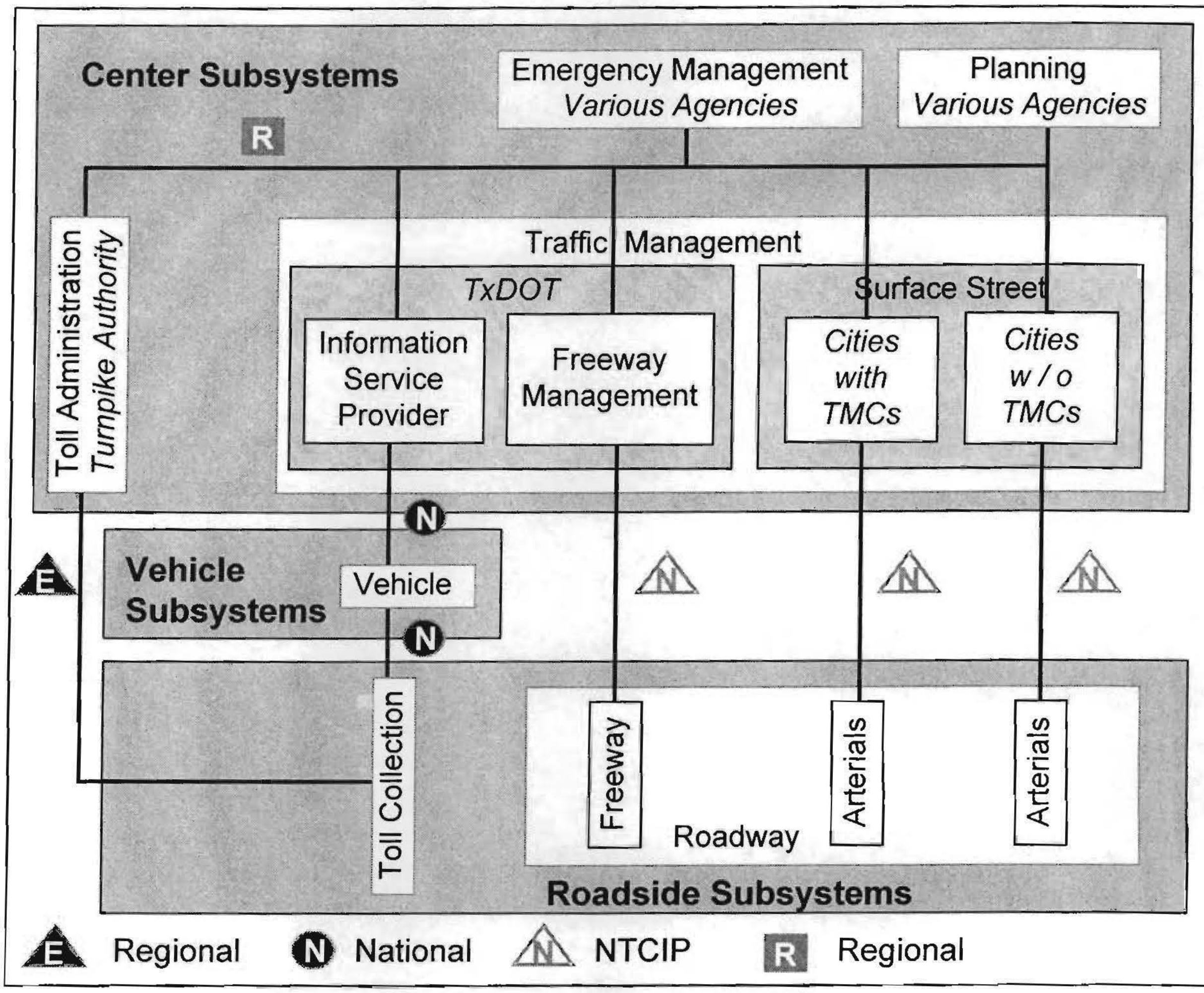

Figure 5-6. Recommended Dallas Area-Wide Standards

5.6 Communications Protocols

Communications protocols are key elements in implementing an ATMS/ITS system. Currently, in the traffic signal local controller technology arena, there does not exist a common set of protocols for communications. Therefore, it is difficult to develop an integrated system that provides interoperability between manufacturers' products. Furthermore, there is a desire by customers to view local controllers as "field processors" acting as a communications and control node performing more than traffic duties (2). These additional functions could include: changeable message sign displays, surveillance camera control, sprinkler system control and air quality monitoring.

NEMA traffic control equipment manufacturers began to formulate a National Traffic Control / ITS Communications Protocol (NTCIP) shortly after finalizing the TS 2 traffic control hardware standard in 1992. Among other considerations, TS 2 Standards addressed communications between equipment components within the cabinet (3). However, it did not pertain to communications protocols between traffic signal local controllers and other devices external to the cabinet.

As NEMA's discussions proceeded, the FHWA sponsored a Signal Manufacturers Symposium in Washington, D.C., in May 1993. The participants included NEMA members, the FHWA, states, cities and other industry representatives. The conclusion of the Symposium was to identify five priority issues for action (4). They were as follows:

- Development of a communications standard;
- Designation of the local controller as a "field processor" for various control applications;
- Simplification of operations and maintenance of traffic signal control equipment;
- Improvement of procurement practices; and
- Deployment of options with identified funding.

These issues were consistent with published objectives for ITS and also consistent with prior FHWA reports on the following related topics:

- Report on *Operation and Maintenance of Traffic Control Systems* (5);
- Expert panel report on *Traffic Control Systems Operations and Maintenance* (6); and
- Report on *Traffic Control Systems Operations and Maintenance - A Plan of Action* (7).

Specific issues relevant to communications standards that have been emphasized by NEMA in their NTCIP design efforts are (8):

- Develop a design that is fully documented and that could serve as an "open standard;"
- Keep communications separate from applications;
- Define a protocol that can be implemented;
- Allow multiple vendor's products shared use of the same communications path (connectivity);
- Share common functions between like products (interoperability); and

- Enable development of "field processors" that are communications and control nodes in an ITS network (not just local controllers).

The NTCIP design approach is based upon network models that have been designed for other non-transportation systems. Therefore, it is a goal for the protocol to conform to existing network methods and standards. The standards that have been chosen are:

- HDLC - High Level Link Data Control (ISO 3309 and ISO 4335) at the link level (9, 10); and
- Internet Protocol (IP) at network level (11, 12).

The NEMA Traffic Control Systems Section chose these models because (13):

> . . . models were chosen because the communications requirements for traffic control and traffic management generally fall into two levels. These are referred to as *link level* and *network level* communications. At the link level, a communication protocol must deal with passing data between directly connected devices such as a traffic controller connected to an arterial master. At the network level, a protocol must deal with end-to-end oriented communications where data may have to pass through several intervening devices to reach its destination. For example, a telephone conversation passes through several switching stations before reaching the destination party. In a traffic control application, the scenario might be a central computer downloading a controller database through an arterial master.

Both of these standards are based on the seven layer ISO (International Organization for Standardization) network model (14). The seven layers of the ISO model are: physical, data link, network, transport, session, presentation and applications.

Significant progress for developing a publicly available NTCIP occurred during 1994 and the first half of 1995. For almost two years, the Technical Committee of the NEMA Traffic Control Systems Section worked closely with representatives of the May 1993 Signal Manufacturers Symposium Steering Committee to facilitate definition of the protocol. In May 1994 at the recommendation of the Symposium Steering Committee, FHWA asked Oak Ridge National Laboratory (ORNL) to evaluate the work-in-progress draft protocol definition. As a result, ORNL retained a consultant, Opus One, to review the draft and to search for software sources to support the NTCIP. Opus One's conclusion was that no suitable software was available and that it would be cost effective to develop the required software.

From June 1994 through December 1995, the NEMA Technical Committee refined the NTCIP protocol definition so that it was nearly complete. Concurrently, ARINC has been contracted by FHWA to write a public domain software code for NTCIP. At the January 1996 TRB meeting, a proof of concept demonstration of the NTCIP code was exhibited. The schedule for completion of the NTCIP is to have the communications protocol complete by April 1996 and to have object definitions for traffic actuated controllers available by June or July 1996.

5.7 References

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6. DALLAS AREA-WIDE ITS STRATEGIC DEPLOYMENT PLAN

6. DALLAS AREA-WIDE ITS STRATEGIC DEPLOYMENT PLAN

Chapter 6 summarizes the recommended ITS Deployment Plan for the region. The chapter provides proposed staging of projects and estimated costs and benefits for the recommended ITS Deployment Plan.

