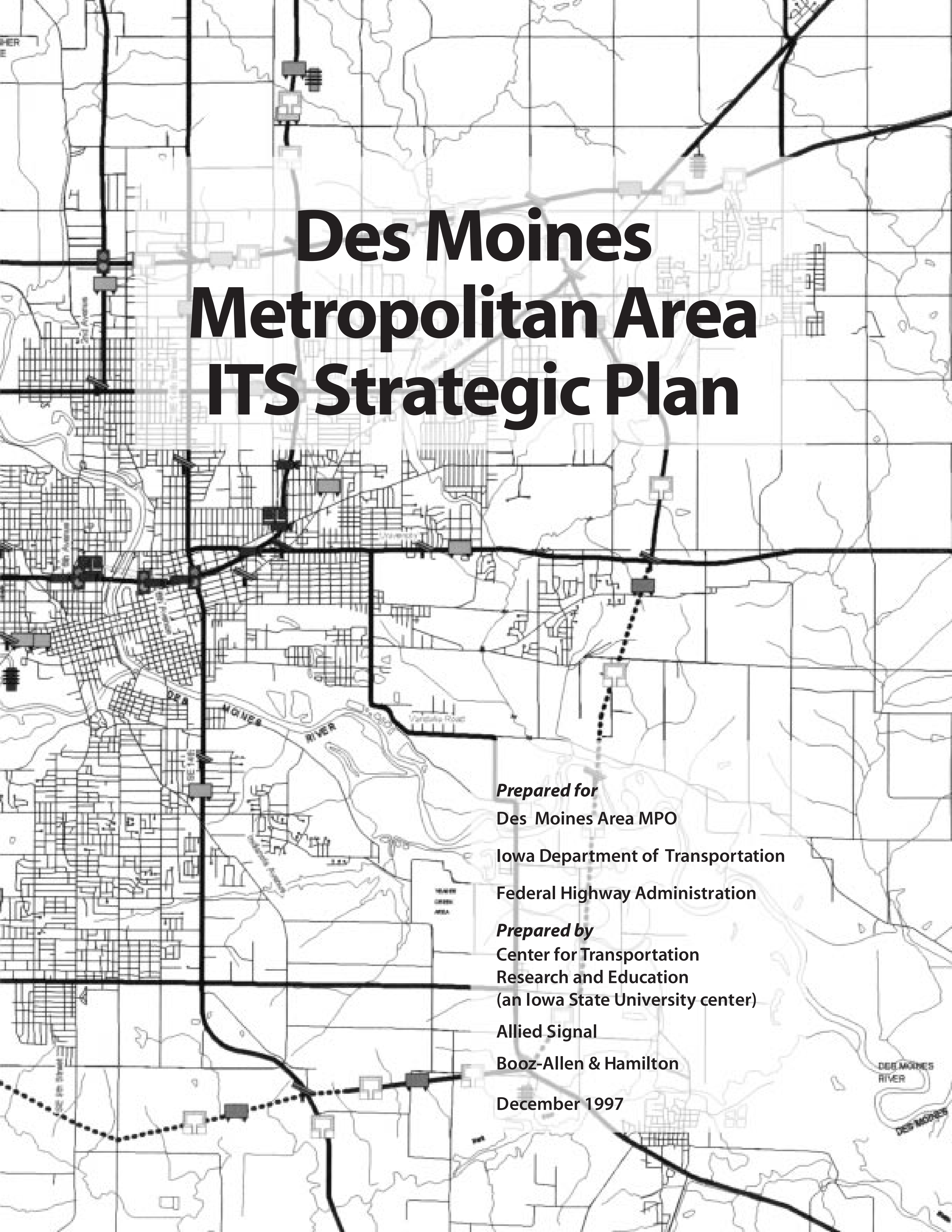
Des Moines Metropolitan Area ITS Strategic Plan



Prepared for

Des Moines Area MPO

Iowa Department of Transportation

Federal Highway Administration

Prepared by

Center for Transportation
Research and Education
(an Iowa State University center)

Allied Signal

Booz-Allen & Hamilton

December 1997

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Introduction

The purpose of this document is to report on the conclusions of the Intelligent Transportation Systems (ITS) Early Deployment Study (EDS) for the Des Moines metropolitan area. The objective of the study was to develop a strategic plan for the development of appropriate ITS market packages for the Des Moines metropolitan area.[1] This document is intended to serve as a road map for the incorporation of ITS applications in projects that are proposed for future transportation improvements. To do this, the study makes ITS deployment recommendations for the near term (one to five years into the future) and provides a framework for medium and long term deployment of ITS functions in the metropolitan area and sketches a plan for future ITS infrastructure.

The study has been a two-year effort that progressed through a number of successive iterative steps to build up to this report. Although ultimately the principal product of the study was to be this technical strategic plan, other less tangible goals of the study were to increase the level of understanding of ITS technology through presentations and discussions, to build prototype ITS applications, and to develop a forum for members of the technical community to focus on the role of ITS in the Des Moines metropolitan area. By building a better understanding of ITS and even creating champions for ITS in the Des Moines metropolitan area, the study process actually helped to smooth many of the institutional issues that commonly stymie ITS deployment.

In the process of conducting the EDS, a number of products were developed. These included two prototype traveler information systems, methodologies for compiling transportation system elements inventories and accident data for display and queries in a geographic information system (GIS), and a graphic simulation model database for the I-235 corridor. Also during the process of conducting this study, five major reports (this one being the fifth) were developed. It is the purpose of this report to provide a capstone to the process and to identify specific ITS functions and infrastructure for development in the Des Moines metropolitan area.

1 The accepted terminology for ITS functions changed during the course of the study from user services to market packages.

Institutional Framework for Success

The ITS EDS area was the Des Moines metropolitan area defined by the Des Moines Area Metropolitan Planning Organization (MPO). The MPO Planning Area includes portions of Dallas, Madison, Polk, and Warren counties. Within the urban Planning Area, there were numerous public organizations with responsibilities for the operation and/or enforcement of transportation facilities and services (state, cities, counties, transit agencies, airports, police, etc.), along with private travelers and carriers with a stake in transportation services and facilities. Although some ITS market packages may be within the authority of one organization to implement, ITS functions should not be constrained by organizational authority or jurisdictional boundaries. In fact, many ITS functions are, by definition, regional services stretching across metropolitan areas and beyond. For example, traffic management cuts across all jurisdictional boundaries because traffic congestion and incidents do not respect jurisdictional lines. Because ITS crosses boundaries of authority (e.g., police and public works departments), success in implementing ITS requires first establishing champions of ITS services within the various operating agencies and giving one organization the authority to integrate ITS services across lines of authority (e.g, across police and public works departments) and across boundaries of local government.

The only transportation agencies with region-wide responsibilities are the MPO, the Iowa Department of Transportation (Iowa DOT), and the Iowa Department of Public Safety, Iowa State Highway Patrol. Clearly, the MPO and the Iowa State Highway Patrol can serve as champions, partners, and catalysts for development of ITS services in the Des Moines metropolitan area. Because the Iowa DOT is the only agency that owns and operates highway facilities in all of the metro area cities and counties in the study area, it is recommended that the Iowa DOT take the lead in developing the systems to support ITS market packages emanating from its core highway facilities in the Des Moines metropolitan area. That is not to say that only users of Iowa DOT highways will benefit from ITS technology. Figure 1-1 shows functional classifications of highways likely to benefit from the deployment of ITS technology in the metropolitan area. While the Iowa DOT owns and maintains more of these roads than any of the local agencies, all the jurisdictions must partner together to successfully implement ITS.

Table 1-1 further emphasizes the need for cooperation among agencies and jurisdictions and gives some indication of the potential relative importance of ITS to each of these jurisdictions. For example, about one half of the highways in urban areas classified as municipal arterials or higher (160 miles) are located within the boundaries of the City of Des Moines, while roughly one third of the urban area’s roadways to benefit from ITS are located in the City of Des Moines; 12 percent of the highways to benefit from ITS are in the City of West Des Moines, and eight percent are City of West Des Moines municipal arterials.

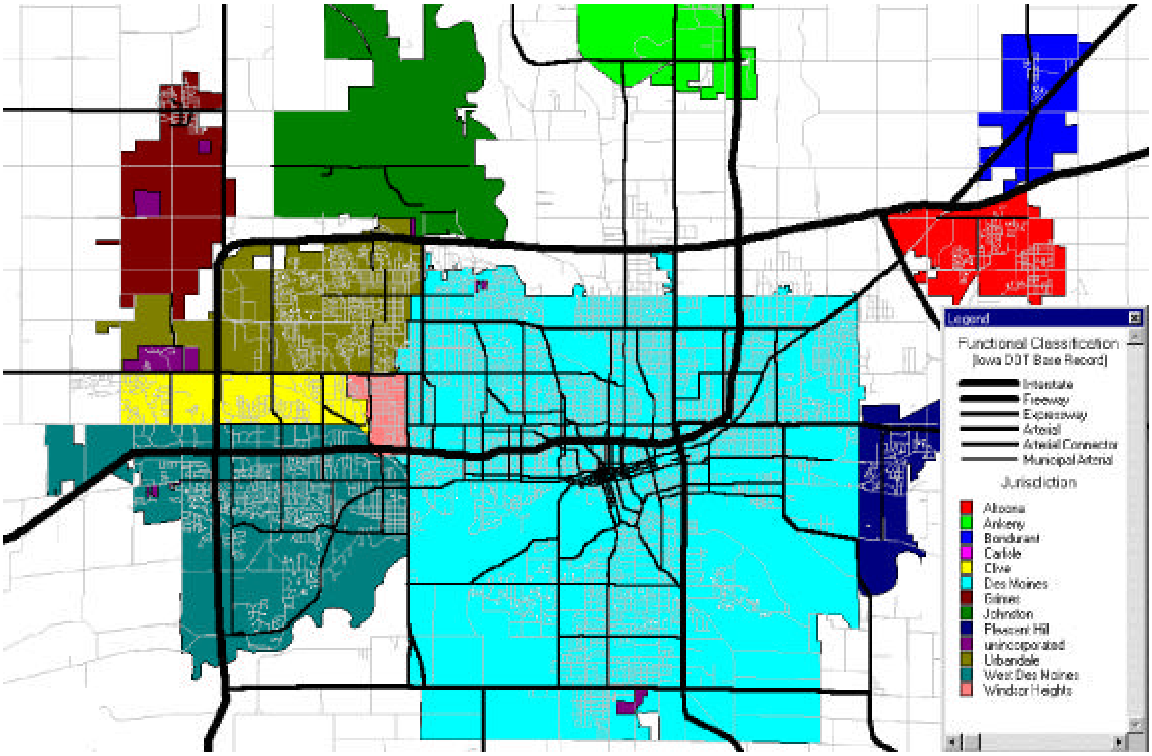

Figure 1-1 Highways Potentially Benefiting From ITS Services in Des Moines Area

Table 1-1 Roadways Benefiting From ITS By Jurisdiction (in miles)

	Primary Roads					Total	Municipal		
	Interstate	**Freeway**	**Expressway**	**Arterial**	**Arterial Connector**	**Primary**	**Arterial**	**Totals**	**Percent**
Des Moines	8.92	5.07	5.17	10.55	22.94	**52.65**	107.53	**160.18**	54.42
West Des Moines	9.30			1.00		**10.3**	24.92	**35.22**	11.97
Ankeny	3.77				8.76	**12.53**	8.49	**21.02**	7.14
Urbandale	6.38			.0.19	2.6	**6.57**	12.96	**19.53**	6.64
Johnston							10.87	**10.87**	3.69
Clive	1.0				5.77	**6.77**	4.01	**10.78**	3.66
Pleasant Hill		0.63	2.69		1.31	**4.63**	2.33	**6.96**	2.36
Bondurant			3.19		2.64	**5.83**	1.06	**6.89**	2.34
Grimes				2.17	1.44	**3.61**	1.31	**4.92**	1.67
Waukee					2.65	**2.65**	1.12	**3.77**	1.28
Altoona		0.8			1.04	**1.04**	2.70	**3.74**	1.27
Norwalk					2.88	**2.88**	0.78	**3.66**	1.24
Polk City					2.49	**2.49**		**2.49**	0.85
Windsor Heights	0.76					**0.76**	1.66	**2.42**	0.82
Carlisle				0.68		**0.68**	1.21	**1.89**	0.64
Cumming									0
City Totals	**30.13**	**5.70**	**11.05**	**14.59**	**51.92**	**113.39**	**180.95**	**294.34**	100
Unincorporated	31.02	3.99	3.68	17.40	24.98	**81.07**		**81.07**	
Iowa DOT	49.6	7.7	5.7	29.5	65.4	**157.9**		**157.9**	
Totals, Metro Area	**110.75**	**17.39**	**20.43**	**61.49**	**142.3**	**352.36**	**180.95**	**533.31**	

Working hand in hand with local governments in the region, other related state agencies, and other private stakeholders, the Iowa DOT is the obvious candidate to be the lead developer of the region-wide core ITS infrastructure and programs.

Conceptual Framework for ITS Architecture

ITS applies advanced technology, computers, information systems, and improved processes to deliver services that allow personal and commercial travelers to make more informed decisions and enable travelers and operators of transportation systems or services to better manage their vehicle or transportation system. Although the numerous transportation stakeholders have a variety of perspectives on transportation services and facilities, clearly all of them want to promote economic vitality and enhance the quality of life by maximizing traveler and freight mobility while minimizing the related temporal, psychological, economic, safety, and environmental costs. ITS is a tool that supplements and enhances conventional transportation improvements (e.g., widening highways) to achieve these desired results; in fact, ITS may be critical to providing adequate transportation systems or services in situations where conventional improvements are necessarily limited or unfeasible.

The basis for ITS functions is the concept of increasing mobility and reducing transportation costs through improved transportation services. Thus ITS functions provide the conceptual framework for ITS market packages, which are specific efforts to improve transportation service. ITS functions, for example, are to provide travelers and commercial vehicle operators with accurate and timely route choice and travel time information, to provide traffic management resulting in more efficient use of highway capacity, and to provide transit patrons with current vehicle arrival information. These functions are made real through ITS market packages, which are supported in turn through the use of ITS infrastructure. Thus, ITS functions (e.g., better traveler information, improved traffic management, better intermodal information, etc.) provide the conceptual framework that drives ITS market packages and the ITS infrastructure and strategies necessary to provide these services. Figure 1-2 illustrates how the conceptual framework for ITS is driven by the goal to maximize mobility and to minimize costs and how this in turn drives the specific needs for ITS infrastructure and market packages.

The physical ITS infrastructure provides the technology tools to collect and process transportation data. ITS technology infrastructure measures the condition of the highway system and transit through a variety of surveillance systems. The condition data are then brought to a processing facility to be fused to create meaningful information to support the delivery of ITS functions. Although processed transportation-system condition data may be distributed to and used by a variety of agencies and organizations within the region, an architecture that allows data to be fused at a central point facilitates the

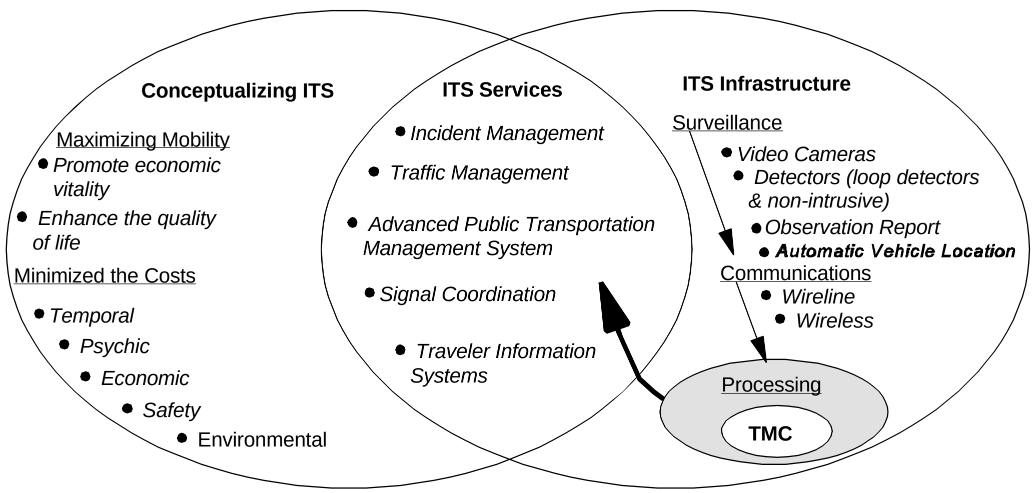

Figure 1-2 Conceptual Architecture

development of information across lines of authority (e.g., policy data, traffic condition data, and transit vehicle data) and across jurisdictional boundaries. By fusing data across lines of authority and jurisdiction, the resulting information becomes richer, providing more complete and meaningful information regarding the entire transportation system. The core of the fusing or processing capabilities is the metropolitan Traffic Management Center (TMC). The ITS infrastructure is illustrated by the right-hand circle in Figure 1-2.

The ITS infrastructure (i.e., surveillance, communications, and condition data processing) delivers information to support ITS market packages (i.e., incident management, traffic management, traveler information, etc.). As shown in Figure 1-2, ITS market packages are really the union of ITS concepts and ITS infrastructure. It is through the union of ITS concepts (e.g., better traveler information leading to greater mobility) and the use of advanced transportation technologies (i.e., ITS infrastructure) that ITS market packages may be realized.

Through the course of the Early Deployment Study, the desired functionality of ITS systems in the Des Moines metropolitan area was identified. The study, conducted under the direction of the steering committee (consisting of regional stakeholders), found that the following functions are desirable:

- improving mobility in the urban area by more quickly removing incidents
- providing travelers with better and more current information so they can make better driving choices
- improving the management of traffic in high accident locations to reduce costs
- providing other functions to improve mobility and reduce costs in the Des Moines metropolitan area

It is the purpose of this report to recommend deployment of ITS surveillance, communication, and processing infrastructure in the short term and to provide a framework for ITS infrastructure deployment in the medium and long term. The suggested ITS infrastructure provides the tools to support the delivery of ITS market packages that serve the desirable functions identified above; therefore, the study will recommend steps stakeholders can take to make these market packages operational. However, it is the responsibility of the regional stakeholders and a requirement for future design-level studies to assign responsibilities, develop institutional and operational agreements between organizations, and provide resources to deliver the desired ITS market packages.

Unlike larger urban areas, the Des Moines metropolitan area transportation system has not become clogged by congestion. Des Moines area freeways, transit services, and arterial streets provide a relatively good level of service. This implies that Des Moines metropolitan area, unlike more congested urban areas, is not motivated to develop ITS market packages to avoid or mitigate large investments in capacity improvements to temper burgeoning congestion. Instead, the region has the opportunity to build up and target ITS infrastructure strategically, without pressure to make investments to alleviate existing congestion.

With the opportunity to build and plan in mind, this ITS plan was developed based on the following principles:

- Identify achievable, economically feasible, and sustainable early winners for ITS projects.
- Build the core infrastructure incrementally using interoperable systems, while recognizing that the development of the ITS infrastructure and the services identified require a long-term commitment.[2]

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[2] "Interoperability is the capability of two systems to operate with each other, exchange information efficiently, and utilize the capabilities in each of the systems

- Develop core ITS infrastructure in partnership with other transportation development programs and stakeholders with similar objectives. Clearly the I-235 reconstruction, the Iowa Communications Network's interest in building a core fiber optic network in Des Moines, and the development of a new signal system for downtown Des Moines are current or planned activities that present significant opportunities for synergy with the development of a core ITS infrastructure. Capitalizing on opportunities to work in parallel with other projects will help to accelerate the construction of ITS infrastructure.

Plan Development Process

This plan was developed through a number of iterative steps. The first step in the process was to identify a steering committee for the project. The steering committee represented a broad variety of stakeholders from the metropolitan area. The first steering committee task was to review and critique the proposed work plan and begin to become more familiar with ITS.

The first significant activity for the project was to lay the groundwork for the study. This was done by conducting an inventory of transportation mapping and data management, travel and transportation management, public transportation, and the current status of the use of ITS services in the Des Moines metropolitan area.

During the inventory phase, the most extensive work was conducted while populating map databases with inventory data. The data sets were then compiled in a GIS database. MapInfo, a desktop GIS software, was selected as the database system. Two databases were constructed. The Central Iowa Automated Mapping (CIAM) map base was used for urbanized Polk County, while the Iowa DOT's map base was used for the entire study area. The CIAM map base provided greater accuracy, and hence the CIAM maps were used where they were available.   Additional data (or layers of information) were imported for geographic features, streets, highways, railroads, airports, corporate limits, and county boundaries.

Layers were then built in the MPO area map base for traffic counts, traffic accident data from the Iowa DOT's Accident Location Analysis System (ALAS), traffic signals, and signal systems. This database has continued to evolve and has become part of an integrated transportation management system. During 1997 and 1998, similar databases will be developed, region by region, for the entire state of Iowa and will contain other

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effectively." Taken from "ITS Architecture Standards Development Plan," prepared by the Joint Architecture Team, prepared for U.S. Department of Transportation, June, 1996, p. 5.

related transportation data from other transportation management systems (e.g., pavement and bridge management data).

Using the inventory of existing systems facilities, traffic and transportation characteristics and attributes, and existing ITS services, the steering committee targeted five topic areas to concentrate on. They included:

- Incident Management
- Traveler Information
- Advanced Traffic Control
- Commercial Vehicle Operations
- Data Management

For each topic, a different approach was taken to study related issues and to identify candidate ITS services. For incident management, traveler information, and advanced traffic control, a committee was developed to identify goals and objectives, institutional issues, and systems requirements. For commercial vehicle operations, project staff worked directly with the Iowa Motor Carriers Association (IMTA), and the IMTA convened IMTA members to review the work developed by the project staff. Data management issues were identified through project staff discussions with technical staff for the constituent agencies and a meeting with constituent groups. The work in each of these topic areas resulted in the identification of specific market packages for further focused refinement.

To assist the subcommittees in visualizing traveler information systems, two static Internet home page systems were built. One of the systems presented transit information, including route and schedule information for all of the Des Moines Metropolitan Transit Authority's (MTA) fixed route service. The other system provided information and identified points of interest to truck operators.

The next step in the planning process was to conduct a review of ITS technology. To do this, a detailed review that AlliedSignal had conducted for the Maricopa County Department of Transportation (the county containing Phoenix, Arizona) was reviewed and updated. The technology review included an evaluation of 169 technologies with respect to 12 criteria. The criteria included categorization and description of the technology, supportability of the technology, technology costs, and judgmental evaluations of the technology's benefits and negative and positive attributes.

Given a thorough understanding of the technology and the desired ITS services, the study developed an ITS deployment plan with projects spaced in time over the short, medium, and long term. The list of projects was developed by study staff through a series of meetings with constituents for each group of functions and with the steering committee.

The steering committee approved the proposed list of projects during its June 20, 1997 meeting.

The project plan identified 45 separate projects or phases of activities to be developed through a program of projects spread over time. Most of the activities identified are to be completed or will be under way within the first five years of the planning period (1997 to 2002). The I-235 reconstruction planned for the year 2002 provides a watershed for the proposed ITS projects. Prior to reconstruction, the focus is on the incremental establishment of ITS services in the urban area and improvement of reconstruction diversion routes. During reconstruction, the focus turns to implementing ITS infrastructure on the I-235 corridor as part of the reconstruction.

It is the purpose of this report to define a road map for the development of surveillance, communication, and transportation system condition-data processing systems to support the provision of ITS market packages. Once accepted, the next step for the deployment of ITS services in the Des Moines metropolitan area is to move to the system design.

Study Participants

The study was a joint project of the Des Moines Area MPO, the Iowa DOT, the Federal Highway Administration, the Center for Transportation Research and Education, AlliedSignal, and Booz, Allen and Hamilton. The study was directed by a steering committee that included a broad variety of stakeholders. They included:

- The Des Moines Area Metropolitan Planning Organization - Tom Kane, Executive Director
- Iowa Department of Transportation - Marty Sankey, I-235 Coordinator; Timothy Crouch, Traffic Control Engineer; Michael Audino, Director, Field Services Division
- Iowa State Highway Patrol - Steve Marsh, Captain
- Federal Highway Administration - James Hogan, Design and Traffic Operations Engineer
- City of Des Moines, Traffic and Transportation Department - Gary Fox, Office Director
- City of Des Moines, Police Department - Bob Lohrman, Enforcement Officer
- Polk County Engineering Department - Mark Wandro, Assistant County Engineer
- Des Moines Metropolitan Transit Authority - Donna Grange, Paratransit Director
- City of West Des Moines, Public Works Department - Duane Wittstock, City Engineer
- City of West Des Moines, Police Department - Bob Rushing, Captain
- City of Windsor Heights, Fire Department - Al Hunter, Fire Chief
- Iowa Motor Truck Association - Scott Weiser, President
- Greater Des Moines Chamber of Commerce - Kent Sovern
- Des Moines International Airport - William Flannery, Aviation Director

A number of other organizations and individuals contributed to the study by completing questionnaires and meeting with study staff members. These contributors ranged from ITS technology manufacturers to Des Moines area hotel managers who are potential users of traveler information services.

What's Next?

This report clearly identifies specific projects, provides cost estimates for the projects, and suggests a starting point of design. Therefore, the next step in moving the Des Moines metropolitan area to deployment of ITS services is to program improvements and conduct detailed design of the system elements. Because ITS projects involve high technology with which staff and transportation decision makers are generally unfamiliar, and because the benefits are not as easily understood or as tangible as highway reconstruction or bridge building, ITS projects have been more difficult to promote, particularly in areas like Des Moines where congestion has not yet become intolerable. As a result, champions for ITS within the Des Moines metropolitan area must be generated and continually reinvigorated. The steering committee represents a good core of Des Moines area ITS champions. Therefore, it is recommended that the Early Deployment Study steering committee continue to work together as a deployment steering committee following the completion of this project. Meetings should be scheduled regularly (e.g., once every other month) to discuss deployment action items.

Report Organization

As part of the ITS Early Deployment Study, several ITS projects and initiatives were identified. These are listed in Table 1-2 along with an approximate time frame. The implementation, benefits, and cost of each project is discussed by chapter in this report. Each chapter discusses a specific function or functions of the proposed Des Moines metropolitan area's Intelligent Transportation System. Although functions are discussed separately, they are largely interdependent. The chapters and their order are:

Chapter 2 Public Transportation Systems
Chapter 3 Commercial Vehicle Operations
Chapter 4 Service Patrols
Chapter 5 Priority Corridors
Chapter 6 Interjurisdiction Signal Coordination
Chapter 7 Advance Transportation Management/Traveler Information System
Chapter 8 Incident Management
Chapter 9 Pre-Trip Traveler Information

An underlying assumption of the deployment plan is that institutional issues that commonly stymie deployment of ITS will not slow or halt the deployment of ITS in Des

Moines. Further, the recommendations made in this plan are based on the assumption that the Iowa DOT will lead the development of a Transportation Management Center. The promotion of ITS deployment is consistent with the Iowa DOT program to support the deployment of ITS as defined in the recently released state transportation plan, “Iowa In Motion.”[1]

References

1 Iowa Department of Transportation, “State Transportation Plan - Iowa In Motion,” adopted by the Iowa Transportation Commission, July, 1997, p. 77.

