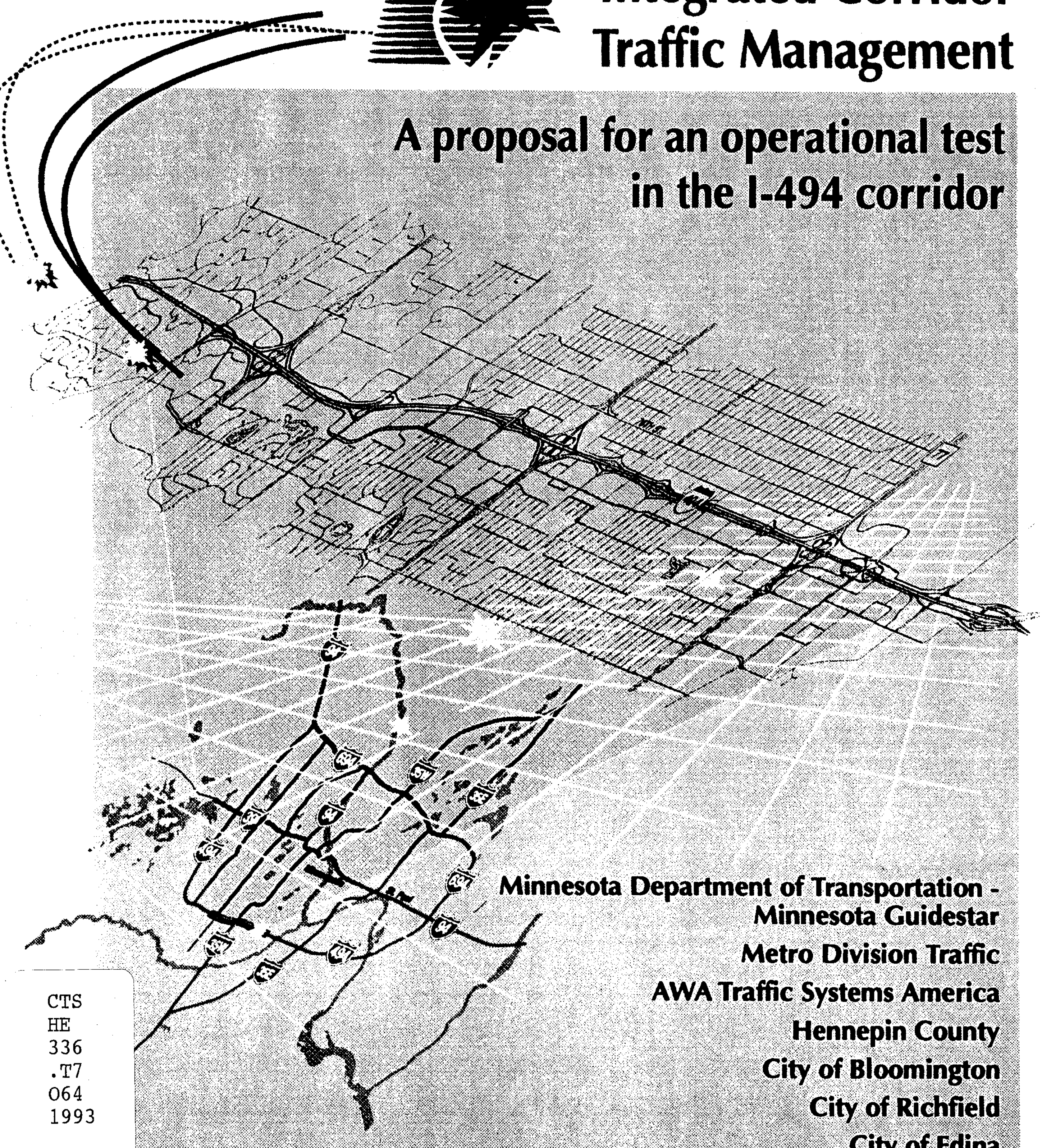
Integrated Corridor Traffic Management



A proposal for an operational test in the I-494 corridor

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City of Bloomington
City of Richfield
City of Edina
Center for Transportation Studies -
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OFFER TO THE

U.S. DEPARTMENT OF TRANSPORTATION

IVHS OPERATIONAL TEST PROGRAM

OPERATIONAL TEST OF INTEGRATED CORRIDOR TRAFFIC MANAGEMENT (ICTM) IN THE I-494 CORRIDOR

34th Avenue South To East Bush Lake Road
Cities of Bloomington, Richfield and Edina
Hennepin County
State of Minnesota

JUNE 1993

SUBMITTED BY:

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1.0 EXECUTIVE SUMMARY

The Minnesota Department of Transportation, Hennepin County, the Cities of Bloomington, Edina, Richfield, and private sector companies propose the Operational Test of an advanced traffic management system called Integrated Corridor Traffic Management (ICTM). The I-494 Corridor was chosen for the proposed test. The initial limits, from east to west, are 34th Avenue South and East Bush Lake Road. The north/south limits include the existing parallel routes formed by 76th-77th Streets on the north and 79th-80th Streets on the south.

Implementation of the proposed operational test will occur in four modules spanning a four year period. The approximate cost of each module ranges from $1.5 to $2.5 million. Each module will be evaluated for its effectiveness prior to the implementation of the successive module.

An integrated approach is needed to adequately handle current, short-term, and long-term travel demand in the I-494 Corridor. The I-494 Corridor Study found that no realistic I-494 mainline improvement would satisfy forecasted travel demand within the corridor without the development of a parallel arterial system. Studies associated with the preparation of the I-494 Draft EIS corroborated that finding. These same studies found that the average trip length on I-494 is less than two miles long. Redirection of these local/short trips to a convenient, continuous, more efficient parallel arterial will reduce delays, congestion, and the number and severity of incidents on I-494.

The goal of the proposed demonstration of ICTM is to improve the efficiency of traffic movement throughout the I-494 Corridor. This will be achieved by applying a combination of traffic management strategies developed through inter-jurisdictional cooperation and coordination. These strategies will be applied to both the freeway and the adjacent arterial system. The major components and objectives of the modules are as follows:

Module 1

The most significant ICTM components in this module include the implementation of an adaptive traffic control system at 15 interchange signals, the preparation of incident/special events management, public relations and motorist information plans, and the installation of video image detection/automated data collection at two arterial intersections.

The major objective for Module 1 is to improve traffic flow at interchange signals thereby improving traffic flow through the Corridor on intersecting arterial routes.

Module 2

This module involves the integration of interchange traffic signals with ramp meters under the adaptive control system, the implementation of operations plans developed in Module 1, and the deployment of video imaging technology at five freeway sites. A transparent interface between the integrated corridor's regional computer and TMC computer systems will also be implemented.

The most important objectives for this module are: achieving an integrated freeway and arterial traffic control system; testing the effectiveness of adaptive traffic control on freeway ramp meters; interfacing existing freeway management system with the integrated corridor control systems; and measuring the effectiveness of selected incident management strategies developed in Module 1.

Module 3

In Module 3, 42 signalized intersections on parallel and intersecting arterial routes are added to the adaptive traffic control system. Portable traffic control equipment and route guidance signs are utilized as tools for further implementation of incident management and motorist information plans. Four critical intersections will be fitted with video imaging technology for vehicle detection and automated data collection. Motorist information centers (terminals/monitors with real-time transportation information) will be installed at five major employment centers within the Corridor.

The primary objectives of this module are to improve the efficiency of traffic flow on intersecting and parallel arterial routes, to better utilize the existing corridor, and to use portable traffic control devices for incident/special events management.

Module 4

ICTM components to be implemented in the last module include CCTV surveillance on alternate routes, permanent signing (route blazing and LCD changeable message signs) on alternative routes, and additional motorist information centers at major commercial traffic generators.

The objective is to improve on arterial traffic flow efficiencies achieved in Module 3 by providing additional information to system operators and motorists.

The evaluation of the proposed ICTM Operational Test will document the effects of a wide range of traffic management strategies applied to the corridor with respect to four basic objectives set down by the ICTM Management Team. In short, those objectives are:

- Implement a corridor-wide adaptive traffic control system;
- Demonstrate an inter-jurisdictional approach to managing traffic flow and operating the traffic control system within the I-494 Corridor;
- Utilize advanced technologies in operating and evaluating the ICTM system; and
- Provide motorists with real-time traffic information.

Under each of the basic objectives paraphrased above are secondary objectives that further define the steps necessary to attain the goal of improved operational efficiency in the I-494 Corridor. Specific measures of effectiveness have been identified for the secondary objectives.

Evaluation of operational plans (e.g. Incident Management Plan) and determining the effectiveness of inter-jurisdictional cooperation/coordination will be accomplished through subjective analysis methods (e.g. user assessment questionnaires).

According to the I-494 Draft EIS, economic growth in the Corridor is expected to increase the number of vehicle trips by approximately 45 percent by the year 2010. The total number of vehicle miles of travel is expected to increase by that same amount. Travel times are expected to increase by 60 percent within the Corridor given the forecast growth and currently scheduled infrastructure improvements. Average travel times on I-494 will double unless demand is severely restricted through the existing freeway management system. Clamping down on access to the freeway will reduce the level of service on parallel and intersecting arterial routes.

Many freeway corridors in the Twin Cities Metropolitan Area are experiencing similar economic and traffic growth characteristics. The proposed operational test of ICTM holds particular promise for increased efficiency in traffic movement through these congested freeway corridors considering the limited resources available for immediate capacity improvements.

The success of this project, or any endeavor involving multiple jurisdictions, will be determined by the degree to which all affected agencies participate and benefit. There is a long history of cooperation among governmental agencies, the motoring public and the private sector in the planning of transportation improvements for the I-494 corridor. This spirit of cooperation continues with a commitment made to the integrated corridor traffic management concept by these agencies. Member representatives from each agency have actively participated throughout the project planning process. To promote further interaction and cooperation, Mn/DOT's Guidestar organizational structure will be used to oversee project administration and all participating agencies are represented on the ICTM Management Team. Technical support will be provided by the Center for Transportation Studies at the University of Minnesota. Detailed information relating to the various partners and their contributions is provided in the program funding section of the proposal.

2.0 PROJECT BACKGROUND

The Twin Cities Metropolitan Area (TCMA) has over 300 miles of freeway. Like many other major urban centers, the TCMA faces growing traffic congestion. Between 1972 and 1984, the number of freeway miles with severe congestion tripled from 24 miles to 72 miles. At the present pace, the number of freeway miles experiencing severe congestion in the year 2010 will double the 1984 figure.

There are many contributing factors to the increasing congestion within the TCMA. Some of the more significant factors include growing population, urban sprawl and dual income households. The continuing increase in congestion has been further compounded by the motoring public's preference to become more mobile.

Over the years, motorists have developed a dependence on the freeway system to transverse the Metropolitan Area. The average trip length on radial freeways is five miles while that average drops to less than two on the most congested circumferential freeways.

In an attempt to manage this congestion, an extensive Freeway Traffic Management System was initiated by the Minnesota Department of Transportation (Mn/DOT) in the 1970's. Covering almost half of the freeway miles, the system includes comprehensive surveillance, management, and motorist information subsystems. The department has also developed a motorist aid program as the first step in establishing an incident management program.

The system currently consists of 317 ramp meters, 108 closed circuit television (CCTV) cameras, 33 changeable message signs (CMS), the Mn/DOT Traffic Radio Program and a Cable TV Traffic Channel. By the end of 1996, the system will manage 75% of the freeway network through a combination of 450 ramp meters, 200 CCTV cameras, 70 CMSs and an expanded motorist information system.

Although ramp metering has significantly improved travel flows and management of minor incidents during peak travel times, freeway congestion has increased to a level where even minor incidents on heavily travelled freeway segments result in excessive delays, motorist frustration and environmental impacts.

Several factors played a primary role in the creation of this situation. During freeway system design in the early 1960's, trends such as urban sprawl and dual income households were not yet commonplace and hence not properly considered by transportation planners. Forecasted traffic increases, and the additional freeway capacity needed due to these developments, were thus severely underestimated.

Traffic management is performed on other TCMA roadways through a hierarchy that includes Mn/DOT, counties and cities. Mn/DOT assumes responsibility for freeway systems and trunk highways while the counties and cities retain control over the other signals and systems associated with the arterial network.

Independently developed signal strategies include fixed time control, traffic actuated control, "closed loop" systems and central computer systems. Many of the local strategies, while adequate for non-peak congestion levels, provide a level of service that is below optimum during peak travel conditions. While preprogramming for special event travel flows is possible, municipal governments do not have the personnel nor the funding available for frequent updates. In many cases fixed time systems that are capable of being adjusted, have not been in several years.

The impact of multiple traffic control strategies is most evident at the jurisdictional boundaries where changes in those strategies produce a break in signal coordination, increasing travel times. Local travellers often use the freeway network for short trips because of this time delay. Even during periods of incident-caused congestion, commuters tend to use the freeway rather than alternate routes. Expansion of the freeway network alone will not adequately address increasing congestion levels. Major reconstruction will not meet future demand for capacity without the development of parallel arterial systems that will remove these short trips from the freeways.

The IVHS America Strategic Plan submitted to Congress by the United States Department of Transportation lists as one of its major objectives:

> ***"To increase the volume of people and goods that can be moved on existing facilities and in highly travelled corridors."***

The Minnesota Department of Transportation agrees and supports this objective. Through the implementation of a single ICTM plan, Mn/DOT believes that this objective can be demonstrated in a manner that could lead to expansion of the concept to the entire Metropolitan Area.

Figure 1 highlights Minnesota's TCMA and the proposed ICTM Operational Test Area.

3.0 PROJECT OVERVIEW

The ICTM concept reflects a need to manage traffic movements in a singular coordinated fashion as opposed to multiple agencies managing their own individual components.

A multitude of benefits will be derived through the successful application of ICTM strategies. While these benefits will be chronicled in greater detail later in the proposal, the following warrant immediate comment:

- Maximize traffic movement throughout the corridor by better utilization of the existing freeway and arterial streets (ie. more efficient use of the entire road network by encouraging short trips on local streets and regional trips on the freeway).
- A significant reduction in delays, travel times, fuel consumption and emissions through improved signal coordination and green time usage provided by an adaptive control system. Reduced fuel consumption and emissions will promote more favorable environmental conditions.
- Increased motorist safety through congestion management.