6.1 Prioritization of Travel Corridors

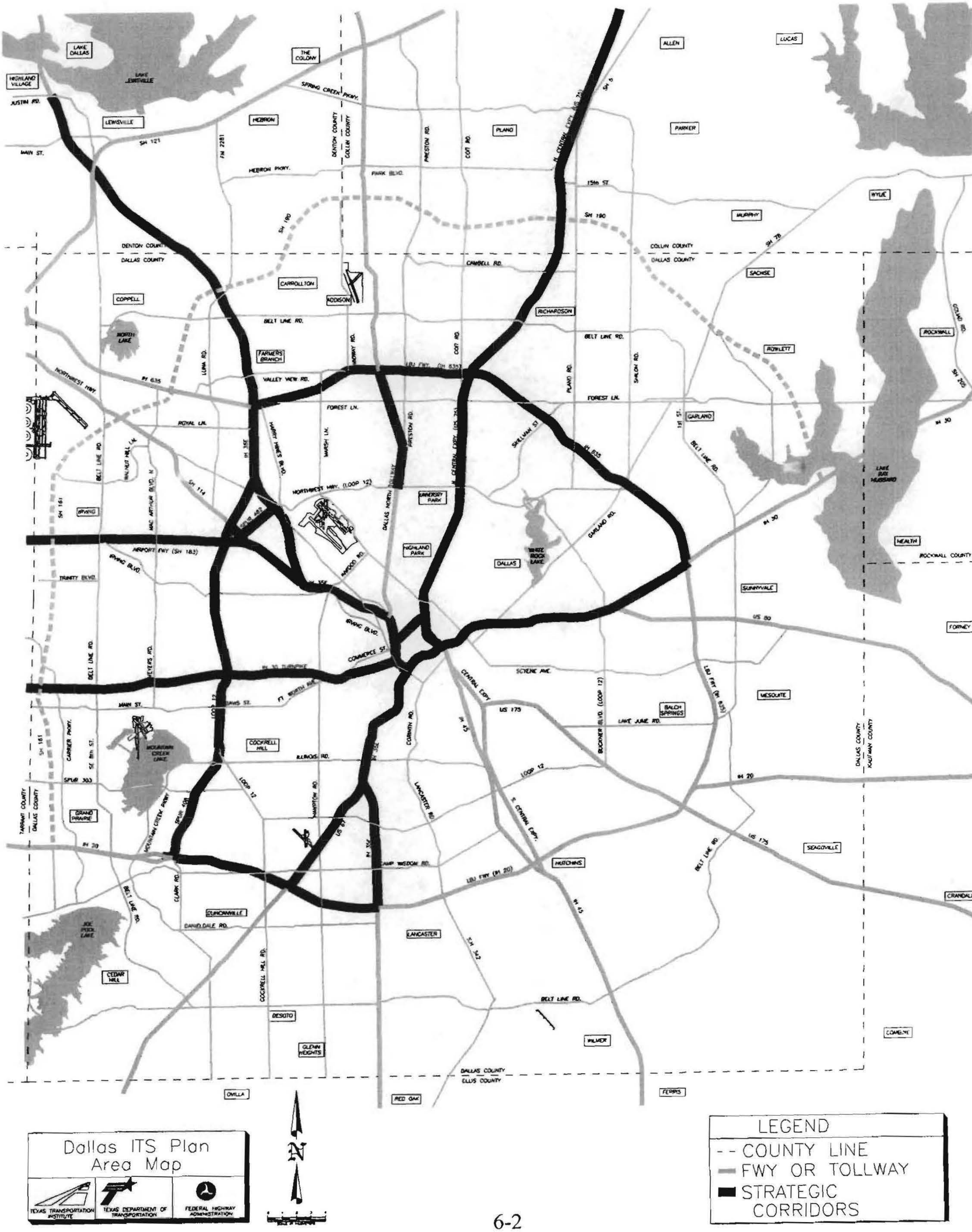
Early in the project, the Steering Committee agreed that freeways and freeway corridors would receive primary emphasis since the focus of the project is improved incident management. Regional arterials (as designated in North Central Texas Council of Governments' Mobility 2010 Plan Update) within those freeway corridors would also be included in the plan.

Given that the potential for incidents is generally proportional to congestion, freeways experiencing Level of Service (LOS) E or F in 1994 that are projected to continue experiencing LOS E or F in 2010 were considered "Strategic Corridors" and candidates for near-term implementation. Projects within Strategic Corridors are considered Priority 1 projects. The 1994 Peak Hour LOSs were determined from the 1994 ADT map published by TxDOT and existing lane configurations as well as from studies of area congestion locations. The 2010 Peak Hour LOSs were taken from the NCTCOG Mobility 2010 Updated Plan adopted in 1994 (1).

In addition to LOS considerations, a freeway facility may be considered strategic if it is of regional significance, such as one which provides a continuous corridor through the region. A freeway corridor may also be considered strategic if it provides a critical link between two strategic corridors either for continuity or to extend the communications backbone.

Strategic locations for early implementation are therefore identified by virtue of severe LOS deficiencies, safety considerations, critical links to strategic facilities and/or regional significance. In the deployment plan described subsequently, Priority 1 elements are recommended for implementation in the near-term, one to five years. Figure 6.1 depicts Strategic (Priority 1) Corridors.

Figure 6-1. Strategic Corridors



Other corridors are categorized as either Priority 2, 3, or 4, and are recommended for implementation in the medium-term, 6 to 10 years. The medium-term elements extend the near-term priorities toward developing the Dallas Area-Wide Intelligent Transportation System. Medium-term elements are categorized as either Priority 2, 3, or 4 according to their corresponding freeway's Peak Hour LOS for 1994 and 2010 as follows:

- Priority 1
  Freeways currently operating as LOS E-F and projected to continue operating at LOS E-F through the year 2010.

- Priority 2
  Corridors where freeways are currently operating at LOS D with projected 2010 LOS E-F; or

  Corridors where freeways are currently operating at LOS E-F with projected improved operations for the year 2010 of LOS D or better resulting from improved facilities or alternate facilities being in place.

- Priority 3
  Corridors where freeways are currently operating at LOS A-C with projected 2010 operations degrading to LOS D or LOS E-F; or

  Corridors where freeways are currently operating at LOS D with projected improved 2010 operations of LOS A-C resulting from improved facilities or alternate facilities being in place.

- Priority 4
  Corridors where freeways are currently operating at LOS A-C and projected to continue operating at LOS A-C through the year 2010.

Figure 6-2 illustrates freeway corridors by deployment implementation priorities. All near-term deployment elements are Priority 1 or strategic for implementation. Timing of implementation may also be influenced by other factors, such as funding availability, compatibility with regional projects, and the opportunity for incorporation into larger highway construction projects. The following sections decribe individual implementation elements.

Figure 6-2. Implementation Priorities

6.2 Deployment Plan

The deployment plan presented here emphasizes ITS elements that can be deployed without a total system deployment yet can enhance incident management, are effective in reducing congestion, and can be integrated into the ultimate implementation plan. It also recognizes and incorporates existing ITS elements that are currently in place or imminent, such as the TxDOT CMSs and the Transportation Management Satellite, as well as municipal computerized traffic signal control systems. TxDOT's Transportation Management Satellite will serve as the focal point for transportation information and management until such time as the Dallas Area Transportation Management Center (DATMC) is in place. Due to the absence of a permanent communications backbone for most of the freeway corridors, much of the initial data communication for system monitoring and information delivery will be via leased voice pairs or ISDN lines.

6.2.1 Functional Areas

ITS elements in the deployment plan discussion are classified into the following functional areas:

- System Management;
- Surveillance and Monitoring;
- Information Delivery;
- Control; and
- Data Communications.

6.2.2 Existing ITS-Related Systems

TxDOT has already implemented a solid base of ITS related systems that will be incorporated into the overall ITS plan. Table 6-1 describes existing ITS related systems within the Dallas area by the functional areas described above. Construction on the Transportation Management Satellite has already begun. Many local cities already have in place or under construction advanced traffic control systems with central control and monitoring capability. Communication links between the systems and the Transportation Management Satellite will allow sharing of video and traffic data among the participating agencies.