Table 1-2 ITS Projects

PROJECT CATEGORY		1 1998	2	3 SHORT TERM	4	5 2002	6	7	8 MEDIUM TERM	9 2006	10	11	12	13 2010	14	15	16 LONG TERM	17 2014	18	19	20
SURVEILLANCE	Project Implementation	Video surveillance at I-235 high accident locations Iowa DOT																			
	Project Implementation	Evaluate phased surveillance plan for I-235 & I-35/80 Iowa DOT																			
	Project Implementation		Install Phase 1 surveillance for I-235 & I-35/80 Iowa DOT																		
	Project Implementation					Install final I-235 surveillance as part of I-235 reconstruction Iowa DOT															
	Project Implementation	Establish phased surveillance for diversion routes from I-235 Iowa DOT / Local agencies																			
	Project Implementation		Install diversion route surveillance prior to I-235 reconstruction Iowa DOT / Local agencies																		
	Project Implementation								Surveillance plan for other major travel corridors D.M. MPO / Iowa DOT												
	Project Implementation									Phasing off Corridor Surveillance Iowa DOT / local agencies											
SIGNAL SYSTEM	Project Implementation	Evaluate ramp metering strategies for I-235 reconstruction Iowa DOT																			
	Project Implementation		Install temporary ramp metering for pre-I235 reconstruction Iowa DOT																		
	Project Implementation						Re-evaluate ramp metering strategies Iowa DOT														
	Project Implementation		Evaluate priority corridors for signal coordination Iowa DOT / Local agencies																		
	Project Implementation			Phased Corridor Coordination Iowa DOT / Local agencies																	

Table 1-2 ITS Projects

PROJECT CATEGORY		1 1998	2	3	4	5 2002	6	7	8	9 2006	10	11	12	13 2010	14	15	16	17 2014	18	19	20
TRANSPORTATION MANAGEMENT AND INFORMATION CENTER	Project Implementation	Phase 1 Freeway Management Center (for I-235 video surv.) Iowa DOT																			
	Project Implementation	Coord. D.M. CBD signal system w/ Freeway Management City of D.M. / Iowa DOT																			
	Project Implementation		Expand Freeway Mgt. Center w/ ramp metering & diversion route surveillance Iowa DOT																		
	Project Implementation			Coordinate surveillance input from all agencies Iowa DOT																	
	Project Implementation					Coordinate input to metro-wide HAR Iowa DOT															
	Project Implementation				Establish metro-wide traffic management & signal coordination Iowa DOT / Local agencies																
TRAVELER INFORMATION	Project Implementation	Coordinate traveler information web site D.M. MPO																			
	Project Implementation	Add airport info to web site D.M. Airport & MPO																			
	Project Implementation		Deploy kiosks at key loca D.M. MPO / Iowa DOT				Establish and implement phasing plan for kiosks D.M. MPO / Iowa DOT														
	Project Implementation		Coordinate web site w/ Cable TV D.M. MPO / Iowa DOT																		
	Project Implementation		Implement Highway Adv. Radio Iowa DOT / local agencies					Metro-wide Highway Advisory Radio Iowa DOT / Private participation													
	Project Implementation	Enhance transit vehicle tracking METRO																			
	Project Implementation				Add real-time traffic information to kiosks & web site D.M. MPO / Iowa DOT																

Table 1-2 ITS Projects

PROJECT CATEGORY		1 1998	2	3	4	5 2002	6	7	8	9 2006	10	11	12	13 2010	14	15	16	17 2014	18	19	20
TRAVELER INFORMATION	Project Implementation			Evaluate need for additional variable message signs for Des Moines freeway system Iowa DOT																	
	Project Implementation	On-going coordination and maintenance of traveler inforrmation activities (annual cost) Des Moines MPO / Iowa DOT																			
INCIDENT MANAGEMENT	Project Implementation	Enhance Freeway Service Patrol Iowa DOT					Operate Freeway Service Patrol (on-going through year 20) Iowa DOT														
	Project Implementation			Establish Incident Response Tracking Iowa DOT/ Response agencies																	
	Project Implementation			Coord. Freeway Mgt. w/ Incident Response (annual cost) Iowa DOT / Response agencies																	
PUBLIC TRANSPORTATION	Project Implementation	Develop plan for electronic fare payment METRO																			
	Project Implementation		Implement electronic fare payment METRO																		
	Project Implementation		Install signal priority equipment on transit vehicles METRO																		
COMMERCIAL VEHICLE OPERATIONS	Project Implementation	Maintain CVO traveler information web site Iowa Motor Truck Association																			
	Project Implementation			Coord. Operation Respond w/ D.M. Incident Response Iowa DOT / State Patrol / Emergency Response Center																	
	Project Implementation			Determine ITS needs of Intermodal Center for I-35 Corridor D.M. MPO																	

Table 1-2 ITS Projects

PROJECT CATEGORY		1 1998	2	3	4	5 2002	6	7	8	9 2006	10	11	12	13 2010	14	15	16	17 2014	18	19	20
DEPLOYMENT SUPPORT	Project Implementation	Interim Peak Hour travel Demand Model D.M. MPO / Iowa DOT																			
	Project Implementation			O-D studies for improved model D.M. MPO																	
	Project Implementation				Dynamic peak hour model D.M. MPO																
	Project Implementation	Maintain annual update to GIS database of signal locations D.M. MPO																			
	Project Implementation	Annual evaluation of ITS Strategic Plan and status of implementation D.M. MPO																			

2

Public Transportation Systems

The study steering committee recommended that the Des Moines Metropolitan Transit Authority (MTA) implement two ITS applications: one to prioritize the automated traffic signal timing plans to accommodate MTA buses in downtown Des Moines, the other to automate the payment of bus fares with electronic fee cards.

Traffic Signal Prioritization for Buses

Traffic signal priority for buses may be provided through active or passive measures. Passive measures are those that are programmed into the signal system's design or are part of the signal system's predetermined signal timing plan. Passive strategies may involve programming signal timing plans to provide green phase progression at the travel time of buses rather than at the travel time of automobiles or permitting buses to make specific movements at intersections that other traffic cannot make. Active measures involve real-time-responsive signal systems that provide green priority for approaching transit vehicles (prioritization) or that simply interrupt the normal signal cycle and turn the signal green in the direction of the bus's travel (preemption).

Of the two active strategies, prioritization at traffic signals involves making real-time adjustments to traffic signal timing plans to increase the likelihood that the signal will be green when the transit vehicle enters the intersection. Preemption, on the other hand, interrupts the signal's normal timing plan to ensure that the signal will be green when the vehicle enters the intersection.

Early methods (1960s and 1970s) for reducing bus delays at intersections involved preempting the normal traffic signal cycle. Because traffic signal controller processors at that time did not have the computing capabilities to adjust themselves in real time, prioritization strategies were not an alternative. Preemption, however, does not take into account the delays (or user costs) associated with providing priority treatment for the bus receiving preemption. Specifically, preemption and turning the light green in the direction of the bus's travel causes an interruption of traffic flow in opposing directions. The resulting delays are not taken into account in preemption. Further, preemption causes a breakdown in the green phase progression for traffic traveling along the same arterial as the bus and on crossing streets. With advances in traffic signal controller processors, prioritization strategies are now possible that minimize the interruption of general traffic flow and the associated delays and user costs.

Real-time adaptive traffic control with transit prioritization involves one of several methods to reduce the likelihood that a bus will be delayed at a traffic signal and reduce overall bus delays at intersections. The methods involve making marginal adjustments in the traffic signal timing plan to reallocate portions of the signal's cycle time or to adjust the cycle time.

Cycle times are one of the fundamental building blocks of a traffic signal timing plan. Using a very simple example, the cycle time is the time taken from the start of one intersection movement (e.g., a north-south through movement) through all other phases (east-west through movement and left-turn movements) returning back to the beginning of the same movement. The time required to go through all movements and return to the original movement is a cycle. Each movement within the cycle is a phase, and the proportion of a cycle allocated to each phase is the split.

Along an arterial, traffic signals should be synchronized to allow traffic to move from one to the next intersection (at the posted speed or below) without having to stop. The synchronization of green at sequential traffic signals is known as progression. The time between the beginning of the through movement at one intersection and the beginning of the phase in the same direction at the next intersection is known as the offset. To maintain progression in both directions, each signal along an arterial must have the same cycle time length.

If a bus is not going to arrive at an intersection while the light is still green, green time (or priority) may be provided in the direction the bus is traveling by extending the green phase. Or green time may be provided to the bus by cutting off a phase early in a direction opposing to the direction of the bus. Or a new phase design (e.g., skipping a protected left-turn phase) may be adopted to provide priority to traffic flowing in the bus's direction. After the prioritization strategy has been effected, the traffic signal control system will adjust back to its original traffic signal timing. Some of the most sophisticated traffic signal timing and control programs are constantly making marginal adjustments to accommodate current traffic conditions. Such adaptive systems require traffic signal control processors capable of making adjustments in real time.

Generally, priority is provided at the expense of one or more movements. Most modern adaptive traffic signal control strategies try to adjust the traffic signal timing to take into account the total number of people going through the intersection (person throughput) as opposed to the number of vehicles going through the intersection (vehicle throughput). In other words, in theory providing green time will not be taken away from one phase and given to another phase unless the total person throughput is increased. Providing buses priority generally improves person throughput for two reasons:

1. During peak load periods, buses can easily carry as many passengers as can 30 passenger cars and often more. The cost of delaying 30 cars is, therefore, roughly equivalent to the cost of delaying one bus. Because buses have a much more significant impact on total person throughput, they should usually receive priority treatment over automobiles.

2. Heavy vehicles like buses and trucks do not perform as well as automobiles in terms of deceleration and acceleration. Therefore, when heavy vehicles do not stop at an intersection, the delay due to their stopping and starting is not imposed on the traffic flow. Thus, overall traffic flow performance is improved when heavy vehicles are provided priority through intersections. In a recent study of truck prioritizing it was found that delay is reduced for both automobiles and heavy vehicles when heavy vehicles are provided priority treatment through an intersection.[1]

Because they generally improve an intersection's overall person throughput, traffic signal systems providing priority to bus movements can be quite cost effective (see the benefits and costs section of this chapter for more discussion of cost effectiveness). Another advantage is that traffic signal prioritization for buses increases transit travel time reliability. Poor travel time reliability is a major problem for bus systems at transfer points with headways of 15 minutes or longer (e.g., Des Moines). One way to reduce variability in bus travel times is to reduce their dwell time at traffic signals.

It is therefore recommended that the new Des Moines downtown traffic signal system be developed with transit prioritization capabilities. Only signals at intersections along the MTA's routes need to provide intersection prioritization for buses. Figure 2-1 contains a map of downtown Des Moines. Intersections that are part of the downtown signal system are identified by large dots. In downtown Des Moines, there are 56 signalized intersections on bus routes. A number of Urban Traffic Control (UTC) systems are commercially available with prioritization systems.

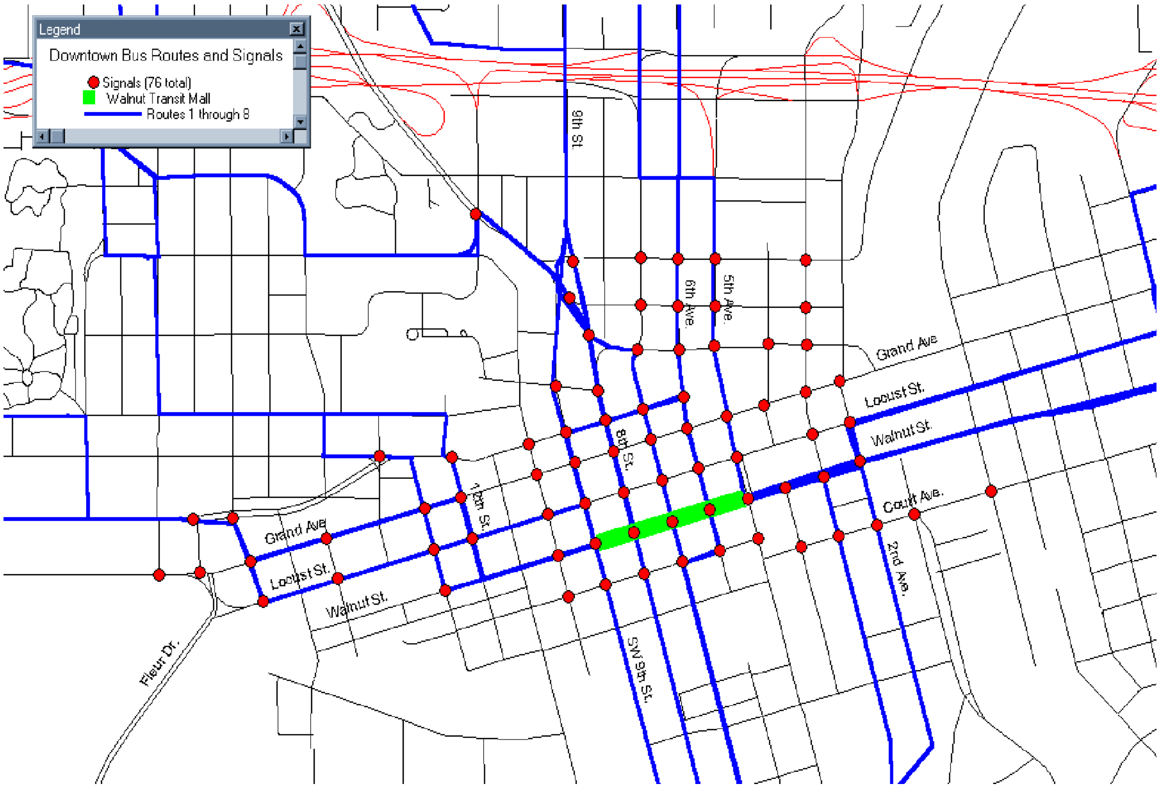

Figure 2-1 Downtown Traffic Signal System and Bus Routes

Traffic Signal Priority System Design

There are several methods for organizing a traffic signal system to activate bus prioritization at traffic signals. All methods require an Automatic Vehicle Location (AVL) system of some kind.

One form of AVL that is very accurate uses an onboard global positioning system (GPS) to determine the location of the vehicle and a radio to transmit the location of the vehicle to a base station at the transit management center. In addition to identifying buses approaching a traffic signal, this type of AVL can continuously identify the location of the bus and transmit location and other management information to the base station. Other management information might include the number of passengers on board or the current mechanical condition of the engine and other bus components.

To actuate the priority treatment at the intersection, the system compares the position of the bus with its scheduled position and, if the bus is running behind schedule, the system requests that the approaching traffic signal system provide the bus priority treatment. This kind of operation requires a connection between the base station at the transit management center and the traffic signal control system.

Other systems involve the use of a bus-mounted device to communicate directly with an approaching traffic signal to request priority treatment for the bus. Such a system may use a radio frequency transponder mounted on the bus. A roadside reader in advance of the intersection identifies an approaching bus and signals the traffic signal controller to provide the bus with priority treatment at the intersection. Other systems may use a short-range radio, infrared, or microwave signal (which may or may not be activated by the driver) to signal the traffic signal controller directly (one of the most poplar systems uses a high-energy infrared strobe to signal the approach of a bus).

Systems are now being tested that include both GPS and AVL systems and an onboard system to communicate directly with an approaching traffic signal (one is being tested by the Napa Valley Transit using an infrared strobe to request prioritization of the signal controller). An onboard computer compares the current location of the bus to its scheduled location on the route. If the bus is behind schedule by a predefined tolerance (e.g., five minutes), the onboard system actuates the signal priority system as the vehicle approaches the intersection. This type of automated system provides the greatest amount of flexibility and functionality.

It is recommended that within five years the downtown Des Moines traffic signal system capabilities be developed to provide priority treatment for buses using driver-prompted signals emitted from the vehicle. This capability should be investigated as part of the new downtown signal system study. It is further recommended that the MTA investigate other onboard electronics that could be incorporated into this system in the future. Emergency vehicles in the City of Des Moines currently can preempt traffic signal timing along planned emergency routes using strobes mounted on the vehicles. A similar system with the same but upgraded technology would provide the greatest flexibility to expand. The City of Des Moines and other cities in the metropolitan area are familiar with this technology and are using it to preempt traffic signals for emergency vehicles. The familiarity with and use of the technology would support future expansion of signals with prioritization capabilities to areas outside of downtown. In the future, as the Des Moines MTA upgrades its vehicles by integrating AVL systems and onboard computers into its fixed route fleet, it can build in capabilities to perform self-actuation of signals.

Benefits and Costs

Public transit systems that have adopted priority treatment at traffic signals have reported a number of benefits. These include reduced variability in travel times, improved regularity of services (reduced deviation from actual and scheduled headways), reduced operating costs due to improved fuel consumption performance, and increased ridership.[2]

The benefits depend on the unique application of the priority treatment, but in case studies involving 20 European cities the transit systems experienced an average 50 percent reduction in delay time due to bus prioritization at traffic signals.[3]

Typically, buses on transit routes on arterial streets experience 30 percent of their run time at red traffic signals. With traffic signal prioritization, run times can be reduced by 15 percent if the entire route includes priority treatment for buses at all traffic signals. Even though priority treatment is recommended only in downtown Des Moines, the cost savings could be significant. For example, a bus travel time savings during the peak period is typically valued at approximately eight dollars per minute. A delay savings of only five minutes for one bus per weekday would result in an annual benefit of $10,000. The equipment costs for prioritization systems are typically $1,500 per bus (for an emitter and in-vehicle hardware) and about $5,000 per intersection (for the signal mast arm receivers and control cabinet hardware). Not all MTA vehicles would have to be equipped, only those on routes into the downtown core and those assigned peak period trips. The MTA has estimated that it would equip up to 30 buses with emitters ($45,000).

Fifteen of the signalized intersections on MTA bus routes are already equipped with an infrared receiver and controller hardware for preemption by emergency vehicles (fire trucks), and six additional intersections are planned to be equipped for emergency preemption. Therefore, at most 35 intersections would require completely new equipment. The existing equipment would have to be updated, but much of it could be reused. First, however, a traffic engineering study of the downtown system should be conducted to determine which intersections actually require prioritization. For example, because delays due to boarding and alighting are a large source of delay along the Walnut Transit Mall during the peak period, prioritization may be ineffective in reducing delay. A traffic engineering study of prioritization at intersections in the downtown is recommended as part of the downtown signal system study.

In the 20 European case studies mentioned earlier, priority treatment systems provided an economic payback equal to their capital cost in three to 16 months. At the same time, minimal costs were imposed on traffic traveling through the intersection in opposing directions, and traffic in general may have benefitted by the expedited movement of slow buses through intersections.[4]

Electronic Fare Payment

Electronic fare payment involves paying for services using electronic media rather than using cash, tokens, or paper transfers. Electronic payment is most commonly done with magnetic stripe cards or with cards containing a microprocessor (smart cards). Transit operators employ electronic fare payment for three principal reasons:

1. To avoid the cost of managing cash payments. Managing cash has several costs that managing electronic payments does not. Cash management costs range from the cost of physically managing cash to the cost of security. Electronic systems provide better control and can more fully automate accounting and billing operations.

2. To provide greater convenience and flexibility for fare payment to customers. With electronic payment, customers do not have to carry cash. Payment for services can be made from multiple sources. For example, fares may be fully underwritten or subsidized by employers, public agencies (e.g., human services agencies), or shopping centers. Partial or full subsidies can be funded by these organizations with the knowledge that the funds will be used only for their intended purpose.

3. To automate collection of management information. Through the use of electronic payment and electronic transfer usage information, management has ready access to ridership and travel pattern information.

Convenience to the customer is a direct benefit for the transit system's riders. However, most of the other benefits involve reducing costs or accessing better management information for the transit system.

Electronic Payment Structure

Personal electronic payment is almost always conducted with a card and a card reader. The card either acts like an electronic purse and electronically carries value or identifies an account upon which credit or funds may be drawn. When designing an electronic payment system, there are basically three attributes of electronic payment technology and systems to consider:

1. Market size. There are fixed costs for both providers of electronic payment services and their customers. For service providers, fixed expenses include the cost of computers and hardware to control, accept, and dispense electronic payment, as well as the cost of establishing financial relationships with electronic payment partners. For the customer, depending on the sophistication of the technology, the card itself can cost as much as $20. Expensive systems can only be justified if their fixed costs can be spread across many uses and users.

2. Electronic card type. The principal card types are magnetic stripe cards, where data processing capabilities reside on the reader, and smart cards, where data processing occurs primarily on the card via a built-in microchip.

3. Functionality. The functionality of a card is determined both by the number of functions you can use it for and by the extent to which each function is automated.

Generally, the lowest functioning smart cards offer greater functionality than the most robust magnetic stripe cards.

Selecting a technology is a trade-off among these three attributes. When the electronic payment card is used for only one purpose (e.g., paying transit fares) and does not support a variety of uses (e.g., banking, human services, identification/driver's licence, parking payment, vending machine purchases, etc.), the volume of users and uses does not warrant the high fixed costs associated with high functionality. Systems that limit themselves to one purpose (e.g., paying transit fares) or a just a few select services (e.g., paying transit fares and purchasing parking at public garages) are closed systems. In other words, the value represented by the card cannot be used outside a closed and defined set of activities. An open system is available for use by any organization that meets the criteria for participation. For example, credit cards or ATM cards are examples of open systems (e.g., credit cards can be used to pay for purchases at all retailers who have met the card company's criteria). Cards like common magnetic stripe ATM-debit cards are single application cards. In the case of an ATM card, the card's only application is to withdraw funds from a bank account. Multi-application cards allow the user to conduct multiple functions, such as store health records, work in vending machines, serve as a credit card and drivers's licence, etc. There is a fundamental difference between a multi-application card and a card that can be used with multiple merchants.[5]

The study group recommends that, given the size of the transit user population in Des Moines and the lack of banking or public sector partners immediately available to support electronic payment, the Des Moines MTA start with a closed system and look for opportunities to migrate to higher functionality, multi-purpose systems in the future (five to 10 years). The Transit Cooperative Research Program of the Transportation Research Board is currently conducting a research project to further examine the role of electronic payment in transit and define a migration path to multi-application cards.[6] The results of this project should be quite useful to the MTA in mapping out its own migration path. In the short term (one to five years), however, it is recommended that the MTA migrate from its current cash-based system to a magnetic stripe card system and readers with read-write capabilities. It will be necessary to maintain dual systems (cash and magnetic stripe cards), thus diminishing the economies of using completely cashless systems. However, electronic payment will reduce security risks, improve cash flow control, provide more flexibility for fare payment, and offer new opportunities for marketing transit services.

The current standard fare boxes deployed in the MTA's fleet can be upgraded to accept thick, coated paper or polyester-reinforced paper tickets with read-write magnetic stripes and a thermal surface for electronically writing/storing the remaining value of the card ("stored-value"). The tickets cost five to 15 cents each. The same system has the capability to read transfers to provide transfer control. The transfer capabilities can also trace trips linked between routes to support better operational management and route planning. Transfers paid for with magnetic stripe cards cost two to five cents per transfer.

These fare box enhancements can support the migration to electronic payment using smart card technology in the medium term (five to 10 years). Upgrading the fare boxes will cost in the range of $3,000 to $4,000 per bus.

Smart Card Technology

Although magnetic stripe fare cards are more convenient than cash for fare payment, offer better cash-flow control, and automate accounting and management information, magnetic stripe technology has its faults. Magnetic stripe fare cards represent a closed system and are not integrated into a wider range of financial and personal information services. Further, because the read-write systems are mechanical systems, they are prone to failure and require maintenance. And processing magnetic stripe cards at fare boxes is generally slower than paying with tokens and only marginally faster than paying with cash.

High-end magnetic stripe cards, however, can provide a great amount of flexibility. Iowa State University, for example, uses high-end magnetic stripe cards for faculty, student, and staff identification cards. The ID cards may also be used as ATM cards at participating banks and to pay for services or products at participating campus stores, restaurants, and book stores; to access personal ISU records at kiosks; to check out ISU library books; and to pay for other campus services. To be able to provide this high level of functionality, the cards contain two magnetic stripes (as opposed to the common single stripe).

Compared to magnetic stripe cards, smart cards offer an order of magnitude improvement in the level of data that can be stored and processed (as opposed to read-write and store) on the card. Embedded in a smart card are a small microprocessor and nonvolatile, electrically erasable, programmable, read-only memory (EEPROM). The principal purpose of the microprocessor is to perform security checks to guarantee the incorruptablility of the information stored on the card. Smart cards can store about 80 times as much data as can magnetic stripe cards, allowing them to serve multiple applications on one card (e.g., fare payment card, credit card, library check-out card, and a driver's licence including driving history all in one card). Typical smart cards store three kilobytes of data, and some can store up to eight kilobytes.

Worldwide, electronic payment and other personal services are migrating from identification cards and magnetic stripe cards to smart cards. In France, for example, 22 million bank card holders have smart cards, and all automatic teller machines accept smart cards as well as traditional magnetic stripe cards.[7] The primary reason that Europe and other parts of the world are embracing smart card technology more quickly than is the United States is that Europe has not had the telecommunication infrastructure to support online banking capabilities. Smart cards are better suited to offline applications and, therefore, because smart cards are suited to performing security checks offline, they were more quickly adopted in Europe.

One type of smart card is the contact card. This card contains a small array of electrical contacts on one surface of the card for carrying data from the card to the reader and for carrying electricity to the card. Stored value contact-type smart cards, with very little processing capability, have been used for years in Europe at pay telephones. Hard-wired into their logic is the ability to deduct funds but never to increase the stored value.

The other type of smart card is a proximity smart card, or contactless smart card. Proximity cards use radio frequency communications to transmit information between the reader and the card. Normally, they have a range of one to 10 centimeters. The card's antenna is embedded in the plastic. The advantages of contactless cards are that they do not have exposed connections that can wear out and render the card worthless and, since the user is not required to physically place the card in contact with a reader receptacle, transactions take place much more quickly. In fact, contactless smart cards are quite attractive in transit operations where passenger throughput is an issue.

The study group recommends that the Des Moines MTA eventually migrate to contactless smart cards with other partners in the metropolitan region.

Benefits and Costs

It is difficult to estimate the exact customer benefits due to the convenience of cashless payments when riding transit. Perhaps the Des Moines MTA could make better route planning and operations decisions if it had better information on ridership and transfers provide by electronic payment systems, but it is difficult to estimate what those benefits would be. However, it is reasonable to believe that with electronic payment the MTA would have better control over fare collection, diminishing the potential for loss of fare receipts, and reducing the opportunities not to collect fares or to accept erroneous transfers.[8]

The MTA has estimated that the total cost to upgrade fare boxes to accept magnet stripe payment cards will be $325,000. In 1995 the MTA reported collections of $2,350,000 in passenger fares (this does not include revenues received due to contracts or other means).[9] Assuming revenue increases of five percent per year and a social discount rate of four percent per year, only a three percent improvement due to better fund control is required to recoup the initial capital investment over a five-year period. In other words, if the improvement in control and efficiency of fare processing is equal to only three percent of the fare payments, the cost of the new equipment will be recovered in five years. The equipment purchased today will also support the MTA's future migration from magnetic stripe cards to smart cards in another five to 10 years.

Public Transportation Systems Recommendations Summary

Two ITS functions are recommended to support the improvement of transit services within the Des Moines metropolitan area. The first recommendation involves developing the capability to provide priority treatment at signalized intersections for transit buses in the downtown Des Moines area. Prioritization is recommended as a feature of the new downtown signal system. At first, a simple system is recommended involving a driver actuated signal from the bus to the traffic signal to request priority treatment at the approaching intersection. Later, as more onboard technology is integrated into the MTA's buses, the system could be upgraded to include the ability to request priority treatment at an intersection automatically. To support the deployment of bus prioritization in the downtown signal systems, an engineering study should be conducted to define the technical requirements.

The second recommendation is to implement electronic fair payment using magnetic stripe card technology. Initially, the electronic payment card will be a closed systems, useful only for payment of transit services. Over a five-year period, the MTA should attempt to migrate to an open system, where electronic payment can be used for bus services and to purchase other services or goods. Eventually the MTA should migrate to multi-purposed smart card technology.

References

1 Kamyab, A., Maze, T.H., and Souleyrette, R.R., "Application of Vehicle Specific Information in Adaptive Intersection Traffic Signal Control," Transportation Quarterly, Vol. 50, No. 2, Spring, 1996, pp. 159-168.

2 Hounsell, N.B., Farges, J.L., Fox, K., Taranto, C.Di, "Public Transport Priority at Traffic Signals: Results of a European Collaborative Study," Proceedings of the ITS World Congress, Orlando Florida, 1996.

3 Ibid, p. 4.

4 Ibid, p. 3.

5 "Mulitpurpose Fare Media: Developments and Issues," Research Results Digest, Transit Cooperative Research Program, June, 1997 - No. 16, p. 3.

6 Multisystems, Inc., "Potential of Multipurpose Fare Media," Transit Cooperative Research Program, Project A-14, (scheduled for completion, September, 1997).

7 Tomkowiak, S. And Hofland,P. “A Computer in Your Wallet,” BYTE Magazine, June, 1996.

8 Tanenhaus, R., “Economics of Electronic Card Systems for Public Transportation,” Proceedings of the ITS World Congress, Orlando, Florida, 1996.

9 Section 15 data reported to the Federal Transit Administration.

3

Commercial Vehicle Operations

As explained in the “Transportation Issues Report” prepared for this Early Deployment Study, most of the ITS services for commercial vehicle operations (CVO) are under the purview of state and federal governments. ITS services to support domestic and international electronic screening; automation of administrative processes for carriers moving freight or passengers in intrastate, interstate, and international commerce; and automation of safety inspection are under the authority of the state and federal governments. However, it is within the purview of Des Moines metropolitan area interests to promote the adoption by state and federal governments of ITS market packages that will make freight and passenger transportation to, from, and through the Des Moines metropolitan area safer and more efficient. By reducing transportation costs and increasing safety, ITS-CVO market packages can make Iowa goods more cost competitive in distant domestic and international markets. The study group therefore recommends that Des Moines interests support the progressive adoption of ITS applications for CVO by the state of Iowa and by other states in the Midwest and the facilitation of ITS by the federal government.