- Increased driver awareness and reduced frustration due to more comprehensive motorist information concerning travel delays and available alternate routes.
- Reduced incident impact and duration using coordinated incident management response techniques.

After evaluating six potential freeway corridors, Mn/DOT selected a segment of I-494 to demonstrate the benefits of integrated corridor traffic management. Traffic management in this corridor is currently performed by Mn/DOT, Hennepin County, and the Cities of Bloomington, Richfield and Edina.

A graphical representation of the corridor's limits, components and jurisdictional responsibilities is provided in Figure 2.

The success of this project, or any endeavor involving multiple jurisdictions, will be determined by the degree to which all affected agencies participate and benefit. There is a long history of cooperation among governmental agencies, the motoring public, and the private sector in the planning of transportation improvements for the I-494 corridor.

This spirit of cooperation continues with a commitment made to the ICTM concept by these agencies. Member representatives from each agency have actively participated throughout the project planning process. To promote further interaction and cooperation, Mn/DOT's Guidestar organizational structure will be used to oversee project administration. All participating agencies are represented on the ICTM Management Team.

Technical support will be provided by the Center for Transportation Studies at the University of Minnesota. Detailed information relating to the various partners and their contributions is provided in the program funding section of the proposal.

At the heart of the proposed system is a singular, real time traffic adaptive control system. The system will be capable of automatically responding to predictable changes in traffic demand as well as unforeseen fluctuations resulting from incidents. The ability to adaptively vary the metering rates at ramp signals and the signal timing at interchanges and other intersections will also be provided.

Since the project corridor is an integral part of the existing Freeway Management System, the adaptive control system will pass collected volume and occupancy data to the existing Traffic Management Center computer system. All existing user and system functions will be retained.

The previously referenced Draft EIS for the I-494 corridor found that no realistic mainline improvement alone would satisfy forecasted travel demand within the corridor. The need to develop a parallel arterial system to accommodate short trips within the corridor is evident in Figures 9 and 10 (See Appendix). Taken from the I-494 Draft EIS, these figures depict projected corridor capacity deficiencies by the year 2010 in no-build and build scenarios respectively. The forecasted Average Annual Daily Traffic (AADT) volumes for 2010 shown in Figure 11 (See Appendix) indicate that between 122,000 and 171,900 vehicles per day will use the freeway test segment.

ICTM OPERATIONAL TEST AREA

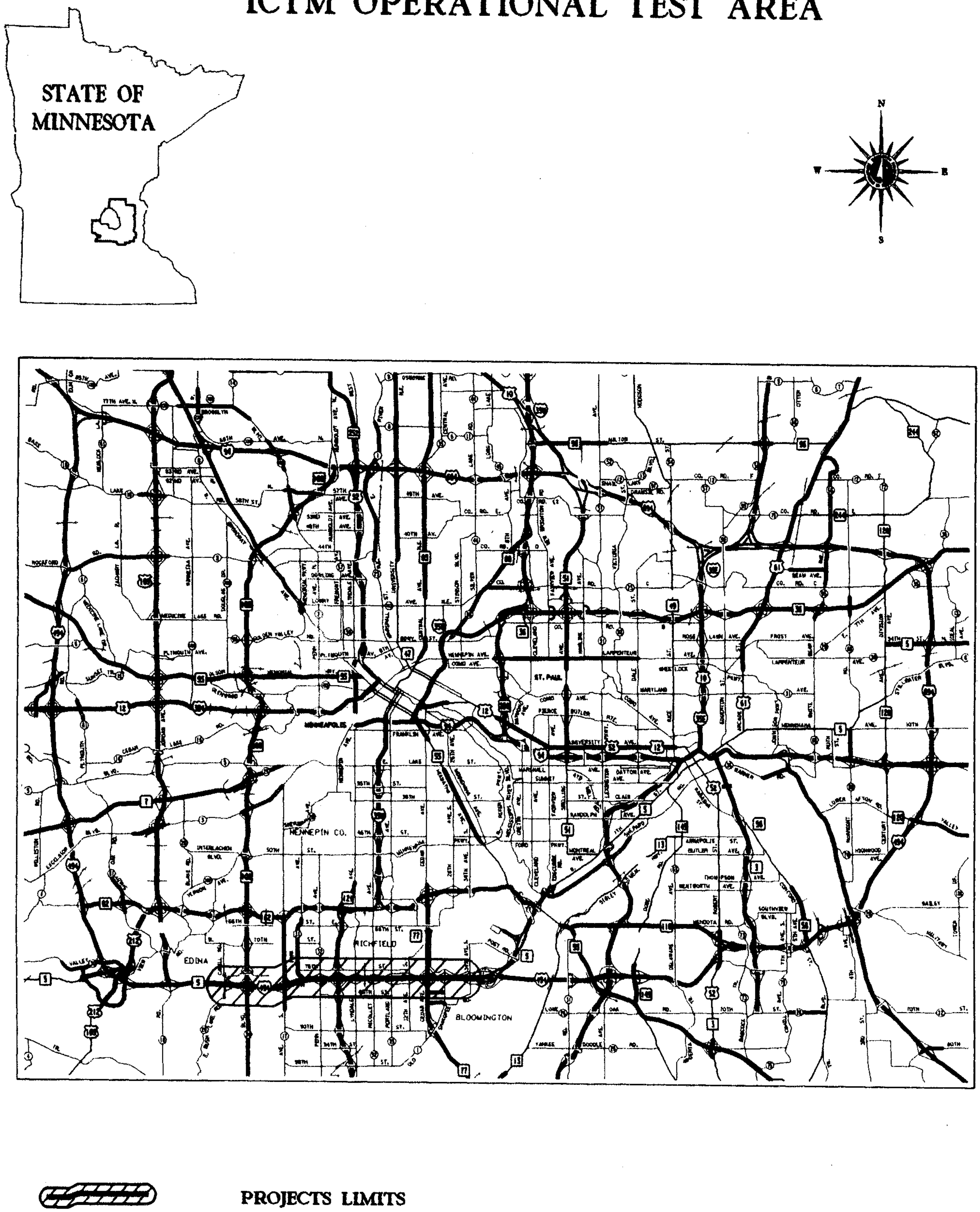


FIGURE 1

I-494 ICTM PROJECT LIMITS & EXISTING TRAFFIC CONTROL COMPONENTS

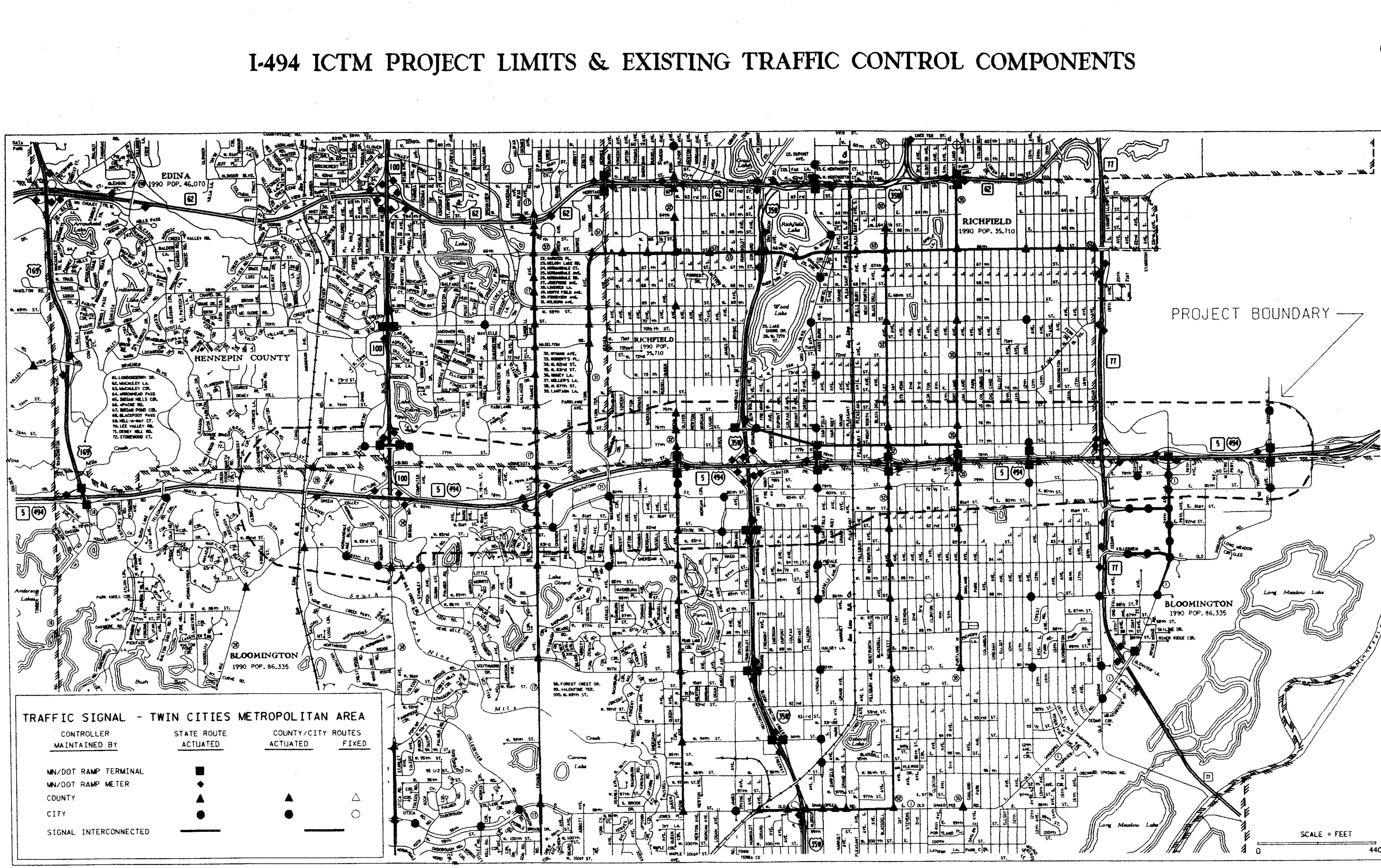


FIGURE 2

Implementation of the adaptive traffic control system is intended to address the study findings. The system will coordinate all signals within the corridor and provide progression along intersecting and parallel alternate routes of I-494. This coordination will markedly improve travel conditions during off-peak hours and on the shoulders of the peak periods. Significant improvements in traffic flow are anticipated when incidents occur on the freeway.

The improvement in travel times resulting from better coordination and progression will ultimately promote the use of the arterial system for short trips. This shift of the short trips to the arterial network will be a significant contributor to the reduction of recurrent congestion on the freeway.

Incident and special event management are also important components of the proposed ICTM system. Detailed plans will be developed to address both of these components. These plans will include a comprehensive motorist information program. Through this program, motorists will be kept appraised of the type, location and status of incidents and special events. Alternate routes will also be suggested.

The emergency vehicle preemption equipment currently used by several of the participating agencies is a light-emitting system. This hardware is fully supported by the adaptive traffic control system that is planned for the corridor.

As with any major transportation improvement, a significant investment will be required by all project participants. Inter-agency cooperation was critical in establishing the modular approach to project implementation. In an effort to provide improvements that can be both demonstrated and evaluated, the project has been divided into four modules. Group decisions were made considering whether or not components were "doable, manageable, cost effective, and measurable", and under what time frames each could be realized. The length of Minnesota's summer construction season was also a factor in determining what could be accomplished in each module.

Many other travel corridors in the Twin Cities Metropolitan Area are experiencing congestion levels similar to those in the I-494 corridor. The potential use of integrated corridor traffic management in these corridors places a premium on evaluating the proposed system's effectiveness. An evaluation strategy has been developed and will be finalized during the project's preliminary design stage.

4.0 PROJECT PROCESS

Evaluating multiple qualified corridors, selecting a single corridor, and developing an ICTM system provided a daunting challenge for the project's core members. To address this challenge, the group decided at its first meeting to adopt a Quality Improvement (QI) approach.

QI, the organizational and management philosophy of Mn/DOT, is based on the works of W. Edward Deming. It is also known as Total Quality Management or Continuous Quality Improvement. The QI process involves a full-participation ideal, a systematic approach to goal achievement, and a data-based decision making process.

Team focus and a common goal are integral to the QI success. The team agreed to utilize various QI components to aid in completing its objectives. These included writing a mission statement to insure focus and agreement, and using structured meeting agendas with stated objectives to facilitate progress.

By using the QI process, productive working relationships have developed within the group which will be necessary as the project evolves. With so many agencies represented within the group, difficulties often surface that tend to undermine a project of this magnitude. Following the QI steps helped keep the group goals at the fore and allow the group to develop the ICTM concept and prepare this proposal.

5.0 PROJECT OBJECTIVES/MISSION

The ICTM System planning group made a commitment to better serve the motoring public. A goal of conforming with the Metropolitan Council's objectives to fulfill the directives of the Intermodal Surface Transportation Efficiency Act (ISTEA) was adopted. As guidance in forming a coordinated effort to improve traffic flows in the I-494 Corridor, the group adopted the following mission statement and objectives for the project:

MISSION STATEMENT

To implement an operational test that will demonstrate that more efficient corridor transportation movement can be achieved through cooperative jurisdictional effort, freeway and arterial integration, real-time adaptive traffic control strategies, incident management, advanced technologies and comprehensive motorist information services.

OBJECTIVES

1. Implement an adaptive traffic control strategy that will rapidly respond to anticipated fluctuations in typical traffic demand and unexpected impacts resulting from incidents and special events.
   - Increase traffic flows through corridor intersections using improved allocation of signal green times and area wide signal coordination.
   - Maintain appropriate levels of service between the arterial signal control component and the freeway management component.
   - Develop corridor wide incident and special event management plans.
   - Provide a safer driving environment by reducing accidents, stops, delays, and fuel consumption.
2. Demonstrate that multiple transportation agencies, each with a responsibility to their own constituents and governing body, can simultaneously represent the interests of all parties and improve travel conditions throughout the I-494 Corridor.
   - Develop operational and signal control philosophies that reflect a corridor wide perspective.
   - Develop inter-jurisdictional operations and maintenance strategies.
   - Provide financial, personnel or equipment resources in support of the proposed project.
   - Identify definitive roles and responsibilities for all project participants to guarantee representation for all communities.
   - Jointly develop system design and architectural solutions to travel improvement challenges faced within the corridor.
   - Establish physical communications links to disseminate system information to all agencies.
3. Integrate available advanced technologies in the collection and dissemination of corridor information.
   - Utilize advanced vehicle detection techniques to achieve operational improvements and reduce maintenance costs associated with existing vehicle detection strategies.