Table 6-1. Existing ITS Capability

Functional Area	Elements		Description
Management and Operations	Centers	TxDOT	Transportation Satellite Center under construction
		Cities	City signal systems
		DART	DART operations center
	Mobility Assistance Patrols		Ten service vehicles
	Incident Management		No formal integrated plans
Surveillance and Monitoring	Vehicle Detectors	Freeways	Test sites on IH 30 and US 75 (video detection)
		Arterials	As part of City signal control systems
	CCTV	Freeways	Three cameras on US 75; One portable trailer
		Arterials	Cameras in Garland, Richardson, and Plano
	Wireless		Cellular to 911
	Vehicle Probes		DART buses
Information Delivery	Info to Home/Work		Dial-in to TxDOT (lane closures)
	Info to Drivers		CMS at various locations on US 75, IH 635, IH 35E, Sp 366, IH 30
	Info to Media		News releases, private traffic information services
	Info to Transit Users		Dial-in for schedules
Control	Signal Operations for Incidents		Manual overrides
	Ramp Metering		None
	Adaptive Signal Operations		None
	Lane Control Signals		Reversible lanes on Ross Ave and Live Oak St in east Dallas
Data Communications	Video	Freeways	Direct cable/leased lines
		Arterials	CATV in Richardson, Garland, and Plano
	Traffic	Freeways	None
		Arterials	Local communications network
	Control	Freeways	Cellular and leased lines
		Arterials	Local communications network
Interagency Communications (Cities, TxDOT, DART, Counties)	Communications		Telephone

6.2.3 Near Term Deployment (1 to 5 Years)

All near-term deployment elements are considered to be Priority 1 or top priority projects. Within Priority 1, projects are sub-divided as either Group A, Group B, or Group C, as shown below:

- Group A includes freeway management projects that have been completed or are under construction, and other complementary ITS elements on and off freeway;

- Group B includes freeway management projects that are under design and other complementary ITS elements on and off freeway; and

- Group C includes freeway management projects considered to be Priority 1 from a congestion level or regional significance aspect that are not funded at this time. Other complementary ITS elements on and off freeway are also specified.

Timing of implementation may also be influenced by factors such as funding availability, compatibility with regional projects, and the opportunity for incorporation into larger highway construction projects.

The Intelligent Transportation Infrastructure (formerly known as the Core Infrastructure) components of an Intelligent Transportation System as described by the FHWA are (2):

- Freeway Management Systems;
- Traveler Information Systems;
- Incident Management Programs;
- Traffic Signal Control Systems;
- Transit Management Systems;
- Electronic Toll Collection Systems;
- Electronic Fare Payment Systems;
- Emergency Response Providers Systems;* and
- Rail Road Crossings Systems.*

* Infrastructure components added in January 1996.

The Dallas Area-Wide ITS Plan near-term priorities will concentrate in four general areas, all of which support and form a basis for implementation of the core infrastructure features and their sub-elements:

- Improved incident freeway management procedures;
- Collection and assimilation of real time traffic and travel information;
- Processing and management of traffic and travel information; and
- Dissemination of traffic and travel information.

Table 6-2 shows an overview of the near-term implementation plan. Individual elements and their interactions are described in the following sections.

Table 6-2. Near-Term Deployment

FUNCTIONAL AREAS	ELEMENTS		NEAR TERM DEPLOYMENT (1-5 YEARS) Priority 1		
			Group A	Group B	Group C
Management and Operations	Centers		Transportation Management Satellite	Tie in strategies to Satellite	Tie in IH 635 (north) to Satellite Design Dallas Area TMC
	MAP		Emphasize Mobility	Expand coverage level →	→ →
	Incident Management		Total station units for accident investigation	Incident Management Training Traffic Safety Officer	Improved clearance procedures
	DART		DART representative in Satellite	Flexible routing	Electronic fare
Surveillance and Monitoring	Vehicle Detectors	Freeways	Detectors on US 75	Non-intrusive detectors at strategic locations	Detectors on LBJ
		Arterials	Detectors in City signal systems →	→ →	→ →
	CCTV	Freeways	CCTV on US 75	Compressed Video/ISDN on IH 35E, IH 30, US 67, SH 183	Portable CCTV CCTV on IH 635 (north)
		Arterials	Extend Existing Systems	CCTV at strategic locations (CATV or Compressed Video/ISDN)	
	Wireless		EMS radios Monitoring Cellular phones	Cellular *999	Cellular positioning
	Probes			DART probes	MAP vehicle probes
Information Delivery	Info to Home/Work		Commercial Radio Metro traffic	Dial-in Internet	CATV Kiosks
	Info to Drivers		CMS on US 75, IH 635, IH 35E, IH 30 (various locations)	CMS & HAR on IH 35E (north), SH 183	CMS & HAR on IH 35E (south), US 67 (south), IH 635 (north)
	Info to Media		Phone link Internet →	→ →	→ →
	Info to Transit Users			Dynamic schedule arrival times	Paratransit arrival notification
Control	Signal Operations for Incidents		Incident timing plans for US 75 (Tier 1)	Incident timing plans at strategic locations (Tier 1)	Incident timing plans on IH 635 (north) (Tier 1)
	Ramp Metering		Install ramp metering infrastructure (conduits and pullboxes) as part of freeway construction projects	→ →	→ →
	Lane Control Signals		Arterials		Lane control signals on IH 635
Data Communications	Video	Freeways	Fiber and ISDN on US 75	ISDN at strategic locations	Fiber on IH 635
		Arterials	CATV	ISDN/CATV →	→ →
	Traffic	Freeways	Fiber on US 75	ISDN at strategic locations	Fiber on IH 635
		Arterials	Local communications network	Local communications network →	→ →
	Control	Freeways	Cellular/ISDN/Leased Voice Grade	→ →	→ →
		Arterials	Local communications network	Local communications network →	→ →
Interagency Communications (Cities, TxDOT, DART, Counties)	Communications		Phone link Internet	Initial wide area network (TxDOT, Dallas, Plano, Richardson)	Expand wide area network

6.2.3.1 Management

Management of traffic and transportation as referred to in this implementation plan includes a freeway management center, traffic information processing center, city traffic signal control systems, incident management program, and mobility assistance patrols.

6.2.3.1.1 Management Centers

- Transportation Management Satellite

  Until implementation of a Dallas Area Transportation Management Center is completed, the Transportation Management Satellite will serve as the focal point for freeway management and information exchange activities. Currently under construction, it will be located on the North Central Park and Ride Site near the US 75 and IH 635 interchange. CCTV, CMSs, HAR and vehicle detectors deployed on US 75 will be operated and monitored from this location. As other critical freeway locations (IH 35E, SH 183, US 67) are implemented, they will also be tied into the Transportation Management Satellite, as will the IH 635 control and monitoring systems associated with HOV lanes after they become operational.

- City Traffic Signal Control Systems

  City traffic control systems will continue to operate autonomously. When incidents identified by the Transportation Management Satellite warrant implementation of incident timing plans, cities would be notified. Video and traffic data will be shared between control centers.

- DART Operations Center

  The DART Operations Center will continue to operate autonomously, but information affecting traffic operations will be exchanged.

- Regional Transportation Management Center

  At present, TxDOT's Dallas and Fort Worth Districts are proceeding with plans for a Transportation Management Center (TMC) in each District. These TMCs will be linked with high speed communications lines, which will allow rapid exchange of data and coordinated control and management strategies. Dallas and Fort Worth District staffs have had and will continue to have discussions regarding a future Bi-District Transportation Management Center. Such a regional TMC logically would be located somewhere along the Dallas and Tarrant County boundary and would be linked to the area TMCs in Dallas and Fort Worth.

6.2.3.1.2 Mobility Assistance Patrols

The nucleus of a strong Mobility Assistance Patrol (MAP) program is currently operating on the Dallas area freeways; as funding permits, the MAP program would also be expanded. The term Mobility Assistance Patrol is used to indicate an emphasis on restoring capacity (improving mobility) as opposed to a service patrol. Services would still be a part of the MAP's duties during off-peak hours, but the primary focus during peak hours would be on restoring capacity. In addition to clearing the freeway of minor incidents, the MAP would also take on expanded responsibilities during clearance of major incidents. At the request of the commanding officer at the scene, MAP personnel would set up traffic control, allowing traffic to move safely by the scene while securing the safety of those handling the incident and associated investigation. This will sometimes involve assuming responsibility for removal of vehicles and cargo under the authority granted to TxDOT by the Texas Legislature in 1991.

As part of its interagency work with the Dallas District of TxDOT, TTI will conduct a detailed evaluation of the MAP operations.

6.2.3.1.3 Incident Management Program

Recommendations for upgrading and improving incident management procedures were previously discussed in Chapter 2.

6.2.3.2 Surveillance and Monitoring

Surveillance of traffic and travel will be accomplished using several sources of information. No single source of information will provide sufficient traffic data and information for control and information delivery functions. Sources of information in the near-term will include Closed Circuit Television, vehicle detectors, probe vehicles (DART fleet and toll tags), and cellular telephone reports.

6.2.3.2.1 Vehicle Detectors

- Freeways

  A guiding philosophy for the plan development has been to minimize installation of vehicle detectors where cutting of existing pavements is required. It is recommended loop detectors be installed only in conjunction with other primary construction projects, and non-intrusive detectors (radar, acoustic, video) will be utilized to the extent possible at other freeway locations. Video imaging (machine vision) detectors will be installed on IH 635 north as part of the HOV system project, and loop detectors are being installed on US 75 during its reconstruction. In the near-term, non-intrusive detectors would be installed at critical locations (freeways experiencing LOS E or F in both 1994 and 2010).