Although most ITS-CVO functions are in the domain of the state and federal governments, three ITS-CVO functions were identified by the steering committee as being in the purview of metropolitan interests and were, therefore, examined further for ITS infrastructure planning in the Des Moines metropolitan area. These three functions include the following:

- Commercial traveler information to allow commercial vehicle drivers to make more informed decisions regarding travel in, around, and through the Des Moines metropolitan area.
- Facilities (e.g., intermodal terminals, rest areas, free trade zones, terminal access facilities, etc.) and services (e.g., points to conduct electronic commerce, customs services, communications services, etc.) to support ITS-CVO programs like the I-35 corridor initiative being supported by the North American Superhighway Coalition.

- Use of ITS technology to more quickly and accurately determine the characteristics of and mitigation strategies for incidents involving hazardous materials.

Commercial Traveler Information Systems

During the course of the EDS, a static prototype commercial traveler information system was built to illustrate such a system. The static system is an application of the World Wide Web (Web), the graphical part of the Internet. Although motor carriers commonly use electronic communication, most wide-area communication in the motor carrier industry is still point to point using radio, satellite, cellular telephone, or telephone line communication; the industry has generally not yet migrated to the use of and reliance on the Internet. Because the Web is not commonly used by motor carriers, it is not commonly available at truck stops and other CVO service and rest points. However, a few truck brokers do post loads on the Web, and more CVO-oriented services are becoming available on the Web. For example, the U.S. Department of the Treasury is making its international trade automation software available on the Web, and carriers can route their credentials and international shipment manifests back to the federal government using the Web. The development of CVO-oriented Internet services, and motor carriers' reliance on them, is likely to increase in the future.

In urbanized areas, ITS projects have been initiated to provide traveler information to CVOs, focusing on providing motor carrier dispatch offices with projected and real-time traffic condition information, the location and impact of incidents, and weather-related traveler information. The I-95 Corridor Coalition's Information Exchange Network (IEN) is a good example of traffic information being processed for use by CVOs.[1] The IEN acts as a conduit for exchange of information among various transportation authorities along the corridor; specific information is then distributed to commercial vehicle dispatchers for immediate trip planning within the corridor. A similar project is being developed in the Southern California Priority Corridor, where an intermodal traveler information system will distribute traffic and traveler information to motor carrier dispatchers.[2] As motor carriers increasingly rely on the Web for information and services, the Web will be a logical avenue for distributing such real-time information to dispatchers and motor carrier operators.

The study team recommends that the prototype commercial traveler information system developed during the course of this study be migrated to a computer Web server under the management of the Iowa Motor Truck Association (IMTA). (The migration would be accomplished as soon as the IMTA completes the development of its own Web page). Most of the static information on the existing system is likely to remain current for one to two years, but the IMTA should periodically review the system and update the database to accommodate changes. For example, the list of truck equipment service providers in the system, along with their addresses, services provided, and contract information, should be updated as new businesses enter the market and as old ones drop out. The IMTA should also upgrade the system periodically to include additional sources of information coming online in the future (e.g., statewide highway construction information and roadway weather information). At this time, the ITS infrastructure in Des Moines and in Iowa does not support the ability to provide real-time traffic information and traveler information. Within the next one to three years, however, when real-time traffic information becomes available for I-235 and I-35/80, the traveler information system could be expanded to include dynamic traffic information.

Benefits and Costs

The benefits of developing a commercial traveler information system in Iowa are unknown. However, there is a great deal of interest in gaining access to information like that contained in the existing static commercial travelers information system. For example, the system contains information on low-clearance bridges in the Des Moines metro area. Werner Enterprises, the third largest motor carrier in the United States, has developed its own computerized national database of low clearance bridges that dispatching personnel can query to identify the location of low clearance bridges by zip code. Unfortunately, few motor carriers have the resources to develop such a database, and Werner's database will soon be made obsolete by such routine highway activities as overlaying the streets and reducing the clearance under critical bridges.

As motor carriers develop Internet capabilities, the commercial traveler information system is likely to become more useful to motor carriers. Further, when the information available through the system becomes dynamic (e.g., current weather and current highway conditions), the system will be quite valuable to motor carriers for routing and scheduling vehicles in and around the Des Moines metropolitan area.

The cost of maintaining the existing static information system is less than $2,000 per year. When dynamic capabilities become available, the cost of formatting the information specifically for CVOs should be insignificant.

ITS Services to Support International Commerce

The focus of land-based international trade to and from the Des Moines metropolitan area has been on I-35. This is because I-35 is the most direct route to the Mexican border through the international port at Laredo, Texas. Roughly 40 percent of the value of all surface trade between Mexico and the United States crosses the border at one of the three bridges at Laredo. During the 12-month period ending March 1995, the Laredo crossing accounted for over $40 billion of trade. Further, the Laredo crossing connects with Mexican highways that provide the most direct routes to Mexico's most industrialized region in and around Mexico City and other locations in central Mexico. Because of the importance of I-35 to increasing international trade with Mexico, I-35 is being promoted as an international trade corridor.

The North American Superhighway Coalition (NASCo, previously named the I-35 Corridor Coalition) is spearheading the promotion of I-35 as an international trade corridor. NASCo is a Dallas-based group organized by several local governments (predominantly counties) in Texas that straddle I-35. In an effort to attract funding for infrastructure improvement on Texas segments of I-35 and to boost international trade (predominantly with Mexico), the group began promoting the I-35 as a North American Free Trade Agreement (NAFTA) trade corridor.

The immediate goal of NASCo is to have I-35 officially designated as a NAFTA trade corridor in the national transportation reauthorization bill that will replace the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which expired September 30, 1997. The designation "NAFTA trade corridor" is new and has no specific facility requirements or funding. Most proponents assume that the designation of a highway as a NAFTA trade corridor will result in the highway having a higher funding priority and receiving higher design standards than interstate highways.

NASCo, as part of its strategy to elevate the status of I-35, has already successfully sought the designation of I-35 as a high-priority corridor. The category "high-priority corridor" was created by ISTEA, and high-priority corridors were officially designated under the National Highway System Designation Act of 1995. The designation of I-35 as a high-priority corridor allowed the states along I-35 to apply for and receive funding to conduct a corridor planning study. The corridor planning study was initiated in the summer of 1997 and is scheduled to be completed in the summer of 1998. It will address concepts for the corridor, including the development of ITS infrastructure and ITS services along the corridor.

In the spring of 1997 NASCo independently published its own plan for the corridor. This plan calls for several ITS services along the corridor, including the following:

- Electronic screening to allow screened motor carriers to bypass safety and weight inspection points along the entire corridor.
- Electronic safety verification to allow enforcement officers to electronically verify a the safety performance of a truck, its driver, and the motor carrier along the entire corridor.
- Electronic single-point procurement of motor carrier credentials for domestic and international movements.
- Electronic screening at the U.S. border with Mexico.
- Real-time intercity traveler information.

Most of these services are a function of state governments or the federal government and are therefore outside the control of interests within the Des Moines metropolitan area. The part of the proposed service in which the Des Moines metropolitan area may have a role is the promotion of international and domestic trade through a proposed facility that NASCo is calling an International Trade Compliance Center. As conceptualized, these centers would include the following services:

- Commercial carrier compliance with domestic and international commercial regulations. Services would include providing access to electronic systems that provide carrier credentials to move drivers, goods, and trucks in international and domestic transportation (e.g., electronic procurement of state credentials and electronic processing and forwarding required international border crossing credentials to U.S., Mexican, and Canadian customs officials) and federal inspectors to support international trade.
- Support services for over-the-road trucking (e.g., equipment repair and servicing).
- Cargo terminals/transportation transfer sites for goods moving in international and interstate commerce.
- Warehousing (general and bonded) and distribution facilities.
- Sites for companies involved in international trade to locate.
- Support services for local manufacturing and service companies.
- Support services for passenger and personal international travel.

Similar mixes of transportation services exist in and around international border ports of entry and at a few inland ports. The Alliance, in Fort Worth, Texas, represents an enormous model for a NASCo International Trade Compliance Center. The Alliance covers approximately 13 square miles of land and includes access to I-35E, an intermodal rail yard, and a cargo airport. The Alliance also includes a foreign free-trade zone and a freeport tax exemption (allowing the movement of products and goods through the state of Texas without incurring inventory taxes) and is an enterprise zone providing tax incentives to new companies located at the Alliance. All the ancillary services available provide strong business reasons for firms to locate at the Alliance. Although a smaller but similar facility may be located within the Des Moines metropolitan area, developers must look for compelling business reasons for firms to conduct business through a Des Moines center or even locate at a Des Moines location rather than somewhere else.

The only ITS-related services envisioned by NASCo to reside within an International Trade Compliance Center are those to automate carrier compliance with domestic and international commerce regulations. The processing and procurement of credentials may be conducted with electronic processes similar to other forms of electronic commerce. The international credential processing system, the North American Trade Automation Prototype (NATAP), is already available over the Internet, and most other applications are migrating to the Internet for communications. If an International Trade Compliance Center were located in the Des Moines metropolitan area, the only ITS infrastructure that would be necessary is computers and high-speed data transmission lines. The communication and computing assets necessary to support an International Trade Compliance Center should be part of the facility design.

Some of the more complex issues for the development of such a facility are likely to be the physical design of the facility, the intermodal connections (access to rail, truck, and air intermodal facilities), developing partnerships/agreements between carriers, design of the intermodal information systems, agreements between the agencies and organizations required to support international trade (e.g., Immigration and Naturalization Service, U.S. Department of Treasury, U.S. Department of Agriculture, etc.).

The Des Moines metropolitan area interests also have an opportunity to support international commerce along I-35, and specifically in the Des Moines area, by supporting and promoting Iowa's implementation of the national systems architecture developed for ITS-CVO applications and its implementation by neighboring states. The national ITS program for CVO has developed a systems architecture for ITS-CVO entitled Commercial Vehicle Information Systems and Networks (CVISN). CVISN supports all the ITS-CVO market packages (e.g., domestic and international electronic regulatory screening, credentials, and safety; electronic one-stop shopping for credentials, etc.) identified in the national ITS system architecture. Along the I-35 corridor, the states of Minnesota and Missouri are national leaders in working to implement the CVISN architecture. Kansas, working closely with Missouri, is not far behind in the development of its systems and is developing a business plan to implement the CVISN architecture. Iowa, Oklahoma, and Texas, unfortunately, have not viewed the adoption of the national architecture as a priority and have not accepted offers of federal funds (requiring equal state match) to develop business plans for adoption of the national architecture.

If I-35 is to function as an ITS-CVO corridor, all the states in the corridor should adopt the national ITS-CVO architecture. This includes upgrading their motor carrier information systems to be compatible or interoperable with national standards. Adoption of the national architecture will allow the ITS system to operate as envisioned along the I-35 corridor, facilitating the movement of international trade. The study team therefore recommends that Des Moines metropolitan area interests actively promote Iowa's and other Midwestern and southwestern states' progressive adoption of the national ITS-CVO systems architecture.

Also, if I-35 is to function as an ITS-CVO corridor, Iowa and the other states along the corridor may want to establish a third-party organization to operate and manage interstate ITS-CVO activities. Currently all existing ITS-CVO corridors or programs have developed such third-party organizations. Several western states participate in the PrePass program provided by HELP Inc., a private nonprofit organization. PrePass provides electronic screening services on a fee-per-vehicle-pass basis. The Advantage

I-75 program is operated through the University of Kentucky's Kentucky Transportation Center. The Kentucky Transportation Center receives federal ITS Operational Test funding to manage corridor-wide electronic screening services. In the future, when the operational test funding is no longer available, the program will be funded by the participating states (there is no fee for passing a weigh station on I-75). The I-95 Corridor Coalition, which is not technically an ITS-CVO corridor in the same sense as I-75 and has not yet implemented any ITS-CVO services on the corridor, has a third-party organization that manages the business of the coalition. A similar technical organization should be developed on the I-35 corridor to work simultaneously with all the states along the corridor, and the study team recommends that Des Moines metropolitan area interests actively promote the development of such an organization.

Benefits and Costs

The benefits of developing a Trade Compliance Center are still unclear; however, the ITS infrastructure costs are insignificant in comparison to the total infrastructure and property costs. Clearly, the benefits of the Alliance have been significant for Fort Worth. A facility with similar intermodal and international services is proposed for the Kansas City are,a and Kansas City Southern Industries recently announced its plans to build such a facility at the Richards-Gebaur Memorial Airport on the southeast side of the metropolitan area.

A Des Moines Trade Compliance Center would require access to computers and high-speed data lines. The software to conduct electronic processing of credentials for international and interstate commerce is or soon will be in the public domain. For example, the NATAP software is available free over the Internet. Software to allow motor carriers to purchase domestic credentials electronically is under development and will be available within six months to one year. What is not yet in place are the state systems to accept credential requests electronically.

For I-35 to function as an international trade corridor supported by ITS and be consistent with the concepts developed for the I-35 corridor, the states along the corridor must adopt and implement the national ITS architecture. Further, successful implementation of ITS services along the corridor will require that an organization operate corridor-wide services; typically this has been a third party organization. It is almost impossible to estimate the benefits of more reliable travel times and the ability of international and domestic enforcement officials to concentrate their resources on high-risk carriers rather than stopping and inspecting all trucks. It is also difficult to isolate the benefits to Des Moines area business of improving I-35. However, CTRE did develop an estimate of the cost of delaying trucks at all inspection points along I-35. The costs of delay alone are currently over $20 million per year and are expected to rise to over $100 million per year by 2007. If exports and imports with Mexico continue to escalate at their current rate, the cost could be well over $250 million by 2007.

Hazardous Materials Response

The ultimate vision for response to an incident involving a hazardous material spill or a potential hazardous material spill is for onboard equipment to notify the responders of the exact location of hazardous materials spills; identify the hazardous materials on board, the quantity of the hazardous materials, and the magnitude of the spill; and communicate a procedure for response and cleanup to the first responders. Unfortunately, such a system is not yet available. Efforts have been made to automate the delivery of hazardous materials information to first responders. Operation Respond has developed an inexpensive computerized tool to determine the nature of the cargo on board vehicles operated by carriers participating in the Operation Respond program.

Operation Respond was started as a partnership between the Port Terminal Railroad of Houston and the Federal Railroad Administration in 1992. More recently, several rail and motor carriers, chemical manufacturers, and the National Institute of Occupational Safety and Health (NIOSH) have supported Operation Respond's development of a hazardous materials information system. The Operation Respond Institute is a private, nonprofit organization. The system used to support hazardous material first responders is the Operation Respond Emergency Information System (OREIS).

Under the OREIS, once a hazardous materials potential spill or spill has occurred, emergency responders identify the equipment by the carrier's vehicle number (power unit or/and trailer number) displayed on the outside of the vehicle. The vehicle number is then keyed into a personal computer running OREIS software. Using a telephone modem, the computer is linked with the carrier's database. With the appropriate password, the emergency responder's computer extracts the data on the cargo from the carrier's computer. The contents of the cargo are identified by standard transportation commodity code (STCC). For any contents identified as hazardous, the computer immediately displays emergency information from either the U.S. Department of Transportation's North American Emergency Response Guide or the American Association of Railroads's Chemical List.

The carriers fully enrolled in Operation Respond include most Class I Rail Carriers (including the Union Pacific Railroad) and Chemical Leaman Tank Lines and Yellow Freight Systems. Other major motor carriers are evaluating Operation Respond and are expected to enroll shortly.

The study group recommends that the Des Moines metropolitan area adopt the use of the OREIS software as part of its hazardous materials response program. The Des Moines Fire Department's Hazardous Materials Response team provides 24-hour dispatch service and hazardous spill cleanup services for eight central Iowa counties and the cities in those counties--Polk, Boone, Story, Marshall, Marion, Warren, Madison, and Dallas counties--an area that includes the entire Des Moines metropolitan area. As a result of the Des

Moines Fire Department's leadership in hazardous materials spill cleanup, the project team recommends that the computer with the OREIS software reside at its offices.

Benefits and Costs

The OREIS software operates on a standard IBM-compatible microcomputer and requires a telephone modem. The software cost is $360 for a single system and $25 per month for membership. Assuming that the Des Moines Fire Department would have to purchase a new computer and a dedicated telephone line for the computer, the cost of the system would be less than $4,000. If the software could be mounted on an existing microcomputer, the system costs may only be $360. Once the system is in place, the annual operation cost is only $300 ($25 per month).

There are no estimates of the benefits of having more timely and accurate information when a hazardous spill occurs. However, the ability to more quickly mitigate a spill reduces the public's exposure to risk and clears a blocked highway more quickly. A recent Transportation Research Board study of emergency response to hazardous material spills found that it is not unusual for emergency responders to be unable to find the information they need to treat a spill, nor is it unusual for responders to experience significant delays in getting the information they need.[3] Saving time in the case of an extremely hazardous spill could significantly reduce risks to the public and to the responders. At the very least, a quicker response could lead to reduced traffic delays while the incident is being cleared.

Commercial Vehicle Operations Recommendations Summary

The majority of the ITS market packages related to commercial vehicles are within the purview of state and federal governments and not regional or local government. As a result, there are few action ITS items which governments and organization within the Des Moines metropolitan area have the authority to implement. On the other hand, it is within the interests of the Des Moines metropolitan area to promote safe and efficient commercial vehicle movements from, to, and through the Des Moines area. To this end, interests in the Des Moines area can encourage state and federal officials to implement ITS applications that promote CVO efficiency and safety.

To support commerce, it is recommended that the Iowa DOT and other state agencies in the region adopt and implement the national architecture for CVO (CVISN) and implement ITS-CVO market packages in cooperation with states in the region and federal agencies. This is particularly true if Iowa, and particularly the Des Moines metropolitan area, wishes to participate in the plans developed for the I-35 corridor by the North

American Super Highway Coalition. It is further recommended that the metropolitan area examine its role with respect to the development of an International Trade Compliance Center.

A specific item recommended in this chapter includes the migration of the existing Internet-based Commercial Traveler Information System to the Iowa Motor Truck Association's (IMTA) Internet Web pages. The IMTA should be responsible for maintenance of the Web page. Another specific recommendation is that the Operation Respond Emergency Information System (OREIS) be deployed at the Des Moines Fire Department's Hazardous Materials Response team headquarters.

R e f e r e n c e s

1 Neudorff, L.G., Galley, D., and Wintermute, J., "The I-95 Corridor Coalition Information Exchange Network," Proceedings of the ITS America Annual Conference, Washington, D.C., June, 1997.

2 Mosley, G., Kerr, J., and Prince, J., and Zaghari, A., "Showcase Meets the National ITS Architecture," Proceedings of the ITS America Annual Conference, Washington, D.C., June, 1997.

3 Transportation Research Board, "Hazardous Materials Shipment Information For Emergency Response," Transportation Research Board Special Report 239, Washington, D.C., 1993.

4

Service Patrols

The main objective of a service patrol is provide incident clearance services and to keep the highway free from temporary blockages due to minor incidents. Typically service patrols clear minor cargo spills, remove debris from the highway, tow or push disabled vehicles off the roadway, assist drivers with minor mechanical problems, administer first-aid, control small vehicle fires, perform other tasks to assist stranded motorists, report on traffic conditions, and assist with traffic control and coordination in the case of a major incident (an accident).

Service patrols are known to operate in more than 35 U.S. metropolitan areas, and there are probably many more urban areas with service patrols that are not documented in the literature (e.g., Des Moines).[1] These programs usually consist of a fleet of light-duty trucks, equipped with two-way radio communications with the traffic control center. The trucks are usually equipped with emergency signs and devices, gasoline, antifreeze and other consumables, and tools. Often the trucks are equipped to push vehicles. Service patrols usually operate along defined routes, although some are dispatched on demand. Typically, the patrols operate only during the peak periods on weekdays; however, their hours of operation may vary with the local conditions and demand.

The number of service patrols varies dramatically with both the types of services the service patrols provide and the size of the coverage area. Los Angeles has the largest fleet of service patrols with 80, but an urban area like Des Moines may require only two.

Existing Des Moines Area Service Patrol

A service patrol vehicle is already operated in the Des Moines metropolitan area by Alexander "Big Boy" Motor Sports, a Des Moines commercial auto repair center. The service patrol, known as the Rescue Truck (the operator is known as Rescue Bob), is a pickup truck equipped with a compressor, generator, gasoline, small tools, jumper cables, a warning light bar and rotating ember warning light, etc. Rescue Bob has been a fireman and is, therefore, trained in emergency response strategies (e.g., first aid). The Rescue Truck circulates on the Des Moines freeway system providing help to distressed motorists.

Its services range from providing first aid and traffic control at accident sites to acting as a guide vehicle for lost motorists. Rescue Bob also provides traffic reports over a Des Moines radio station. The hours of operation of the Rescue Truck are during the morning peak period from 5:30 a.m. to 9:00 a.m. and in the afternoon peak from 4:00 p.m. to 7:00 p.m. Local police departments have coordinated and cooperated with the operation of the Rescue Truck and have provided Rescue Bob with instruction on operating procedures.

The Rescue Truck's operation is financed by the owner of Alexander Motor Sports, Dave Alexander. Advertising for other organizations has been placed on the truck in exchange for services or equipment. For example, Airtouch Cellular provides cellular telephones and air time in exchange for advertising mounted to the truck. However, the truck, fuel, and the driver's wages are provided by Alexander Motor Sports, which plans to add a second truck in early August 1997. Ultimately, Alexander Motor Sports plans to equip the two trucks with push bumpers to allow them to push disabled cars off the right-of-way.

The Rescue Truck is a very popular and positive charitable activity conducted by a private organization. Further, it seems reasonable that the spirit of starting the service should be encouraged. However, in the long-run and once a Transportation Management Center (TMC) is established, a more direct linkage between private philanthropic activities and traffic management activities should be established. For example, a relationship would have to be established between the TMC and private service patrol providers regarding operating procedures, communications, and responding to the TMC's directions. Perhaps this might result in a private-public partnership and even an opportunity to allow other members of the business community to participate in the service.

Until a TMC is established, local and state police agencies are encouraged to research the legal ramifications of allowing a private organization to perform functions reserved by the Code of Iowa for peace officers (e.g., direcingt traffic and pushing disabled vehicles off the right-of-way). It was not within the scope of services for this project to analyze the legal liability of planned services; it would be prudent, however, for the transportation agencies that cooperate with Rescue Bob to seek legal counsel. The Iowa DOT General Counsel believes it would be unlikely that there would be any legal liability for law enforcement agencies in the metropolitan area so long as the services are being provided independently by a private organization. In fact, the Code of Iowa encourages good Samaritans. However, a motorist assistance operation that routinely provides services normally reserved for peace officers with the full knowledge and cooperation of enforcement officials may not be construed as operating independently. Hence, any local and state agencies could become a party to any liability created by Rescue Bob's actions.

Once a legal opinion is available, all relevant organizations involved (e.g., city police departments, the Iowa State Highway Patrol, the Iowa DOT, and Alexander Motor Sports) are encouraged to enter into a memorandum of agreement (MOA). The MOA should identify the interest of the organizations to cooperate and the responsibilities of each organization.

Services Required

The Rescue Truck has been operating for five months (as of August 1, 1997). During this period, the service assisted 674 motorists, an average of six motorists per week day. During this period, the truck traveled roughly 36,000 miles or roughly 350 miles per day. Based on estimates made for the transportation issues report, there are currently about 18 non-accident incidents per day in the Des Moines Metropolitan area. Therefore, a second motorist assistance truck is probably needed.

For several reasons, the service should be institutionalized and conducted in coordination with the public agencies. Currently, there is no assurance that the service will continue to be offered and no specification of the level of service provided. Once a TMC is established, the service patrol should work in coordination with the TMC and, therefore, a formal relationship between the organizations should be designed.

Benefits *and Costs*

Assuming a two-vehicle service patrol is established to work during peak traffic periods on week days, each vehicle travels roughly 350 miles per day, the operators works split shifts (four hours in the morning and four hours in the afternoon), and the vehicles can be housed at an existing facility, the annual cost of operation is estimated to be between $160,000 and $200,000 per year. The estimates include wages and fringe benefits costs of the operators, mileage costs of the vehicles, and supplies. Currently, with the private sector operating this service, the cost to metropolitan transportation agencies is nothing. This provides a substantial reason to encourage continued private sector participation.

Nine studies were found that have evaluated motorist assistance programs and arrived at benefit-to-cost ratios for services in the Charlotte, Chicago, Denver, Hayward (California), Houston, Los Angeles, and Minneapolis-St. Paul metropolitan areas and for Ontario provincial emergency patrol. Benefit-to-cost ratios ranged from 2.3 to 1 to 36 to 1.[2] Most of these studies used traffic simulation models to estimate the benefits of more quickly clearing minor incidents. All of them included reduced delay due to quicker clearance of incidents, some included reduced vehicle emissions and fuel consumption due to more quickly clearing incidents, and some included the value of the assistance to the motorist. These nine case studies and other reported experiences clearly identify the beneficial service that a motor assistance patrol provides.

Service Patrol Recommendations Summary

The private sector is already providing service patrol services at no cost to public agencies. Because this service is being provided through private funding, public agencies are being saved the cost of providing this service through public funds (an estimated cost of $160,000 to $200,000 per year). Therefore, it is recommended that continued private involvement in this service be encouraged through the development of a private-public sector partnership and institutionalizing this service.

The first step in institutionalizing the private service is to have a legal opinion developed. The current service is operating in coordination with law enforcement and is conducting activities routinely reserved for law enforcement officers. The legal opinion should address the potential for legal liability exposure to public agencies due to actions of the private sector patrol and what prudent actions should be taken to minimize legal liability while allowing the service to continue. Assuming that any legal issues can be resolved, the enforcement agencies should develop a memorandum of agreement with the private sector service patrol that defines responsibilities and the intent to cooperate. Later, once the transportation management center (TMC) is built, the memorandum of agreement will need to be amended to include a working relationship protocol between the service patrol and the TMC.

References

1 Ogden, M.A., "Council Report Summary: Guidelines for Establishing Freeway Service Patrols by ITE Traffic Engineering Council Committee 4M-36," ITE Journal, February, 1996, p 31.

2 California PATH, "Incident Clearance," Decision Support System, University of California, Berkeley, 1996.

5

Priority Corridors for Arterial Traffic Management

Conventional traffic engineering and transportation planning methods are designed to optimally satisfy forecasted traffic volumes under normal conditions rather than to adjust and respond to evolving traffic conditions. But the need for swift responses and immediate information distribution is most critical when transient events, like a severe winter storm or a traffic accident on a critical link of the urban freeway system, occur. One of the hallmarks of ITS is its ability to respond to transient transportation congestion and to provide traveler information in real time.

Because of the importance of I-235 to highway transportation within the Des Moines metropolitan area, its reconstruction will be the most significant transient event to affect the area's transportation system in the foreseeable future. Because ITS functions are specifically designed to reduce the impact of transient incidents, ITS could play a significant, positive role in helping mitigate the impact of I-235 reconstruction on traffic.

On a week-to-week and perhaps even day-to-day basis during reconstruction, commuters who normally travel along I-235 will be faced with a variety of challenges resulting from interchange closures, congestion due to lane closures, turbulence in traffic flow resulting from construction activity near the travel lanes, and other dynamic events that will partially reduce the capacity of the freeway. Parallels may be drawn between reductions in capacity due to reconstruction and similar reductions caused by transient traffic incidents (both as compared to traffic flow under "normal" freeway operating conditions). In fact, the proposed reconstruction of I-235 will essentially amount to a multi-year "incident" during the reconstruction period.

The purpose of this chapter is to identify locations and arterial streets that will experience the greatest impact from traffic diverted from I-235 as a result of reconstruction and to plan ITS improvements along these identified routes to minimize the impact of the added traffic.

I-235 Reconstruction Traffic Diversion Estimates

I-235 is generally a four- to six-lane freeway between the north system interchange and the southwest system interchange in Des Moines. From the north system interchange to University Avenue, it is a four-lane, north-south facility, and from University Avenue to the southwest system interchange, it is an east-west facility with four to six travel lanes. The freeway was constructed during the 1960s and reflects the design standards of that time, with several closely spaced interchanges, lefthand entrance and exit ramps, and other features that do not meet modern, national highway design standards.