- Implement data collection technologies to gather information to classify vehicles and measure delays, stops, travel time, queue lengths, volume, and occupancy.
- Provide faster responses to corridor incidents through the use of improved incident detection algorithms and technologies.
- Utilize a variety of technologically advanced methods to convey real-time motorist information.
- Implement distributed, intelligent control equipment to adaptively respond to anticipated traffic demand and unexpected traffic fluctuations resulting from incidents.
- Facilitate current corridor communications requirements and provide additional capacity for anticipated system enhancements.

4. Provide comprehensive motorist information services through a variety of communications tools.
    - Provide real-time information on corridor levels of service including travel times and speeds.
    - Inform motorists of incidents and special events affecting corridor traffic flows and suggest alternate routes to accomplish avoidance of these areas.
    - Disseminate existing and planned construction activities for the corridor.
    - Educate travellers about multi-modal alternatives available in the Twin Cities area.
    - Provide road condition information, particularly related to adverse weather conditions.

6.0 CORRIDOR SELECTION

Initially, six freeway corridors were considered for use in the demonstration project. Mn/DOT selected these corridors based on traffic volumes, accident counts, freeway capacity constraints and the availability of suitable alternate parallel arterial routes.

Until a final corridor was selected, group participation was limited to representatives from Mn/DOT and AWA Traffic Systems America, the project's primary private partner. Mn/DOT participants included representatives from the TMC Freeway Operations Section, Metro Signal Operations and the Minnesota Guidestar Unit.

The group identified eight corridor criteria that would be used to select two corridors for intensive field evaluation. The criteria were as follows:

- **Incidents, accidents and known problems within the corridor.** Special emphasis was placed on the number of incidents per mile, documenting existing problems and assessing the impact that accidents have on the corridor.
- **Suitability of alternate routes.** Both intersecting and parallel alternate arterial routes were examined.
- **Agency and community acceptance.** The potential for positive acceptance by transportation related agencies and the general public within the affected corridor were considered.
- **Benefit - Cost Ratio.** Potential benefits to be gained in the corridor were compared with the projected costs needed to accomplish integration.

- **Capability and compatibility of existing infrastructure.** Issues such as the existence of Mn/DOT's ramp metering system, design and geometrics of alternate routes and the existence of other traffic management systems were considered.
- **Potential for expansion within the corridor.** The region around each corridor was reviewed to determine if the integrated system could provide benefits if expanded beyond the initial corridor limits.
- **Impact of other construction projects in the corridor.** The positive and negative impacts of other planned construction activities and their impact on the project were analyzed.
- **Corridor ability to meet project objectives.** The quantity and type of ramp meters, intersecting arterial signals and parallel alternate signals were reviewed to determine if a representative sample existed to clearly demonstrate the project objectives.

The six potential corridors were ranked by the core ICTM participants. This ranking determined that the I-35W and I-494 corridors clearly presented better opportunities to demonstrate the benefits of ICTM.

Extensive field evaluation was conducted on the two corridors including an assessment of hardware, communications and geometric constraints. Representatives conducted site visits, observed peak conditions and met with the agencies responsible for traffic management in the corridor.

Site visits included field observation and evaluation of the corridor's ramp metering system and signal systems. Special emphasis was placed on the condition and age of control hardware, the communication schemes utilized and the existence and condition of detectors. The design and geometric constraints on the intersecting and parallel alternate route intersections were also documented.

Video surveillance capabilities available through Mn/DOT's Traffic Management Center were utilized to observe a.m. and p.m. peak traffic conditions. Both corridors were also driven in peak and non-peak conditions.

Conversations with local traffic agencies focused on providing an overview of the proposed ICTM System. The agency's receptiveness to the project was then gauged. Each agency's control philosophies and future plans were also explored.

After completing the preliminary evaluation, the following factors led to the selection of the I-494 corridor for the proposed Operational Test.

- Willingness of all jurisdictions to cooperate with and support the ICTM concept;
- Stronger interest in the ICTM concept was expressed by all jurisdictions within the corridor;
- The existence or planned addition of new controller hardware (controllers, conflict monitors, terminal strips, wiring, etc.) to simplify integration with the adaptive

control system;

- Significantly more detection exists;
- Existing loop detectors approximate the size, shape and placement necessary for integration with the adaptive traffic system will significantly reduce the project's cost;
- Intersecting and parallel arterial routes, necessary for the ICTM concept, can be used without modifying geometrics or changing the existing traffic patterns; and
- Communication resources could be devoted to the ICTM system and not shared with the existing traffic management system.

7.0 CORRIDOR OVERVIEW

The segment of I-494 selected for the demonstration project consists of a 5.3 mile stretch of freeway, two parallel alternate routes and nine intersecting arterial streets. East Bush Lake Road forms the western boundary of the corridor while the corridor's eastern boundary is 34th Avenue. Parallel alternates include 76th/77th Streets to the north and 79th/80th Streets to the south.

Refer to Figure 2 for a graphical representation of the ICTM Project Limits and Components. Jurisdictional responsibilities are also indicated.

The corridor contains twenty-five ramp meters, thirteen mainline detector stations and fifteen interchange signals. Intersecting and parallel alternate routes contain an additional 42 signals. Two Changeable Message Signs (CMS) and three Highway Advisory Radio (HAR) signs can be found as well as seven Closed Circuit Television (CCTV) cameras.

All ramp meter signals and detector stations are equipped with Safetrans type 170 controllers. Signals on parallel and intersecting arterial routes utilize NEMA type controllers of various ages and manufacturers. Extensive plans already exist to upgrade older control equipment over the next several years.

Standard freeway loop detection consists of 6-foot by 6-foot detectors that are normally located at half-mile spacings along the freeway and at entrance and exit ramps. Signalized intersections have varying types and quantities of detection. Conduit and feeders are available to allow modifications that will provide the detection characteristics required by the proposed adaptive control system.

Mn/DOT's existing Freeway Management System utilizes a comprehensive communications system in the corridor. The system consists of a single mode fiber backbone that carries video, video control signals and data communications to distributed "nodes" in the network. Copper and multi-mode fiber then link these nodes to individual video cameras, ramp meter controllers, detector stations and changeable message signs.

Although the fiber network terminates just prior to the proposed corridor, functionality is maintained using multi-core copper cable. Plans are in place to upgrade communications to the node for this corridor with fiber. Communications to ramp meters/detector stations is accomplished through a "multi-drop" scheme with 15 controllers on a single line. The transmission rate is 1200 baud. There are no current communications links between the fiber backbone cable and other traffic signal controllers in the corridor.

Seven independently operating "closed loop" systems currently operate in the corridor. These systems control 25 of the corridor's 57 total signalized intersections. All other signals operate in an isolated fashion. The closed-loop systems also use a multi-drop communications format. Future construction plans in the corridor include a provision for similar communications capabilities to other groups of signals.

With the exception of the closed loop systems referenced above, no communications capabilities are evident at other signals in the corridor.

Mn/DOT monitors freeway operations from a system located at its Traffic Management Center. The system includes comprehensive surveillance, monitoring, management, motorist information and motorist aid subsystems. A graphical view of the system is provided in Figure 3.

A system of video cameras allows real time monitoring of the freeway network and on/off ramps. Current congestion levels and operating speeds are displayed on a wall map. Motorist information is provided in part through a Changeable Message Sign (CMS) System. An additional group of fixed signs announce traffic radio broadcasts (KBEM-FM 88.5 MHz) that originate from the center.

A ramp metering system forms the heart of Mn/DOT's freeway management system. Ramp metering is initiated automatically based on flows, occupancy or time of day. Freeway volume and occupancy data is reviewed off-line on a continuing basis and utilized to recalculate metering rates. Metering rates are preset in the controllers based on this data analysis.

Dual lane control is typical at the majority of ramp meters (to reduce the impact of queuing) with each lane given green alternately to meet the defined metering rate. At TH 77, an additional lane is provided for high occupancy vehicles (HOV) and is included in the metered sequence. Future construction plans include HOV ramps at France Avenue, Nicollet Avenue, and TH 169.

EXISTING I-494 TRAFFIC MANAGEMENT SYSTEM

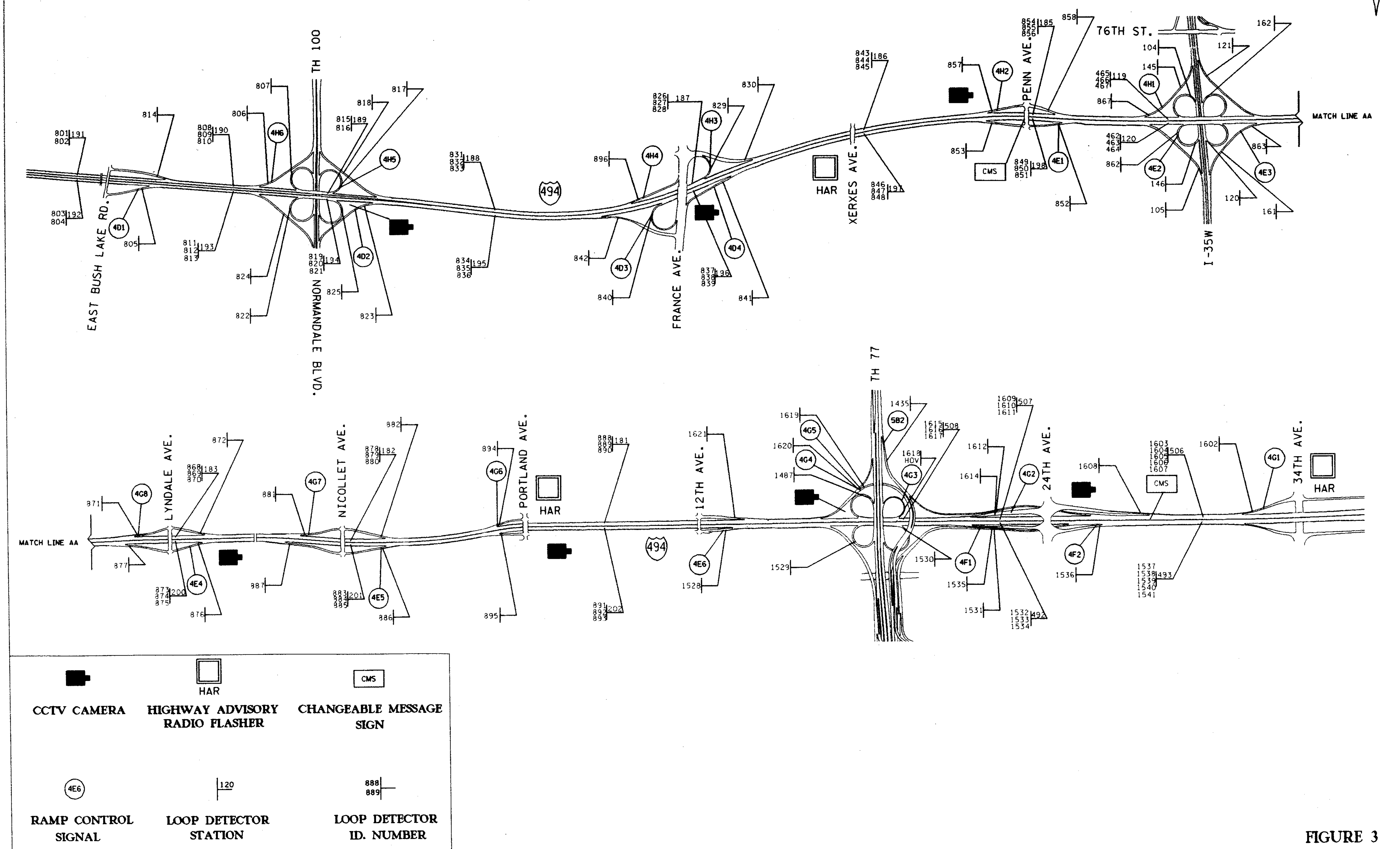


FIGURE 3

8.0 ADAPTIVE CONTROL SYSTEM SELECTION

An extensive literature search was conducted on demand responsive traffic control systems/adaptive control systems (refer to Appendix B for listing). Below summarizes the various control systems that are currently available.

SCOOT - Split, Cycle and Offset Optimization Technique
SCATS - Sydney Coordinated Adaptive Traffic System
OPAC - Optimization Policies for Autoadaptive Control
MOVA - Microprocessor Optimized Vehicle Actuation
CARS - Control Autoadaptativo para Redes Semaforizadas
Prodyn - France

Only two of the above systems are fully operational at the present time; SCOOT and SCATS. The term operational implies readily available, functional in grid and arterial networks as well as isolated intersections.

ICTM requires some kind of traffic adaptive system to automatically respond to planned and unplanned traffic variations. While the FHWA has stated a preference for using American technology in operational tests, the lack of an American adaptive system necessitates the use of a foreign technology in this project. SCATS was the preferred system for the following reasons:

- SCATS is the only adaptive system that has the control algorithms needed to support freeway ramp metering and arterial signal control.
- The system allows local governmental agencies to cooperatively manage the corridor while still retaining jurisdictional control of their traffic signals and/or ramp meters.
- Ramp metering and signal control decisions are based on real time detector information instead of prediction models, allowing the system to adaptively respond to varying traffic conditions.
- The system was developed by practicing traffic engineers over a period of two decades, with software enhancements made based on real world experiences. This is the same approach that was used to develop the ramp metering system at the Mn/DOT Traffic Management Center.
- The system is capable of running in various modes of operation and supports multiple phase options.
- SCATS has a hierarchical architecture that aids in system expansion.
- SCATS has been successfully implemented around the world including Australia, New Zealand, Hong Kong, China, and Singapore.

The ICTM project proposed in this document is uniquely different than other IVHS operational tests in the following ways:

- The project demonstrates the ability of multiple agencies to jointly manage and operate an integrated corridor system.