- Arterials

  Detectors will be present in individual city signal systems.

6.2.3.2.2 Closed Circuit Television

Closed circuit television will be implemented to a limited degree on both freeways and arterials. Video images will be available for sharing among agencies via a Wide Area Network.

- Freeways

  CCTV cameras are being installed on US 75 during its reconstruction and will be monitored from the Transportation Management Satellite. Cameras are also planned for IH 635 north. Strategic locations identified for early implementation (SH 183, IH 35E, IH 30, and US 67) would also be monitored via compressed video (CV) transmitted over leased ISDN lines.

- Arterials

  Richardson, Garland, and Plano have installed CCTV cameras as part of their cable television system. Other cities with funding committed for the installation of surveillance cameras include Carrollton, Dallas, Farmers Branch, Grand Prairie and Mesquite. Additional locations identified for early implementation where cable television systems are not available would be monitored via compressed video (CV) transmitted over leased ISDN lines.

6.2.3.2.3 Cellular Telephone Reports

Cellular telephone reports have become the dominant means of incident detection. In the near-term, 911 calls going to city emergency services will serve as an incident detection mechanism. However, 911 is experiencing overload, and it is recommended that a separate, free cellular line (*999) for reporting freeway incidents be provided. Establishing communication links, either telephone or radio, between the Transportation Management Satellite and city emergency services will be a high priority as the near-term hardware and management systems are implemented in the Transportation Management Satellite.

6.2.3.2.4 Vehicle Probes

Vehicle probes are another source of traffic stream evaluation and monitoring. Although some commercial products are currently deployed or under development, the primary source of such information in the near future is the

DART fleet and toll tag equipped vehicles. Equipping the MAP vehicles or other public agency vehicles with GPS antennae and transmitters would add to the information sources. Should a vehicle tracking vendor offer a proven product at a reasonable price, it could also be incorporated into the surveillance subsystem. As cellular positioning matures and becomes proven, it is recommended it also be incorporated into the Transportation Management Satellite.

6.2.3.3 Information Delivery

Information delivery to travelers will take place at several sites and by various modes. Both the private sector and the public sector will be involved in information delivery. The following discussion of information delivery is categorized by where the information is delivered.

6.2.3.3.1 Information to Homes or Work Sites

Traveler information obtained by the various surveillance systems will be made available through commercial radio and television, commercial kiosks or computer terminals at employment and recreational centers, and commercial traffic information providers, such as Metro Traffic and Shadow Traffic. With the proliferation of the Internet, a homepage providing real-time traveler information also provides a cost effective information delivery medium. As the information base is expanded, homepages specific to individual corridors may be developed. Dial-in information may also be provided to callers through recorded messages.

- <u>En-Route Information to Motorists</u>

  Changeable message signs are presently provided at various freeway locations throughout the Dallas area. Additional CMS sites and Highway Advisory Radio (HAR) are planned for IH 35E (north) and IH 635 in connection with the HOV lane construction. Additional sites identified as critical from a congestion, safety, or operational aspect are recommended to be implemented. These include IH 35E (south) and US 67.

6.2.3.3.2 Information to Media

Initially, information to radio and television or other media will be via phone links or dial-in systems. Internet homepages, updated on a near real time basis will also be accessible to media as well as to the general public.

6.2.3.3.3 Information to Transit Users

The DART Transit Operations Center will be linked to the Transportation Management Satellite, and work space is provided in the Transportation Management Satellite for DART personnel. All information coming into the Transportation Management Satellite will be available for distribution to DART patrons.

6.2.3.4 Control

In the near-term, most control functions will continue to be locally based with traffic data and information sharing among agencies providing for more efficient operations.

6.2.3.4.1 Signal Operation for Incidents

During the course of the plan development, the Steering Committee adopted a procedure for signal operation during major incidents. The approach calls for jointly (TxDOT and cities) developed incident timing plans (ITP) to be implemented by individual cities affected upon notification of an incident by the Dallas Area Transportation Management Center. In the near-term, the Transportation Management Satellite will notify those cities (Tier 1) with central signal control capability. Initially, only those cities adjacent to US 75 would be affected. As surveillance information sources are expanded to other freeways, the program would be expanded to additional cities with borders adjacent to freeways being monitored.

6.2.3.4.2 Lane Control Signals

- <u>Freeway Locations</u>

  Lane control signals (LCS) for the purpose of incident management are currently being utilized and evaluated in the Fort Worth District. As the Transportation Management Satellite becomes fully functional, consideration should be given to adding LCS at critical locations. In addition to non-recurrent congestion, LCS can also be used to mitigate recurrent congestion. Recurrent congestion locations where freeway LCS may be beneficial include entrance ramps with heavy volumes, freeway merges, and freeway-to-freeway direct ramps.

- <u>Arterial Locations</u>

  It is recommended that cities explore opportunities to increase capacity and mitigate congestion through the use of LCS on regional arterials experiencing unbalanced peak hour traffic flows.

  It is also recommended that dynamic lane assignment signs be used to maximize approach capacities at intersections experiencing changing traffic patterns throughout the day. Cities should explore opportunities to use dynamic lane assignment signs at intersection approaches with changing traffic patterns throughout the day. Prime candidates for dynamic lane assignment installations include intersection approaches on freeway service roads and freeway diversion routes. Other intersection approaches locations that should be considered are those located near major traffic generators, such as Fair Park, Reunion Arena, and high density employment areas.

6.2.3.5 Data Communications

It is recommended that transmittal of detector data and video, as well as control commands, continue on the local communications network (LCN) within cities and on available fiber optic cable or leased lines for freeway functions. Except in special circumstances such as critical links, it is recommended fiber optic cable be installed primarily as part of other freeway reconstruction projects due to the high cost of conduit installation on existing facilities.

6.2.3.5.1 Video Images

- Freeway Locations

  Transmission of video on US 75 initially will be leased via ISDN lines and will convert to fiber optic cable as the fiber backbone is installed as part of the US 75 reconstruction. Locations identified as critical will be interconnected via ISDN lines. IH 635 locations will be interconnected to the Transportation Management Satellite via fiber optic cable installed as part of the HOV lane construction.

- Arterial Locations

  Video within cities will be transmitted primarily on local CATV channels where cable franchises allow; where franchises do not allow, locations identified as critical will be served by ISDN lines with compressed video formats.

6.2.3.5.2 Traffic Data

- Freeway Locations

  Transmission of data on US 75 will initially be via leased ISDN lines and will convert to fiber optic cable as the fiber backbone is installed as part of the US 75 reconstruction. It is recommended that locations identified as critical for near-term deployment be interconnected via ISDN lines if fiber is not available. IH 635 locations will be interconnected to the Transportation Management Satellite via fiber optic cable installed as part of the HOV lane construction.

- Arterial Locations

  Transmission of data within cities will be via local communication networks associated with local traffic control systems.

6.2.3.6 Interagency Communications

The essential tenet of the distributed concept for the Dallas Area-Wide ITS Plan is the sharing of video and traffic data among the various agencies for the purpose of coordinated, integrated transportation management, particularly during incident conditions. Ultimately, a Wide Area Network (WAN) will provide for interagency communication. Initially, interagency communications will be by telephone and through an Internet Homepage. TxDOT, Dallas County, and the Cities of Dallas, Plano, and Richardson are entering into an agreement for design and testing of an experimental Wide Area Network. The system will most likely be Internet based, and other cities will be allowed to join the network as it is developed. Based on the experience with this test, the WAN will be expanded if proven successful, or else another approach will be developed.

Communication and shared management between TxDOT's Dallas and Fort Worth Districts will be essential. Two pilot projects on SH 183 with links between the two districts are currently underway. These projects are the first in the state where two TxDOT Districts will be interconnected for mutual ITS traffic management. One project will deploy surveillance and information delivery hardware, such as CCTV, detectors, CMSs, kiosks, and dial-in traveler information. The second project will involve sharing of traffic data and video between the Dallas and Fort Worth Districts for the purpose of coordinated information delivery. A fiber optic cable link is planned.

6.2.3.7 Summary of Near Term Deployment Priorities

All elements described as near-term (1-5 years) are considered Priority 1 for implementation. Within Priority 1, projects are subdivided as Group A, Group B, or Group C, not necessarily indicating schedule or timing.

6.2.3.7.1 Group A

Group A includes freeway management projects that have been completed or are under construction and other complementary ITS elements on and off freeway:

- Transportation Management Satellite (under construction at US 75 and Churchill Way);
- Transportation Management Satellite monitoring, control and user interface (under development);
- CCTV and detectors on US 75 (under construction);
- Changeable Message Signs (in place on various strategic freeway locations);
- City signal systems and CCTV capability monitoring;

- Cell phones for incident reporting;
- Internet homepage for traffic information; and
- Incident condition signal timing plans on US 75.