A preferred alternative has been selected for proposed improvements to I-235 that will include six travel lanes the entire length of I-235 and will improve design standards and entrance and exit ramps. An environmental review is currently being completed for the preferred alternative; hence, a firm construction schedule has not yet been set for the project.

To assess the potential opportunities for ITS applications in the I-235 corridor, a methodology was proposed and demonstrated during the course of the EDS. The method was used to identify corridors most likely to be affected by capacity reductions on I-235 due to the phasing of I-235 reconstruction and, therefore, most likely to benefit from ITS technologies (particularly from advanced traveler information and traffic control). The purpose of this activity was to identify only those corridors that will most likely be affected by traffic diverted from I-235 during reconstruction. The methodology cannot estimate the traffic volumes diverted, only where traffic is likely to increase when capacity restrictions occur on I-235. Identifying these corridors allows the targeting of appropriate ITS technologies for implementation in advance of the reconstruction so that traffic may be diverted more efficiently during reconstruction and other incidents.

The methodology employed to identify diversion routes for incidents on I-235 and for the proposed I-235 reconstruction was based on a travel demand model analysis of various scenarios with reduced capacity on I-235. The travel demand model used was a modification of the Des Moines metropolitan area travel demand model, originally developed by Wilbur Smith and Associates (WSA). The original 24-hour model was modified to approximate peak-hour conditions in 2005. Corridors were identified that are likely to experience additional traffic diverted when various sections of I-235 are under construction. Example reconstruction phasing scenarios and their respective capacity reductions were defined to determine likely diversion routes. A more complete description of the modeling methodology is given in the report, “Evaluation of User Services and ITS Marketing Packages.”

Although a modified version of the travel demand model currently in use at the Des Moines Area MPO was used to identify and evaluate the effect of I-235 reconstruction on local arterials, a more robust modeling environment (one designed specifically for peak-hour modeling) should be pursued and is recommended in a separate chapter of this report. However, the example scenarios and capacity reductions identified in this section can alert the Iowa DOT and local jurisdictions to the need for ITS improvements in those corridors.

Four capacity reduction scenarios were developed along I-235. The four scenarios represent sections of I-235 that may experience capacity reductions during a potential reconstruction phase. However, each scenario was created only for the purpose of this study and does not necessarily reflect phasing that will occur during actual reconstruction of I-235. Each scenario defines a capacity reduction on the freeway link beginning and ending at interchanges with major arterial streets allowing travelers to exit I-235. Although the Iowa DOT does not anticipate closing I-235 at any time during reconstruction, the capacity on the model links between the interchanges was set at zero to determine which routes would be potentially impacted by a capacity reduction. Setting the capacity at zero results in the maximum possible diversion and was done purely to examine where diverted traffic would likely flow.

The phasing scenarios represented capacity reductions on the links between the interchanges listed below:

1. From the I-80/35 northeast system interchange to University Avenue
2. From University Avenue to Cottage Grove Avenue
3. From Cottage Grove Avenue to 63rd Street
4. From 63rd Street to the I-80/35 southwest system interchange

The corridors identified as likely to experience increased traffic volumes are highlighted in Figure 5-1. The red line indicates corridors expected to experience an appreciable increase in total traffic volume. The width of the red line indicates the relative increases in traffic volumes. That is, those corridors with the widest red lines are likely to receive the most diverted traffic. The traffic diverted from I-235 to arterial streets by the model in the area of the interchanges where I-23"s capacity is reduced to zero results in unrealistically high assignment of traffic to those interchanges. Therefore, the relative impacts in the vicinity of the University Avenue bridge, the Cottage Grove interchange, and 63rd Street interchange are exaggerated. They do, however, show the most heavily affected corridors. These corridors should become the highest priority for arterial traffic management. The 11 corridors with highest increase in average daily traffic (ADT) are as follows:

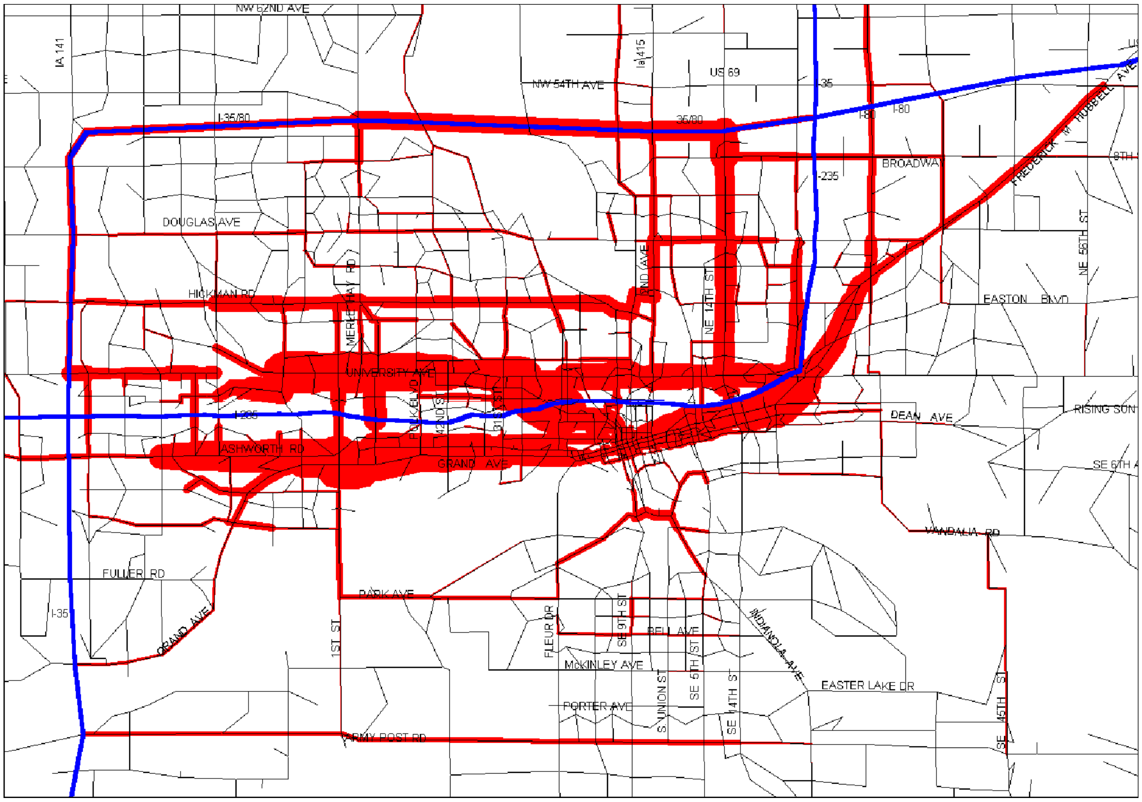

Figure 5-1 Traffic Diversion Routes During I-235 Reconstruction

- Hubbell Avenue from E 33rd Street to Grand Avenue (Des Moines).
- Grand Avenue from Fleur Drive to 19th Street (Des Moines, West Des Moines).
- Grand Avenue from 2nd Street to Hubbell Avenue (Des Moines).
- University Avenue from I-235 to 86th Street (Des Moines, Windsor Heights, Clive).
- Ashworth Road from 63rd Street to 35th Street (West Des Moines).
- NE 14th Street from University Avenue to I-35/80 (Des Moines).
- 56th Street from University Avenue to Grand Avenue (Des Moines).
- Hickman Road from Euclid Avenue to 86th Street (Des Moines, Urbandale, Iowa DOT).
- I-35/80 from NE 14th Street to Merle Hay Road (Iowa DOT).
- Delaware Avenue from University Avenue to Broadway (Des Moines).

ITS Improvements

The results of the model show the effects on arterial streets that might initially be expected as a result of I-235 reconstruction. On the east-west segment of I-235, parallel arterial roads will be most significantly affected (e.g., Grand Avenue, University Avenue, Hickman Road, and I-35/80). On the north-south segment of I-235, parallel roads will be most significantly affected (e.g., NE 14th Street, NE 2nd Street, and Hubbell Avenue). In the chapter of this report covering the advanced transportation management/transportation information system (ATMTIS), recommendations are made for ITS improvements along these routes.

6

Interjurisdiction Traffic Signal Coordination

Traffic signal coordination has nearly always proved to be a cost-beneficial transportation improvement. For example, an Iowa study of traffic signal improvements conducted in the late 1980s found that the benefit-to-cost ratio of coordinating traffic signal along arterial streets in 16 Iowa cities ranged from negligible benefits to 55.58 to 1, with an average benefit-to-cost ratio of 14.2 to 1.[1] During this project, several intersections and arterial signal systems were retimed and improved in the City of Des Moines, resulting in an average benefit-to-cost ratio of 11.16 to 1. On one arterial street where signal timing plans were improved, the benefit-to-cost ratio was greater than 300 to 1.

These Iowa results are typical of findings throughout the country. For example, the Automated Traffic Surveillance and Control (ATSAC) program in Los Angeles, a program to install and operate an interconnected and coordinated traffic signal system, resulted in a 9.8 to 1 benefit-to-cost ratio, reducing travel time by 12 percent, intersection delay by 32 percent, and intersection stops by 30 percent.[2]

In the Des Moines metropolitan area, coordinating traffic signals and maintaining efficient traffic signal timing faces two challenges. The first challenge involves institutional issues and resources available within individual cities responsible for signal management and maintenance within their own jurisdictions. The second challenge involves the institutional issues and resources available for coordinating traffic signal systems and ramp meters between jurisdictions where parts of the facility (e.g., an arterial street) are under the jurisdiction of several governments.

Although city professional staff understand that traffic signals must be retimed periodically to accommodate changing traffic patterns and volumes, resources are not commonly available to develop new timing plans and then adjust signal times to current conditions. For example, the 300 to 1 benefit-to-cost ratio cited above for a traffic signal improvement in the City of Des Moines was a result of having allowed signal timings to fall seriously out of adjustment with current traffic patterns before adjusting the timing plans. This particular improvement did not involve the purchase of new equipment, only the development of new timing plans for an existing signal system. Similar findings have been found under other similar circumstances. The traffic signal retiming program Fuel Efficient Traffic Signal Management (FETSIM), for example, resulted in a benefit-to-cost ratio of 58 to 1 when a total of 3,172 traffic signals were retimed throughout California.[3]

But the benefits of traffic signal retiming are primarily accrued by the public in reduced delays, reduced travel times, and consequently reduced fuel usage and are not returned directly to city agencies; therefore, cities find it difficult to budget special traffic signal retiming studies. Further, because the typical motorist does not understand the costs of inefficient traffic signal timings, the general public rarely sees inefficiently timed traffic signals as a severe problem for local government to solve.

Cross-jurisdictional coordination of traffic signals on arterial streets that cross a jurisdictional boundary is relatively uncommon, unless the two jurisdictions implement a signal system as a joint project. Most cities program and budget signal systems independently within their own budgets and design signal timing to suit their own jurisdictional needs. Unless jurisdictions procure systems through a joint agreement, the systems are usually operated independently. As an example of how endemic the lack of signal coordination is between jurisdictions, even though the Minnesota Department of Transportation (MnDOT) has operated ramp meters on the metropolitan area's interstate system for over 25 years, only within the last two years has MnDOT begun coordinating the timing on ramp meters with signals on adjacent suburban surface streets through the Integrated Corridor Traffic Management ITS field operational test project.[4]

A notable example of multiple jurisdiction cooperation to interconnect and coordinate existing traffic signal systems is a project conducted by western San Bernardino County, California, where six jurisdictions cooperated to coordinate 113 signals on eight arterial streets operated by six different jurisdictions (local governments and the California Department of Transportation).[5] Similar to jurisdictions within the Des Moines metropolitan area, cities participating in the San Bernardino integration program operated both 170 type controllers and NEMA controllers. The agencies in the project were connected using the most convenient media of communication (e.g., fiber optic, microwave). New signal timing plans were developed to take advantage of the ability to cooperate across jurisdictions. The multiple jurisdiction cooperation to synchronize signals resulted in an estimated 15 percent average increase in speed, 17 percent decrease in stops, and 12 percent decrease in fuel consumption.

Two methods may be used to manage the interconnection and coordination of traffic signal systems among jurisdictions. In urbanized areas where the management of surface street traffic signals is under the authority of a metropolitan transportation authority or where the center city controls the preponderance of traffic signals in the urban area, the traffic signal management center can be co-located with the Transportation Management Center (TMC). The close proximity of both functions facilitates the integration of freeway management and management of the arterial street systems. In other communities, where responsibility for traffic signals is distributed across a number of jurisdictions, the management of signals is left under the control of each jurisdiction and communication takes place between bordering communities. In other words, traffic management responsibilities are distributed but coordinated through communications and pre-determined plans.

Given that the responsibilities for traffic signals in the Des Moines metropolitan area are spread across several organizations, distributed control is the more appropriate approach, with communication among systems along arterial streets that cross jurisdictions.

Recommended Interjurisdiction Coordination

Coordinating traffic signals across jurisdictions in the Des Moines metropolitan area involves two types of coordination:

- Coordinating potential ramp meters at interchanges with signal systems on arterial roadways crossing or parallel to the metered interchanges.
- Coordinating traffic signals along arterial roadways that cross jurisdictional boundaries, particularly those routes that will become the principal diversion routes during I-235 reconstruction.

Coordinating Traffic Signals with Freeway Interchange Signals and Ramp Meters

Further evaluation of the potential for ramp metering at several interchanges on I-235 and two interchanges on I-35/80 is recommended in chapter 7. The principal purpose for ramp metering is to reduce the incidence of disruption in smooth traffic flow in and around interchanges that may result in traffic accidents and that reduces the effective capacity of the freeway. One of the principal issues that investigators of ramp metering must evaluate is adequate and safe storage for the number of vehicles expected to queue at ramp meters. Because the original designers of the interchanges in the Des Moines metropolitan area did not have ramp metering in mind when they developed the original interchange geometry, vehicle storage is likely to be a significant problem if ramp metering is implemented. Vehicle storage problems can be reduced if both the ramp meters and surface street traffic signals are used together to manage traffic approaching interchange ramps.

If ramp meters are found to feasible on the ramps identified along the portion of interstate north of downtown Des Moines, it is particularly important that plans for the ramp meters are accommodated in plans for the proposed downtown signal system. By coordinating signals on streets leading to interstate ramps, the likelihood will be reduced that traffic will be released to ramps at a faster rate than the ramp meters can handle.

In the future, the Des Moines Area Freeway Incident Management Committee may wish to examine opportunities for coordinating ramp meter control with traffic signal systems on streets parallel to the interstate to accommodate traffic diverted off the interstate during an incident. This is one of the purposes of the tests being conducted in the Minneapolis-St. Paul metropolitan area to integrate arterial traffic control with ramp meters. When more traffic is diverted to the arterial street system due to an incident on the interstate, traffic signal timings are adjusted to favor increased traffic moving on the arterial system parallel to the interstate.

Coordinating Signals along Arterials that Cross Jurisdictional Boundaries

During some phases of the I-235 reconstruction, traffic traveling north and south will be diverted to arterial streets (principally NE 14th Street and NE 2nd Avenue). The traffic signals on these streets are maintained by one jurisdiction, the City of Des Moines and, therefore, interjurisdictional coordination is not required.[1] East-west traffic diversion routes are a completely different matter. One of the principal east-west diversion routes, University Avenue in the west, forms the boundary between West Des Moines and Clive, runs through Windsor Heights, crosses the entire width of Des Moines, and leaves the east side of Des Moines into the city of Pleasant Hill.[2] All of these jurisdictions operate traffic signals along University Avenue. University Avenue crosses the most boundaries, but Douglas Avenue, Hickman Road, Ashworth/Grand Avenue, and Hubbell Avenue are all principal diversion routes that face similar interjurisdictional issues.

The first issue for the jurisdictions involved is the institutional barriers associated with cooperating across jurisdictional boundaries. Institutional barriers range from the lack of a clearly defined mandate to the lack of intellectual or physical resources. In this case, however, I-235 reconstruction provides the cities along the corridor with a clearly defined problem (i.e., mitigating congestion along diversion routes) and a deadline. The approaching reconstruction of I-235 provides a clear mandate for the affected cities and provides an opportunity to promote action on interjurisdictional signal coordination.

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1 On both NE 14th and NE 2nd streets there are signals owned by the Iowa Department of Transportation but through an interagency agreement, they are maintained by the City of Des Moines.

2 University Avenue actually extends west to the City of Waukee, but Waukee has no traffic signals.

A second issue is the different communication protocols or proprietary communications standards of the various brands of traffic signal controller equipment used by cities in the Des Moines metropolitan area, Polk County, and the Iowa DOT. Traffic controllers and signal systems have been developed using proprietary protocols. Thus, communication protocols are brand- or software-developer specific. The lack of interoperability among different brands of traffic controllers has created a host of problems within single jurisdictions and makes interjurisdictional coordination extremely difficult.

For example, the signals on University Avenue along the Clive/West Des Moines border are coordinated and interconnected. The signal controller in Windsor Heights along University Avenue is the same brand as those used by West Des Moines and Clive, but they are not interconnected and are coordinated using time-based coordination. The signal systems along University Avenue in the City of Des Moines are coordinated and interconnected but are a different brand and use a completely different system architecture from the brand used in the suburban communities. The signal systems in each city have been timed to move traffic efficiently along each segment of the corridor, but such independent timing plans are not necessarily the most efficient way to move traffic along the entire corridor.

In the future, the National Transportation Communications/ITS Protocol (NTCIP) will allow traffic controllers and other microprocessor-controlled traffic control devices (e.g., changeable message signs, ramp meters, video surveillance, etc.) to communicate through a common, object-oriented communications protocol.[6] The stated objective of the NTCIP is to "provide a communications standard that ensures the interoperability and interchangeableness of traffic control and Intelligent Transportation System (ITS) devices. The NTCIP is the first protocol for the transportation industry that provides a communications interface between disparate hardware and software products. The NTCIP effort not only maximizes the existing infrastructure, but also allows for flexible expansion in the future, without reliance on specific equipment vendors or customized software."[7]

Development of the NTCIP was initially proposed and initiated by the National Electrical Manufacturers Association (NEMA) in 1992. In 1993 the Federal Highway Administration (FHWA) became involved in the standards-making process. Later a partnership was developed between NEMA, the American Association of State Highway and Transportation Officials (AASHTO), and the Institute of Transportation Engineers (ITE); under FHWA funding, NEMA, AASHTO, and ITE formed a Joint NTCIP Standards Committee in 1996. To date, the only NTCIP standard available is for controllers developed under National Electronic Manufacturers Association (NEMA) standards.[3] It is unclear that existing NEMA equipment will comply with NTCIP, and

[3] All suburb cities operate a NEMA traffic signal control equipment but the City of Des Moines operates type 170 controllers.

existing equipment may require upgrading and modifications to operate under NTCIP. Standards for other types of equipment are being promulgated.

The NTCIP will clearly make interjurisdictional coordination of traffic signals an easier task. Even if the standards were available for all electronic traffic control devices, modifications, additions, and upgrades to existing hardware would have to be made to support the adoption of the NTCIP, and additional interconnection would be required to support interjurisdictional coordination of traffic signals.

To support interjurisdictional coordination of traffic signals, it is recommended that the Des Moines Area MPO develop a Des Moines metropolitan area committee of traffic signal managers and engineers from Polk County, the Iowa DOT, and all the cities in the metropolitan area with signal systems, particularly those cities that will be most affected by the I-235 reconstruction. The committee should select its own mission and objectives, but clearly the most pressing issue is the support of interjurisdictional coordination of traffic signals on I-235 reconstruction diversion routes. It is also recommended that the committee write and have member jurisdictions sign a memorandum of agreement committing the agencies to support interjurisdictional traffic signal coordination.

One of the first responsibilities of the recommended committee would be to seek engineering assistance to determine hardware, communications, and software requirements and to determine a recommended signal system management architecture to enable interjurisdictional traffic signal coordination. Plans should first focus on the principal I-235 reconstruction diversion routes. Once the physical requirements have been determined, a financial package must be developed. Finally, the committee should develop new corridor-level signal timing plans.

Interjurisdictional Traffic Signal Coordination Recommendations Summary

It is recommended that the approach taken for coordinating traffic signals across jurisdictional boundaries in the Des Moines metropolitan area be one of distributing the control to the operating cities with communication across jurisdictional boundaries rather than attempting centralized control of signals and signal systems. Two types of traffic signal coordination are recommended: 1) coordination between traffic signal systems and proposed ramp meters, and 2) coordination between traffic signal systems across and along jurisdictional boundaries.

If ramp metering at high accident ramps is found to be feasible, then arterial street signal systems in the area of the ramp should be timed or adapted to timing plans that work cooperatively with the meters. This issue should be studied further as engineering studies are conducted to determine the feasibility of ramp meters on the Des Moines area interstate system.

Interjurisdictional coordination of traffic signals along arterial streets that cross jurisdictional boundaries or are along jurisdictional boundaries, particularly arterial streets that are major traffic diversion route during I-235 reconstruction, should be promoted. It is recommended that the Des Moines area MPO develop a Des Moines metropolitan area committee of traffic signal managers and engineers from Polk County, the Iowa DOT, and all the cities in the metropolitan area with signal systems, particularly those cities that will be most affected by the I-235 reconstruction. The committee should select its own mission and objectives, but clearly the most pressing issue is the support of interjurisdictional coordination of traffic signals on I-235 reconstruction diversion routes. It is also recommended that the committee write and have member jurisdictions sign a memorandum of agreement committing the agencies to support interjurisdictional traffic signal coordination. Once a memorandum of agreement has been executed, a traffic engineering study should be conducted to determine the equipment, communications, and financial resources necessary to complete interjurisdictional coordination. Finally, the plan must be implemented by the signal operating agencies.

References

1 Maze, T.H., Hawkins, N.R., Graham, J., and Elahi, M., “Iowa’s Statewide Traffic Signal Improvement Program,” ITE Journal, May, 1990, pp. 27-31.

2 Bureau of Transportation Statistics, “Intelligent Transportation Infrastructure Benefits: Expected and Experienced,” U.S. Department of Transportation, 1997.

3 Deakin, E. A., May, A. D. and Skabardonis, A. (1984) Energy savings from signal timing optimization: evaluation of California's statewide program. Compendium of Technical Papers. Institute of Transportation Engineers. Meeting (54th: S. F., CA), pp. 13-16 - 13-20.

4 Taylor, L., Lowrie, P.R., and Greene, S., “Integrated Corridor Traffic Management: The First Step to Freeway and Arterial Integration,” Proceedings of the ITS World Congress, Orlando, Florida, September, 1996.

5 Murthy, A.S.N., “Application of ‘ITS’ In Signal Synchronization,” Proceedings of the ITS America Annual Meeting, Washington, D.C., June, 1997.

6 NTCIP Steering Group, “The National Transportation Communications/ITS Protocol: An Introduction,” ITE Journal, December, 1995, pp. 36-40.

7 Symour, E.J., and Patel, R.K., “Impact of the NTCIP Standard on the deployment of the Intelligent Transportation Infrastructure,” Proceedings of the 7th Annual ITS America Meeting, Washington, D.C., 1997, p. 8.

7

Advanced Transportation Management/Traveler Information System

The advanced transportation management/traveler information system (ATMTIS) planned for the Des Moines metropolitan area focuses on the interstate system and highways built to interstate design standards. However, because most of the focus of the ATMTIS is to assist in managing traffic and mitigating congestion during reconstruction of I-235, additional key ITS infrastructure assets will be located on arterials serving as alternate routes for traffic diverted from I-235.

The initial ATMTIS elements are built around the core interstate facilities (the I-235 and I-35/80 loop). In the long term (10 to 20 years) the system will be extended to the U.S. 65 and Iowa 5 outer loop around the east and south side of the metropolitan area. Proposed activity on the core system is divided into four time frames: 1) immediate improvements, 2) improvements to be made within the next five years, principally to help mitigate the impact of reconstruction of I-235, 3) improvements to be made during reconstruction in five to 10 years, and 4) long-term improvements in 10 to 20 years.

The predominant assets planned for the system include a Transportation Management Center (TMC), a communication system between the TMC and roadside equipment, traffic detection equipment, freeway ramp metering demonstration, video surveillance, changeable message signs (CMS), and highway advisory radio (HAR). Many of the improvements made in the one- to five-year time frame are intended to manage traffic during reconstruction of I-235.

In most urban areas, ATMTIS assets are deployed as part of a system. For example, a TMC, video surveillance, traffic detection, and one or more motorist information systems (VMS, HAR, or both) are deployed simultaneously over a portion or the entire urban freeway system. With the exception of ramp metering it is, therefore, difficult to assess the benefits of individual asset categories (e.g., video surveillance alone).

ATMTISs deployed in metropolitan areas across the country have resulted in travel time reductions of 20 to 48 percent, travel speed increases of 16 to 62 percent, increases in the effective capacity of the freeway by 17 to 25 percent, a decrease in accident rates of 15 to 50 percent, and resulting reductions in fuel consumption and emissions.[1] These results were accumulated from evaluation of systems in urban areas much larger than the Des Moines metropolitan area (e.g., Minneapolis/St. Paul, Detroit, Los Angeles, etc.). Unfortunately, there is not significant experience available to make similar projections for medium-sized urban areas, but it is reasonable to expect positive results in Des Moines, particularly with respect to safety and incident- or construction-induced congestion.

Transportation Management Center

A TMC is the core element of a traffic management and surveillance system. It is where highway system condition information is gathered and processed and traffic management strategies are developed and implemented to address the identified traffic problems. Management strategies involve a broad variety of actions including developing an appropriate response to an incident and directing the execution of that plan, adjusting traffic control to current conditions, and distributing information on traffic conditions to partner agencies and to available transportation information systems (e.g., HAR, VMS, broadcast radio, etc.). A high-level system diagram for a Des Moines area TMC is shown in Figure 7-1.

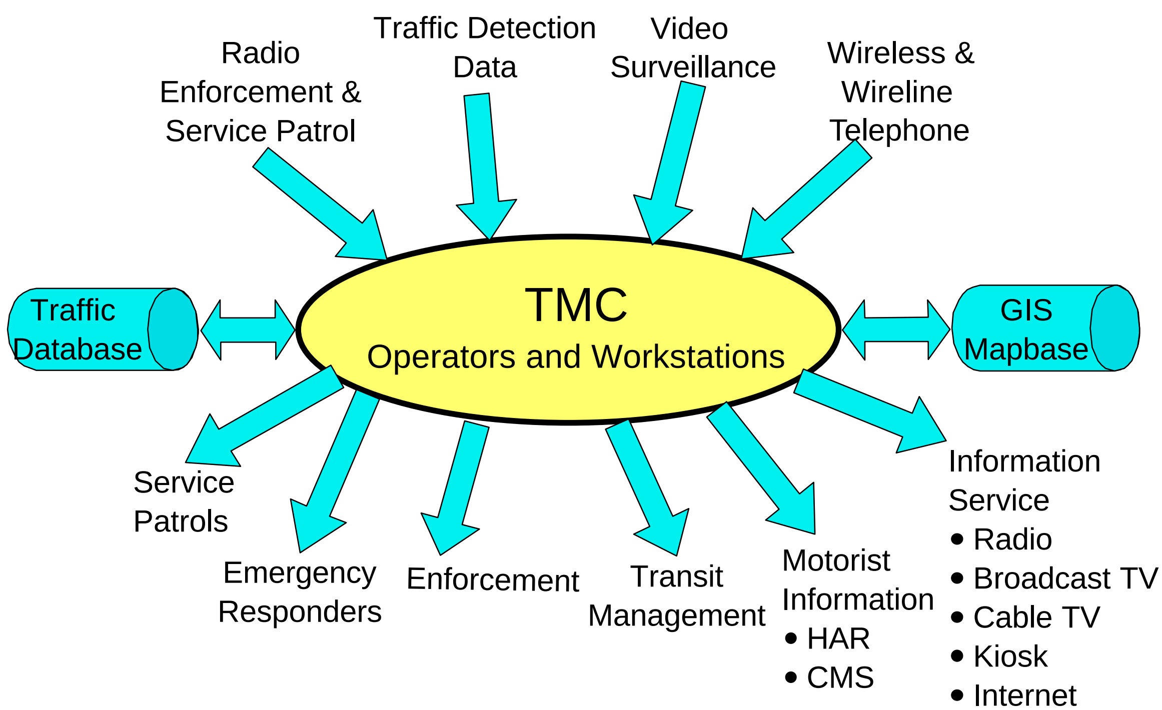

Figure 7-1 Transportation Management Center Functionality

Because traffic issues do not follow geographical boundaries or lines of authority (e.g., policy versus traffic engineering), a TMC should similarly have multi-jurisdictional coverage, and its design and operation should include input from the relevant stakeholders. In most existing cases, metropolitan, regional, or statewide TMCs are established by the state department of transportation, and it is recommended that the Iowa DOT be the lead agency in the development of a Des Moines TMC. In other metropolitan areas, TMC staff often include state transportation agency staff, staff of the metropolitan transit authority, highway patrol staff or other police agency staff, and city and/or county transportation staff members. In Des Moines, the scale of the TMC may warrant one or two staff members operating the TMC at a time. Therefore, it may not be reasonable to expect that more than one organization will contribute staff to the TMC's operation. On the other hand, it may be possible to co-locate the TMC at an existing facility where one or more of the collaborating organizations are currently housed, thereby developing a multiple-agency transportation agency team.