- Control of ramp meters and traffic signals is accomplished through a single system.
- This project is a comprehensive program that incorporates all the necessary components needed to successfully demonstrated ICTM.
- Advanced technologies are utilized at critical locations to assess the benefits of ICTM through automated data collection devices.
- Existing detection will be incorporated into the system to influence the traffic control decisions.
- The system provides the ability to monitor traffic movement within the corridor to assess the effectiveness of various traffic control strategies and diversion techniques.

9.0 PROJECT COMPONENTS

The success of any "system" is the complete integration of its separate, but interrelated components. The key components associated with the ICTM system are depicted in Figure 4 and detailed below.

9.1 SYSTEM INTEGRATION

The basis of the ICTM project is the coordinated control of ramp meter and interchange signals with the signals on parallel and intersecting routes. A single, integrated control system is proposed for the corridor. The ICTM System Network is illustrated in Figure 5 with the new components indicated within the dashed lines.

SCATS is proposed as the real time system to provide integrated ramp metering and signal control. The system contains the fundamental control algorithms necessary to accomplish this integration to support both the traffic signals and ramp meter operations. SCATS will be applied to vary the ramp metering rates and signal timings at interchanges and other signalized intersections in response to fluctuating traffic conditions.

The system will allow control of all signals within the corridor and provide coordination along both parallel and intersecting arterial routes. Discontinuities currently experienced at jurisdictional boundaries will be eliminated.

The ramp meters and detector stations from the existing freeway management system (FMS) will be transferred to the regional computer. Integration between the corridor regional computer and the TMC computer is necessary to keep the freeway management system intact and maintain data integrity. The regional computer will pass volume and occupancy data to the freeway management computer system to support the existing functions (eg. status map). TMC control room operators will be able to override the ramp meters within the I-494 corridor through a terminal access.

Each ramp meter controller will have the ability to determine, in real time, an optimum metering rate to match the constraints of a nominated downstream measuring point and the measured volume from its upstream mainline detectors. The system will have the ability to monitor the actual on-ramp volume to determine when metering should commence and terminate.

I-494 ICTM PROJECT COMPONENTS

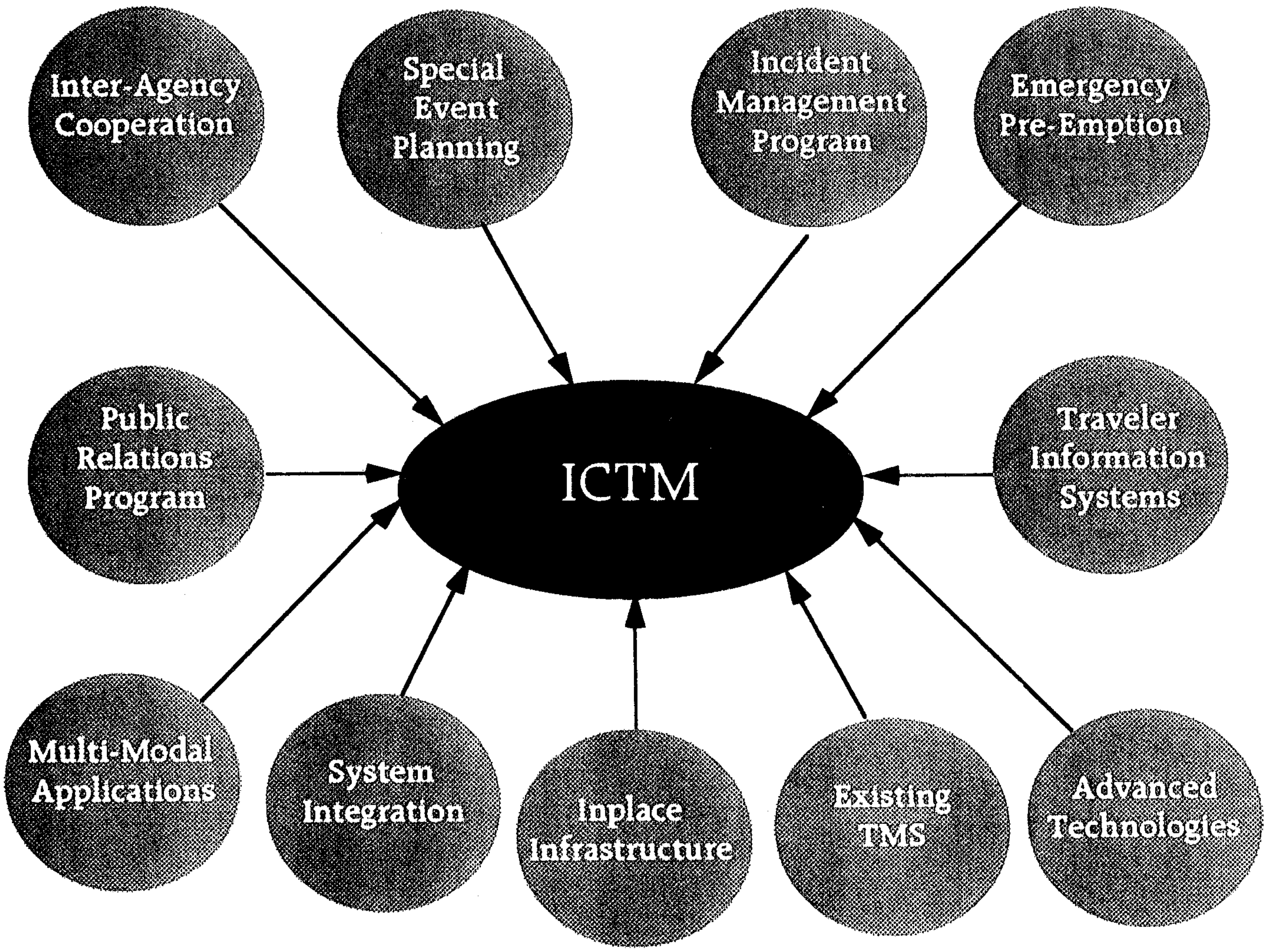


FIGURE 4

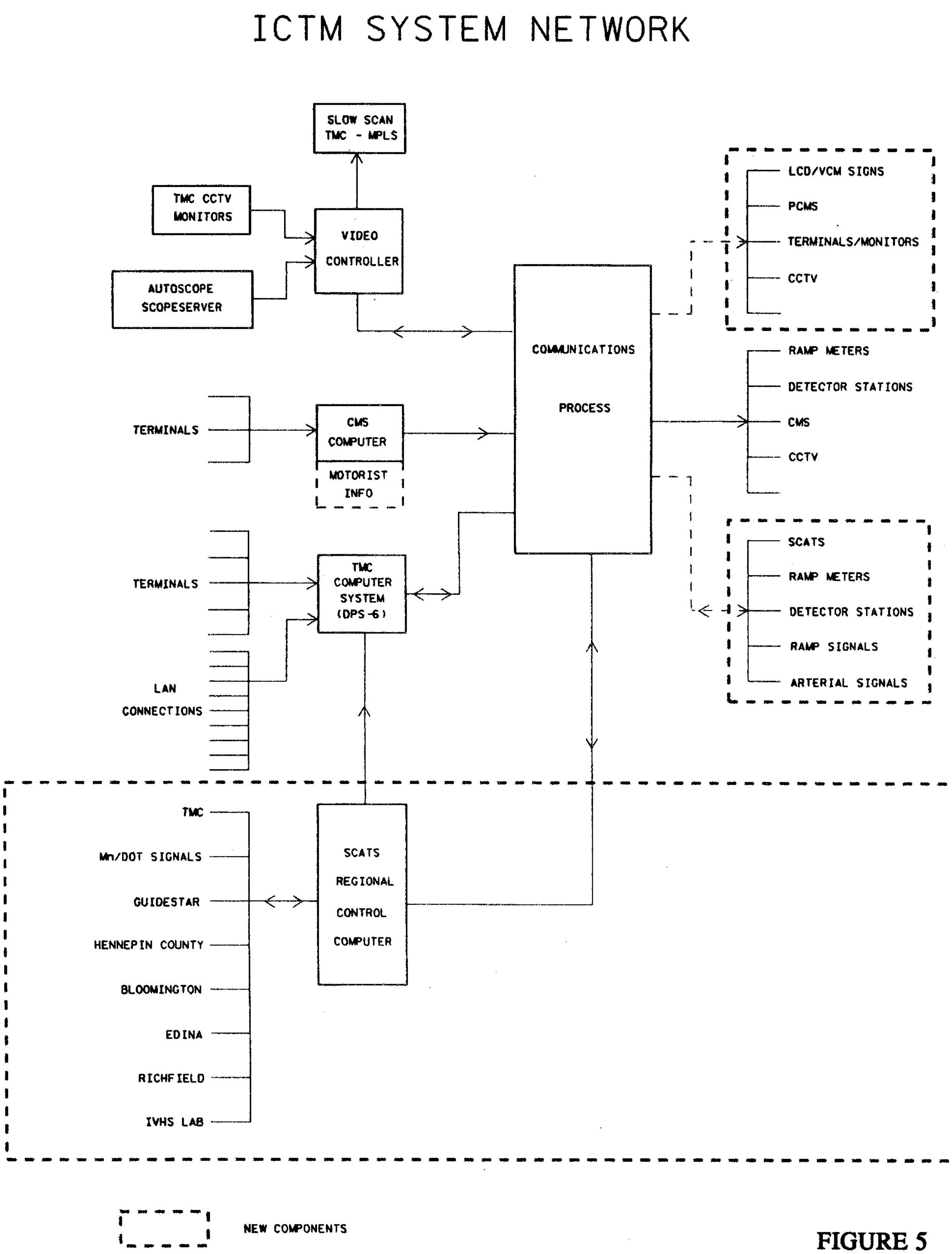

ICTM SYSTEM NETWORK
SLOW SCAN TMC - MPLS
TMC CCTV MONITORS
VIDEO CONTROLLER
AUTOSCOPE SCOPESERVER
LCD/VCM SIGNS
PCMS
TERMINALS/MONITORS
CCTV
COMMUNICATIONS PROCESS
RAMP METERS
DETECTOR STATIONS
CMS
CCTV
TERMINALS
CMS COMPUTER
MOTORIST INFO
TERMINALS
TMC COMPUTER SYSTEM (DPS-6)
SCATS
RAMP METERS
DETECTOR STATIONS
RAMP SIGNALS
ARTERIAL SIGNALS
LAN CONNECTIONS
TMC
Mn/DOT SIGNALS
GUIDESTAR
HENNEPIN COUNTY
BLOOMINGTON
EDINA
RICHFIELD
IVHS LAB
SCATS REGIONAL CONTROL COMPUTER
NEW COMPONENTS

FIGURE 5

The metering rate will be continuously variable and not constrained to a limited number of discrete values. Saturation flow for each monitored mainline and ramp lane will be continuously calibrated and automatically adjusted by SCATS to reflect any change in traffic conditions.

Mn/DOT's current ramp metering algorithm makes no automatic adjustments for queues that develop on ramps. Such a strategy can result in queues extending back to the arterial street network and significantly reduce signal capacity at these locations.

Opportunities exist with the integrated system to distribute queues more effectively across all corridor ramps while still maintaining the overall constrained input flow to the freeway. This will be accomplished through automatic variation of metering rates and by encouraging the use of alternate ramps. Biased signal settings and the motorist information program will be used to encourage use of the alternate ramps.

Typically, the function of interchange signals is not directly tied to freeway performance. Through adaptive control, however, increased traffic at exit ramp approaches will be met with an immediate response. Traffic will be moved away from the freeway more quickly while also being balanced against competing demand on local streets.

Adaptive control of exit ramp signals will also play a vital role in managing freeway incidents. These signals will provide the control mechanism to direct traffic away from the incident. Both automatic and operator directed responses will be available to modify the signal timing parameters that will assist in moving traffic.

The performance of other signals in the corridor will also improve as a result of the adaptive control system. Control strategies developed for the corridor will insure that flow on both the parallel and crossing arterial routes will be optimized. This will minimize stops and delays while also protecting sensitive residential areas from traffic intrusion.

As a part of the integrated system, signal timings at all non-ramp signals will be adjusted to meet the specific requirements of large incidents and/or special events. Either predefined strategies or direct operator intervention will be utilized to meet these requirements.

User access will be provided to city, county and Mn/DOT system operators through remote terminals. These terminals will be standard DOS based personal computers using Windows and SCATS specific commands. All existing functions and capabilities currently available from the TMC's System will be retained with the new system.

Each user will have independent access to the system database. Protection from unauthorized modifications to signal timing parameters under their jurisdictions will also be provided.

The user interface will provide a manual override capability to change ramp metering rates and/or signal timings. Manual intervention will also be available for implementing and modifying incident plans in real time.

Implementation of the ICTM System will occur with minimal modification to on-street control and detection equipment. Both 170 and NEMA controllers will require modification or replacement in order to operate under the direct control of the SCATS computer. The 170 ramp meter controllers and detector stations will require a simple card replacement. NEMA based signals will need replacement of the controller with a SCATS/NEMA compatible controller. In both cases, the modification can be made on-site with minimal modifications to the site cabinet layout.

Detection at many existing signals is adequate for data collection and/or control purposes. Some additional loop detectors will be necessary to meet the precise data requirements of the adaptive control system. All existing mainline and ramp detector loops will be reused with SCATS. One additional detector per entrance ramp will be necessary to provide queue information to ramp signal controllers. This will ensure that on-ramp queues will not block traffic on local streets. Many signalized intersections contain extensive use of detection and already have conduit, feeder cable and sensors in place. Where possible, these loops will be retained in their current state or modified to fulfill SCATS detector requirements. The only additional detection needed is at some critical stop line locations.

Existing communications interconnects and standards will be utilized for the ICTM system. The adaptive control system master will connect to the existing fiber/copper network that provides communications to ramp meters and detector stations. The multi-drop communications standard that is employed for ramp meter signals and signals controlled by closed loop systems will be expanded throughout the corridor.

9.2 SCATS

SCATS is a complete computer based area traffic control system that encompasses hardware, software and a unique control philosophy. It operates in real-time, adjusting signal timings in response to variations in traffic demand and system capacity.

Unlike "fixed time" or "semi-responsive" systems, SCATS requires no precalculation of signal timing plans. Logic and algorithms in SCATS analyze real-time traffic data provided by vehicle detectors to produce signal timings which are suitable for the prevailing traffic conditions.