In addition, TxDOT's Mobility Assistance Patrols are currently operating in an expanded mode.

It is essential that implementation of the Transportation Management Satellite and the associated traffic monitoring systems proceed expeditiously so that a nucleus for other early action ITS related functions can go forward. Incident timing plans would be developed and implemented for those areas where surveillance is present on US 75. Information delivery and other elements would be initiated as information sources become available.

6.2.3.7.2 Group B

Group B includes freeway management projects that are under design and other complementary ITS elements on and off freeway:

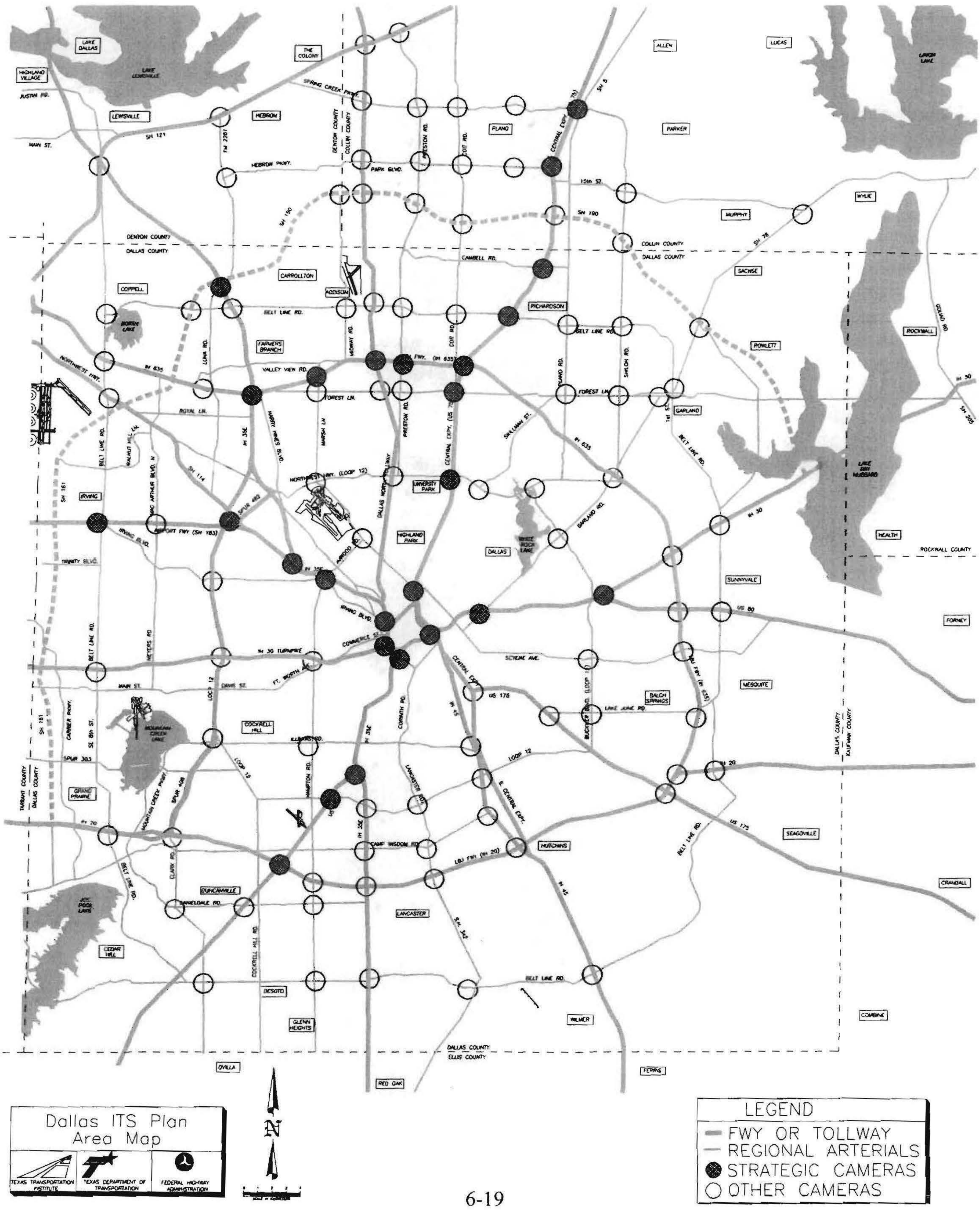
- Expand freeway monitoring and information delivery to other strategic corridors;
- Implement initial wide-area communications network (TxDOT, Dallas, Plano, Richardson, Dallas County);
- Initiate incident management training;
- Assign Traffic Safety Officer;
- Initiate cellular incident reporting systems;
- Expand city signal systems and CCTV capability monitoring;
- Expand use of DART vehicle tracking system (probes); and
- Implement flexible routing for DART buses.

In addition to the Mobility Assistance Patrols and improved on-site incident management, the primary service to travelers is delivery of information either for pre-trip planning or en-route decision making. In order to provide information to the traveler, there must be a reliable source of information and a means to convey it. Until the DATMC is implemented and a backbone communications system is available, data from information sources such as vehicle detectors or CCTV cameras would be transmitted to the Transportation Management Satellite over leased lines (video from the CCTV cameras would be transmitted using a compressed format). While continuous coverage in these potential corridors is not feasible at this time, selective placement of CCTV cameras, including on top of private or public buildings, would give a wider field of view.

In addition to critical designated freeway locations, other freeway locations would be considered for CCTV camera and CMS deployment prior to full regional capability at freeway-to-freeway interchanges and at freeway-to-regional arterial interchanges. Figure 6-3 illustrates the deployment of CCTV cameras according to this criteria.

Incident timing plans for cities with central signal control capability would be developed and implemented for those areas where surveillance is present; information delivery and other elements, as shown previously in Table 6-2, would be deployed as information sources become available.

Figure 6-3. Preliminary Camera Locations



6.2.3.7.3 Group C

Group C includes freeway management projects considered to be Priority 1 from a congestion level or regional significance aspect which are not funded at this time. Other complementary ITS elements on and off freeway are also specified:

- Expand freeway monitoring and information delivery to other strategic corridors;
- Expand wide-area communications network;
- Implement improved incident clearance procedures;
- Distribute information to travelers via CATV and kiosks; and
- Collect electronic fares on DART.

6.2.4 Medium-Term Implementation Plan (6-10 years)

The Dallas Area-Wide ITS Plan's medium-term elements will extend the near-term priorities toward developing an area-wide Intelligent Transportation System for the Dallas area. The most significant medium-term addition to the ITS is the Dallas Area Transportation Management Center (DATMC). Table 6-3 lists an overview of the medium-term implementation plan. Medium-term elements are categorized as either Priority 2, 3, or 4, as previously described and illustrated in Section 6.1 and Figure 6-2 respectively. Individual implementation elements are described in the following sections.

Table 6-3. Medium-Term Deployment

FUNCTIONAL AREAS	ELEMENTS		MEDIUM TERM DEPLOYMENT (6-10 YEARS) (Priority 1 elements are shown in Table 6.2 - NEAR TERM DEPLOYMENT)		
			Priority 2	Priority 3	Priority 4
Management and Operations	Centers		Implement DATMC		
	Incident Management		Add special equipment	Implement shared HAZMAT	
	DART		DART Representatives in DATMC		
Surveillance and Monitoring	Vehicle Detectors	Freeways	Extend vehicle detection →	→	→
		Arterials	Tie in City system detectors →	→	→
	CCTV		Extend CCTV →	→	→
	Wireless		Extend cellular positioning capability	→	→
	Probes		Public vehicle probes	AVI/AVL	Commercial vehicle probes
Information Delivery	Info to Home/Work		Extend kiosks →	→	→
	Info to Drivers		Extend CMS and HAR →	→	→
	Info to Media		Direct video, graphics, and text link	→	→
Control	Signal Operations for Incidents		Extend incident timing plans (Tier 1) & frontage roads (Tier 1&2)		→
	Ramp Metering		Develop ramp metering plan	Ramp meters at critical locations	Expand Metering
	Adaptive Traffic Signals		Incorporate as proven →	→	→
	Lane Control Signals		LCS at critical locations →	→	→
Data Communications	Video	Freeways	Expand fiber/ISDN →	→	→
		Arterials	Expand CATV/ fiber/ISDN →	→	→
	Traffic	Freeways	Expand fiber/ISDN →	→	→
		Arterials	Local communications network →	→	→
	Control	Freeways	Expand fiber/ISDN →	→	→
		Arterials	Local communications network →	→	→
Interagency Communications (Cities, TxDOT, DART, Counties)	Communications		Expand wide area network →	→	→

6.2.4.1 Management

Management of traffic and transportation as referred to in this implementation plan includes a freeway management center, traffic information processing center, city traffic signal control systems, incident management program, and mobility assistance patrols.