At this time, only a temporary site is recommended for a TMC. The requirements for an initial Des Moines TMC are relatively simple. The TMC will require a computer workstation and console, wall space for video monitors, high-speed communication capabilities with enough bandwidth to carry several channels of video, and several telephone lines. Initially, the space occupied by the TMC could be less than 500 square feet. In Figure 7-2 is included a drawing of an example layout for the work area in the Des Moines TMC.

It is recommended that the possibility of moving to a permanent site be reviewed as part

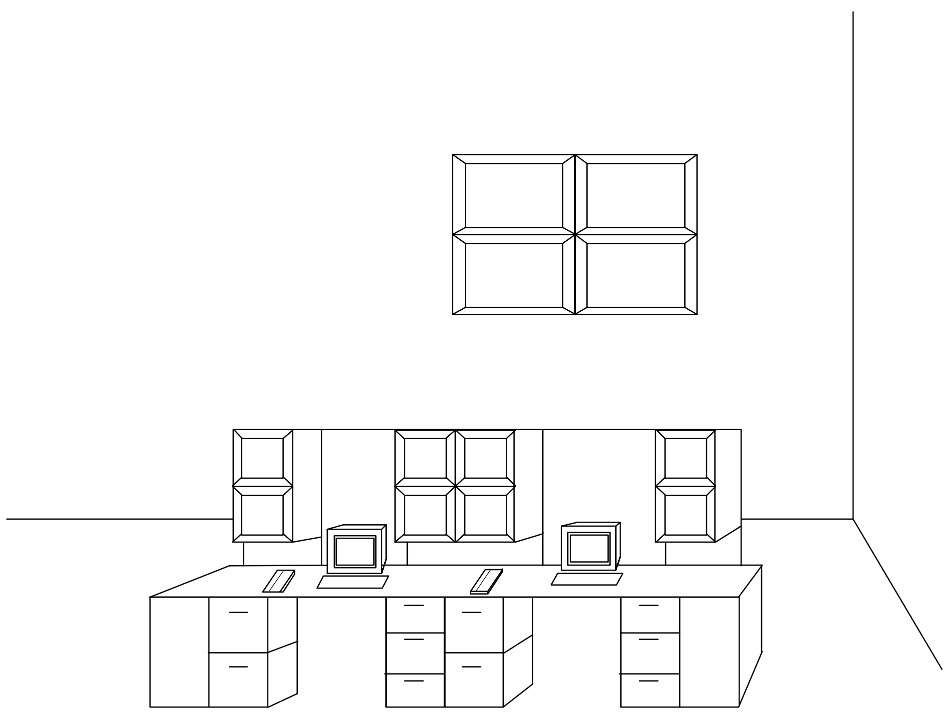

Figure 7-2 Example TMC Work Area

of the I-235 reconstruction activity. A permanent site for the TMC could be located as part of the process of gearing-up for traffic management and public information distribution during reconstruction.

Although no exhaustive study was made of potential sites for an initial TMC, obvious candidates include the STARC Armory in Johnston, the Iowa DOT maintenance residence in Clive, and the City of Des Moines Armory. Although space may be a problem if the TMC were located at the City of Des Moines Armory, the armory has been proposed as a Des Moines hub for the Iowa Communications Network and provides the opportunity to be in close proximity with the City of Des Moines Traffic and Transportation Office and the Des Moines MPO. The Iowa DOT's maintenance office provides the opportunity to be co-located with other Iowa DOT personnel and to share management, staff, and facility resources. The maintenance office is also located close to I-35/80, thus providing fairly easy access to the fiber optic network proposed run in the right-of-way of I-35/80.

STARC Armory is the recommended site for the TMC. STARC Armory is the site of the state's Emergency Operations Center (EOC), the operational center for the Iowa Communications Network, and the central Iowa dispatch center for the Iowa State Highway Patrol. As a result of the importance of the facility, the communications systems, security, power, and other ancillary services are suited for a TMC. The room occupied by the Iowa State Highway Patrol dispatcher also has ample room to house the TMC. Given that the patrol's dispatchers perform functions related to those performed by a TMC, the co-location should create synergy between the two functions. Further, in preliminary discussions with personnel from the Emergency Management Division of the Iowa Department of Public Defense, they were more than positive about the possibility of locating the TMC within the EOC.

Providing access to the data and video generated by the ATMTIS to other considered sites, as well as to the Des Moines Metropolitan Transit Authority, city police, local Highway Patrol field office, the Iowa DOT, and city offices throughout the metropolitan area will be inexpensive and utilize common technology. It is proposed that an Extranet be used to provide interagency sharing of data, images, and graphics. An Extranet is a collaborative network that uses Internet technologies to link together a defined group of individuals or organizations.

Cost Estimate

It is assumed that the Transportation Management Center (TMC) will be located in an existing building and all that is necessary is the computer hardware, computer software, computer peripherals, and video monitors. Further, it is also assumed that software from an existing Transportation Management Center can be obtained and modified for the Des Moines metropolitan area. The costs of the computer systems and software systems are approximately $120,000 to $150,000 for TMC computers and computer equipment and $250,000 for TMC (ATIS/ATMS) software.[1]

Video Surveillance and Video Detection

Video surveillance, along with traffic detectors, is a principal means for gathering transportation system condition information. Although detector data alone can provide quantitative information on the condition of traffic flow (e.g., traffic volume, speed, flow, and the presence of an incident), only visual data can confirm incidents and interpret accident information to determine the appropriate response. In general, it is far quicker and more cost effective to port an image of an incident scene to a trained operator at the TMC rather than waiting until a trained responder (e.g., police, fire personnel, or service patrols) arrives at the scene to assess the severity of the incident and determine the correct response. However, full-motion video has significant bandwidth requirements, making the communication system expensive. Nevertheless, video cameras that can capture qualitative incident information are, and always will be, a major component of transportation surveillance.

Video surveillance is proposed in phases, with the first being implemented on I-235 and the high accident location along I-35/80. Prior to the reconstruction of I-235 in the next one to five years, surveillance is recommended for the major reconstruction diversion routes. Traffic detection is only proposed on facilities built to interstate standards, again in phases. The entire length of I-235 is initially proposed for video surveillance because of reconstruction of the facilities. The recommended systems are mobile and can be repositioned during reconstruction and then placed optimally following construction.

Video image processing (VIP) is one form of non-intrusive traffic detection device. Non-intrusive devices are those devices that cause minimal disruption to normal traffic operations when installed.[2] These are systems which do not need to be installed in or on the pavement but are mounted overhead, to the side, or beneath the pavement by pushing the device in from the shoulder. In addition to the benefit of not disrupting traffic when installing or maintaining devices, non-intrusive technology is not impacted by interaction between the pavement, repetitive loadings, and water penetration of the pavement. On heavily trafficked roadways in areas like central Iowa where each winter exposes the pavement to several freeze/thaw cycles, traditional loop detectors tend to break or malfunction due to mechanic action in the pavement. At locations where lane availability is critical due to high-volume and high-speed traffic, repairs to detectors can be costly and can cause significant traffic delays. For durability reasons and for ease in maintenance,

[1] The cost estimates provided do not include the cost of system integration and system design. These costs are included in the total costs presented at the end of this chapter.

non-intrusive detection technology has become popular. VIP technology is recommended at locations on I-235 but other, less costly, non-intrusive technology is recommended at other locations on the interstate design standard facilities (specifically, radar detection technology).

VIP detection systems identify vehicles and traffic flow parameters (presence, volume, speed, and flow) by analyzing video images.[3] Using specially designed microcomputers, VIP detection systems digitize images and analyze digital data for changes in the image background. The computer identifies changes in the contrast level between the pixels (picture elements) that make up the image. Information about the vehicle passage, presence, speed, length, and lane-change movement can be supplied, depending upon the type of image processing technique. The most common VIP detection system in the United States uses tripwire approaches, where virtual detectors are located on the image of the roadway surface. The VIP analyzes the portion of the image containing the detection zone and detects vehicles crossing the detection zone similarly to a conventional inductive-loop detector. Several detection zones can be analyzed in one image and, therefore, one camera can cover several lanes and ramps. The limiting factor is the camera's field of vision. One VIP system can analyze images from several cameras. For purposes of the planning, it was assumed that one VIP system could supervise cameras covering three interchanges.

VIP detection technology has been in use in traffic applications since 1987. As computer technology has improved, the functionality and capabilities of VIP systems have improved.

VIP detection has a significant benefit in that the cameras can also be used for video surveillance. Therefore, the video detection systems planned for I-235 can be used to serve both video surveillance and traffic detection requirements.

Those video surveillance and video detection assets recommended for the immediate implementation along I-235 are strategically placed so that the entire facility may be monitored. At the same time, video surveillance is recommended at the high accident location along I-35/80. The interchanges or bridges nearest the location of the proposed camera are listed in Table 7-1 and Table 7-2. These locations are also identified in the system map in Appendix A. If at all possible, the camera should be located at a position outside the area of reconstruction so that video surveillance can continue uninterrupted.

Table 7-1 Locations of Video Surveillance and Detection Cameras on I-235 for Immediate Implementation

I-235 Interchanges or Bridges	
Northeast I-235 & I-35/80 System Interchange	Video Surveillance
Euclid Avenue Interchange	Video Surveillance

Gutherie Avenue Interchange	Video Detection
Easton Boulevard Interchange	Video Detection
E. 14th Street Interchange	Video Detection
E. 6th/Pennsylvania Interchange	Video Detection
2nd Avenue	Video Detection
7th Avenue	Video Detection
Cottage Grove Avenue	Video Detection
42nd Street	Video Detection
56th Street	Video Detection
63rd Street	Video Detection
73rd Street/8th Street	Video Detection
22nd Street	Video Detection
35th Street/Valley West Drive	Video Surveillance
Southwest I-235 & I-35/80 System Interchange	Video Surveillance

Table 7-2 Locations of Video Surveillance and Detection Cameras on I-35/80 for Immediate Implementation

I-35/80 Interchanges or Bridges	
Northeast I-235 & I-35/80 System Interchange	Video Surveillance
E. 14th Street	Video Surveillance
Merle Hay Road	Video Surveillance
Hickman Road	Video Surveillance
Southwest I-235 & I-35/80 System Interchange	Video Surveillance

Following the implementation of video surveillance along the I-235 and I-35/80 loop, video surveillance is recommended for the major reconstruction arterial diversion routes in the next one to five years (the period before reconstruction). The general locations of the cameras are shown on the system map, but the locations are not as well defined as those for immediate implementation. The east-west routes recommended for video surveillance to the west of downtown include Douglas Avenue, Hickman Road, and Grand Avenue. The east-west routes east of downtown recommended to receive video surveillance include University Avenue and Hubbell Avenue, with extended surveillance eastward on I-80 to the U.S. 65 interchange. Surveillance is recommended on the north-south routes north of downtown on 86th Street, Merle Hay Road, 63rd Street, Martin Luther King Boulevard, East 2nd Avenue, and East 14th Street. Surveillance is recommended on north-south streets south of downtown on Fleur Drive and SE 14th Street.

In the five- to ten-year time frame, it is recommended that video surveillance be extended west from the I-235 and I-35/80 interchange and to the southwest to the future Iowa 5 and I-35 interchange. Beyond ten years, video surveillance is recommended for the development along the U.S. 65 and Iowa 5 loop around the south and the east edge of the metropolitan area.

Cost Estimate

To obtain cost estimates for the for video surveillance and video detection, vendors were interviewed and bid tabulations were reviewed from advance traffic management systems implemented in Phoenix, San Antonio, Cincinnati, and Northern Virginia (suburban Washington, D.C.). Using actual costs derived from prior projects takes into account the cost not only of the device (e.g., the camera) but also of the related items to make the device operational (e.g., foundations, electrical conduit and trenching, mobilization, traffic control, etc.). The cost of a video surveillance camera, mounted on a pole, with full pan, tilt, and zoom capabilities is about $40,000 (not including the communications systems). The approximate costs for installing the surveillance cameras during each phase are listed below in Table 7-3. These numbers should only be viewed as indicative of the actual cost.

Twelve additional cameras will be required for the video detection equipment to be temporally located on I-235 and moved during construction. To perform video imaging processing requires an additional field processor for every three cameras and thus four field processing units are required for an estimated cost of $680,000.

Table 7-3 Estimated Video Surveillance Costs

Phase	Number of Cameras	Approximate Cost
Immediate	8	$320,000
1 to 5 years	13	$520,000
5 to 10 years	3	$120,00
10 to 20	7	$280,00

Vehicle Detection

Non-intrusive vehicle detection devices are recommended, rather than the more common in-the-pavement inductive loop detectors, for two principal reasons: 1) they are not prone to destruction due to mechanical action from the repetitive load or from freeze/thaw cycles and 2) when they do require maintenance, the maintenance is not performed through maintenance actions on the roadway itself (e.g., saw cuts, patching, loop replacement, etc.). Some technologies described as non-intrusive require the device to be mounted immediately over the travel lane and face forward towards traffic. Because mounting the device may require blocking traffic below, it is not completely true that non-intrusive devices eliminate the need to disrupt traffic and the related risks of working in traffic. Some non-intrusive vehicle detection devices are mounted on the side of the road or are pushed through conduit under the pavement; these can be maintained and installed without disrupting traffic.

The Minnesota Department of Transportation recently (May 1997) completed a study of various non-intrusive vehicle detection technologies for the Federal Highway Administration.[2] This study evaluated several technologies currently available or in the prototype development stage. The study does not make strong recommendations favoring one technology over the other, but the report does identify the shortcomings and advantages of specific technologies. Technologies evaluated included passive and active infrared, passive magnetic, microwave, radar, passive millimeter wave radar, passive acoustic, ultrasonic, and video (VIP). Most of the technologies examined are being newly applied to traffic detection and, as a result, the systems are quickly evolving.

Only two technologies currently allow the simultaneous collection of detection in more than one lane: 1) video and 2) radar. Radar detectors are much less costly than video, and communication requirements are relatively low since all that is being transmitted from the detector to the TMC are summary traffic statistics. Further, the radar device tested by the Minnesota Department of Transportation can be mounted on a pole on the side of the road. The radar device then looks down on the highway at a 90 degree angle to the direction of the traffic, while simultaneously detecting vehicles in all lanes of traffic (sidefire mounting). The sidefire configuration is illustrated in Figure 7-3. Radar technology is recommended and has been used to develop cost estimates for traffic detectors. However, at the time of actual implementation, a current assessment of technology should be conducted. For example, the Iowa DOT is currently testing a passive magnetic device that pushes into conduit under the road. Passive magnetic technology works by measuring changes in the earth's magnetic flux created when a vehicle passes through the detection zone. If the test results are positive, the Iowa DOT may wish to implement passive magnetic technology. Both radar and passive magnetic technology provide presence, volume, occupancy, and speed and have enough intelligence to provide vehicle classification data.

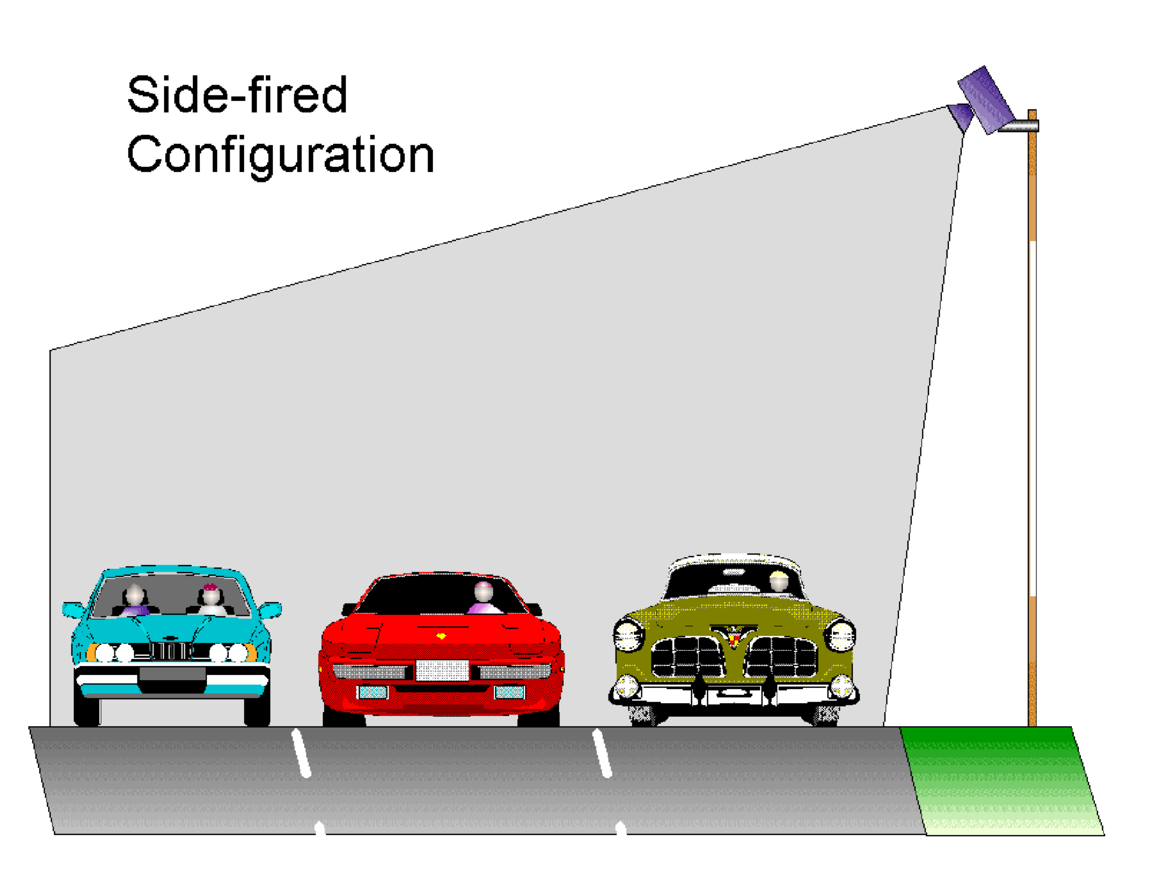

Figure 7-3 Radar Vehicle Detector in Side-fire Configuration

The recommended plan calls for the placement of traffic detection on I-35/80 immediately. Because the recommended technology is both non-intrusive and pole mounted on the shoulder, the detectors can be removed during the reconstruction planned for I-35/80 between the 86th Street and the I-235 system interchange. The next step during the one to five year time frame will be to populate I-35 and I-80 beyond the northeast and southwest system interchanges with traffic detectors. In the five to ten year time frame, the plan recommends extending the detectors further out on I-35 and I-80, and in the ten to twenty year time frame to populate the U.S. 65 and Iowa 5 loop with traffic detection. The approximate location of vehicle detectors are shown on the system map in Appendix A.

Cost Estimate

The cost of the detectors is relatively modest in comparison the pole and other equipment which must be procured to support the detector in the side-fire configuration. The approximate cost of the entire installation is about $24,000. The estimated cost of deploying detectors is show in Table 7-4.

Table 7-4 Estimated Radar Detector In Side Fire Configuration Costs

Phase	Number of Detectors	Approximate Cost
Immediate	9	$216,00
1 to 5 years	4	$72,000
5 to 10 years	4	$72,000
10 to 20	7	$374,000

Highway Advisory Radio

Highway Advisory Radio (HAR) is considered part of the core ITS infrastructure in most urban areas with an ATMTIS. HAR is a low-output (10 watts or less) radio transmitter used to provide traveler information. HAR is an effective means of distributing all kinds of traveler and general interest information in a local area. Common models of high-power HAR are rated to transmit in a 2.5 mile radius from the antenna, but the signal commonly carries much further, up to a distance of 15 miles depending on the conditions. One of these stations, located near the midpoint of I-235 (near downtown), would be sufficient for covering most of the entire length of I-235.

The Federal Communication Commission allows governmental agencies to operate on available AM radio frequencies. There are certain restrictions on the frequencies that HARs should avoid so that they do not interfere with licensed radio stations.

There are two general types of HARs: 1) trailer mounted mobile and 2) stationary. The Iowa DOT currently operates mobile HARs for providing motorists with warnings of congestion at work zones and advice on alternative routes to avoid congestion. So far, the results of the Iowa DOT's experience with HARs have been quite positive. Given that almost all cars have AM radios, in comparison to other means of communicating traveler information (e.g., Changeable Message Signs), HAR is a fairly inexpensive means of transferring en route, real-time information to travelers. HARs provide broad coverage and can communicate more complete and complex information than fixed location devices.

The HAR proposed for the Des Moines Metropolitan area would be at a stationary site with the principal purpose of warning drivers of traffic conditions which may result in delays or facility closures and providing travelers with path and/or mode options. HARs provide travelers with en route information for the making of travel routes or mode choices. The principal benefit to motorists is to allow them to make more informed route or mode choices and to reduce delays resulting from non-reoccurring congestion due to incidents and weather. The HAR can also be used to provide secondary benefits such as identifying travel mode options or the availability of parking spaces.

One of the most common misconceptions of the operations of HARs is that HARs are competitors to broadcast media traffic reporters. Instead, broadcast traffic reports and HARs should be seen as complementary systems. Broadcast reports focus on broad issues to appeal to a large audience throughout the urban area. Commercial traffic reports are usually intermixed with other programming and commercials. HARs should focus on very current and localized information and provide information with enough detail to make en route path and mode decisions. In addition to warning motorists of incidents and other traffic tie-ups, HARs can include information on roadway weather, guidance to available parking facilities, upcoming special events, transit alternatives, current and future roadway construction, and other traveler information not commonly provided in typical commercial traffic information broadcasts.[4]

For motorists to have faith in the information originating from HARs, the information must be useful, accurate, and timely. Maintaining credibility in the information provided by HARs is of extreme importance to their success and, therefore, appropriate resources must be devoted to planning, managing, and broadcasting messages and to the timeliness of HAR broadcast messages. Some urban areas have had difficulty in regaining credibility in a HAR once faith in the messages being delivered has been lost by the public. A Federal Highway Administration sponsored study identified common problems with HAR information that has caused the public to no longer follow the message being delivered by the HAR.[5] The identified problems include:

- Broadcasting information contrary to existing conditions.
- Providing information that is unclear or cannot be heard in time to make the appropriate en route modification to travel path or mode to make a difference.
- Recommending a course of action that motorists believe is not significantly better than their intended actions.
- Presenting motorists with information they already know.

It is recommended that the Des Moines HAR operate continuously during the morning and afternoon peak period. When there are no traffic incidents, special events, or severe weather, it is recommended that the HAR report that there are no unusual occurrences, report on the current level of congestion, and provide other relevant information, particularly information on future construction activities, the availability of parking in downtown lots in the morning, and transit alternatives. When there are exceptional events (e.g., an incident on I-235) motorists can be notified either through the variable message signs on the inbound legs of I-35 and I-80 or through static signs with flashing lights or rotating beacons. It is also recommended that the system be put in place immediately and that control for the system be located in the TMC. As part of the operational plans for the TMC, an examination should be made of the staffing requirements to manage the HAR (as well as the changeable message signs) to maintain information currency and relevance. Additional HARs are proposed in the northeast, northwest, southwest, and southeast corners of the metropolitan area in the future. The approximate location of the proposed HARs are shown on the system map.

Cost Estimate

Highway advisory radio systems can vary greatly in cost depending on the number of options requested and the amount of support required in installation and initial operation. Costs of deploying fixed location HARs in other urban areas have varied from $55,000 to $110,000. The plan currently call for one HAR to be installed immediately, three in five to 10 years, and two in 10 to 20 years.

Changeable Message Signs

Changeable message signs (CMS) have been in use since the early 1970s and are used to convey information which cannot be conveyed adequately with a static sign. In other words, a CMS should convey a message which changes with time. While early signs were limited to a few fixed messages, modern signs are capable of changing the text to any combination of words and letters (often called Variable Message Signs) through remote computer control. Traditional signs have conveyed and changed their messages through mechanical means (e.g., rotating drums or rotating reflective disks or rectangles); modern changeable sign technology has become solid state and messages are conveyed through a matrix or matrices of light sources. Light emitting technology has been used in CMSs for sometime, with an array of light bulbs being the first light emitting technology. The CMS market place is moving to a few newer light-emitting technologies, including fiber optic arrays, light-emitting diodes (LED), hybrid combinations of fiber optic or LED, and rotating reflective disks.[6]

A recent National Cooperative Highway Research Program synthesis of practice found that 27 state transportation agencies (including the Iowa DOT) are currently operating permanently mounted CMSs, and some have been operating CMSs since the mid-1970s.[7] The permanent CMSs on I-35 north of the northeast I-35 and I-80 interchange and east on I-80 and on I-35 south of the southwest I-35 and I-80 interchange and west on I-80 have given the Iowa DOT significant experience with the use and value of CMSs.

CMSs are generally considered part of the core infrastructure for most urban ATMTIS. Although they are generally seen as one part of an entire system, it is difficult to divide out the impact of variable message signs alone. However, as long as the message delivered by the message signs is timely and accurate, they provide an effective means to convey motorist information. Almost all urban ATMTIS designs include CMSs.

Similar to messages provided by an HAR, the most significant problem with CMSs is the credibility of the messages provided. Motorists will lose faith in the CMSs if the messages are not current, if they tell the motorist something they already know, or if they are confusing or inaccurate.[8] Motorists will tend to ignore a CMS if the signs are used to routinely convey greetings or other non-critical information (e.g., “Welcome to Des Moines”). Like HAR, they should convey information that is current and assists the motorist in making real-time decisions regarding routing, safe vehicle operation, or other immediate issues in the local area. Like HAR, however, this places a further requirement on the TMC operator(s). This should be taken into account when determining the staffing requirements for the TMC.

It is recommended that additional CMSs be deployed principally to help manage traffic during the reconstruction of I-235 and that the CMSs be located on the primary diversion routes. It is also recommended that small CMSs be mounted on a mast arm over the inbound lane on the principal arterial diversion routes. The approximate proposed locations are shown on the system map.

Typical freeway CMSs are sized large enough to allow motorists traveling at freeway speeds to read them easily. Because the small CMSs recommended in this study will be deployed on arterial streets where motorists will be traveling at slower-than-freeway speeds, motorists should be able to read the signs more easily. Therefore, the recommended CMSs can be more compact than those on typical freeways. To minimize costs, compact message signs with a single line of text are recommended.

Standard, interstate-scale, multiline CMSs are also recommended on the I-35/80 loop. On the northern portion of I-35/80, signs are needed only in the eastbound direction; on the western portion of I-35/80, a sign is needed in the southbound direction.

All CMSs should be put in place in the next one to five years, in advance of I-235 reconstruction. As experience is gained with the CMSs planned for I-235 diversion routing, others may be put in place further outside in the metropolitan area on the legs of I-35 and I-80 leading into Des Moines in the five- to 10-year time frame.

Cost Estimate

Changeable message signs vary greatly in price and there is significant diversity in the quality of units available. The prices could also change as the number of procurement of CMSs build. Two types of CMS are planned for the Des Moines metropolitan area, freeway mainline signs and arterials signs. Although freeway mainline CMSs are fairly common, arterials systems are not. In installations around the country, freeway mainline systems have varied from $115,000 to $190,000. Arterial CMSs ranged from $55,000 to $90,000. As a result actual prices could vary significantly from those estimated. The approximate costs for CMSs for freeway mainline system and arterials systems are listed in Tables 7-5 and 7-6 respectively. These are only estimates and should only be used for planning purposes.