In addition to providing the obvious benefits of integrating the control of otherwise independently operating signals, SCATS provides other significant benefits. The ability to monitor the operation of all signals from a central point means that the traffic operation of the system can be maintained with minimal resources. Operating parameters in regional computers and local controllers can be checked and modified by means of a terminal connected to any regional computer or local controller. Centralized reporting of most equipment and operational fault conditions is a very significant advantage. This reporting allows faults to be quickly diagnosed and rectified.

SCATS has been designed in a modular configuration to suit the varying needs of small, medium and large system users. Currently, Digital Equipment Corporation (DEC) computers are used throughout. A single regional computer can control signals at up to 128 intersections. Expansion of the system is possible by installing additional regional computers.

Users with multiple regional computers typically add a central monitoring computer that allows centralized access for data input, monitoring and traffic data collection. A management computer, which provides system management support, data collection and analysis, data backup, fault analysis and system inventory facilities is also available.

SCATS provides three control modes for the operation of signals. The adaptive mode, known as Masterlink, provides the integrated traffic responsive operation. In the event of a regional computer failure or a loss of communications, local controllers can revert to a cable-less linking form of operation known as Flexilink. Flexilink synchronizes adjacent signals by selecting signal timing plans by time of day. Local vehicle actuation facilities are also operational in this mode. Signals may also operate in an isolated mode with local vehicle actuation being the sole operating strategy.

Any of the modes can be set by an operator using a SCATS terminal or by time of day. Signal operation can be centrally monitored in all modes provided that communications is maintained. A very wide range of system parameters can be varied through timetables or manual intervention. All operator commands and monitoring functions are available from any input terminal. Availability is subject to the security access afforded to each operator as defined in the database.

Extensive graphics support is also provided by SCATS with four levels of color display provided. An intersection display shows phasing design with real time detector operation and signal group greens. The sub-systems display shows the selected layout with traffic flow and density information using detector data. A regional display gives an on-line representation of traffic flow conditions by means of coloration. The whole system display shows a colorized map with regional boundaries and the traffic conditions of the six most heavily used sub-systems in each.

Traffic information for all control functions is measured using stop-line inductive loop detectors. All detectors are capable of being defined as strategic detectors. Information from detectors is pre-processed in the local controller and sent to the regional computer for the strategic calculations. The three primary control parameters (stage splits, cycle lengths and offsets) are varied directly in response to the changes in measured traffic flow.

In a series of coordinated signals, offsets must be varied with traffic demand to minimize stops and delays. SCATS selects offsets based on free flow travel time and degree of saturation. This approach to offset selection minimizes the number of stops for the predominant traffic flows.

Cycle length is varied to meet the overall level of traffic demand. In general, increased cycle time increases system capacity. SCATS requires that all signals which are coordinated must share a common cycle time (or sub-multiple). System minimums/maximums and other traffic parameters for the corridor will be established by the ICTM Management Team.

SCATS determination of phase splits is essentially one of maintaining equal degrees of saturation on competing (representative) approaches. However, control may be biased to favor principal traffic movements when demand approaches saturation.

9.3 INCIDENT MANAGEMENT

A comprehensive incident management plan is an essential component of ICTM. During Module 1 incident management plans will be developed to address all possible incident types.

In many cases, a low level automatic system response may be all that is required to manage an incident. On-ramp metering rates will adjust to compensate for the capacity reduction and any consequent queue formation will be spread across ramps within the zone. On-ramp signals will continue to monitor queue formation to minimize the impact on intersecting and parallel arterial routes.

Following a major incident, a predefined incident plan will be necessary. Vehicles will be diverted from the freeway and directed via preselected alternate routes, to rejoin the freeway at a suitable downstream location. Signal timings at the affected arterial signals will automatically adjust to cope with the significant change in traffic patterns and demand.

The procedure for dealing with major incidents will include several well defined steps. Among these steps are detection, verification, rapid response and removal, travel information services and coordinated traffic control. Mechanisms such as traditional loop detectors, CCTV, motorist calls, and video imaging will be utilized for detection and verification of incidents. The severity of an incident will dictate the proper response. Predefined plans and traffic control strategies will govern. CMSs and radio broadcasts will be used for motorist information. State Patrol, Highway Helpers, towing services, maintenance personnel and emergency vehicles could be involved.

The Highway Helper program was initiated to remove stalled vehicles from the travelling roadway, assist stranded motorists and aid the State Patrol with incident management. There are presently six heavy duty pickup trucks that patrol 82 miles of the most congested freeway segments. The Highway Helper program currently operates on a portion of I-494 corridor. This program will be expanded during Module 1 to dedicate a person to the corridor.

Interagency agreements will produce predefined plans for a coordinated response to major incidents. These plans will identify preferred alternate routes for emergency types of freeway blockages. Participating local traffic officials are confident that sufficient spare capacity exists to temporarily divert traffic from I-494. Traffic flow on the alternate routes will be facilitated through traffic control measures that include signing, traffic adaptive signal coordination, and integration of freeway ramp and arterial signals. Traffic control measures will be supplemented through a comprehensive motorist information program. Specific tools that will be utilized include CMSs, static signing, motorist information stations, cable television, commercial radio (KBEM-FM) and HAR.

As part of a towing pilot project, three private organizations currently provide towing services in the corridor. Vehicles are dispatched after verification of an incident and the need for a tow. This pilot project will be expanded and the tow trucks will be dispatched concurrently with the State Patrol. These companies will also be asked to actively participate in the incident management strategy.

9.4 SPECIAL EVENT MANAGEMENT

An additional feature of the ICTM system will be its ability to manage planned, unusual or "special" events. Since control is integrated throughout the corridor, more effective movement both to and from the event can be achieved. Strategies will be developed and implemented for the entire corridor.

Examples of special events that have previously impacted the I-494 corridor include the World Series, Super Bowl, U.S. Open Golf Tournament and the opening of Bloomington's Mall of America. Major traffic generators affecting the corridor that consistently create special event traffic conditions include the Mall of America, the Met Center, the Mpls-St. Paul International Airport, Southtown Mall and Southdale Mall.

Several factors will influence the response that is made to special events. Among these factors are the size, frequency, time available for planning, and the vicinity of the event.

Many small special events will be automatically addressed by the adaptive control system. Adjustments will be made in response to fluctuations in traffic patterns and activities associated with the special event.

Large-scale special events will be addressed in a fashion that is similar to that previously described for major incidents. Predefined plans and motorist information systems will again be utilized. Traffic control measures such as signs and clearly identified alternate routes will be used. Special traffic control equipment from the Blaine Sports Center, the local community, and the Highway Helpers will be utilized whenever possible.

Special event traffic resulting from continuous generators such as the Mall of America will be addressed through a suite of predefined plans. These plans will be implemented either automatically in response to certain threshold parameters being met or through manual intervention by a system operator.

The flexibility of the adaptive control system easily allows for the rapid development and storage of special traffic plans for arterial control. Minimal advance notice will be required to develop these plans and others related to the integrated system. Generic plans will be developed to address events that do not allow advance preplanning. System operators will then modify the generic plans in response to the unique traffic conditions created by the event. Specific traffic control plans will not be developed for special event generators located outside of the corridor. System components such as the motorist information program, will be utilized, however, in an effort to facilitate travel into and out of the corridor.

A comprehensive incident management and special event plan will be developed in Module 1 of the project. An on-going process will be implemented in each module to continuously fine tune these plans. A planning group will be formed to discuss and apply the updates. The group will consist of representatives from Mn/DOT, Hennepin County, the Cities of Bloomington, Richfield and Edina, the State Patrol and local enforcement agencies. Representatives from the cable television and radio stations will also be asked to participate along with towing companies that service the corridor.

9.5 TRAVELER INFORMATION

Successful and timely delivery of information to corridor users will be necessary to accomplish the goals and objectives of the incident and special event strategies. An extensive motorist information network will be used for that purpose. The key components of this program will be fixed and portable CMSs, fixed route guidance signs, HAR, cable television, commercial radio and motorist information stations. While some new equipment will be required, a wealth of these devices currently exist and can contribute to the project.

A system of fixed CMS has already been implemented along the freeway segment of the corridor. This system will be supplemented with the placement of portable CMSs at other critical junctions within the corridor. Both Mn/DOT and other project participants have these portable signs. The flexibility provided by these portable devices will allow motorist information to be provided more closely to the location of incidents and special events.

Fixed alternate route guidance signs were designed during a previous attempt to provide an incident management plan for the corridor. These signs will serve as the foundation for the fixed signage component planned for the integrated corridor project.

Radio station KBEM (88.5 FM) currently provides updated traffic reports from Mn/DOT's TMC. KBEM's existing format will be enhanced to include alternate route advice during incidents and special events occurring in the corridor.

The local cable television provider will be approached during the motorist information planning process to seek its participation in the project. Information provided through cable television will permit motorists to make travel plans prior to their departure from home. Information stations located at major employment centers and key traffic generators will provide current travel condition information. These stations will consist of a simple display terminal that will provide constantly updated data.

9.6 EMERGENCY PRE-EMPTION

To maintain consistency throughout the State of Minnesota, a light-emitting system has been adopted as the standard for emergency vehicle pre-emption. The Cities of Bloomington and Richfield have extensively employed emergency pre-emption equipment within their jurisdictions. Upgrades with this system are planned on all existing routes scheduled for reconstruction in the corridor. There are five locations where the pre-empt system will be upgraded to conform with current standards.

The identical light-emitting system has been successfully interfaced with SCATS in Oakland County, Michigan. SCATS supports both passive and active pre-emption for emergency vehicles, rail road, transit and pedestrians. Emergency vehicle inputs are monitored by SCATS intersection traffic controllers. Upon receiving an emergency vehicle pre-empt demand, SCATS immediately relinquishes system control and allows the local controller to service the demand.

9.7 MULTI-MODAL APPLICATIONS

A variety of multi-modal applications exist, are planned or are under consideration for the corridor. Bus services are provided at major traffic generators and large employment centers. Future plans call for HOV lanes and several HOV ramp meter bypasses. These HOV lanes and ramps may be used by motorcycles, busses, and two-person car pools. Bike paths and walkways are included in the arterial reconstruction plans in the corridor.

Initial phases of the ICTM project will focus on using the previously referenced motorist information program to promote public transit services and provide pertinent corridor information to transit users. As additional multi-modal applications are introduced, methods will be explored to incorporate these applications into the integrated corridor.

9.8 ADVANCED TECHNOLOGIES

The current project plan contains multiple examples of advanced technology usage including video imaging, automated data collection, and license plate recognition and matching. Another application is the testing of incident detection algorithms on both freeway and arterial systems as they become available.

Video imaging will be used by the adaptive control strategy and as a method for automated data collection. A video imaging product will provide permanent loop detector emulation capabilities at six critical intersections and five freeway sites. Portable video imaging devices will also provide temporary detection at intersections under construction or experiencing failure of the permanent detection.

Data to be collected using video imaging will include volumes, speed, density, occupancy, queue length and vehicle classification. This information will be used for evaluation purposes and as a primary contributor to future development programs to enhance the performance of the integrated corridor.

License plate recognition and matching will be used to conduct travel time and origin-destination studies. Setting up the corridor with these advanced technologies will provide an opportunity to test other traffic control strategies as they evolve without major infrastructure modifications.

9.9 PUBLIC RELATIONS

The success of the ICTM concept will be determined by the general public's acceptance of the system. A comprehensive public relations campaign will be formulated during Module 1 and utilized throughout the project.

The plan will focus on the following:

Client Assessment: Mechanisms will be identified and utilized to determine client needs and assess the project's effectiveness from a user perspective. Potential techniques include questionnaires, surveys and focus group interviews.

Education: Various communications mediums will be identified and utilized to increase public awareness of the project and its purpose. Educational efforts will be targeted at specific clients including the general public, local community leaders and elected officials.

Community liaison: Existing community outreach programs will be used to educate the general public and solicit comments on the proposed project. Forums such as citizen's advisory groups will be targeted.

Tools: Potential tools such as brochures, community newsletters, cable television, the existing traffic management center radio channel, cable television, newspaper articles, press releases, town meetings and telephone hotlines will be evaluated and utilized to communicate with the general public.

9.10 PROJECT TRANSFERABILITY

ICTM project applications having potential transferability to other corridors either within the TCMA or around the country include:

- Overcoming inter-jurisdictional issues;
- Methods used to cooperatively manage and operate the corridor;
- A single system approach to freeway and arterial control;
- Enhancements to freeway and arterial control strategies;
- Special event and incident management plans and strategies;
- Methods for advanced incident detection;
- Use of advanced technologies to automate traffic data collection; and
- Live laboratory design.

10.0 GLOBAL BENEFITS

The potential benefits of an ICTM system are extensive and will be shared by cities, counties, the State, and the motoring public. A fully integrated corridor will provide a system that is responsive to all types of changing traffic conditions. Signal coordination across jurisdictional boundaries will result in more efficient, adaptive and flexible signal operations throughout the corridor during normal traffic flows, incidents, emergencies and special events. The integration of ramp meters and traffic signals will provide a physical alternative for short trips within the corridor and the movement of traffic temporarily diverted due to incidents. Public perception will be improved because of cooperative corridor management instead of independent jurisdictional control.

Each participating agency will be the recipient of substantially improved management and maintenance capabilities through on-line monitoring and programming features provided by the adaptive traffic control system. Real-time alarm indications are provided for high density (congestion), controller failures, detector failures and 23 other types of failures. For historical purposes, the system will also maintain a database of traffic data and system failures.

The motoring public will benefit from reduced delays, stops and travel times. Fewer stops will reduce gasoline consumption and air pollutants. The entire corridor will be safer due to quicker response and removal of incidents, a comprehensive motorist information program, an incident response team and motorist aid program. Quicker removal of incidents results in fewer secondary accidents and minimizes the duration and impact of incidents. The motorist information program will provide a mechanism for advising motorists of roadway conditions and incidents while driving or at major traffic generators.

Studies have shown that the use of adaptive traffic control in an arterial environment can reduce stops by 40%, delays by 20% and fuel consumption by 12% when compared to a fully optimized fixed time system. Simulated comparisons of adaptive traffic control and optimized fixed time systems in a similar environment have shown a reduction in air pollutant emissions of 7%.