6.2.4.1.1 Management Centers

- Dallas Area Transportation Management Center

  The Dallas Area Transportation Management Center (DATMC) would now serve as the focal point for all freeway management and information exchange functions. The DATMC will house freeway management hardware/software and operations personnel as well as equipment and personnel for interfacing to and exchanging information with other local control systems. The DATMC should also accommodate emergency management services personnel, DART operations personnel, MAP dispatchers, and possibly police personnel from local cities. It will also be in direct communication with the Fort Worth Area Transportation Management Center regarding data exchange as well as coordination of operations on a regional basis.

- City Traffic Signal Control Systems

  Tier 1 city traffic control systems would continue to operate autonomously. Where incidents identified by the DATMC warrant implementation of incident timing plans, cities would be notified, and they will respond accordingly. Information affecting traffic operations will be exchanged.

- DART Operations Center

  DART Operations Center will continue to operate autonomously; however, information affecting traffic operations will be exchanged with other agencies. DART operations personnel will have designated work stations in the DATMC.

- Mobility Assistance Patrols

  MAP personnel would now be dispatched from the DATMC.

6.2.4.1.2 Incident Management Program

It is recommended that the incident management program be upgraded and improved by the addition of regionally shared special equipment such as a heavy duty wrecker or inflatable bags for quickly righting overturned large vehicles. Shared HazMat equipment is also recommended; equipment would be stored within the District, as well as within the Fort Worth District, with interdistrict use of major HazMat equipment.

6.2.4.2 Surveillance

CCTV and vehicle detectors would be extended according to priorities indicated previously in Figure 6-2. AVI and AVL probes would be incorporated as feasible from the commercial vehicle and private vehicle sector.

6.2.4.3 Information Delivery

Information delivery to travelers would be extended by kiosks, CMSs, and HAR as previously indicated by the priorities shown in Figure 6-2. Direct video, graphics and textual data would be made available to the media.

6.2.4.4 Control

Surface street control functions would continue to be locally based with traffic data and information sharing among agencies, providing for improved efficiencies of operation. Incident timing plans would be implemented as increased surveillance sources become available. Direct control of frontage road intersections during incidents would be implemented at locations in cities without computer control capabilities. Ramp metering would be implemented in capacity deficient freeway sections and at freeway sections where incident experience is at a level warranting ramp control.

6.2.4.5 Data Communications

Data communications media would be extended according to priorities indicated previously in Figure 6-2. Extension of fiber cable would be primarily in areas where other construction is taking place. Alternative communications media may become available and should be investigated; in particular, more companies will be offering fiber, and other media and lease rates will likely be very competitive.

6.2.4.6 Interagency Communications

The Wide Area Network as developed in the near-term will be extended to other areas as more information is available from agencies through the DATMC.

6.2.5 Long-Term Implementation (11 years +)

Projects considered for implementation in the long-term are those considered to be in research or development phases. These would include collision avoidance systems, automated vehicle operations, and other vehicular control systems. These systems hold promise in both safety and in realizing more roadway capacity; however, these systems, still in research and development stages, are outside the planning horizon of this study.

Most of these developments will be vehicle-based and will not depend to a great extent on ATMS for operation. Data exchange may be desirable, and the system design should reflect an open architecture, to the extent practical.

6.3 Dallas Area-Wide ITS Plan Benefits and Costs

Based on system elements specified in the area-wide plan, detailed benefits and cost data for the recommended plan were developed. The following sections describe the evaluation criteria and expected benefits and costs of the recommended plan.

6.3.1 Benefits Evaluation Criteria

Benefits of traffic management and control systems can accrue in terms of both quantifiable values and in more subjective non-quantifiable benefits. Traditionally, the prime method of system justification or evaluation is a benefit/cost analysis that compares benefits accruing to the public in terms of dollars compared to capital, operating, and maintenance dollar costs of system projects. Benefits measured in dollars include travel time savings, reduction in accidents, and reduction in fuel consumption.

Other benefits are less readily measurable in dollar terms. For example, reduction in vehicle emissions are less readily quantifiable in dollars, although it is generally recognized that reduction of pollutants can have an effect on respiratory illnesses and even death rates for persons afflicted with such ailments. Harmful effects on the environment, such as on plant and animal life, are real but not easily put into dollar terms. Reduction of fuel consumption is readily measurable in dollar costs of fuel, but such reduction also contributes to an accepted national goal of less dependency on fossil fuels, which is not quantifiable.

For purposes of the cost/benefit analysis for the Dallas Area-Wide Early Deployment Planning Project, dollar cost savings from three measurable criteria will be used:

- Motorist delays;
- Fuel consumption; and
- Accidents.

Costs and benefits were derived from review of the experience of operational systems. Subsequent to tabulation and analysis of costs and benefits by project staff, FHWA published an informal report with estimated costs for ATMS "Core Infrastructure Elements II" (3). Comparison of the two data sources indicated that the assumptions and estimates by the project staff were generally in accord with the FHWA report.

6.3.1.1 Annual Motorist Delay Costs

Implementation and operation of an Intelligent Transportation System can be expected to reduce motorist delay in two categories: recurrent and non-recurrent congestion. Recurrent congestion may be addressed through efficient traffic signal control (including ramp metering); pre-trip information to assist travelers with route, departure schedules and modal choice; and en-route signing (visual or audio) to influence diversion. Based on annual delay estimates for Texas urban areas developed by the Texas Transportation Institute (TTI), motorists' delay costs associated with recurrent and non-recurrent congestion, are an estimated $340 and $570 million respectively for the Dallas area (4). Non-recurrent congestion, caused by accidents and other incidents, is addressed through incident management functions, such as monitoring of cellular reports of incidents, detection of incidents by vehicle detectors or CCTV, and Mobility Assistance Patrols. In support of incident management, en-route and pre-trip planning information delivery may also be employed.

6.3.1.2 Annual Fuel Consumption Costs

Reduction in freeway delay produces a generally proportional reduction in fuel consumption. Based on TTI studies for the Dallas area, it is estimated that annual fuel costs associated with recurring and non-recurring congestion exceed $55 and $92 million respectively (4).

6.3.1.3 Annual Accident Costs

Texas Department of Public Safety records indicate there were 10,519 reported accidents on Dallas area freeways in 1994. Of these accidents, 0.7% involved fatalities, 54.8% were injury accidents, and 44.5% involved property damage only (5). Using a weighted average cost of $14,794 per accident, the total costs resulting from accidents in 1994 exceeded $155 million. In addition to the reported accidents, many minor accidents (without injuries or major property damage) occur and go unreported.

6.3.2 Dallas Area-Wide ITS Plan Estimated Benefits

Most benefits accruing from advanced freeway and freeway corridor management and information systems are interrelated. Delivering various user services will often involve the same hardware and management elements. For example, a CCTV system may contribute to early detection and verification of incidents for dispatch of appropriate emergency services. The same CCTV system may also provide a source of information for messages on CMSs or real-time flexible routing of transit vehicles. The benefits of each function, if it were a stand alone system, would be tangible and measurable. However, the benefits of stand alone systems are not necessarily additive. In order to account for the interrelated nature of user benefits attributable to the recommended elements, the benefits of the various systems were analyzed using a root of squares summed analysis (RSS). The resulting analysis, while conservative, indicates that substantial benefits can be realized from an advanced Intelligent Transportation System and can also account for the interrelatedness of control elements.

6.3.2.1 Non-Recurrent Freeway Congestion

Non-recurrent (incident related) freeway congestion accounts for well over half of the total freeway congestion and is most readily addressed by advanced freeway management techniques. Incident detection and clearance and the provision of traveler information for pre-trip planning and for route selection during trips are elements contributing to reduction of delays due to non-recurrent congestion. Table 6-4 indicates the estimated impact of various ITS elements and their combined impact; using the RSS analysis, the combined ITS elements resulted in estimated reductions in non-recurrent congestion of 48% and 23% for strategic and other freeways respectively. As previously illustrated in Figure 6-2, strategic freeways primarily entail all freeways experiencing LOS E or F in both 1994 and 2010 (Priority 1 freeways), with other freeways, being either Priority 2, 3, or 4.