Table 7-5 Estimated Freeway Mainline CMS Costs

Phase	Number of CMS	Approximate Cost
Immediate	0	$0
1 to 5 years	3	$345,000 - $570,000
5 to 10 years	2	$230,000 - $380,000
10 to 20	7	$805,000 - $1,330,000

Table 7-6 Estimated Arterial CMS Cost

Phase	Number of CMS	Approximate Cost
Immediate	0	$0
1 to 5 years	13	$715,000 - $1,170,000
5 to 10 years	0	$0
10 to 20	0	$0

Ramp Metering

Ramp metering involves mounting a traffic signal head, cycling from red to green, on entrance ramps to freeway design standard facilities. The meter controls the flow of traffic from the ramp to the merge area with the mainline. Ramp metering improves the throughput of the facility, generally increasing both traffic speed and density (resulting in a greater traffic flow) and improving safety.

If the combination of upstream mainline and ramp flows exceeds the capacity of the freeway, ramp metering can be used to keep downstream traffic volumes above critical levels. Even if the volume of vehicles temporarily exceeds capacity, a critical volume can result in a breakdown of smooth traffic flow. Once smooth traffic flow is interrupted, turbulence in the traffic stream creates a temporary reduction in flow and the traffic shock wave may degrade flow to stop-and-go movement. Either way, the throughput of the roadway is reduced. Metering reduces the chance of exceeding the capacity of the mainline by temporarily storing vehicles on ramps and in storage areas adjacent to ramps.

Ramp metering can also reduce the chance of turbulent flow resulting from multiple entering vehicles attempting to merge with traffic on the mainline. Groups of vehicles merging into the mainline may attempt to force themselves into the mainline creating turbulence and contributing to flow breakdown. By breaking up groups attempting to merge with the mainline through metering, the merging process can be smoothed, allowing traffic volumes to reach the theoretical capacity of the facility.

Field installations of ramp metering have delivered quite positive results. Ramp metering has shortened the duration of congestion during the peak period. At several locations, ramp metering has resulted in increases in overall vehicle throughput and ramp metered highways experience volumes of more than 2,100 vehicles per hour per lane. By reducing or eliminating turbulence in the traffic stream, increased average speeds have been reported after installation of ramp metering, with increases in speeds up to 50 percent and up to a 30 percent reduction in accidents.

Ramp metering has been tested in various forms since the 1960s in Detroit, Chicago, and Los Angeles. Since these early experiments, systems have been put in place in many other cities and, generally, metering has resulted in improved throughput and increased safety.

Clearly the most troublesome issue regarding the implementation of ramp metering is public acceptance. The traffic-flow relationships which allow ramp metering to be beneficial involve abstract concepts which are not easily understood by the general public. The experience in some urban areas, where the benefits of ramp metering have been widely publicized, has been positive. In other urban areas, where ramp metering was not accepted by the public, a high violation rate of metering and even vandalism of the equipment was experienced.

It is recommended that a detailed design study be conducted of ramp metering at high-accident interchanges along I-235 and I-35/80. Ramp metering is proposed primarily as a means to improve safety in high-accident locations. On I-235, ramp metering would be an intermediate solution prior to redesign and reconstruction of I-235 and during reconstruction to improve the capacity of traffic lanes that will be heavily taxed by additional construction-related traffic volumes. Following reconstruction, ramp metering may be further reconsidered. Some urban areas have temporarily deployed ramp metering. Austin, Texas, for example, implemented metering on ramps in a bottleneck area of I-35. When the bottleneck was removed through geometric improvements, the ramp meters were removed.

Table 7-8 identifies the number of interchanges and link accidents which occurred during the peak periods in 1993 along I-235 and I-35/80 and indicates locations where further detailed study of ramp metering is recommended. Further study is required to identify whether it is possible to conduct ramp metering given the ramp geometry, the adequacy of acceleration and deceleration distances, and storage area on the ramps. Inadequate storage area for vehicles at ramps can cause queues which adversely effect the flow and safety of the surface streets leading to the interstate. Assuming that adequate storage capacity does exist, a ramp meter timing plan and operation and physical design would have to be developed.

Ramp metering operation typically involves detection on the mainline in the area of the ramp merge area, possibly upstream of the merge area but certainly downstream, a presence detector at the traffic stop line, and queue length detectors to ensure that metering does not back-up queued traffic into the surface streets.   The meter itself involves a signal head, a signal controller (hardware and software), and communication lines to transmit data back to a transportation management center. The cycle of the meter is most commonly governed by local fixed-time operation, but may involve a system where the timing is responsive to the traffic volume on the mainline in the immediate area or is controlled centrally based on system-wide conditions.

Benefits and Indirect Costs

Standard traffic signal hardware is used in ramp metering and, therefore, the costs are low. On the other hand, ramp metering typically results in significant cost savings resulting from improved safety and increased throughput.

Several indirect costs are commonly cited to argue against the use of ramp metering. These indirect costs include those resulting from diverting trips away from the interstate or to another time of day, inequitably favoring individuals making long trips over those making short trips, and promoting longer trips.

Table 7-8 Peak Period Accidents at Interchanges and Along Links

LOCATION	Interchange Accidents (weekday)			Link Accidents (weekday)			Meter Study Recommendation
I-235 Interchanges	AM Peak	PM Peak	Total	AM Peak	PM Peak	Total	
NE 35/80/235 System Interchange	9	2	11				

Euclid Avenue	7	2	9	10	2	12	Study Metering
Guthrie Avenue	1	2	3	2	0	2	
Eaton Boulevard	0	3	3	0	0	0	
University Avenue	2	2	4	1	2	3	
E. 14th Street	10	18	28	1	2	3	Study Metering
E. 6 Avenue/Pennsylvania	5	22	27	9	10	19	Study Metering
7th/5th/2nd Avenue	5	22	27	2	8	10	Study Metering
Keosauqua Way	7	4	11	1	4	5	Study Metering
Cottage Grove Avenue	0	4	4	1	3	4	
31st Street	3	5	8	6	3	9	
35th Street	4	0	4	1	1	2	
42nd Street	6	6	12	7	7	14	Study Metering
56th Street	3	1	4	4	7	11	
63rd Street	3	9	12	4	5	9	Study Metering
73rd Street/8th Street	9	23	32	6	16	22	Study Metering
22nd Street	5	5	10	3	3	6	
35th Street/Valley West Drive	7	11	18	4	2	6	Study Metering
SW 35/80/235 System Interchange	0	2	2	3	0	3	
I-35/80 Interchanges							
University Avenue	2	7	9	1	0	1	
Hickman Road	4	2	6	1	2	3	
Douglas Avenue	6	5	11	1	0	1	
Iowa 141	3	1	4	3	4	7	
86th Street	No Interchange in 1993			0	0	0	
Merle Hay Road	6	11	17	0	0	0	Study Metering
2nd Avenue	0	2	2	2	11	13	Study Metering
E. 14th Street	4	5	9	1	1	2	
NE 35/80/235 System Interchange				0	2	2	
Total	111	176	287	74	95	169	

- **Diversion.** There are two types of diversion: diversion by route and by time. By metering ramps, drivers may avoid the delay imposed by the meter and be diverted to use arterial streets to make their trip. Thus, some of the traffic that would otherwise be carried by the freeway is now traveling on arterial streets. However, trips that are diverted to arterial streets from the interstate are probably short trips, where the delay at the meter consumes a significant proportion of the total trip duration. Interstate highways were never really intended to support short-distance trips and, therefore, diverting short trips onto arterials roads may be desirable. Diversion by time involves motorists shifting their travel times to avoid delays induced by ramp metering.

Evaluations of ramp metering have shown as much as a 15 percent reduction from pre-meter volume during the peak period, thus spreading travel over a longer period and making better use of freeway capacity.

- **Equity.** Ramp metering favors travelers making longer trips at the expense of people making shorter trips. Trips starting on the freeway outside of the metered region are not delayed at all. Individuals within the metered portion of the highway are delayed to provide the individuals from outside of the metered region with an uncongested trip; thus, one group gains (long-distance travelers) to the detriment of another group (short-distance travelers). Further, even if both short and long-distance travelers are delayed at ramp meters for the same duration, the long-distance traveler spends a smaller proportion of his/her trip delayed and has the travel time reduced over the greater travel-time distance. Thus on a proportional basis, long-distance travelers have their travel time reduced by a greater proportion than short-distance travelers.
- **Promotion of Long-Distance Trips.** Related to the equity issue, an uncongested facility upstream of metered ramps provides an incentive to replace short trips with longer trips. For example, due to ramp metering, the commuter trip home from work may take even less time than it would without ramp metering and, thus, supports even longer (in distance) commuter trips.

For the three reasons above and the costs associated with developing, operating, and maintaining ramp metering, detractors have argued against ramp metering. On the other hand, the benefits of ramp metering are quite substantial. For example, when an evaluation of the ramp metering on I-35 E in St. Paul, Minnesota was made 14 years following its introduction in the 1970s, travel speeds were still 16 percent higher (from 37 to 43 mph) than they were before metering, even though traffic volumes increased by 25 percent. The number of peak period accidents had decreased over the 14-year period by 24 percent, while the number of accidents per million vehicle miles decreased by 38 percent. In another example, in Portland Oregon, ramp metering on I-5 (the major north/south interstate highway in the Portland metropolitan area) resulted in an increase in speed during the northbound afternoon commute from 16 to 41 mph, and an overall peak reduction in accidents of 43 percent. Similar examples have been observed throughout the country.

To put this in perspective, based on 1993 accident statistics, there were approximately 200 accidents during the morning peak periods at the Des Moines interchanges for which further study of ramp metering is proposed. (On the links between these interchanges, there were 187.) Assuming that metering in Des Moines conservatively decreased accidents at the high-accident locations by 25 percent, 50 fewer accidents would occur. Based on the conservative average accident cost of $11,500 per accident for all types of accidents (accident types include accidents involving property damage only, personal injury, or fatality), over one-half million dollars per year in accident costs alone would be saved. The cost of the delay imposed on other traffic due to the accident and the ensuing accident clean-up would also be saved. Assuming that 30,000 vehicles are traveling an average of five miles each on the Des Moines freeway system during the morning and afternoon peak periods, and assuming the average vehicle speed is increased by five miles per hour (mph) from 35 mph to 40 mph, an aggregate of 536 travel hours per peak period would be saved.[9] Also assuming that the commuters' time is valued at only twice the minimum wage rate ($10.30/hour), a very conservative economic savings from reduced travel times due to ramp metering is $2.8 million per year.

Direct Costs

Assuming that ramp metering is ultimately deployed at the locations where further study of ramp metering has been proposed, the cost of each ramp meter is approximately $30,000, exclusive of communications back to the TMC. The estimate was based on local costs provided by the City of Des Moines Traffic and Transportation Department and includes the cost of the signal; a controller and foundation; conduit, cable and power; and loop detectors on the mainline and the storage area.

For cost estimation purposes, the I-235 entrance ramps in the core area, near downtown Des Moines and at the Merle Hay and NE 2nd Street interchanges on I-35/80 were assumed to metered in both directions. Outside of the core area (e.g., the Euclid Interchange or the 73rd street interchange) entrance ramps were assumed to be metered only in the inbound direction. This resulted in estimated nineteen ramp meters for a cost of $570,000. The locations of intersections proposed for ramp metering are shown on the system map.

Communications Network

The TMC is the core of the ATMTIS, and the communications network serves as its nervous system. The communications network gathers the data and video along the roadway and brings them to the TMC where they are analyzed and where transportation management strategies are developed and implemented. The communication network then carries the commands back to the field devices through which the transportation management strategies are enacted. Further, it also carries the information to other agencies and locations where it can be used in more effectively providing transportation resource management and incident response services.

The size of the network is determined by the number of resources providing and demanding communications bandwidth (capacity), and by the dispersion of those resources. The greatest demand upon a communications network supporting an ATMTIS is the transmission of video surveillance images. As stated earlier, full motion, color, broadcast-quality video is extremely bandwidth intensive. Thus, many agencies have found that through the use of video compression technology, excellent quality video can be delivered and displayed at the TMC at much lower cost than was previously achievable.

Video compression is achieved by special compression algorithms implemented in the communications electronics, through devices known as CODECs (enCODer/DECoder), similar to modems commonly used with personal computers. The technology used as the basis for cost estimates in this study assume that each video signal, which would consume 90 million bits per second (MBPS) if uncompressed, instead consumes only three MPBS in compressed format. This technology is being used in a number of traffic management systems around the United States.

Prior to the advent of current communications technologies, providing communications services for a system such as ATMTIS was expensive, and required extensive maintenance to achieve adequate levels of reliability. As ITS has grown in popularity, commercial technologies such as communications over fiber optic networks (like the Iowa Communications Network (ICN)) have been adapted to transportation applications. The fiber optic transmission equipment initially implemented by telephone companies has now been upgraded to withstand the severe roadside conditions required of transportation systems, and has become both smaller and more affordable as part of an overall ITS system. The greatest part of the communications network cost is most commonly now not the fiber optic cable and electronics, but the trenching and placement of conduit for the cabling.

The network recommended for the Des Moines ATMTIS is illustrated in figure 7-4. It is composed of two concentric loops, joined at the TMC. By using a loop architecture, the “self-healing” nature of the commercially available synchronous optical network (SONET) standard based equipment can be used to guarantee that the system remains operational even if the network is completely severed at any point. Concentric loops allow us to distribute the communications bandwidth requirement, reducing the overall capacity (and therefore cost) of the multiplexing equipment. Since the networks join at the TMC which will serve as the switching point, data and video from any point in the system can be distributed to any other point (or center) attached to the network. Through applying a commercial standard, Iowa is guaranteed multiple competing suppliers and a technical solution that will continue to advance and be upgradable as Iowa’s needs mature.

It will be possible to reduce the cost of the network implementation by taking advantage of construction planned for the Des Moines interstate system and the southeast bypass. It is recommended that installation of suitable conduit be planned in the I-235 reconstruction, and in the construction of the southeast bypass loop. Such conduit has already been implemented along I-35/I-80 on the north edge of Des Moines, and should be available up Merle Hay to the STARC Armory in conjunction with the Iowa Communications Network (ICN).

In order to avoid destruction of communication resources supporting the I-235 reconstruction period, it is recommended that analyses be undertaken of either locating safe areas well outside the I-235 work zone for temporary installation, or that consideration be given to running a temporary network through existing conduit along Ashworth and Grand. In the latter plan, the network would be migrated to I-235 after the interstate reconstruction is completed. The fiber in place along Ashworth and Grand could be turned over to the cities of Des Moines and West Des Moines for their use in support of traffic signal control systems.

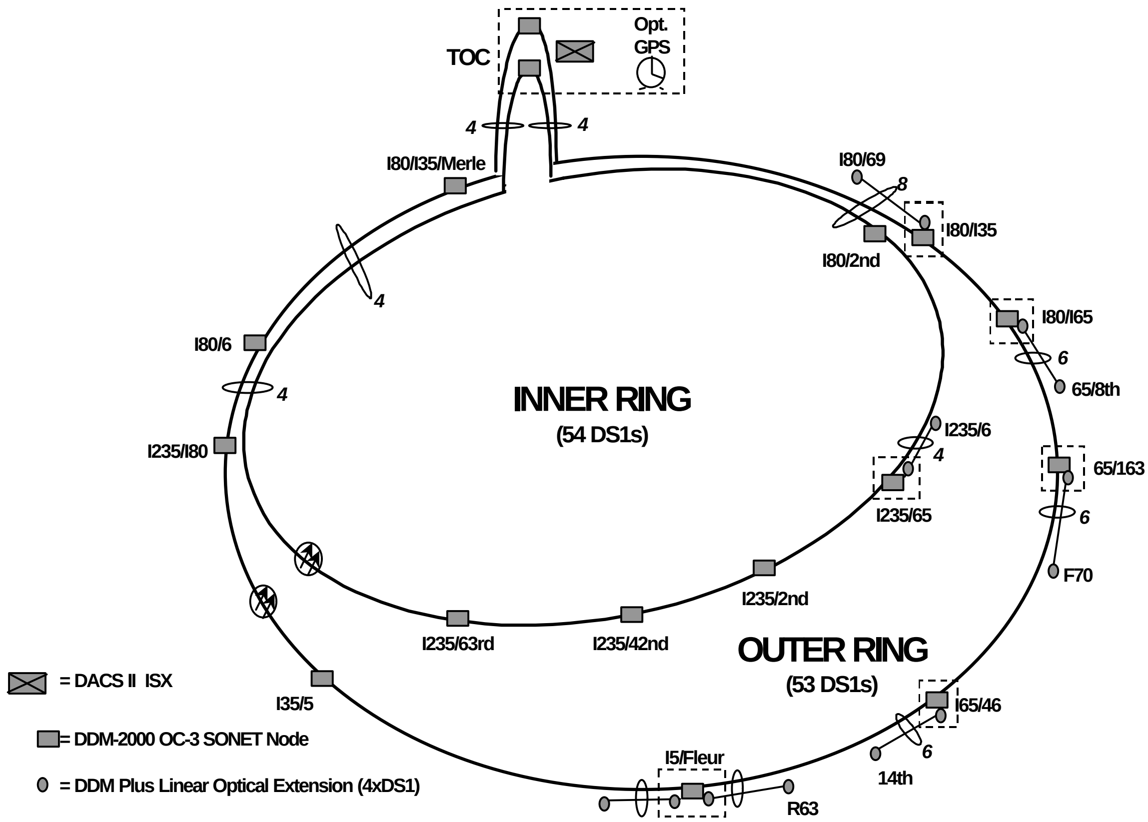

Figure 7-4 High Level Architecture of ITS Communication Network

The overall communications “backbone” transmission rate is recommended as 155 MBPS, identified in the telecommunications trade as Optical Carrier 3 or “OC3.” A series of communications hubs will be placed around the roadway network, at which the high speed channel will be tapped for adequate capacity at lower speeds to support the CCTV cameras, camera pan/tilt units, VMS, detectors, ramp meters, and HAR. Through the use of fiber optic modems, requirements several miles from each hub can be serviced without installing additional hubs; in several instances nearby interchanges have already been analyzed for this approach, further reducing overall network cost. Preliminary analysis indicates that the suggested rate and architecture can support significant growth. Further, it is recommended that the final product selected be fieldupgradeable to the next higher bandwidth level, OC-12 (622 MBPS), should additional opportunities for employment of the network arise in the future.

Cost Estimate

The cost of the fiber optic communication network for the ATMTIS is estimated at $15.7 million. This is a worst-case estimate and assumes that the sole user of fiber optic system is ATMTIS and that the cost of the system is not shared with other public agencies or that a barter for services arrangement (right-of-way inexchange for communication services) is not reached with a communication company. Of this cost, $11.75 million is for trenching, conduit, and cable. A significant portion of this can be considered for inclusion in the I-235 reconstruction and in construction projects for the 65/5 southeast loop. This cost has been spread through four time periods, with the TMC, the "inner loop," and I-235 alternate considered as immediate need, the conduit for the southeast loop in the one- to five-year timeframe, and the equipment for that loop in the five- to 10-year timeframe.

The system pricing assumes the installation of 24-fiber single mode optical cable throughout the network. The cost of splicing, testing, termination, and full documentation has been included in the estimate.

Unit prices for trenching and conduit were provided by the Des Moines DOT based on current experience. Different rates have been used for trenching in urban, mixed urban/rural, and rural environments. Project-level costs for such items as mobilization, systems design, and system integration have been maintained at the project level, and are not reflected in the communication line item. Full list prices for a professionally configured system have been used for the communication equipment, with the expectation that better pricing will be experienced in the competitive bidding process. Minor equipment, such as modems and codecs, has been included with the field equipment line items rather than as part of the communication system.

The communication system concept cost includes nodes at major interchanges along the interstates. Only a single “center” is included in the estimate, although the architecture accommodates multiple centers with access to computer and video transmissions from throughout the network.

Estimated ATMTIS Costs

In Table 7-9 are summarized the estimated costs of the traffic management street and office hardware and traveler information systems. Added to the systems discussed in this chapter are incident management system and plan and the cable television and Internet traveler information systems. Included also are the costs for system engineering and integration. In cases where a range of dollar values was given in the text of the chapter, average value is used in the estimates below. Annual maintenance and operating cost typically range from five to 10 percent of the initial capital cost. These are only estimates and accurate cost information should be a result of engineering design.

Table 7-9 Estimated Total ATMTIS Cost

	Planning Period			
ATMTIS Hardware Assets	Immediate	1 - 5 Years	5 - 10 Years	10 - 15 Years
TMC Hardware	$135,000	--	--	--
Video Surveillance	$320,000	$520,000	$120,000	$280,000
Video Detection	$680,000	--	--	--
Vehicle Detectors	$216,000	$72,000	$72,000	$374,000
Highway Advisory Radio	$82,500	--	$247,500	$165,000
Freeway Changeable Message Signs	$0	$457,500	$305,000	$1,067,500
Arterial Changeable Message Signs	$0	$942,500	$0	$0
Ramp Metering	$570,000	$0	$0	$0
Communications System	$7,143,000	$5,893,000	$0	$676,000
Total Hardware Costs	$9,146,500	$7,885000	$744,500	$2,562,500
Hardware Engineering/Design	$914,650	$788,500	$74,450	$256,250
System Integration	$914,650	$788,500	$74,450	$256,250
Total Hardware, Design, and Integration	$10,975,800	$9,462,000	$893,400	$3,075,000
ATMTIS Software and Systems				
Cable Television System/Interface	$200,000	--	--	--
Internet Information System	$30,000	--	--	--
Incident Management Plan	$50,000	--	--	--
Incident Information System	--	$50,000	--	--
TMC Software and Customizing	$250,000	--	--	--
Total Cost for Software and Systems	$530,000	$50,000	$0	$0
Grand Total	**$11,505,800**	**$9,565,000**	**$893,400**	**$3,075,000**

ATMTIS Recommendations Summary

A number of recommendations were made in this chapter. All the roadside ITS assets were recommended in this chapter. Recommendations were also made regarding the location equipment for the TMC and the communication system architecture. The location of the TMC is proposed for the STARC Armory, co-located with the Iowa State Highway Patrol Central Iowa dispatching center. The site for the TMC should be reexamined as part of the I-235 reconstruction programs. The roadside ITS assets recommended are listed in Table 7-10 and the proposed locations of those devices is shown in the system map.

Table 7-10 Number of ITS Roadside Devices

	Number of Devices			
Roadside Asset	**Immediate**	**1-5 Years**	**5-10 Years**	**10-15 Years**
Video Surveillance cameras	8	13	3	7
Video Detection Cameras	12	0	0	0
Radar Vehicle Detectors	9	4	4	7
Highway Advisory Radio	1	0	3	2
Freeway CMS	0	3	2	7
Arterial CMS	0	13	0	0
Ramp Meters	19	0	0	0

The ATMTIS is the core piece of ITS infrastructure for the Des Moines deployment. Shown in Figure 7-5 is a very high level systems architechure for ATMTIS. On the left side of the diagram are shown the transportation system condition in puts from the various through one of the three identified information servers (the incident Extranet server, the pre-trip traveler information Internet server, or the cable TV server discussed in the following two chapters). The TMC can also use provide traveler information through CMSs and HARs and can invoke management actions through the service patrol, enforcement personnel, and ramp meters.

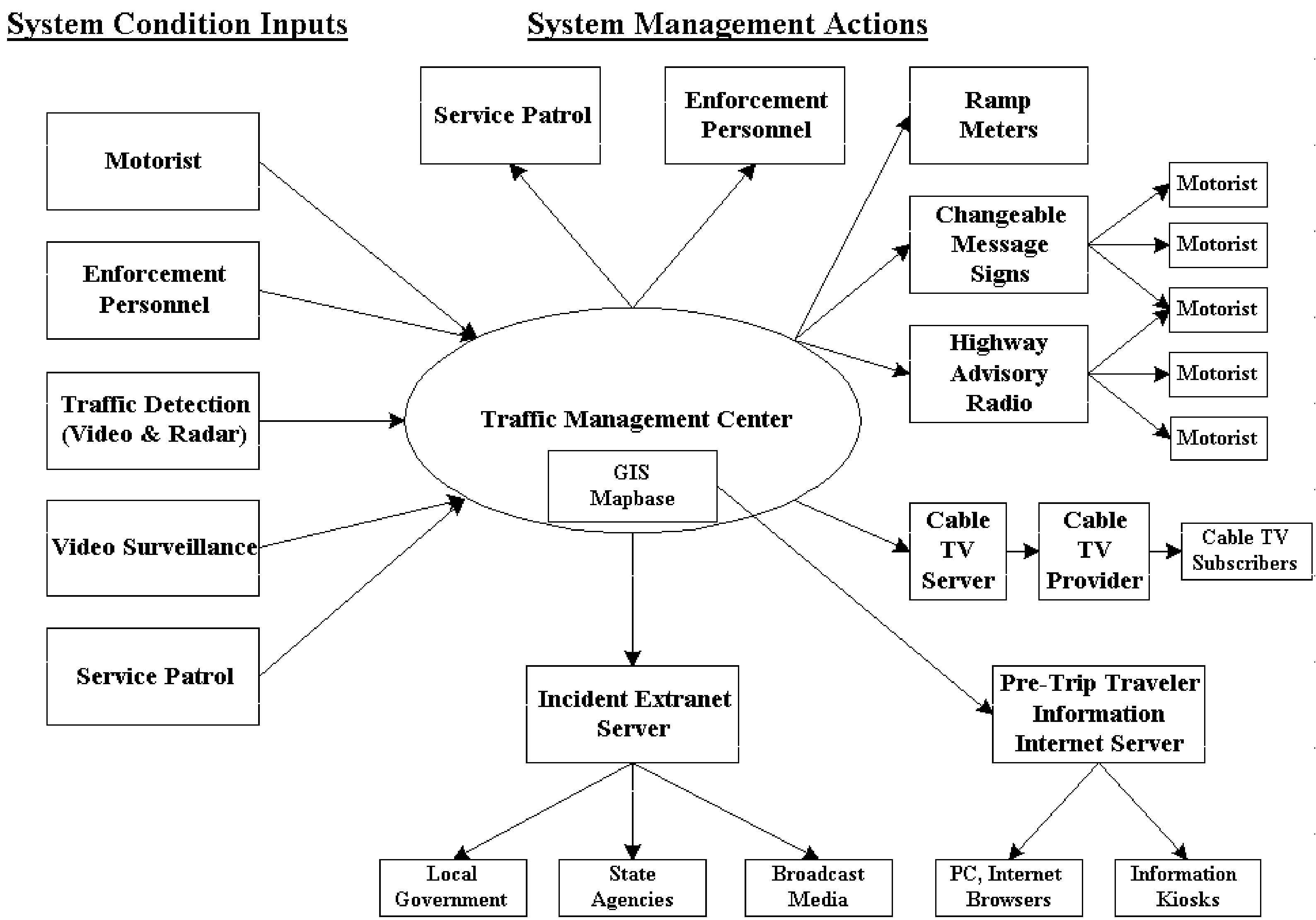

Figure 7-5 High Level ATMTIS Systems Architechure

R e f e r e n c e s

1 U.S. Department of Transportation, "Intelligent Transportation Infrastructure Benefits: Expected and Experienced," Joint Program Office, Washington, D.C., 1997.

2 Kranig, J., Minge. E. and Jones, C., "Field Test of Monitoring of Urban Vehicle Operations Using Non-Intrusive Technologies," prepared by the Minnesota Department of Transportation and SRF Consulting Group, Inc. Prepared for the Federal Highway Administration, Washington, D.C., 1997.

3 Klein, L.A., "Vehicle Detector Technologies for Traffic Management Applications," ITS Online (on the Internet).

4 The Scientex Corporation, "State's Policies, Guidelines, and Procedures for VMS/HAR Systems," Rockville, Maryland, 1994.

5 U.S. Department of Transportation, "Highway Advisory Radio Message Development Guide," Federal Highway Administration, Report No. FHWA/RD-82/059, Washington, D.C., 1982.

6 Dudek, C.L., "Changeable Message Signs," National Cooperative Highway Research Program, Synthesis of Highway Practice 237, 1997, pp. 32-34.

7 Ibid, p. 10.

8 "Seeing Isn't Always Believing ... The Public Speaks Out on Variable Message Signs," RCE Intelliscope, Vol. 1, No. 2, Summer, 1995.

9 Estimate made using the Des Moines transportation demand model.

8

Incident Management Coordination

Congestion and unproductive delays on roadways are caused by either regularly recurring congestion during routine travel patterns or by non-recurring events (incidents). An incident is defined as an accident, vehicle breakdown, spilled load, or other event on or near a roadway that impedes the normal flow of traffic. Incidents can range from routine breakdowns (e.g., an overheated car) to catastrophic accidents (e.g, an overturned and burning hazardous material tanker) to meteorological conditions (e.g., thick fog or blowing snow). Most experts believe that incidents cause the majority of all congestion (the most popular estimate is that 60 percent of all congestion is caused by incidents), but it is hard to estimate the costs of incident-induced delays.