While several "closed loop" systems have been introduced into the corridor, many intersections operate in an isolated mode. Based on this, the implementation of adaptive traffic control on intersecting arterial and alternate routes will produce reductions in stops, delays, fuel consumption and emissions that are significantly higher than the figures reported above.

11.0 PROJECT ADMINISTRATION

Administration of the ICTM project will occur within the existing committee structure of Minnesota Guidestar. The committee structure is designed to provide a clear chain of command and lines of accountability. A graphical representation of the Project Administration structure is provided in Figure 6. The specific project teams associated with the ICTM system have been highlighted.

Project Administration

Minnesota Guidestar Organizational Structure

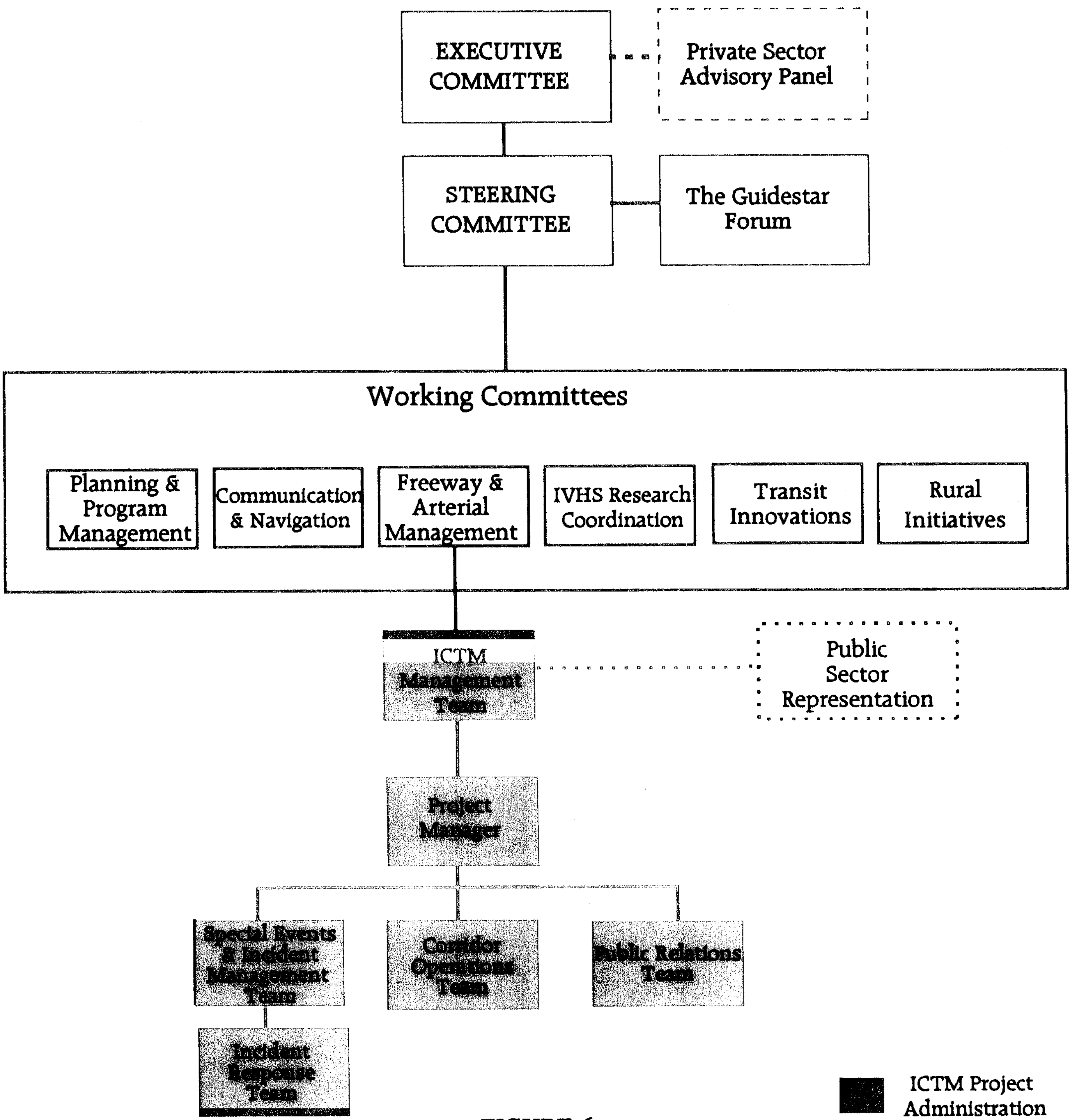


FIGURE 6

Guidestar's Executive Committee ensures that the program remains focused on its goals and objectives. This group also controls Guidestar's financial aspects and approves public/private partnership guidelines and agreements. The Steering Committee provides a structure for information exchange and managing multiple interdependent projects and partners. Committee members develop and maintain strategic plans, budgets and annual work plans. Guidestar's Freeway and Arterial Management Committee is the technical working committee associated with the ICTM project. Technical working committees coordinate, implement and manage Guidestar programs. Responsibilities include:

- Identifying operational tests and deployments,
- Developing project work plans,
- Preparing funding requests,
- Seeking appropriate project participants, and
- Coordinating and managing project implementation and evaluation activities.

The ICTM Management Team is an on-going committee that developed the ICTM concept and prepared this proposal. The management team is composed of representatives from the private and public sector, and academia. This team will be responsible for establishing the Special Events and Incident Management Team, Corridor Operations Team and Public Relations Team, and determining each team's roles and responsibilities. In conjunction with a consultant, the team will also finalize and implement the evaluation plan.

A full-time project manager will be appointed for the project and will serve as a liaison between the ICTM Management Team, other project teams, participating agencies and any outside contractors that are retained. Day to day financial management and reporting will also be the project manager's responsibility.

The special event and incident management team will develop the operational plans needed to handle both planned and unplanned events within the corridor, monitor effectiveness of plans, and develop recommendations for the placement of traffic control devices. The incident response team is the field group that is charged with implementing the incident and special event plans.

The public relations team is charged with developing and implementing a comprehensive motorist information and public relations plan. The public relations plan will address educational, marketing, and community liaison issues to most effectively promote the ICTM concept. The motorist information plan will recommend traffic generators and employment center sites, equipment and types of information disseminated.

The Corridor Operations Team will consist of operational and maintenance personnel from the participating agencies. This group will be responsible for developing and implementing an interagency plan for providing daily operation and maintenance of the ICTM System.

12.0 IMPLEMENTATION SCHEDULE

The proposed ICTM project staging has been separated into four major modules. Detailed information on these modules is provided in Table 1.

Staging for the ICTM control system was based on an extensive review of future construction plans for the corridor. Planned construction activities are detailed, by year, in Figure 7. The system integration for the traffic control components are depicted in Figure 8 and color coded by module. Below outlines the key components for each module:

Module 1

- Implementation of the adaptive control system hardware and software.
- Interface of 15 freeway interchange signals with the adaptive control system.
- Training for all participating agencies on the installation, maintenance and usage of the system.
- Development of incident management/special event, motorist information, public relations and evaluation plans.
- Expansion of Mn/DOT's Highway Helper program in anticipation of the forthcoming incident management plan.
- Implementation of video imaging at two critical interchange signals to provide detection and automated data collection capabilities.

Module 2

- Incorporation of 25 ramp meters into the adaptive control system.
- Training that focuses on the ramp metering portion of the system.
- Integration of the adaptive control system and the existing freeway management computer system.
- Implementation of five video imaging devices on the freeway segment of the corridor.
- Phase 1 implementation of the incident management/special event, motorist information and public relations plans.
- Evaluation of improvements derived from implementing the adaptive control system at interchange signals.
- Collection of before data necessary to evaluate future modules.

Module 3

- Integrated control of the total corridor with the addition of 42 intersecting arterial and parallel alternate signals to the adaptive control system.
- Training that focuses on city and county personnel who will be installing, maintaining, and using the adaptive control system.
- Expansion of video imaging to provide detection and automated data collection capabilities at four arterial signals.

ICTM PROJECT STAGING

TABLE 1

Components	Module 1	Module 2	Module 3	Module 4
System Integration	Regional Computer Regional Software Peripherals (7 sites) Interchange Signals 15 Nema/SCATS Logic Units Communication Costs Loop Detectors Est. six/intersection NEMA equipment Training/ Professional Services Installation/Operation/Maint.	TMC/SCATS Interface Software Develop. TMC Ramp Metering Strategy Ramp Meters 32 Interface Cards Communication Costs Detection @ Ramps 170 Training/ Professional Services Installation/Operation/Maint.	Alt. Route Signals 42 Nema/SCATS Logic Units Communication Costs NEMA equipment Training/ Professional Services Installation/Operation/Maint. Loop Detectors Est. six/intersection	
Incident Management	Incident Management Plan Motorist Aid Services	Traffic Management Devices Portable Traffic Control Equipment Portable Route Guidance Signs Motorist Aid Services	Traffic Management Devices Portable Traffic Control Equipment Portable Route Guidance Signs Motorist Aid Services	Permanent Guidance Signs Alt. Route Surveillance – 8 CCTV Motorist Aid Services
Special Events	Special Event Plan Portable Traffic Control Equipment Cones, Barricades, Signs Portable CMS	Utilize Blaine Sport Center Equipment Portable Traffic Control Equipment Cones, Barricades, Signs Portable CMS	Utilize Blaine Sport Center Equipment Portable Traffic Control Equipment Cones, Barricades, Signs Portable CMS	Utilize Blaine Sport Center Equipment Portable Traffic Control Equipment Cones, Barricades, Signs Portable CMS
Advanced Technology	Automated Data Collection/Flexible Detection/Incident Management 2 Interchange Signals, 4 cameras/int.	Freeway Component 5 Freeway Sites, 2 cameras/site ScopeServer Supervisory Computer	Intersection Component 4 intersections, 4 cameras/intersection Workstation	
Motorist Information	Use Existing Motorist Information Tech. Develop Motorist Information Plan		Terminals/Monitors Major Employment Centers 5 sites	Terminals/Monitors Major Traffic Generators 6 sites
Emergency Pre–empt	Install New Opticom System Penn & 494 Contract 77th Street Project	Install New Opticom System Penn & 494 Contract 77th Street Project	Upgrade Older Opticom System (5 Phase Selector to 262 Card)	
Public Relations	Public Relations Plan	Marketing & Education Newspaper Ads Radio Advertising/Public Radio	Marketing & Education Newspaper Ads Radio Advertising/Public Radio	Evaluate Marketing Effort Radio Advertising/Public Radio User Assessment