Table 6-4. Non-Recurrent (Incident) Freeway Congestion Reduction Factors

ITS Element	Strategic Freeways (Priority 1)	Other Freeways (Priorities 2, 3 & 4)
Incident Management Plan / Mobility Assistance Patrols	40%	20%
Roadway Detection (loops, radar, VIP detectors, probes,etc.)	5%	5%
CCTV Cameras	15%	5%
*999 Cellular Phone Hotline for Reporting Incidents	10%	5%
Ramp Meters	5%	3%
Lane Control Signals	5%	3%
Changeable Message Signs (CMS)	15%	5%
Highway Advisory Radio (HAR)	10%	5%
Root of Squares Summed (RSS)	**48%**	**23%**

6.3.2.2 Recurrent Freeway Congestion

Theoretically, in the absence of capacity restricting incidents, there would be no need for traffic responsive information delivery systems since traffic patterns would be thoroughly repeatable. However, even without capacity limiting incidents, day to day traffic variations can have a significant enough effect to warrant freeway traffic control measures. The primary means of controlling traffic demand on freeways is ramp metering. Additional measures would include information delivery to travelers, either pre-trip or en-route, though with lesser effectiveness than in a non-recurrent incident condition. Ramp metering on US 75 in the early seventies resulted in a reduction of delay and accidents of about 15%. Other systems throughout the country have reported similar results with delay reduction as high as 40% or more. For this analysis, a 30% delay reduction factor was used for ramp meters located within strategic corridors.

Initially, ramp metering would be applied only in consistently congested areas where demand upstream of freeway bottlenecks could be diverted to other facilities or other travel modes. Due to geometric constraints on many existing entrance ramps in the Dallas area, this study assumes that ramp metering would be applied at only 40% of the entrance ramp locations within designated strategic corridors in the plan area. Table 6-5 shows the estimated impacts of ITS elements on recurrent freeway congestion. Using the previously described RSS analysis, benefits resulting from the deployment of ramp meters and lane control signals are an estimated 30% and 6% reduction in recurrent delay for strategic (Priority 1) and other (Priorities 2, 3, or 4) identified freeways, respectively.

Table 6-5. Recurrent Freeway Congestion Reduction Factors

ITS Element	Strategic Freeways (Priority 1)	Other Freeways (Priorities 2, 3 & 4)
Ramp Meters (including ramp closures)	30%	5%
Lane Control Signals	5%	3%
Root of Squares Summed (RSS)	**30%**	**6%**

6.3.2.3 Regional Arterial Congestion

In the absence of incidents, congestion on regional arterials is generally consistent from day to day and is managed by traffic control systems where they exist in individual cities. Improvement in system operation can be realized through upgraded hardware and control techniques. Since several cities in the study area have in place central computer signal systems that have been optimized, it is assumed that a conservative 10% delay reduction will occur with upgraded systems and access to information sharing through the Wide Area Network.

Non-recurrent delay due to incidents occurs in two ways. First, diverted traffic from freeway incidents will use the adjacent frontage road and surface street system. The previously described working arrangements for implementation of mutually developed incident signal timing plans would manage traffic and minimize delay under these conditions. Benefits accruing for that situation are included in the benefits for improved freeway incident management measures. A second area where delays due to incidents occur is on surface streets not related to freeway incidents. Detection of such incidents is more difficult than on freeways due to the greater geographical area and the innate greater variability of speeds, stops, and densities. However, several cities have or will in the near future implement CCTV monitoring capability on some city streets. Coupled with incident/system detectors in computer-monitored signal systems, the opportunity for incident detection on arterials will exist.

6.3.2.4 Accident Reduction

Several aspects of accident reduction are related to advanced transportation management systems. Any traffic control system, freeway or arterial, that reduces congestion also reduces accidents. Typically, improved signal operation on surface streets results in accident reductions in the range of 10 to 25%. Guidelines by California Department of Transportation (CALTRANS) for estimating accident reduction due to freeway management and information systems attribute a 25% reduction for systems with ramp metering. FHWA guidelines show a 37% reduction in accidents where comprehensive freeway management systems are implemented. Finally, it has been shown that upwards of 20% of all freeway accidents are secondary accidents occurring upstream of a previous accident.

It is not feasible to apply these reductions to individual facilities due to the overlapping influence of the various control techniques. Therefore, a conservative estimate of 15% will be used in the analysis for overall accident reduction due to advanced transportation management systems.

6.3.2.5 Dallas Area-Wide ITS Plan Benefit Calculations

Benefits in terms of motorist delay savings, fuel savings, and accident reductions will all accrue from the implementation of a comprehensive Intelligent Transportation System. Estimated benefit calculations for the proposed Dallas Area-Wide ITS Plan are shown in Table 6-6 below.

Table 6-6. Dallas Area-Wide ITS Plan Benefit Calculations

Annual Costs	Annual Recurrent Delay Costs ($1,000,000's)	Annual Recurrent Fuel Costs ($1,000,000's)	Annual Incident Delay Costs ($1,000,000's)	Annual Incident Fuel Costs ($1,000,000's)	Annual Freeway Accident Costs ($1,000,000's)	**Total Costs ($1,000,000's)**
Freeways (strategic corridors)	$219.0	$35.6	$389.0	$62.9	$117.0	**$823.5**
Other Freeways	$73.0	$11.8	$129.6	$20.9	$39.0	**$274.3**
Regional Arterials	$48.0	$7.6	$51.4	$8.2	NA	**$115.2**
Totals ($100,000's)	**$340.0**	**$55.0**	**$570.0**	**$92.0**	**$156.0**	**$1,213.0**

Reduction Factors	Annual Recurrent Delay Reduction Factor	Annual Recurrent Fuel Reduction Factor	Annual Incident Delay Reduction Factor	Annual Incident Fuel Reduction Factor	Annual Freeway Accident Reduction Factor
Freeways (strategic corridors)	30%	30%	48%	48%	15%
Other Freeways	6%	6%	23%	23%	15%
Regional Arterials	10%	10%	10%	10%	NA

Annual Benefits	Annual Recurrent Delay Savings ($1,000,000's)	Annual Recurrent Fuel Savings ($1,000,000's)	Annual Incident Delay Savings ($1,000,000's)	Annual Incident Fuel Savings ($1,000,000's)	Annual Freeway Accident Savings ($1,000,000's)	**Total Savings ($1,000,000's)**
Freeways (strategic corridors)	$65.7	$10.7	$186.7	$30.2	$17.6	**$310.8**
Other Freeways	$4.4	$0.7	$29.8	$4.8	$5.9	**$45.6**
Regional Arterials	$4.8	$0.8	$5.1	$0.8	NA	**$11.5**
Totals ($100,000's)	**$74.9**	**$12.1**	**$221.7**	**$35.8**	**$23.4**	**$367.9**

6.3.2.6 Summary of Benefits

6.3.2.6.1 Motorist Delay Savings

Annual motorist delay savings in terms of dollars resulting from implementation of the Dallas Area-Wide ITS Plan are an estimated $74.9 and $221.7 million for recurrent and non-recurrent congestion, respectively. Total annual motorist delay savings (combined recurrent and non-recurrent) are an estimated $296.6 million. (Motorists delay savings were calculated using a time value of $8.92, the value used by NCTCOG in their benefit calculations.)

6.3.2.6.2 Fuel Consumption Savings

Annual fuel consumption savings in terms of dollars resulting from implementation of the Dallas Area-Wide ITS Plan are an estimated $12.1 and $35.8 million for recurrent and non-recurrent congestion respectively. Total annual fuel consumption savings (combined recurrent and non-recurrent) is an estimated $47.9 million. (Fuel consumption savings were calculated using a fuel value of $1.18 per gallon.)

6.3.2.6.3 Accident Reductions Savings

Assuming a 15% reduction of freeway accidents resulting from the implementation of the Dallas Area-Wide ITS Plan, estimated annual accident savings is $23.4 million. (Accident savings were calculated using an average weighted value of $14,794 per accident.)

6.3.2.6.4 Total Annual Benefits

Total annual benefits (sum of motorist delay, fuel consumption, and accident savings) resulting from implementation of the Dallas Area-Wide ITS Plan are an estimated $367.9 million.

6.3.2.6.5 Non-Quantifiable Benefits

In addition to the measurable benefits described in the previous sections, other benefits resulting from the implementation of a comprehensive Intelligent Transportation System, less readily quantifiable, are nevertheless real and advantageous. These benefits include:

- Special event management;
- Heightened sense of personal safety;
- Improved customer service in terms of information and dependability;
- Database for system evaluation and planning;
- Contributing to meeting national goals of reduction of fossil fuel consumption;
- Contributing to meeting national mandates for vehicle emissions reduction;
- Reduction of driver fatigue due to less congestion; and
- Providing a focal point for regional transportation management activities.

6.3.3 Dallas Area-Wide ITS Plan Estimated Costs

Estimated cost data were secured from the literature review and from review of current ITS related planning, implementation and operations studies, as well as from the TxDOT Dallas District. Additionally, order of magnitude costs were cross-checked with a recent informal FHWA report with guidelines for implementation of a core ATMS infrastructure based Intelligent Transportation System. As with benefits, support systems are highly interrelated. For example, a transportation management center without information sources would be less than effective in information delivery. Changeable message signs without an information source for determining message content also would be less than effective. While some elements can work independently, e.g., the mobility assistance patrols, their effectiveness is synergistic when part of an integrated transportation management system. Estimated implementation, operation, and maintenance costs were determined for individual elements and were summarized by the general categories of Management, Surveillance, Information Delivery, Control, and Data Communications for review purposes, but the benefit/cost analysis will be performed on the total system deployment for the reasons stated.