Incidents are of two types: planned and unplanned. Planned incidents involve special events (e.g., the state fair) or maintenance activities (e.g., resurfacing or patching on I-235). Most unplanned incidents do not involve an accident, but are caused by some type of vehicle malfunction. A stalled vehicle partially or fully blocking a traffic lane during the peak traffic period can initiate a traffic flow shockwave, sending a congested facility into unstable and unsafe traffic flow conditions (stop-and-go traffic). At the very least, a stalled car will reduce speeds and cause delays.

The length of delays resulting from incidents is generally believed to increase geometrically with the time it takes to clear the incident. In other words, if 30 minutes rather than 15 minutes is required to clear an incident, the doubling in time results in a delay not twice as long but four times as long. The fact that delays increase geometrically emphasizes the importance of swift and effective management of incidents.

During 1993 (the year used for accident analysis purposes in the “Transportation Issues” report of the Early Deployment Study), 571 weekday accidents were reported on I-235, 40 percent of them during peak travel periods. On I-35/80, 277 weekday accidents were reported, 31 percent during peak travel periods. To be conservative, counting only accidents that occurred on links between interchanges and not those that occurred at interchanges, a total of 398 freeway link accidents occurred during 1993. Nationally, only about 10 percent of incidents result from accidents; therefore, about 4,000 incidents occurred on I-235 and I-35/80 during 1993, roughly 16 per day. Using national averages for length of delay times resulting from incidents, these incidents resulted in approximately 641,841 hours of delay during peak periods and 325,142 hours during off-peak periods. Because of the large number of estimated unproductive hours of delay due to incidents, even a small improvement in managing and responding to incidents could result in very large benefits in the Des Moines metropolitan area.

"Incident management is the systematic, planned, and coordinated use of human, institutional, mechanical, and technical resources to reduce the duration and impact of incidents, and to increase the operating efficiency, safety, and mobility of the highway; by systematically reducing the time to detect and verify an incident occurrence, implement the appropriate response, and clear the incident, while managing the affected flow until full capacity is recovered."[1] Each of the local governmental agencies in the Des Moines metropolitan area, the Iowa State Highway Patrol, and the Iowa DOT (Iowa DOT) has its own process for dealing with incidents on facilities within its jurisdiction. In 1989, to promote intergovernmental cooperation among those agencies for coordinating their incident-management processes on the metropolitan freeway system, a Des Moines Area Freeway Incident Management Committee was formed to discuss interjurisdictional issues and to promote collaboration. However, there is no written agreement among the organizations that identifies responsibilities and defines the lines of collaboration. Further, the committee has not developed a multijurisdictional incident management plan.

The implementation of ITS technology to monitor the condition of the Interstate system and other highways in the Des Moines metropolitan area provides the local and state jurisdictions with an unprecedented opportunity to more effectively and efficiently manage incidents. The Transportation Management Center (TMC) recommended in this report, with its staff and information technology, could provide a focal point and a sense of presence for incident management in the Des Moines metropolitan area, as well as unequaled information collection and distribution capabilities. However, the technology, and the speed at which it operates, necessitates a rather tightly structured protocol for operations and for coordinated actions by agencies involved in responding to incidents.

It is therefore recommended that a structure for an ITS-technology-supported incident management system be developed for the Des Moines metropolitan area, that a protocol be designed for information distribution, and that an interjurisdictional incident management plan be written for the interstate system and other highways built to interstate design standards. The Des Moines Area Freeway Incident Management Committee should serve as the body to oversee and steer the development of these processes.

Incident Management and the Role of ITS

Incident management is already being formally employed in the Des Moines metropolitan area within jurisdictions and informally across jurisdictions. The issue before the EDS steering committee is the role ITS should play in incident management across the entire metropolitan area. The design of the advanced transportation management/transportation information system (ATMTIS) recommended in this report is intended to support better incident management. The proposed ATMTIS does not necessarily change the fundamental objectives of incident management but does make gathering information more automatic and accurate and requires a more exact and defined incident management structure. Using ITS to support incident management will not change the institutional responsibilities of agencies with a stake in incident management; rather, ITS will provide those agencies with better and quicker information, help the agencies control field activities better, and support more efficient response decision making.

Incident management involves five fundamental tasks:[2] incident detection, incident verification, incident response, site management and incident clearance, and motorist information. These tasks are discussed below, along with ways that ITS technology can support each one.[3]

Incident Detection

This task involves determining that an incident has occurred. Traditionally, incident detection involves a motorist at or near the scene contacting a responding agency (usually by a cellular telephone), or enforcement personnel driving by and observing the incident. If the incident is not an emergency (for example, an overheated car on the inside median partially blocking the left lane of I-235 north of University Avenue), it probably would not be detected until observed by an enforcement patrol. Through the traffic detection equipment proposed for the ATMTIS, such an incident is likely to be detected automatically because it would cause an exceptional change in the traffic flow parameters collected by traffic detectors. Once an exceptional change in traffic flow is discovered, video surveillance would be used to verify that an incident has occurred. If the incident is not discovered through detection equipment, it may be observed through routine examination by the video surveillance cameras.

Incident Verification

This task involves determining the nature and severity of the incident. A motorist's assessment of an incident via cellular telephone is often not sufficiently detailed for responders to determine the appropriate response. Conventionally, therefore, verification requires observation by enforcement personnel. With video surveillance, trained personnel at the TMC would be able to examine the incident remotely and verify the nature and extent of the incident. Depending on the architecture of the communication system, the actual video or still pictures captured from the video may be transferred to the responding agency to verify and use to plan its response to the incident.

Incident Response

In this task, the response is activated, communication is initiated with cooperating responding agencies, and the appropriate personnel and equipment are alerted. If the incident is minor (e.g., a disabled vehicle on the interstate), the TMC may be able to direct the service patrol (i.e., "Rescue Bob") to the site to take care of the incident. In such cases, the TMC would also alert appropriate enforcement officials that a service patrol vehicle has been dispatched. In cases of minor accidents, the TMC would alert enforcement officials in the jurisdiction where the accident occurred. In the case of major accidents, the TMC may alert several agencies simultaneously, including first responders, and identify and transmit incident management plans appropriate for the specific incident.

Site Management and Incident Clearance

During this task, actions are taken to clear the incident and to manage traffic while the incident is being cleared. This may be as simple as providing a motorist with gasoline or fixing a flat tire. Or it could be as complex as closing the interstate due to a hazardous material spill, which might involve closing ramps and lanes in several jurisdictions, coordinating emergency medical and hazardous materials teams, and signing and marking diversion routes. Simple incidents can be managed by personnel at the scene. More complex incidents should also be managed by personnel at the scene but in coordination with the TMC. The TMC can provide interjurisdictional communications and surveillance, as well as assistance in executing incident management plans.

Motorist Information

This task involves activating various means to let motorists know an incident has occurred, the impact of the incident on traffic conditions, and, if necessary, diversion routes to allow motorists to avoid the incident. Current conventional methods for alerting motorists of an unplanned incident are quite limited. One of the key features of the ATMTIS proposed for the Des Moines metropolitan area is its ability to alert motorists en route and during pre-trip planning to incidents that may impact their trips. Highway advisory radio and changeable message signs that alert motorists of current conditions and assist travelers in making routing decisions are powerful tools for informing motorists of incidents and can significantly reduce incident-induced, unproductive delays.

Transportation Management Center Incident Management Responsibilities

The incident management roles of metropolitan and state agencies in the Des Moines metropolitan area are not currently defined in a multi-jurisdictional plan. Clearly, it is necessary to define incident management relationships between the proposed TMC and local and state incident response agencies. Therefore, it is recommended that organizations with incident management and incident response responsibilities design a metropolitan incident management plan as soon as possible, even before a TMC is established. After a TMC is implemented, the incident management plan can be modified and a role for the TMC established.

It is recommended that a consultant be hired to facilitate and staff the development of a metropolitan incident management plan and that the Des Moines Area Freeway Incident Management Committee serve as the steering committee for the plan’s development. The reason for suggesting a consultant be used is that prior attempts by committee members to develop an incident management plan have been frustrated by a lack of staff resources to facilitate the plan’s development. The plan should be suitable for current conditions but flexible enough to be modified to take advantage of the proposed ATMTIS’s functionality. The Iowa DOT may wish to use the planning process and the plan itself as a model for developing similar plans in other Iowa metropolitan areas. Once the plan is completed, a memorandum of agreement among the participating organizations should be developed by which the organizations agree to assume the responsibilities identified in the plan and adopted by each jurisdiction’s policy board. Ongoing maintenance of the metropolitan incident management plan should be staffed by the Des Moines Area MPO, steered by the Des Moines Area Freeway Incident Management Committee, and conducted in collaboration with TMC management.

The Des Moines metropolitan incident management plan should clearly delineate the role of the TMC and its staff with respect to minor incidents not involving an accident, minor incidents involving an accident, major incidents requiring on-site management of incident clearance and traffic control, and hazardous material spill accidents. For each of these types of incidents, the TMC may take responsibility or share responsibility for each of the five incident management tasks described above. These responsibilities and the sharing of authority should be defined in the incident management plan.

TMC Incident Management Information System

The development of the TMC provides the opportunity to increase the functionality of incident management communications. Currently, when motorists within the urban area dial 911 on their cellular telephones they are connected to the Iowa State Highway Patrol's dispatch center in STARC Armory. As soon as the call arrives, a Highway Patrol dispatcher attempts to determine the caller's location and then transfers the call to the appropriate jurisdiction. Once the call is transferred, the local agency must start the incident verification and classification process.

Clearly, with the functionality of the TMC and through the use of advanced communications technologies, the process of alerting local governmental agencies can be enhanced and made more efficient. The study group proposes that an incident management information system be built based on Extranet technology and concepts.

An Extranet is a collaborative network that uses Internet technologies to link together a defined group of individuals or organizations. In this case, the Extranet would link incident management stakeholders in the Des Moines metropolitan area, which might include broadcast media traffic reporters. The system architecture of an Extranet system varies but uses common Internet technology (e.g., microcomputers, Internet World Wide Web (Web) browsers, and a communications network), and communications may be carried by an Internet service provider (ISP) over plain old telephone service (POTS) or ultimately expanded to a high-bandwidth network (usually a fiberoptic connection).

The Web "cover page" for the Extranet system could contain a map of the Des Moines interstate system, and the TMC could place icons on the map indicating locations of incidents. Different icons could indicate the nature and the severity of incidents. Each organization would view the map using a common browser. A page for each incident, linked from the cover page via the icons, could include an image of the incident taken from a video surveillance camera. If the communication system is over POTS, then the image might simply be a single still frame, refreshed every 30 seconds; with high-bandwidth communications, the incident page might contain a full motion video. Another page might contain a brief description of the incident and a brief statement regarding the status of the incident's clearance.

Given that most incidents do not involve an accident, most incident clearance can be conducted by the service patrol and may not require intervention from enforcement staff. In this case, the TMC can manage the incident independently of involvement of other jurisdictions. In such cases, only the TMC would be involved in updating the status of the incident. In cases where the incident was cleared by enforcement officials from a local government jurisdiction, the dispatching personnel could be responsible for updating the status of the incident from their browser.

As incidents occur, the Extranet system would record the incident type, the time when the incident was first detected, and when the incident was eventually cleared, as well as other relevant data (e.g., traffic flow information from the closest detector). This information could then be warehoused to be used later as a basis for analyzing the performance of the incident management system and for conducting real-time projections of the likely duration of incidents when they occur.

Benefits and Costs

Two actions are recommended to support the management of incidents. They are the development of an incident management plan and the development of an incident management information system. Fees for a consultant to support these actions should be in the range of $30,000 to $70,000, depending on the extent of services required to support the Des Moines Area Freeway Incident Management Committee. Assuming the incident management system is based on standard Internet technology and operates over POTS, software development may be in the range of $30,000 to $50,000. However, custom-built incident management information systems can and do cost several hundred thousand dollars.

Better incident management results in faster incident clearance, reduced delays, and faster delivery of emergency services during severe incidents. The benefits of better incident management can be quite significant. For example, suppose that incident response and clearance time were cut by one third due to better incident management. Because of the geometric relationship between total delay and time till clearance, this would result in a 66 percent reduction in delays. Based on 1993 accident data in the “Transportation Issues” report published for the Early Deployment Study, almost a million hours per year of vehicle delay is caused by incidents in the Des Moines metropolitan area. Making the very conservative assumption that there is only one occupant in each vehicle, and assuming that motorists value their time at twice the minimum wage ($10.30 per hour), reducing incident response and clearance time by one third would result in an annual economic benefit of nearly $4,000,000 per year. Even a 10 percent reduction would result in over a $1,000,000 per year benefit.

Clearly, additional benefits could be added as a result of reducing the time for emergency services to arrive at severe incidents. For example, if an accident is detected and verified more quickly and emergency medical services are dispatched more quickly, the chances for injured parties to survive a severe accident are greater.

Incident Management System Recommendations Summary

In this chapter, it was recommended that an incident management plan be developed for the Des Moines metropolitan area. The Des Moines Area Freeway Incident Management Committee serves as a body to coordinate interjurisdictional cooperation in incident management but has not successfully completed the development of an incident management plan. Once a plan has been developed, the governmental bodies which are a party to the plan should execute a memorandum of agreement agreeing to cooperate and commit resources to execute the plan in the event of an incident. The incident management plan can be developed and implemented prior to the deployment of a TMC, but once the TMC becomes operational, protocols must be developed for the interaction between the TMC and the agencies with incident management responsibilities in the metropolitan area.

Once the TMC has been developed, it recommended that the TMC manage an incident management Extranet. The Extranet would carry graphical representation of traffic flow and the location and types of incidents on Des Moines freeway design standard highway. The Extranet would allow agencies to view both text regarding incidents and pictures of the incident taken from video surveillance cameras.

References

1 Robinson, J., "What's New in Freeway Incident Detection Response," Presented to the ITE International, Conference, March, 1989, Dallas, Texas.

2 Lists of incident management tasks are identified by several sources. The list referenced here originated in a combination of two sources. Washington State Transportation Center, “Framework for Developing Incident Management Systems,” Prepared for the Washington State Transportation Commission in cooperation with the U.S. Department of Transportation, October, 1995 and, Reiss, R.A., and Dunn, W.M., "Freeway Incident Management Handbook," Prepared by Dunn Engineering Associates, Prepared for the Federal Highway Administration, Washington, D.C., 1991.

3 The involvement of ITS in each incident management task was identified by Kay, J.L., “Intelligent Vehicle-Highway Systems and Incident Management,” ITE Journal, March, 1992, pp. 55-57.

9

Pre-Trip Traveler Information System

En route traveler information systems were discussed in the chapter on the Advanced Traffic Management and Information System. They involve the use of highway advisory radio (HAR) and changeable message signs (CMS) and the distribution of traffic and incident data to the broadcast media. These are systems travelers may access while en route to their final destination, although travelers within the broadcasting range of HAR could listen to HAR messages prior to starting their trip.

Pre-trip traveler information systems, on the other hand, are generally accessed only prior to making a trip. They involve such systems as World Wide Web (Web) pages on the computer Internet, interactive computer kiosks at public locations, and cable and broadcast television. These mechanisms allow travelers to gather information prior to leaving their origin but may be accessed at stopping points en route (e.g., a rest area along the interstate highway).

It is recommended that cable television, the Internet, and kiosks be used in the Des Moines metropolitan area to distribute pre-trip traveler information. Further, it is recommended that these systems be based on an open architecture using a common standard (Internet protocol).

Benefits of Pre-trip Traveler Information Systems

So far, evaluations of pre-trip traveler information services being tested or deployed have focused on usage and acceptance and not on economic benefits. For example, as part of the Los Angeles Smart Traveler project, 78 information kiosks were deployed. The kiosks were evaluated based on their level of use and on users' impressions of their ease of use. The evaluation did not assess the productivity improvements resulting from travelers making better trip decisions as a result of information gained from kiosks. Therefore, it is very difficult to judge the benefits of pre-trip traveler information. However, there is widespread belief that this information is valuable to travelers, particularly in severe environmental conditions or in incident- or highway-construction-induced congestion.

Levels of Access to Pre-trip Traveler Information

One dimension of the possible offering of pre-trip traveler information in the Des Moines metropolitan area is the level of access provided to potential users. The highest level of access to pre-trip information would be provided by broadcast television, which is available to practically every household. The next highest level of access would be provided by cable television. Nearly all households in the Des Moines metropolitan area have access to cable television, but if pre-trip traveler information is restricted to cable television it would not be available to the minority of households that do not subscribe to cable television service or that use alternative satellite-based television services.

The next highest level of access would be provided by the Internet, which requires users to have a computer and an Internet service provider. About half of Iowa's household have a home computer,[1] and computer ownership is presumed to be higher in the Des Moines metropolitan area than in the rest of the state; 82 percent of Iowans have access to a computer either at home or at work. Roughly 25 percent of Iowa's entire population has access to the Internet at home. Because 25 percent of Iowa's households are located in local telephone exchanges that do not have any Internet service provider, and because Des Moines area households can select from multiple Internet service providers, a disproportionately higher percentage of Des Moines area residents can be assumed to have Internet access at home. Not only is Internet use relatively high in Iowa and presumably even higher in the Des Moines metropolitan area, Internet use will continue to grow. In other words, distributing traveler information to the Des Moines metropolitan area through the Internet once the system has been developed (in one to two years) will provide access to 35 percent to 50 percent of the Des Moines metropolitan area's households.

The lowest level of access to pre-trip traveler information systems would be provided by kiosks in public locations.

The broadcast media should be allowed access to information collected and fused at the TMC. These may be done through the Internet and Extranet access.

Cable Television

Cable television is an inexpensive and powerful means of distributing real-time traveler information to a large audience. The principal cable television operator in the Des Moines metropolitan area (TCI of Central Iowa) serves 96,000 households through its Des Moines operation.[2] All cable television subscribers also receive the City of Des Moines' government access channel. This channel is largely under-utilized by the city, and the city would likely be willing to distribute traveler information over the channel during the morning and afternoon peak congestion periods. The channel might also be used to distribute traveler information during off-peak periods when severe incidents have occurred (e.g., an overturned chemical tanker truck) or during severe winter weather.

The cable television traveler information system developed for the Atlanta metropolitan area provides an example of a relatively inexpensive format for an automated traffic information system. It includes a programmed sequence for the presentation of information, with prerecorded announcements describing the information currently being displayed.[3] For example, displayed on the television monitor may be a map showing the average vehicle speeds on the urban freeway system, using colors to indicate the speeds (e.g., red for speeds less than 20 mph, orange for speeds greater than 20 mph and less than 30 mph, etc.). A prerecorded announcement would describe the map and explain how to interpret the colors. After the traffic speed map has been displayed on the screen for a short period, another image may appear with a similar prerecorded description. Although the information is current, the sequence of images and the announcements are preselected. The Atlanta system includes the following materials:

- Professionally recorded video and audio clips that can be played back from a video recorder device.
- Computer-generated graphics, such as congestion and incident maps, that use color-coded icons to present traffic information.
- Four live highway surveillance video feeds from freeway video surveillance cameras.
- A traffic advisory bulletin board displaying messages manually input by an operator at the TMC.
- Background music from a CD player.

Web Page and Kiosk Traveler Information Systems

It is recommended that information dissemination be based on Internet protocols and standards so that the system will be open for future development and integration. Using the Internet as a platform, the traveler information system can be accessed both through Web browsers on personal computers at home or work and through kiosks. For example, the Riderlink program in Seattle, Washington, is based on the Internet, and information can be accessed through kiosks and through ordinary personal computer Web browsers.[4]

The purpose of Riderlink is to provide commuters with information on options other than riding to work alone. It provides an online ride-matching service, as well as information on bus services, roadway construction, traffic and congestion, and other transportation-related information.

In Seattle, four Riderlink kiosks are located in high-traffic areas and generate three percent of the inquires of the system. The kiosks are linked to the host with ISDN connections; connections are made only when the kiosk is activated, and the connection is severed after a period of inactivity. Browsing the Web from the kiosk is restricted to traveler information sites. Touch screens are used instead of a mouse. A common problem with text- and graphics-based traveler information systems is poor presentation of information. The information needs to be easy to access and understand.

A kiosk is fundamentally a durable personal computer built into a special-purpose kiosk stand, with special input and peripheral devices (e.g., touch screen, magnetic or smart card reader, printer, etc.). Therefore, just like a desktop personal computer, the kiosk may be used as a Web browser. To limit communication costs and improve response times, static portions of the Web-based traveler information system can be downloaded onto the kiosk's local hard disk, while dynamic portions of the system can be updated periodically, thus minimizing the need for communications.

Evaluations of existing kiosk-based traveler information systems have shown that kiosks are used more frequently by certain groups. Travelers who are not familiar with the local area are more likely to access information on a kiosk than travelers from the area. Hence, kiosks placed in office buildings are not commonly used by commuters who work in the building. On the other hand, kiosks located in rest areas, where travelers are not making routine trips in familiar territory, are more heavily used. For example, a kiosk located in the Des Moines Convention Center is likely to be used more than one located in the lobby of the Principal Building.

When managed appropriately, kiosks have been found to be worthwhile vehicles for distributing traveler information. However, because a limited number of kiosks can be deployed, traveler exposure to kiosks is limited. When compared to the estimated 35 to 50 percent of Des Moines households expected to have access to the Internet, kiosks should be seen as playing a significant role in only very narrowly defined markets (e.g., rest areas).

A principal weakness of kiosks is their need for maintenance. Like most personal computers, they occasionally lock up and stop operating. When this occurs, they must be rebooted. Another weakness of kiosks involves printer-equipped devices. These devices run out of paper or ink and experience paper jams, disabling the printer and requiring maintenance. Most kiosks require that the equipment be routinely inspected and any consumables (e.g., printer ink) replenished regularly.

Content Provided by Pre-trip Traveler Information Systems

Cable television, Internet Web pages, and kiosks would provide similar pre-trip traveler information.

Cable Television

In addition to graphics and prerecorded messages similar to those defined for the Atlanta system, the study group recommends that a cable television traveler information system in Des Moines include maps showing construction and maintenance work zones, potential alternative routing around work zones or other obstructions, and winter traveler advisories.

Web Pages and Kiosks

Several single-purpose, Internet-based traveler information systems have been prototyped or developed as part of this Early Deployment Study or as part of other activities focusing on the Des Moines metropolitan area or that include Des Moines as part of a statewide system. Systems developed as part the study include a static, interactive commercial traveler (truck operator) information system and a static, interactive transit information system. Both systems currently reside on the Center for Transportation Research and Education's (CTRE) Web server. It was recommended earlier in this report that the commercial traveler system migrate to the Iowa Motor Truck Association's server. The Des Moines Metropolitan Transit Authority (MTA) has expressed a desire to continue the transit information system and has offered to contract with CTRE to perform system updates.

Other traveler-related information systems include the Des Moines area primary and interstate highway work zone Web page (developed and maintained by CTRE), which is updated daily, map-based, and interactive; the text-based road construction and bridge embargo Web pages for the entire state (maintained by the Iowa DOT); the road weather conditions map-based page (maintained by the Department of Public Safety); and the tourism travel Web pages (maintained by the Iowa Department of Economic Development). In addition, many jurisdictions within the state have transportation-related content within their Web pages. Although it is probably impossible (and unnecessary) to have all public agency-generated Web pages integrated into one system, it is recommended that single-purpose pages at the state and metropolitan area level be developed to similar standards so that they can be integrated into a single traveler information system. Given that many of these systems are being developed by or under the sponsorship of the Iowa DOT, developing standards and policy guidance should be the

Iowa DOT's responsibility. Further, the Iowa DOT can promote the adoption of common standards for Web pages with transportation content in all metropolitan areas in the state.

The traveler information system Web pages for the Des Moines metropolitan area should include the same traffic information as the cable television broadcasts: a map of the freeway system showing current average traffic speeds, an incident map, picture frames taken from video surveillance cameras, and special messages generated by the TMC. The traveler information system should also include an interactive, highway work zone and special-events map, and, where appropriate, should recommend diversion routes. Immediately prior to and during the I-235 reconstruction, a separate page dealing with reconstruction issues should be generated to inform the public of the traffic congestion implication of each phase of construction. The transit and paratransit Web pages should be incorporated into the overall traveler information system and, in the next one to two years, the transit information system should be upgraded to include an interactive routing and scheduling facility for planning trips through the entire transit system.

In reports written earlier for this study, one of the applications identified for traveler information was a system providing real-time flight arrivals and departures at the Des Moines airport. Although real-time data are not available in a format that is readily useful to end users in the Des Moines area without Internet access, estimated and actual flight arrival and departure times are available through the Internet on a real-time basis for the major carriers serving Des Moines. Arrival and departure times for scheduled flights could be extracted from the Internet and repackaged in a format that would be useful to Des Moines originating air travelers. This information could be distributed to hotels, motels, and other businesses via FAX, e-mail, or other distribution technology. Because the data are currently available, this is an excellent opportunity to repackage the information, add value, and distribute the information at a fee. Therefore, if there are needs for real-time flight departure and arrival information, the private sector has the opportunity to capture that market.

Role of the Private Sector and Non-transportation Agencies

In addition to the level-of-access issue, another dimension of the possible offering of pre-trip traveler information in the Des Moines metropolitan area is the involvement of the private sector and non-transportation public agencies.

Traveler information can have commercial value and, therefore, the private sector may have a role in collecting, interpreting, and distributing traveler information. For example, in the London, England, metropolitan area, a private company has been granted access to bridges over the principal motorways and has mounted infrared vehicle detection equipment on the bridges to determine traffic volumes and speeds on highway links.[5] This information is then provided to subscribers through an in-vehicle graphical display.

Several large urban areas' pre-trip traveler information systems are operated totally by the public sector, while many urban areas, particularly in the United States, are involving both the public and private sectors in traveler information systems. In the Des Moines metropolitan area, information from the publicly sponsored transportation management center (TMC) could be fused by a private firm with information called in from observers, interpreted and sold to broadcast media traffic reporters, or sold to individuals on a per-telephone-call basis. Alternatively, a private service provider may provide the information free when the message is mixed with a commercial and the service is sponsored by the advertiser.

In the Des Moines metropolitan area, the best opportunities for the private sector to market pre-trip traffic information services involve processing publicly available information for distribution in alternative forms of media. For example, an organization could process traffic and weather information available over the Web from the TMC and provide the information through automated telephone messages or e-mail or by selling the information and sending it via FAX to motels, hotels, and transportation service businesses (e.g., package delivery firms). As discussed earlier, an organization could also extract from the Web real-time flight departure and arrival times at the Des Moines airport and distribute the information at a fee.

Private organizations may find, however, that real-time traffic data are not as valuable in the Des Moines area as they are in larger urban areas where traffic congestion is a more serious and chronic problem. It may be difficult for the private sector to market traveler information in Des Moines. Commercial traveler information for direct consumption by end users is a difficult market. Most travelers in the United States perceive traffic information as a public commodity, like access to a public highway, and therefore do not consider paying for this information.

Partnerships, both with the private sector and with the non-transportation public, should be actively sought. For example, the opportunity to present information on agencies' local attractions at a rest area along the interstate may provide an attractive franchise for a marketing firm. Therefore, at the time of deployment, the Iowa DOT and the Des Moines Area MPO may encourage partnerships through an open and competitive solicitation, similar to the solicitation used by the Minnesota Department of Transportation to select project partners.

It is recommended that the private sector and non-transportation public agencies be encouraged to assume the two following roles in distributing traveler information:

1. The private sector could repackage (and therefore add value to) publicly collected data and sell the information to particular market segments or categories of individuals. For example, publicly available weather and work zone information could be repackaged and distributed for a fee to hotels, motels, and businesses.
2. Both private firms and non-transportation public agencies should be encouraged to partner with the Iowa DOT to cosponsor public kiosks. For example, the Iowa DOT might cosponsor a kiosk with a private marketing firm at an interstate rest area. The Iowa DOT could use the kiosk to provide traveler information, and the marketing firm could use the kiosk to promote lodging establishments, restaurants, and tourist attractions at interchanges and communities in the area. Similar partnerships might be possible with other state and local governmental agencies. For example, a kiosk might be cosponsored by the Iowa DOT and the Iowa Department of Economic Development, and the kiosk would provide both traveler and tourism information.