PLANNED CONSTRUCTION ACTIVITIES BY YEAR

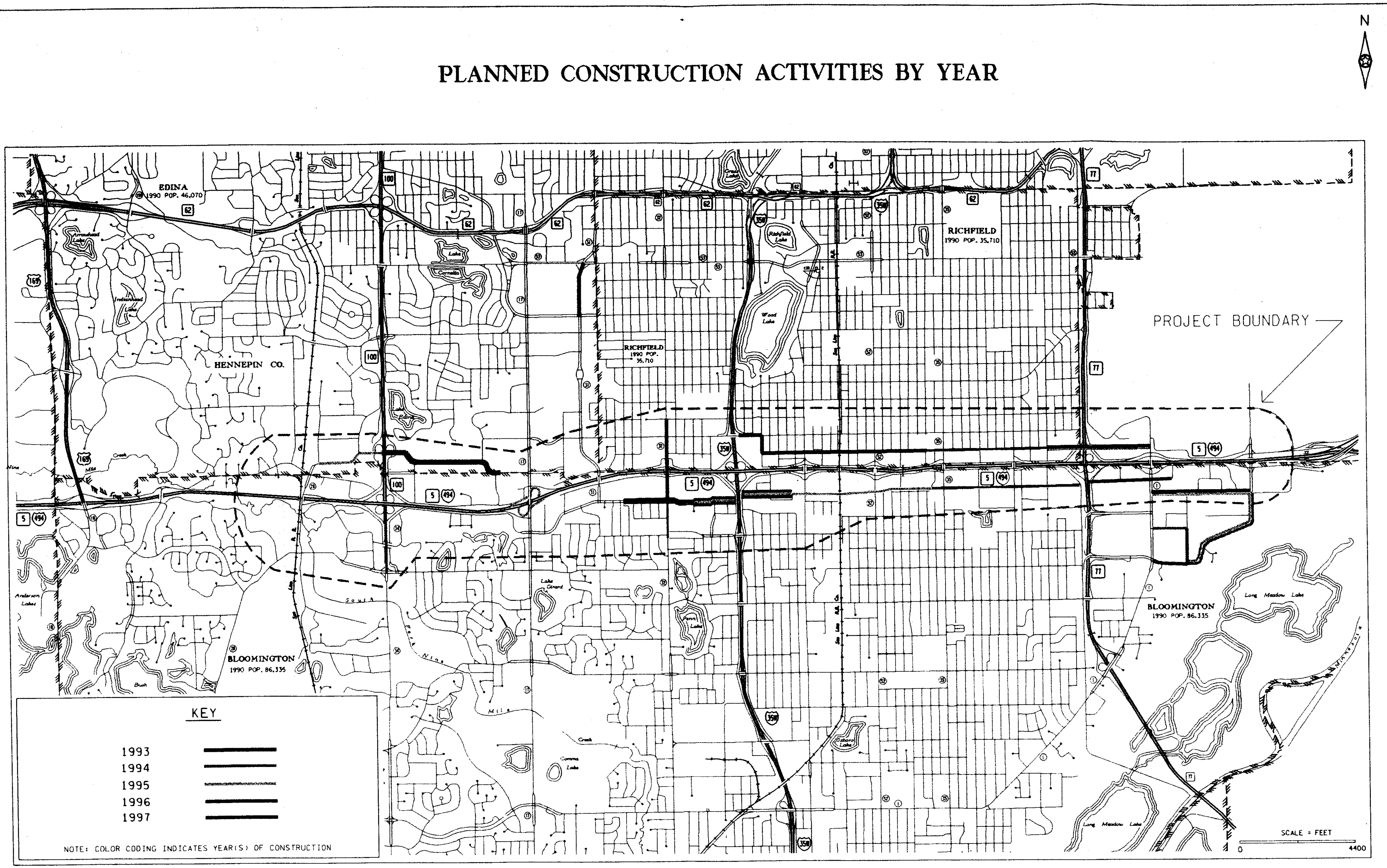


FIGURE 7

ICTM PROJECT STAGING - SYSTEM INTEGRATION

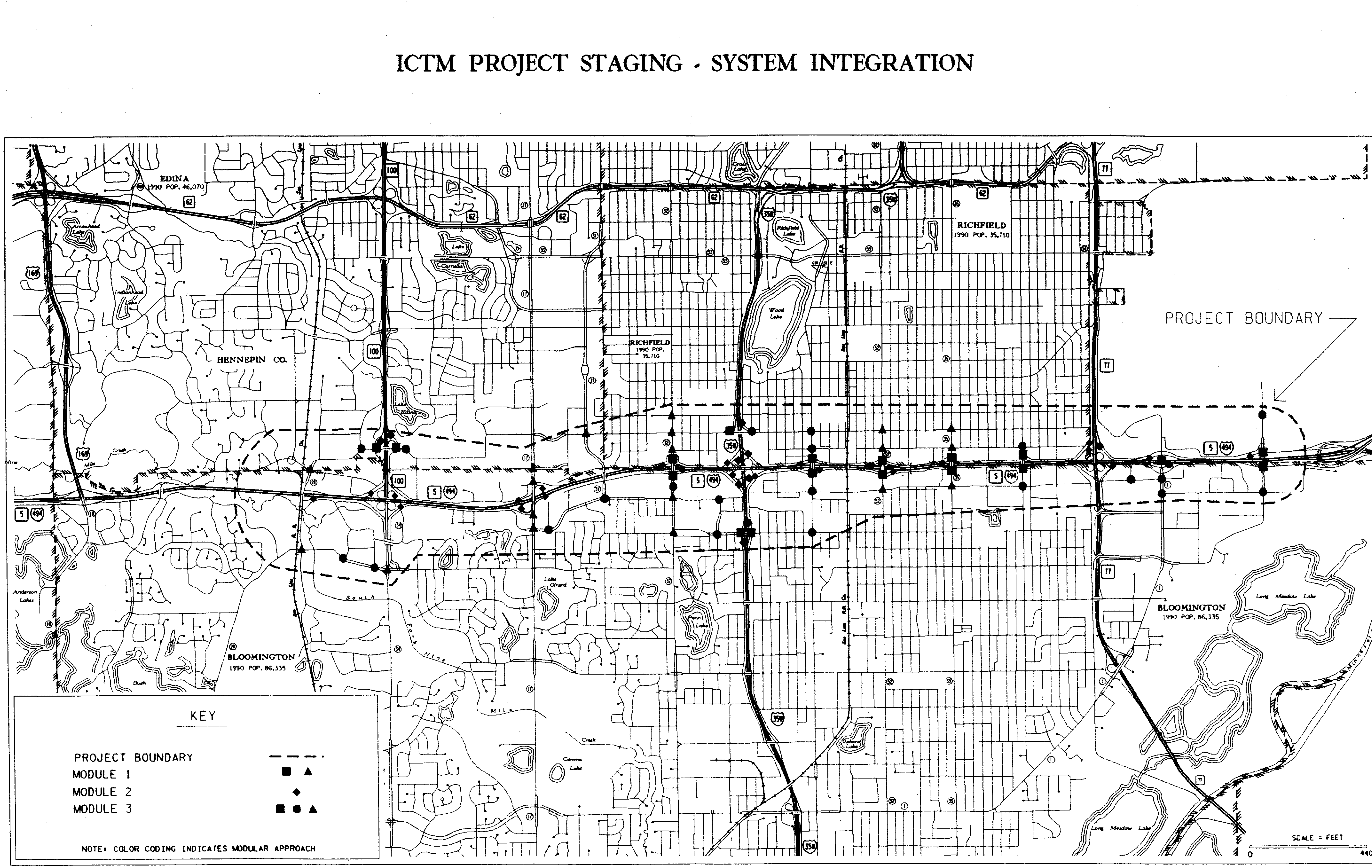


FIGURE 8

- Expanded implementation of incident management/special event and public relations plans.
- Expansion of the motorist information program to include information centers at major employment centers within the corridor.
- Evaluation of the improvements achieved through integrated control of ramp metering and interchange signals.
- Collection of before data at intersecting arterial and parallel alternate routes.

Module 4

- Addition of a fixed signing system to provide alternate route guidance information.
- Expansion of the motorist information program to include information centers at shopping centers and other major traffic generators.
- Performance of marketing research to determine user satisfaction with the system.
- Completion of the system evaluation.
- Preparation of the final report.

The ICTM project schedule is shown in Table 2 with time lines indicated for major activities. The schedule indicates a four year time frame from project initiation. Project duration is subject to change based on equipment deliveries, plan preparation, and weather.

13.0 EVALUATION

An evaluation strategy has been developed to observe the effects of ICTM on the efficiency of traffic movement through the corridor. The evaluation of module components will begin immediately upon funding approval. The intent of the evaluation program is to provide an analysis of the effectiveness of module components prior to implementation of subsequent modules.

Subject to U.S. Department of Transportation approval, an independent evaluator will be chosen by the ICTM Management Team to initiate the evaluation plan. The evaluator will be responsible for the refinement of the operational test goal and its objectives as well as the detailed design of the evaluation plan. The plan is subject to approval of the U.S. DOT to ensure the methodologies and data collected are relevant and useful in the determining the effectiveness of operational test objectives.

The planning group identified four primary objectives for testing the ICTM concept in the I-494 Corridor. They are:

- Implement a corridor-wide adaptive traffic control system;

- Demonstrate an interjurisdictional approach to managing traffic flow and operating the traffic control system within the I-494 Corridor;

ICTM PROJECT SCHEDULE
TABLE 2

MONTH	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48
PROJECT MANAGEMENT																
Motorist Aid																
ICTM Management Teams																
MODULE 1																
Preliminary Engineering																
Environmental Documenation																
Peliminary Design																
Study Design																
Detail Design																
Plan and Specification																
Corridor Management Plans																
Motorist Information Plan																
Public Relation Plan																
Special Event / Incident Management Plan																
Construction and Contract Adminstration																
Regional Computer, Software, and Peripherals																
Video Technology – Interchange Signals																
Interchange Controls and Loop Detectors																
CMS's																
Adaptive Control Training																
NEMA Equipment																
Operational Test																
Evaluation																
Before and After Data Collection																
Data Analysis and Status Report																
MODULE 2																
Preliminary Engineering																
Environmental Documenation																
Peliminary Design																
Study Design																
Detail Design																
Plan and Specification																
Construction and Contract Adminstration																
Video Technology – Freeway																
Ramp Meter Interface Card and Detectors																
Software Integration																
CMS's																
Adaptive Control Training																
170 Equipment																
Operational Test																
Evaluation																
Before and After Data Collection																
Data Analysis and Status Report																
Implement Corridor Plans																
MODULE 3																
Preliminary Engineering																
Environmental Documenation																
Peliminary Design																
Study Design																
Signal Justifaction Report																
Detail Design																
Plan and Specification																
Construction and Contract Adminstration																
Video Technology – Alternate Routes																
Alternate Route Controller and Detectors																
Information Booths at Employment Centers																
Adaptive Control Training																
NEMA Equipment for Cities and Counties																
Operational Test																
Evaluation																
Before and After Data Collection																
Data Analysis and Status Report																
Implement Corridor Plans																
MODULE 4																
Preliminary Engineering																
Environmental Documenation																
Peliminary Design																
Study Design																
Detail Design																
Plan and Specification																
Construction and Contract Adminstration																
Permanent Signing																
CCTV																
Information Booths at Traffic Centers																
Operational Test																
Evaluation																
Before and After Data Collection																
Data Analysis and Status Report																
Implement Corridor Plans																
User Assessment Survey																

- Utilize advanced technologies in operating the ICTM system; and

- Provide motorists with real-time traffic information.

Most of the components of the operational test can be evaluated objectively. Some subjective analysis will be required for the evaluation of operational plans (e.g. Incident Management Plan, Motorist Information Plan, etc.) and measuring the effectiveness of inter-jurisdictional cooperation/coordination.

Evaluation Methodology

The evaluation methodology is represented in Table 3, "ICTM Evaluation Process". Project deliverables, evaluation criteria, before/after data, and methods for collecting data are shown by module. Analysis of Benefit/Cost relationships will be done with respect to each of the project components. The intent is to collect consistent traffic data (eg. travel time, delay, occupancy, and volume, accidents) at critical locations throughout the various modules so that a uniform evaluation approach can be achieved.

As the number of ICTM components that could have an effect on efficiency are many, great care will be taken to identify specific measures of effectiveness for each of the ICTM components. The modular approach to implementing ICTM should help in isolating component effects.

Module 1

The first step toward the integration of the traffic control system in the I-494 Corridor is to implement adaptive control on 15 ramp-terminal signals. Several MOEs have been identified for evaluating the effect of adaptive control on traffic flow (changes in Level of Service, LOS) at the ramp terminals including stops, delays, volumes, queue lengths, and turning movements. Before-data will be collected by traditional methods at seven predefined locations prior to implementation of the adaptive control system. After-data will be collected at the same locations using advanced technologies whenever possible. The adaptive control system can be programmed to emulate traffic control conditions before implementation. An optional automated methodology is available for the collection of before-data. This option will be tested as part of Module 1 for possible future uses.

The implementation of the operational plans (e.g. incident/special events management, public relations, and motorist information) will take place in later modules. Data collection for these operational plans will be collected as part of Module 1. An analysis of the development of operational plans will be used as a MOE for the evaluation of inter-jurisdictional coordination.

Data from other agencies will also be collected. Information on system failures, maintenance logs and complaints will be tracked as will the TMC Incident Log and Department of Public Safety accident data. Travel times will be recorded and before/after data compared. Air quality will be modeled with before/after conditions.

ICTM EVALUATION PROCESS

TABLE 3

	Project Deliverables	Evaluation Criteria	Before/After Data	Methodology Traditional	Adv. Tech
Module 1	Incident Management Plan	Interchange Daily Operations	Volume		x
	Special Event Plan	Atypical Operations	Turning Movement		x
	Public Relations Plan	SCAT Evaluation/LOS etc.	Stops		x
	Status Report	User Assessment	Delays		x
	15 Interchange Signals under	Incidents Impacts	Queue Length		x
	SCATS Control	Motorist Aid Services	System Failures		x
	Agencies Access to System	Fulfill Milestones	Maintenance Log	x	
	SCATS Training on Nema equip.	Environmental Critera	Problem Log–Complaints	x	
	Motorist Inf. Plan		Occupancy Data		
	Apply existing TDM Strategies		Accidents /Incident data	x	
	Data Collection Process		Air Quality	x	
			Travel Times	x	
			Ramp Occupancy–Loop		x
Module 2	Status Report	Daily Operation of Ramp Meters	Volume		x
	32 Ramp Meters under SCATS Control	Monitor & Log Problems	Turning Movement		x
	Ramp/Signal Interface	Incidents Log	Stops		x
	Plan Implementation	Corridor Metering Efficiency	Delays		x
	Utilize Blaine Project Successes	Plan Effectiveness	Queue Length		x
	Adv. Tech. Application on Freeway	Motorist Inf.	System Failures		x
	SCATS training on 170 Equipment	Public Relations	Maintenance Log	x	
		Special Event	Problem Log–Complaints	x	
		Incident Mgt.	Occupancy Data		
		LOS	Accidents /Incident data	x	
		Trip Diversion	Air Quality	x	
		Fulfill Milestones	Travel Times		x
		Environmental Criteria	Ramp Occupancy–Loop		x
Module 3	Status Report	SCATS Operation on Alt. Route	Volume		x
	SCAT Control on Alt. Route Signals	System Operations	Turning Movement		x
	SCATS Training on Nema equipment – Local	Monitor & Log Problems	Stops		x
	Corridor Diversions	Incidents Log	Delays		x
	Motorist Inf. @ Major Employment Centers	Impact of Incident Mgt Plan	Queue Length		x
	Adv. Tech. on Arterial System	LOS	System Failures		x
		Trip Diversion	Maintenance Log	x	
		Fulfill Milestones	Problem Log–Complaints	x	
		Environmental Criteria	Occupancy Data		
			Accidents /Incident data	x	
			Air Quality	x	
			Travel Times		x
			Ramp Occupancy–Loop		x
Module 4	Final Report	Corridor Evaluation	Volume		x
	Permanent Signing on Alt. Routes	Agency Assessment	Turning Movement		x
	Motorist Inf. at Traffic Generators	User Assessment	Stops		x
	Corridor System In–place	Benefit/Cost Relationships	Delays		x
			Queue Length		x
			System Failures		x
			Maintenance Log	x	
			Problem Log–Complaints	x	
			Occupancy Data		
			Accidents /Incident data	x	
			Air Quality	x	
			Travel Times		x
			Ramp Occupancy–Loop		x

The Module 1 Evaluation Report will include benefit/cost relationships with respect to the implementation of adaptive control at ramp-terminal signals. Improvements in traffic flow characteristics are anticipated. The report will also assess the value of inter-jurisdictional coordination/cooperation in the development of the various operational plans to be implemented in subsequent modules.

Module 2

The evaluation strategy for Module 2 will include further evaluation of components in Module 1. The evaluation will be expanded to include an assessment of the integration of 32 ramp meters with the ramp-terminal signals under the adaptive control system. Incident/special event management plans and advanced technologies for data collection will be evaluated. An assessment of diversions (changes in travel patterns) as a possible result of expected changes in the interaction between ramp-terminal signals and ramp meters will be attempted.

Evaluation criteria to be used in Module 2 are changes in freeway LOS, the interaction between ramp meters and interchange signals, failed cycles at ramp-terminal signals, ramp-meter timing, average lengths of queue at ramp-meter signals within the metering zone, and the effects of Incident/Special Events Management Plans.

The effectiveness of portable CMSs and other special event management tools will be demonstrated as part of the National Sports Center (NSC) operational test. Successful special events management devices demonstrated as part of that test will be incorporated into the special events management plan for the I-494 Corridor. The transferability of NSC devices to the I-494 Corridor will then be assessed.