6.3.3.1 Dallas Area-Wide ITS Plan Ultimate Deployment Costs

Table 6-7 on the following page summarizes estimated capital, and operations and maintenance costs by individual ITS elements. The estimated capital (implementation) cost for the ultimate Dallas Area-Wide ITS is approximately $103 million; the corresponding annual operations and maintenance costs associated with the proposed system is $10.7 million.

6.3.3.1.1 Dallas Area-Wide ITS Plan Estimated Annualized Costs

Annualized capital cost for the ultimate system, assuming a 15 year life and a 6% rate of return, is $10.6 million. The combined annualized capital cost and annual operations and maintenance costs for the ultimate system is $21.3 million.

6.3.3.1.2 Dallas Area-Wide ITS Plan Estimated Benefit/Cost Ratio

Using the expected annual savings/benefits ($367.9 million) calculated previously in Table 6-6, an estimated Benefit/Cost ratio of *17.3* will result from deployment of the ultimate Dallas Area-Wide ITS.

Table 6-7. Dallas Area-Wide ITS Plan Estimated Costs

ITS Element Description	Dallas Area-Wide ITS Plan Deployment Quantities																	TOTALS	Dallas Area Wide ITS Plan Estimated Costs			
		Tier 1 Cities								Tier 2 Cities												
	TxDOT	Dallas	Irving	Richardson	Garland	Carrollton	Grand Prairie	Plano	Farmers Branch	Mesquite	Addison	Duncanville	Park Cities	Lewisville	Desoto	Tier 3 & 4 Cities	Turnpike Authority		Unit Capital Cost ($1,000's)	Unit Annual O&M ($1,000's)	Capital Cost ($1,000's)	Annual O&M Cost ($1,000's)
Dallas Area Transportation Management Center (DATMC):																						
Facility & communications	1																	1	$8,000	$600	$8,000	$600
Computers/hardware/software	1																	1	$3,000	$150	$3,000	$150
24 hrs/day, 7 days/week operating staff (average salaries & benefits)	20																	20	$0	$45	$0	$900
System Design & Integration:																						
DATMC/City TMC's/DART	1																	1	$5,000	$0	$5,000	$0
Communications:																						
Fiber (US 75 & IH 635; installed in conjunction with other construction projects) per km	80																	80	$100	$6	$8,000	$480
Fiber (IH 35E, US 67, SH 183 and other strategic locations) per km	100																	100	$140	$6	$14,000	$600
Wide Area Network (WAN) servers	3	1	1	1	1	1	1	1	1	1	1	1	2	1	1		1	19	$7	$0.7	$133	$13
ISDN lines for WAN (installation & lease costs)	24	4	2	2	2	2	2	2	1	1	1	1	2	1	1		1	49	$0.5	$0.8	$25	$39
ISDN lines for field devices (installation & lease costs)	168	70	12			8	6			13	2	3	5	3	7		10	307	$0.5	$0.8	$154	$246
Surveillance & Detection (*denotes demonstration/test projects):																						
Dedicated *999 incident reporting cellular hotline	1																	1	$150	$25.0	$150	$25
24 hrs/day, 7 days/week *999 operating staff (average salaries & benefits)	5																	5	$0	$35.0	$0	$175
Frwy inductive loop detector stations on US 75 & SH 190 (4 frwy lanes/station)	120																	120	$15	$0.8	$1,800	$90
Freeway radar/microwave detector stations (4 frwy lanes/station)	140																	140	$15	$0.8	$2,100	$105
Arterial radar/microwave detectors for temporary detection (per intersection approach)		40	20	12	16	8	12	16	8									132	$5	$0.5	$660	$66
Arterial incident/system detectors (3 lanes/station)		150	30	18	30	12	26	36	8	12	2	4	4	4	10	20		366	$10	$0.5	$3,660	$183
* Video imaging detectors stations (4 frwy lanes/station or 3 arterial lanes/station)	20	4	4	4	4	4	4	4	4									52	$5	$0.5	$260	$26
CCTV cameras w/ live video	60	2		10	10			18	4									104	$25	$1.0	$2,600	$104
CCTV cameras w/ compressed video	140	60	10			6	4			11	1	2	4	2	6	8	8	262	$35	$1.5	$9,170	$393
* Freeway CCTV w/ VIP capability (4 frwy lanes/station)	10																	10	$35	$2.0	$350	$20
* Arterial CCTV w/ VIP capability (per intersection)		2	2	2	2	2	2	2	2									16	$40	$2.0	$640	$32
Probes (AVI/toll tag readers)	60																20	80	$10	$0.5	$800	$40
Control Strategies:																						
Ramp meters	60																	60	$50	$2.5	$3,000	$150
Freeway lane control signals (4 frwy lanes/stations)	120																	120	$20	$1.0	$2,400	$120
Traffic signal upgrades (central computer control & monitoring capability)	45	644	105		56	32	86	22	43	49	8	48	42	52	12	41		1285	$15	$1.0	$19,275	$1,285
Tri-annual arterial traffic signal timing re-evaluations (per traffic signal)	45	1213	155	94	135	75	102	115	48	58	26	50	42	52	12	41		2263	$0	$0.3	$0	$679
Arterial dynamic lane assignment signs (frwy serv. rds, arterials & frwy diversion routes)	50	60	10	8	10	8	8	8	4	4	2	4	4	4		4		188	$3	$0.3	$564	$56
Traveler Information:																						
CMS	90																7	97	$135	$10.0	$13,095	$970
HAR (10-watt)	10																	10	$20	$3.0	$200	$30
Kiosks (TxDOT in conjunction with DART)	50																	50	$30	$6.0	$1,500	$300
Incident Management:																						
Police & Fire incident management training (course development & training)	1																	1	$50	$50	$50	$50
Development & maintenance of area-wide incident response signal timing plans	1																	1	$1,000	$50	$1,000	$50
Mobility Assistance Patrol (MAP) vehicles	20																	20	$40	$8	$800	$160
24 hrs/day, 7 days/week MAP operating staff (average salaries & benefits)	60																	60	$0	$40	$0	$2,400
Portable HAR	4																	4	$40	$4	$160	$16
Portable CMS	10																	10	$40	$4	$400	$40
Portable CCTV	4																	4	$40	$4	$160	$16
Traffic Safety Officer (salary & benefits)	2																	2	$0	$50	$0	$100
																				TOTALS ($1,000's):	**$103,105**	**$10,709**

6.4 Summary of the Dallas Area-Wide Intelligent Transportation System Plan

The Dallas Area-Wide Intelligent Transportation System Plan is the result of the cooperative efforts of a Steering Committee made up of representatives of various transportation agencies in the Dallas area. The plan recommends advanced technology to address transportation-related mobility and environmental issues with particular emphasis on incident detection, clearance and management. The plan conforms to developing national architecture standards while addressing specific needs identified in the Dallas area. A one to five year near-term and six to ten year medium-term deployment plan is specified within the plan. Evaluation of estimated costs and benefits results in a benefit to cost ratio of 17 to 1, meaning that for every dollar invested $17 are returned to the traveling public.

Funding the implementation of the plan elements will be a challenge because there is no designated single source of funding. Therefore, coordination and cooperation among operating agencies (TxDOT, cities, counties, toll authority, and DART) and partnerships with the private sector are essential. Existing systems in cities and counties have been and will probably continue to be funded from sources such as general revenues, bond funds, state and federal sources, and local assistance funds from DART. State funding for implementation of ITS systems has and will probably continue to come from general state highway revenues and various federal sources. Advanced Public Transit Systems have been and will continue to be funded from DART sales tax revenues and demonstration funding. As a prime user of city and state highway infrastructure, DART will also benefit from ITS improvements. Funding for the various ITS systems may also include operational test and demonstration funding from federal sources.

The key to the Dallas Area-Wide Intelligent Transportation System Plan's successful implementation is continued interjurisdictional cooperation and coordination among governmental agencies. North Central Texas Council of Governments has incorporated ITS systems into their planning and programming roles and continues to be an advocate for interjurisdictional cooperation. Intelligent Transportation Systems can play an important role in the region-wide goal of improved freeway incident management and in increased mobility and environmental improvements.

6.5 References

1 *Mobility 2010 Plan Update.* North Central Texas Council of Governments. January 1995.

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5 *Motor Vehicle Accident Database.* Texas Department of Public Safety. Annual analysis by TTI for TxDOT. 1995.