Costs

Fairly standard technology is required to support real-time traveler information over cable television (e.g., personal computers, presentation software, GIS map database, etc.), much of which would be available for other purposes. If full-motion color video is being broadcast, then a high bandwidth communication system is required between the broadcast station and the TMC. However, if full-motion video is not required (e.g., using still pictures to show current traffic conditions), the bandwidth requirements can be greatly reduced. The highest costs of developing such a system are generally associated with the aesthetics of the production of the system (prerecorded messages, quality of the graphics, etc.). Assuming that the communication system between the TMC and television studio already exists, the development of a cable television real-time traveler information system should cost anywhere from $30,000 to $250,000 to develop.[2] The high end of this range would provide professional production of video and audio clips, narration, and layout of information presentation.

To develop and maintain a traveler information Web sight may cost $15,000 to $30,000 per year, assuming the majority of the information developed for the cable television traveler information system can be reused for distribution over the Internet. Costs would be higher if maintenance of the kiosks is included. However, the study group recommends that once the capability has been developed to collect and distribute traveler information for the Des Moines metropolitan area, the capabilities for electronic data exchange would

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[2] The high-end estimate is based on costs taken from the Phoenix Model Deployment Initiative cost estimate for a cable television server and includes program development, a server, system design, system integration and testing, and customizing databases.

be used to distribute common traveler information in other areas of the state (e.g., in Iowa's other urban areas) and to distribute other types of electronic data.

The cost of kiosks depends on the functionality of the equipment. A standard kiosk, without any input or output peripheral devices other than a telephone modem, will cost $20,000 to $25,000. In addition to the cost of the equipment, there are communications costs and maintenance costs.

Pre-Trip Traveler Information Recommendations Summary

Three means of directly communicating pre-trip traveler information were recommended: cable television, personal computers connected to the Internet, and kiosks connected to the Internet. Broadcast media and other information services should be encouraged to access pre-trip information for further distribution to travelers.

Cable television can be broadcast over the government access channel with the permission of the City of Des Moines (cable subscribers throughout the metropolitan area receive the Des Moines government access channel). Automated systems based on computer server have been piloted in other metropolitan areas with great success. These systems use pre-recorded voice messages to describe dynamic computer generated graphics (e.g., traffic flow and speed maps) and live video or pictures of traffic at critical points on the interstate. The graphic images will be derived from the TMC GIS mapbase and video or pictures of traffic will be gather from the video surveillance cameras. The server, software, and the presentation of information can vary greatly with depending on the production quality voice messages, music, and graphics.

An Internet Web page is recommended that includes pre-trip traveler information. Again, dynamic traffic information and pictures will be derived directly from the TMC's mapbase and surveillance cameras. Other less dynamic information (e.g., roadway construction sites and road closures) can be provide through standard Web pages. Kiosks will access the same information through dedicated Internet connections. No recommendation is made regarding the deployment of kiosks at specific locations. However, the Des Moines Area MPO, the Iowa DOT, and the MTA may wish to partner in the sponsorship of information kiosks with other public and private organization like the Des Moines Convention Bureau.

References

1 Selzer Company, Inc. “Study of Iowan’s Attitudes Towards the Citizen Information Network,” Prepared for the State Public Policy Group, Des Moines, IA, August, 1997.

2 Estimated number of household subscribers provide by TCI of Central Iowa.

3 Jenq, J.H., “Lessons Learned in Rapid development of a Cable TV Traffic Information Channel as Part of an Integrated ATIS System - the Success of Atlanta Traffic Channel,” Proceeding of the Annual Meeting of ITS America, Washington, D.C., June, 1997.

4 Burris, M.W., Pietrzyk, M.C., and Crowley, M., “Kiosk Case Studies ... What Works?,” Proceeding of the Annual Meeting of ITS America, Washington, D.C., June, 1997.

5 Yim, Y., and Ygnace, J.L., “Trends and Projects in the Traveler Information Market,” Proceeding of the Annual Meeting of ITS America, Washington, D.C., June, 1997.

10

Deployment Support: New Analysis Models

As part of the Des Moines area's Early Deployment Study (EDS), two computer models were used to support the planning of ITS improvements. However, in both cases, the models were used at a very high level, each lacking the appropriate detail to develop specific plans for ITS assets or, in the case of the simulation model, assist in the actual redesign of I-235, the design for ITS assets. The two models employed were the current travel demand model and a traffic operations simulation model.

The principal use made of the travel demand model was to examine the impact of traffic diverted from I-235 due to reconstruction or other incidents. The traffic simulation model was applied to I-235 to identify the benefits of freeway ramp metering. The simulation database was developed to provide a platform for the future refinement of the simulation model. In this chapter, further refinements are recommended for each model so they will provide more useful support to the making of planning and design decisions.

Travel Demand Model

To assess the impact of the I-235 reconstruction or other incidents, and to facilitate the prioritization of highway facilities for potential opportunities for ITS applications to mitigate the traffic congestion diverted from I-235, a methodology based on the Des Moines area's current travel demand model was developed and used. The methodology was employed to estimate future delays caused by incidents on I-235 and by the proposed I-235 reconstruction and was based on a travel demand model analysis of various scenarios of reduced capacity on I-235. Application of this methodology points out the need for enhanced travel demand modeling tools for planning ITS projects in the Des Moines metro area.

Existing Model

The travel demand model currently used by the Des Moines area metropolitan planning organization (MPO) was originally developed by Wilbur Smith and Associates (WSA) using Tranplan, a PC-based modeling software package. The staff of the Des Moines area MPO has assumed maintenance of the model and WSA developed model scenarios (demand and networks) for 1990 and 2020.

The Des Moines Tranplan models are designed to estimate link traffic flows for 24-hour time periods. Twenty-four-hour capacities for network links are generally estimated by multiplying hourly capacities by a factor ranging from 9 to 11. Hourly capacities are estimated based on facility type and "side friction," an estimate of the amount of mid-block driveway or within-link side street traffic impact on flow.

In all the Des Moines models, travel demand is estimated for four internal trip purposes (home-based work; home-based, non-work; non-home based; commercial vehicles). Socioeconomic/demographic data from the 1980 and 1990 Census, Department of Employment Services (now Workforce Development) and Iowa school districts were used to develop inputs for the trip generation equations for 1990. External-internal trips were estimated, and a growth factor model was used for external through trips. The network data were originally prepared by the Iowa DOT for 1986 and were later updated and revised by Iowa DOT and Des Moines MPO staff for 1990 and 2020. Finally, trip distribution for internal trips was accomplished using a gravity-type model, and assignment was made through an equilibrium process. Model validation and other documentation are provided in a technical working paper by Wilbur Smith Associates.[1]

Limitations of Current Model

The original 24-hour model developed for the Des Moines MPO was not intended to provide hourly estimates and, although peak-hour estimates are likely to reflect region-wide totals, no regional model is intended to provide micro-level traffic forecasting. No feedback for changing land use is provided in this model, which is a limitation of all regional transportation models currently available.

The peak-hour approximation developed for this study is valid for identifying affected corridors, but it is not accurate enough for signal timing or benefit-to-cost ratio analysis. While the corridors identified by this peak-hour approximation are not likely to change given improvements in or even total redesign of the model, what will change are the relative levels of importance of the various corridors (diversion levels) and the precise magnitude of link traffic estimates and turning movement counts.

Required Model

To evaluate benefits of proposed ITS strategies in Des Moines, particularly strategies related to advanced traffic management and traveler information, a new network demand model is needed. This model should be sensitive to the deployment of improved signal systems and the temporal demand elasticity of real-time traveler information. The current, static, 24-hour model is not sensitive to traffic control parameters or to hourly fluctuations in travel capacities and demand. In fact, one researcher reports that while the assumption of such static models "that demand is constant over time" is realistic for intercity freight transportation networks over long periods of time, it does not hold true over short periods of time in congested urban networks."[2] Another researcher reports that "aspects of the transportation system, such as dynamic traffic demand, time-varying signal control timing plans, or traffic incidents, can only be modeled with a dynamic modeling approach."[3] Yet another researcher states, "current models were not intended for use in evaluating congestion pricing, transportation control measures, alternative development patterns, or motor vehicle emissions, so it is not surprising that they are not well suited to those tasks."[4]

At a minimum, a peak-hour model is needed. Benefits of a peak-hour model include the ability to assess the impact of various road closure/diversions on peak-period congestion and the ability to recommend efficient diversions. ITS improvements can thereby be targeted to the most cost-effective corridors. Many urbanized areas in the United States have developed standard, peak-hour models, including those as small as the Centre County MPO (the MPO for the State College, Pennsylvania area) and the Columbia, Missouri MPO. On the other hand, some MPOs even in urban areas larger than the Des Moines metropolitan area (e.g., Omaha, Nebraska) still do not have peak period models.

A further improvement in the model that would provide the capability to evaluate ITS strategies would be afforded by the development of a dynamic traffic network model. Dynamic models are necessary to predict traffic patterns and congestion formation so that traffic route guidance and information schemes can be implemented.[5] In a dynamic model, conditions on the network are estimated incrementally, during relatively short time periods (e.g., five or 10 minutes). More information is needed than is provided in a 24-hour or peak-hour model, particularly with regard to distribution of trip departure times. Although dynamic models cost more to develop, they provide analysts with a tool that introduces the effect of real-time travel conditions on traveler trip decision making.

Due to extensive computational and data requirements, dynamic models have yet to find their way into common metropolitan planning practice. However, because of their capability to model real-time traffic conditions, these models are likely to be implemented in the future in most medium to large urban areas. The models have advantages for the operation of advanced transportation management/transportation information systems.

For example, one researcher has developed a dynamic model algorithm that can be run in near-real time on large-scale networks and used with in-vehicle route advisory systems for traffic management during evacuations and special events.[6] However, the model assumes knowledge of trip departure matrices for 10- to 15-minute periods.

Dynamic models may be the ultimate future direction for transportation planning modeling in Des Moines. At present, however, the development of a conventional, peak-period model would be of greater assistance in supporting the planning and design of ITS deployment in the Des Moines metropolitan area and in other elements of regional transportation planning.

Traffic Operations Simulation Model

Computer simulation is an important tool, allowing traffic and highway engineers to better understand the performance of proposed designs, and modify and experiment with alternative designs within the simulation before designing and constructing the actual system. The simulation helps the engineer to develop more efficient designs and avoid creating systems which will not actually perform as desired. Traffic computer simulations are generally divided into two types; one is a microscopic simulation and the other is macroscopic simulation. In a microscopic simulation model, each vehicle in the traffic stream is modeled as an independent element. Modern microscopic simulations usually include a graphical animation of the simulation where each vehicle traveling through the simulated roadway is represented by an moving symbol through an animated roadway. The engineer can then view animation to better understand how well alternative designs perform. After the simulation has been run, the program totals the flow characteristics of the individual entities to derive the overall traffic flow performance (e.g., average and total delay, and average travel speeds). Macroscopic simulations deal with the flow properties of the aggregate traffic stream and do not simulated individual entities in the traffic. Macroscopic simulations model properties of the entire traffic flow.

During the course of the Des Moines EDS, a traffic operations microscopic simulation model was created. The primary purpose of the model was to investigate the economic benefits of ramp metering on I-235. A simulation database suitable for planning purposes was developed. Further refinement is required to improve the fidelity of the existing database and to add surface streets to make the model useful for traffic and highway engineering purposes. The simulation environment chosen for the development of the simulation model was the Federal Highway Administration’s package “CORSIM.”

CORSIM

CORSIM is one of the most detailed urban simulation models.[7] It is a combination of two individual simulation models: NETSIM, a surface street simulation package, and FRESIM, an interstate highway simulation package. CORSIM allows the user to study the performance of surface streets and interstate highways integrated into a single system, at the microscopic level.

CORSIM requires an extensive database describing the traffic system. A traffic system in CORSIM is presented as a network comprised of nodes and links. The links represent unidirectional streets and freeway sections, and the nodes represent intersections or points at which the highway's geometric property changes.

CORSIM can predict the system's operational performance in terms of measures of effectiveness such as the average vehicle delay, average vehicle speed, fuel consumption and vehicle generated emissions. The model can simulate the impact on the system's performance of changes ranging from traffic signal timing modifications to alternative freeway ramp geometry.

Application to I-235

In a limited study, the feasibility of ramp metering on I-235 was examined using CORSIM. The database for the existing geometry was exacted from aerial photographs and the Iowa DOT's digital cartography files, and traffic volumes were extracted from Iowa DOT's hourly traffic volume maps.

Simulations were performed to examine the existing condition and the traffic flow performance on I-235 following the implementation of ramp metering at interchanges on I-235. The simulation forecasted reductions in delay to vehicle on the interstate as a result of ramp metering. However, because adjacent arterial streets were not modeled, delays to vehicles on adjacent arterial streets could not be measured.

Development of a Design Quality CORSIM Model for the I-235 Corridor

The current CORSIM database will require updating before it will be able to produce design quality simulation. For example, the CORSIM model has the capability of conducting "what if" scenarios for the design and geometry of ramps and merge areas. To develop a high fidelity model which can be used to accurately simulate conditions before and after design, the following tasks must be conducted:

1. The coordinates of the existing highway must be adjusted to better reflect existing conditions and coordinates for the geometry of alternative design scenarios must be developed.
2. Future traffic flow rates must be extrapolated from the existing flows and traffic flows projections using the regional transportation demand model.
3. The geometry of the adjacent street network must be captured and traffic volumes on the arterial system must be estimated for future scenarios.
4. Extensive capacity analysis must be performed to adjust for the installation of ramp meters.
5. Simulations must be performed under a variety of existing and future traffic conditions and under metered and unmetered conditions and a number of future alternative design scenarios.

   The development of the database, calibration and validation of the model, and running the model under a variety of design scenarios will cost an estimated $50,000 to $60,000.

Deployment Support: New Analysis Models Recommendation Summary

The plan presented in this report is intended to serve as a road map for the incorporation of ITS applications in projects that are proposed for future transportation improvements. It provides a framework for future decision making on ITS deployment. It does not make specific planning or design decision recommendations. As the metropolitan area moves closer to making ITS deployment decisions, the accuracy of the information used to support these decisions could be improved by having access to better decision support models. It is recommended that the Des Moines MPO develop a peak-hour travel demand model. It is also recommended that MPO monitor the state of the art of travel demand modeling. There is a great deal of research currently being focused on the improvement of travel demand models and, in the future, it may well be within the resources of the Des Moines MPO to develop a dynamic model.

It was also recommended that the CORSIM model developed during the course of the EDS be further developed so that it can be used to support planning and design decisions for the reconstruction of I-235, the evaluation of ramp metering, and traffic condition modeling when traffic flow on and around I-235 due to reconstruction related decreases in capacity.

References

1 Wilbur Smith Associates, “I-235 Alternatives Analysis and Environmental Impact Statement, Technical Working Paper A, Transportation Model Update and Validation,” Federal Aid Project No. IR-235-2(216)73-12-77, Polk County, Iowa.

2 Drissi-Kaitouni, O. and Hameda-Benchekroun, A. “A Dynamic Assignment Model and a Solution Algorithm,” Transportation Science, Col. 26, No. 2, May 1992, pp. 119-128

3 Lo, H.K., http://cesu2.ust.hk/research/p46.html (Civil & Structural Engineering at The Hong Kong University of Science and Technology), 8/22/97

4 Bureau of Transportation Statistics, Travel Model Improvement Program website, http://www.bts.gov/tmip/tmip.html, 8/22/97

5 Jayakrishnan, R., et al, “A Dynamic Traffic Assignment Model with Traffic-Flow Relationships,” Transportation Research - C, Vol. 3, No. 1, pp. 51-72, 1995.

6 Jansen, B.N., “Convergent Algorithm for Dynamic Traffic Assignment,” Transportation Research Record 1328, pp. 69-80.

7 Federal Highway Administration, “CORSIM Users Manual,” Version 1.03, April, 1997.

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Early Deployment Study Summary and Conclusions

When the Des Moines metropolitan area was selected for this study by the Federal Highway Administration, it was the smallest urban area to be awarded a project to develop an ITS strategic plan. As a result, there was little guidance in the literature regarding appropriate ITS infrastructure for a metropolitan area the size of Des Moines. Naturally, the requirements for ITS infrastructure in Des Moines are not as resource intensive as those of larger urban areas like Detroit, Chicago, and Minneapolis/St. Paul, because the Des Moines metropolitan area does not have similarly high traffic volumes or levels of congestion. As result, one of the primary issues for the steering committee and the study staff was to determine what is the appropriate level of ITS infrastructure deployment in the Des Moines metropolitan area.

This plan recommends rather modest ITS expenditures in comparison to the relatively intensive investment of larger urban areas. For example, the Minnesota Department of Transportation uses an estimate of $500,000 per mile for planning one mile of freeway under a freeway management system, not including the cost of the Transportation Management Center. The proposed Des Moines metropolitan area ATMTIS cost is about $300,000 per mile, including the Transportation Management Center and including the "worst case" cost estimate for a fiber optic communication system. If a barter arrangement with a communications company (exchanging access to the highway right-of-way for access to communication services) is solicited and negotiated, the cost per mile may be as little at $150,000, including a TMC.

Recommendations

In summary, below are listed 19 specific recommendations made in this strategic plan, covering a broad variety of transportation issues ranging from public and commercial transportation to the use of the Internet for traveler information. These recommended projects should become part of the Des Moines "Transportation Improvement Program."

Public Transportation Systems Recommendations

- Develop traffic signal prioritization systems for buses in the downtown Des Moines area, and plan for future expansion of such signal systems outside of downtown. The implementation of traffic signal prioritization will be led by a partnership of the MTA and the city operating the traffic signals (initially the city of Des Moines, but other cities may participate in the future).
- Implement electronic fare payment using magnetic stripe cards, and plan for future expansion of the number of participants providing goods and services via cashless systems and for technology migration to smart cards. Development of an electronic fare payment system will be led by the MTA but, in the future, the MTA should seek other partners in the private sector (specifically, banking and financial service companies) and the public sector. Expanding the number of goods and services that may be purchased using electronic payment will help justify future expansion of the functionality of the electronic payment media.

Commercial Vehicle Operations Recommendations

- Encourage the adoption of the national ITS architecture for commercial vehicle operations by Iowa and other states in the region.
- Migrate the commercial traveler information system developed as part of the Early Deployment Study to the Iowa Motor Truck Association's Internet server.
- Implement the Operation Respond Emergency Information System at the Des Moines Fire Department's Hazardous Materials Response team headquarters. This system will support faster identification of materials spilled or potentially spilled and the appropriate response.

Service Patrol Recommendations

- Request a legal opinion regarding public agencies' liability regarding the operation of private sector organizations routinely conducting activities normally reserved for enforcement officials. The legal opinion should be developed through the legal offices of one the agencies participating in the Des Moines Area Freeway Incident Management Committee.
- Institutionalize the private patrol service through a service performance description and by executing a memorandum of agreement. The memorandum of agreement should be developed through a partnership between the members of the Des Moines Area Freeway Incident Management Committee and the private operator.

Interjurisdictional Traffic Signal Coordination Recommendations

- Coordinate ramp meters and traffic signals at the ramp terminals with traffic signals on adjacent streets where ramp meters are found to be feasible. This coordination should be conducted through an agreement between the city in the area of the ramp and the Iowa DOT.
- Execute an interjurisdictional traffic signal coordination memorandum of agreement between local agencies operating traffic signals. The memorandum of agreement

should state the jurisdictions' commitment to coordinate traffic signals and signal systems across jurisdictional boundaries. The principal focus of coordination should be along the primary I-235 reconstruction traffic diversion routes. The leadership for this activity should be assumed by the Des Moines Area MPO in cooperation with the cities in the metropolitan areas.

- Conduct an engineering study of the physical equipment requirements to coordinate traffic signals across jurisdictions, particularly along I-235 reconstruction traffic diversion routes. It is recommended that the Des Moines Area MPO be the lead agency commissioning an engineering study, in cooperation with the cities participating in the interjurisdictional traffic signal coordination memorandum of agreement.
- Implement traffic signal coordination plan by operating agencies. With overall program monitoring by the Des Moines Area MPO, it is assumed that the cities will implement the interjurisdictional traffic signal coordination engineering recommendations.

Advanced Traffic Management/Traveler Information System Recommendations

- Develop a Transportation Management Center (TMC). It is recommended that the TMC be located at STARC Armory. It is assumed that the Iowa DOT will take the lead in establishing the TMC, in partnership with the Emergency Management Division of the Iowa Department of Public Defense and the Iowa State Highway Patrol and in cooperation with other Des Moines area ITS stakeholders.
- Populate the metropolitan area's roadways with traffic surveillance and management assets (e.g., HARs, CMSs, traffic detectors, etc.), starting at high-incident and high-accident locations, then populating diversions routes for traffic during the I-235 reconstruction, and finally distributing devices on the outer U.S. 65 and Iowa 5 loop. Surveillance and data collection devices include video and radar traffic detectors and video surveillance cameras. Traffic management and traveler information devices include freeway ramp meters, changeable message signs, and highway advisory radio. It is recommended that the Iowa DOT take the lead in populating the metropolitan area highway with traffic surveillance and traffic management field devices. Further, the Iowa DOT is encouraged to seek partnership agreements with the Iowa Communications Network or with private communications companies to exchange right-of-way access for communication services.

Incident Management System Recommendations

- Develop an incident management plan for freeways and freeway-design-standard highways in the metropolitan area. Once the plan is completed, jurisdictions in the metropolitan area should execute a memorandum of agreement to cooperate and commit resources to execute the plan in the event of an incident. The Des Moines Area MPO or the Iowa DOT may take the lead as the contracting organization for the development of the incident management plan, but the Des Moines Area Freeway Incident Management Committee should oversee the plan's development.

- Create an incident Extranet system that provides incident responding agencies with pictures or videos of incidents through a restricted computer network using a standard Internet browser. The Extranet system is part of the ATMTIS systems architecture and must be managed by the organization leading the development of the TMC. Therefore, it is recommended that the Iowa DOT take the lead in developing an incident Extranet system.

Pre-Trip Traveler Information System Recommendations

- Establish a traveler information system broadcast over the government access cable television channel in the Des Moines metropolitan area. The cable television server is part of the ATMTIS systems architecture and must be managed by the organization leading the development of the TMC. Therefore, it is recommended that the Iowa DOT take the lead in developing a cable television pre-trip traveler information system.
- Develop a traveler information system distributed over the Internet and through kiosks. The pre-trip traveler Internet information system is part of the ATMTIS systems architecture and should be managed by the organization leading the development of the TMC. Therefore, it is recommended that the Iowa DOT take the lead in developing a pre-trip traveler information Internet system.

Deployment Support: New Analysis Models Recommendations

- Create a peak-hour travel demand model for the Des Moines metropolitan area. It is recommended that the improvement to the travel demand model be programmed in a future Des Moines Area Metropolitan Planning Organization’s work program and managed by the MPO in partnership with the Iowa DOT.
- Improve fidelity of the existing CORSIM, microscopic simulation model to make it sufficiently accurate to support planning and design decisions. It is recommended that the Iowa DOT take the lead on this activity.

Funding

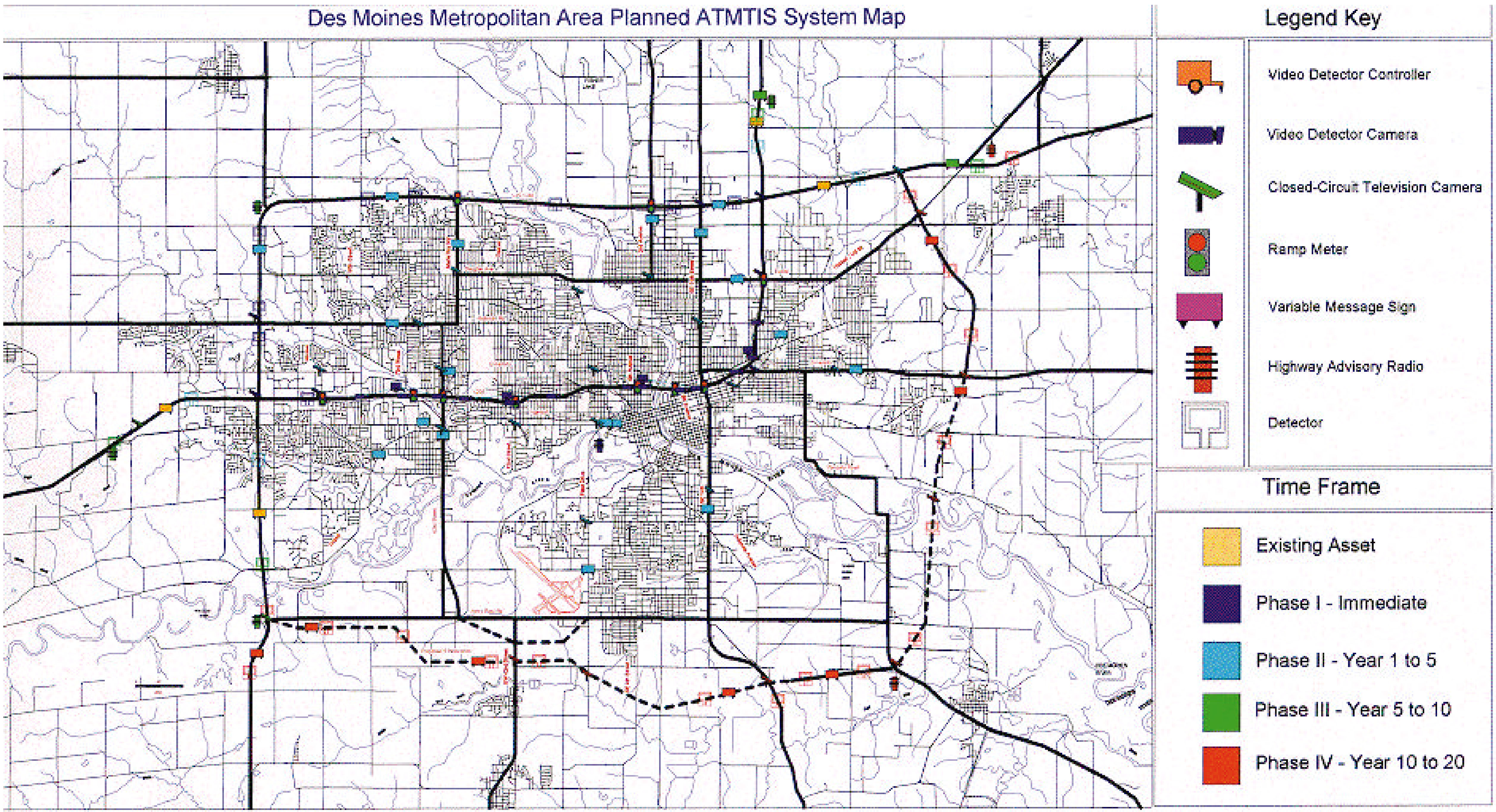
The funding to implement each of these recommendations may be obtained from a variety of sources. In the past, technology similar to the improvements recommended for the Des Moines metropolitan area have been funded as research projects, tests, and demonstrations. The systems recommended for the Des Moines metropolitan area, however, employ technology that has already been demonstrated and is in use elsewhere. Therefore, the systems recommended for the Des Moines metropolitan area are unlikely candidates for demonstration programs.

Many of the specific recommendations may have their own unique funding sources. For example, the electronic fare payment systems should be funded within the MTA's capital improvement program and procured following both MTA and Federal Transit Administration procurement guidelines. Other recommended actions may be funded through capital improvement programs of the participating cities, metropolitan area counties, the Des Moines Area Metropolitan Planning Organization, or the Iowa DOT. The I-235 reconstruction project and the Des Moines downtown signal system project may provide opportunities to include the capital costs of the recommended ITS improvements in the budgets of these projects without significantly increasing the capital costs. In addition, the Iowa DOT may be able to develop a partnership agreement with one or more communications companies whereby the Iowa DOT provides exclusive access to bury fiber optic cable in the highway right-of-way in exchange for communications services. Such barter arrangements have been used in other locations and have been very effective in helping agencies gain access to adequate communications bandwidth for ITS applications.

Conclusion

Now that a strategic plan has been developed, transportation stakeholders in the Des Moines metropolitan area should begin to develop capital budgets to develop and implement the assets recommended in the strategic plan. The plan provides the incentive to move forward by identifying the multitude of benefits that may be accrued by travelers and by transporters of goods once the systems are funded, procured, and deployed.

Appendix A: System Map


Des Moines Metropolitan Area Planned ATMTIS System Map
Legend Key
Video Detector Controller
Video Detector Camera
Closed-Circuit Television Camera
Ramp Meter
Variable Message Sign
Highway Advisory Radio
Detector
Time Frame
Existing Asset
Phase I - Immediate
Phase II - Year 1 to 5
Phase III - Year 5 to 10
Phase IV - Year 10 to 20