A focus of the Module 2 Evaluation Report will be the benefit/cost relationships associated with the integration of ramp-meter and ramp-terminal signals. Anticipated benefits due to the elimination of failed cycles at the ramp- terminal signals and adaptive ramp meter control include a two percent reduction in stops and a five percent reduction in delay. The report will also assess the value of elements of operational plans implemented.

Module 3

System integration will continue in Module 3. Evaluation strategies for previous modules will be expanded to include the integration of 42 alternative route traffic signals with the 47 other traffic control devices operated as part of the adaptive control system.

Evaluation criterion will be expanded to include changes in LOS on alternative routes, changes in adaptive control system operations, hierarchy for adaptive control overrides, and the impacts of Incident Management, Special Events Management, Public Relations, and Motorist Information Plans.

Module 4

The evaluation strategy for Module 4 will be expanded to include the evaluation of alternative route static signing, CMSs on intersecting arterial routes, and the effect of providing motorist information at local traffic generators.

Evaluation criteria added to those identified for previous modules include corridor operations, cooperation among agencies involved in the operational test, and user/motorist and operating agency benefits.

A final report assessing the effectiveness of ICTM will be offered one year after the implementation of Module 4.

14.0 PROJECT FUNDING

The cooperation and commitment of project participants is evident in the funding section. Local governmental agencies and the private sector are contributing professional services, equipment, and resources toward the project. Table 4 gives the ICTM project cost estimate by module along with a cost breakdown by project participant.

The overall ICTM project cost is approximately $7 million dollars with each of the four modules ranging from 1.3 to 2.5 million. The cost split is 70% federal with 30% shared by the local and private sector. The summary does not include cash contributions by each organization, but this figure will be available in the future.

An itemized cost estimate (reference Table 5) provides the hard and in-kind contributions by organization. The contributions by project participants is summarized below.

Each jurisdiction will install and configure controllers for the ramp meters and traffic signals, conduct data collection, furnish and install all permanent traffic control signs, perform construction inspection and administration and support the on-going system operation.

Mn/Dot and Hennepin County will acquire and deploy traffic control equipment to be used for special event and incident management, and contribute staff resources to project design.

Hennepin County will provide materials and labor for the installation of additional detection on the alternate routes.

Mn/DOT will contribute staff resources for a Project Manager, project documentation, system integration and motorist aid services.

Mn/DOT, Hennepin County and the City of Bloomington will install pole extensions and/or wood poles as needed to facilitate advanced technology applications.

ICTM PROJECT COST ESTIMATE
TABLE 4

Components	Module 1	Module 2	Module 3	Module 4	Cost Estimate	Cost Participation			Component Totals
						Federal	Local	AWATSA	
System Integration	$539,400	$360,040	$1,121,000	$325,000	$2,345,440	$1,877,540	$359,600	$108,300	$2,345,440
Regional Computer, software & peripherals Interchange and Alt. Route Signals TMC/SCATS Interface Software Develop. Professional Services and Training Communication Hardware									
Incident Management/ Special Events	$138,000	$185,000	$105,000	$402,250	$830,250	$411,900	$418,350	$0	$830,250
Incident Management & Special Event Plan Motorist Aid Services Traffic Management Devices Permanent Guidance Signs Alternate Route Surveillance									
Advanced Technology	$131,200	$219,000	$500,000	$0	$850,200	$781,200	$69,000	$0	$850,200
Licence Plate Matching Freeway Component Intersection Component									
Travelers Information	$158,000	$130,000	$175,000	$210,000	$673,000	$566,000	$107,000	$0	$673,000
CMS Motorist Information Plan Terminals/Monitors									
Emergency Pre-empt	$0	$0	$25,000	$0	$25,000	$0	$25,000	$0	$25,000
Project Development	$323,400	$245,600	$261,800	$204,800	$1,035,600	$660,000	$375,600	$0	$1,035,600
Predesign Design Project Evaluation Final Project Report Construction Inspection & Administration Data Collection									
Operating Costs	$206,990	$199,040	$292,030	$322,030	$1,020,090	$263,000	$740,230	$16,860	$1,020,090
Staffing Maintenance Customer Service Corridor Management Teams Utilities Public Relations									
Total Costs	$1,496,990	$1,338,680	$2,479,830	$1,464,080	$6,779,580	$4,559,640	$2,094,780	$125,160	$6,779,580

ICTM ITEMIZED COST ESTIMATE
TABLE 5

Components	# of Units	Unit Cost	Total	Federal	HARD MATCH: Mn/DOT	HARD MATCH: Hennepin County	HARD MATCH: City of Bloom.	HARD MATCH: City of Edina	HARD MATCH: City of Richfield	HARD MATCH: AWATSA	IN-KIND PARTICIPATION: Mn/DOT	IN-KIND PARTICIPATION: Hennepin County	IN-KIND PARTICIPATION: City of Bloom.	IN-KIND PARTICIPATION: City of Edina	IN-KIND PARTICIPATION: City of Richfield	IN-KIND PARTICIPATION: AWATSA
Adaptive Control																
Regional Computer	1	57,000	57,000	51,300						5,700						
Regional Software	1	125,000	125,000	112,500						12,500						
Peripherals	7	4,500	31,500	28,350						3,150						
Logic Units	57	3,700	217,900	185,850	4,000	3,200	3,000	400	800	20,650						
Loop Detectors	367	600	220,200	69,000		151,200										
Training & Prof. Services	3	551,840	551,840	463,500						51,500	15,880	5,840	5,840	4,640	4,640	
170 Interface Cards	38	2,200	83,600	68,400	7,600					7,600						
Interface Software	1	84,200	84,200	64,800	12,200					7,200						
Communication Hardware	95	400	38,000	38,000												
Subtotal:			$1,409,240	$1,081,700	$23,800	$154,400	$3,000	$400	$800	$108,300	$15,880	$5,840	$5,840	$4,640	$4,640	$0
Infrastructure																
Communication System																
Fiber Optics	1	1,000,000	1,000,000	800,000	200,000											
Interconnect	1	295,700	295,700	295,700												
CCTV	8	16,000	128,000	102,400	25,600											
Advanced Technology																
Data Collection Devices		11,200	11,200	11,200												
Licence Plate Matching		200,000	200,000	200,000												
Video Technology																
Freeway Component	5	43,800	219,000	210,000	9,000											
Intersection Component	6	70,000	420,000	360,000		30,000	30,000									
Pre-empt 262 cards	5	5,000	25,000				25,000									
Subtotal:			$2,298,900	$1,979,300	$234,600	$30,000	$55,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Motorist Aid																
Incident Management Plan	1	45,000	45,000	45,000												
Towing Service	1	5,000	5,000								5,000					
Highway Helper Program	1	88,000	88,000								88,000					
Traffic Management Devices																
Portable Traffic Control Equip.	1	50,000	50,000		50,000											
Portable CMS	6	40,000	240,000		160,000	80,000										
Guidance Signs		9,750	9,750		2,250	3,750	3,750									
LCD/VCM Signs	12	15,000	180,000	180,000												
CMS	2	130,000	260,000	208,000	52,000											
Motorist Info. Plan	1	28,000	28,000	28,000												
Information Centers																
Traffic Generation	6	10,000	60,000	60,000												
Employment Center	5	10,000	50,000	50,000												
Subtotal:			$1,015,750	$571,000	$264,250	$83,750	$3,750	$0	$0	$0	$93,000	$0	$0	$0	$0	$0
Operating Costs																
Staffing	2	87,000/yr	348,000	168,000							180,000					
Rental Costs	2	20,000	40,000				40,000									
Customer Relations	4	15,000	60,000								15,000	15,000	15,000	7,500	7,500	
System Maintenance	4	12,000	48,000								12,000	12,000	12,000	6,000	6,000	
Utilities		264,600	264,600		131,940		77,880	19,140	35,640							
ICTM Management Teams			164,490								62,180	24,240	21,360	21,330	21,330	14,050
Public Relations		95,000	95,000	95,000												
Subtotal:			$1,020,090	$263,000	$131,940	$0	$117,880	$19,140	$35,640	$0	$269,180	$51,240	$48,360	$34,830	$34,830	$14,050
Project Development																
Preliminary Design		90,000	90,000	90,000												
Detail Design		300,000	300,000	220,000							40,000		40,000			
Construction Inspection & Admin.		200,000	200,000								116,800	36,000	33,700	4,500	9,000	
Project Evalutation		290,000	290,000	290,000												
Data Collection & Analysis		95,600	95,600								41,840	18,840	18,440	7,840	8,640	
Interim & Final Reports		60,000	60,000	60,000												
Subtotal:			$1,035,600	$660,000	$0	$0	$0	$0	$0	$0	$198,640	$54,840	$92,140	$12,340	$17,640	$0
Total Costs			$6,779,580	$4,555,000	$654,590	$268,150	$179,630	$19,540	$36,440	$108,300	$576,700	$111,920	$146,340	$51,810	$57,110	$14,050

Local agencies will participate in the development and implementation of Special Event, Incident Management, and Public Relations Plans. Agencies will also participate in corridor management teams and adaptive control training.

AWATSA will contribute 10% of the adaptive control system components to the project. The match will be for professional services, hardware, training and system integration by AWA personnel. AWATSA also contributed technical support and staff time for corridor evaluations and proposal preparation that is equal to Mn/DOT's cash contribution.

A far greater contribution is the willingness of the local jurisdictions to utilize the existing infrastructure for the operational test. While the value of this contribution is very hard to quantify, the ICTM concept could not be achieved without it. Each organization is agreeing to cooperatively manage and operate the corridor for the more efficient movement of people.

The infrastructure plays a critical role in corridor management. The existing or planned construction within the corridor exceeds $127 million not including right of way acquisitions from some Bloomington and Edina Projects. Refer to Appendix C for specific project costs and descriptions. This amount does not include the reconstruction cost of I-494 which is expected to exceed $750 million. The reconstruction of I-494 is planned to start in 1998. The infrastructure contribution will continue to grow as the corridor is improved through construction activities on the freeway and alternate routes.

15.0 APPENDICES

Appendix A:

Corridor Capacity Deficiencies 2010 No-Build
Corridor Capacity Deficiencies 2010 Build
I-494 Forecasted AADT 2010

Appendix B:

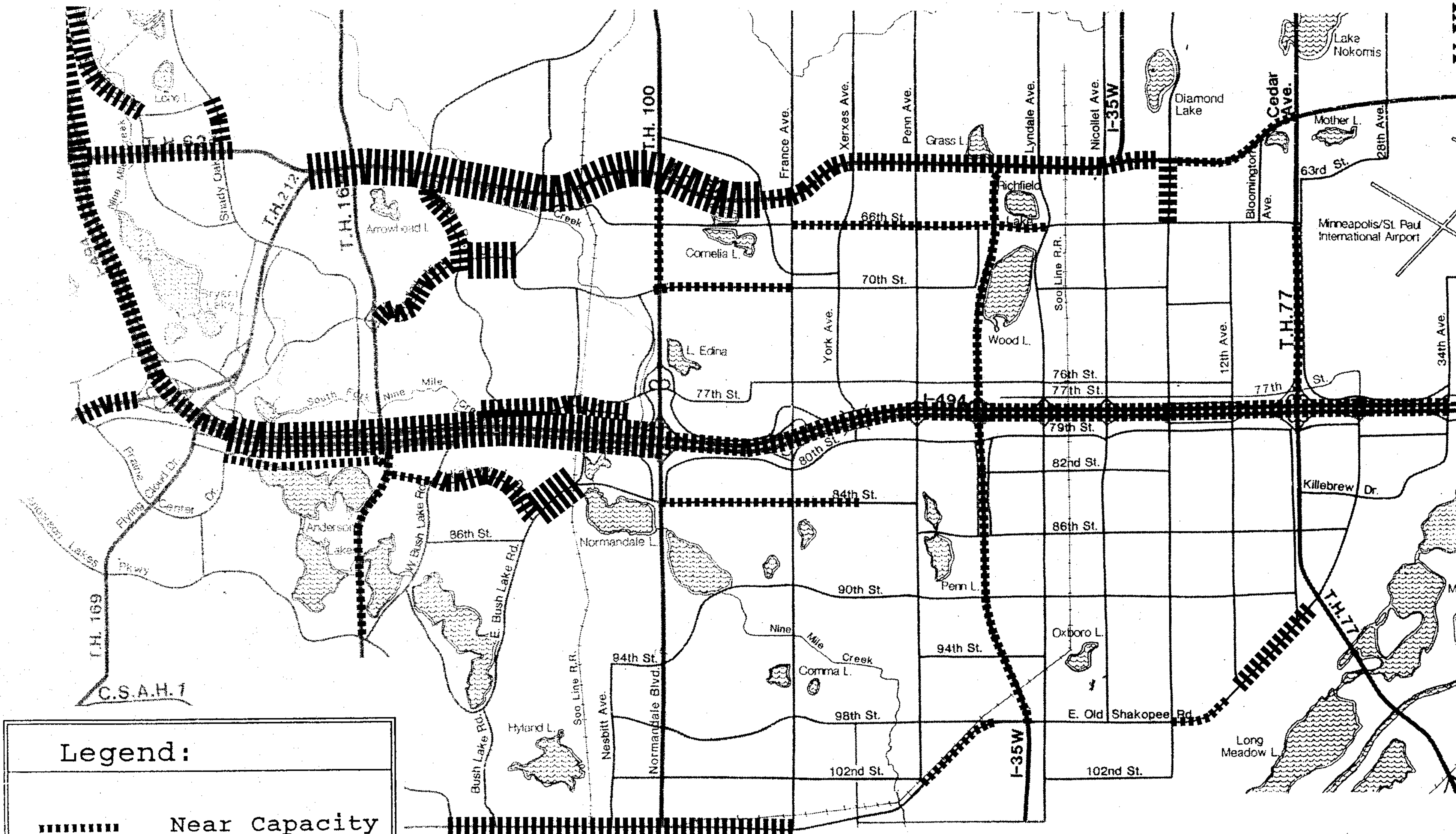
Adaptive Control System References

Appendix C:

ICTM Construction Projects within Corridor

CORRIDOR CAPACITY DEFICIENCIES

2010 NO - BUILD



Legend:

- Near Capacity
- At Capacity
- Above Capacity

FIGURE 9

CORRIDOR CAPACITY DEFICIENCIES

2010 BUILD

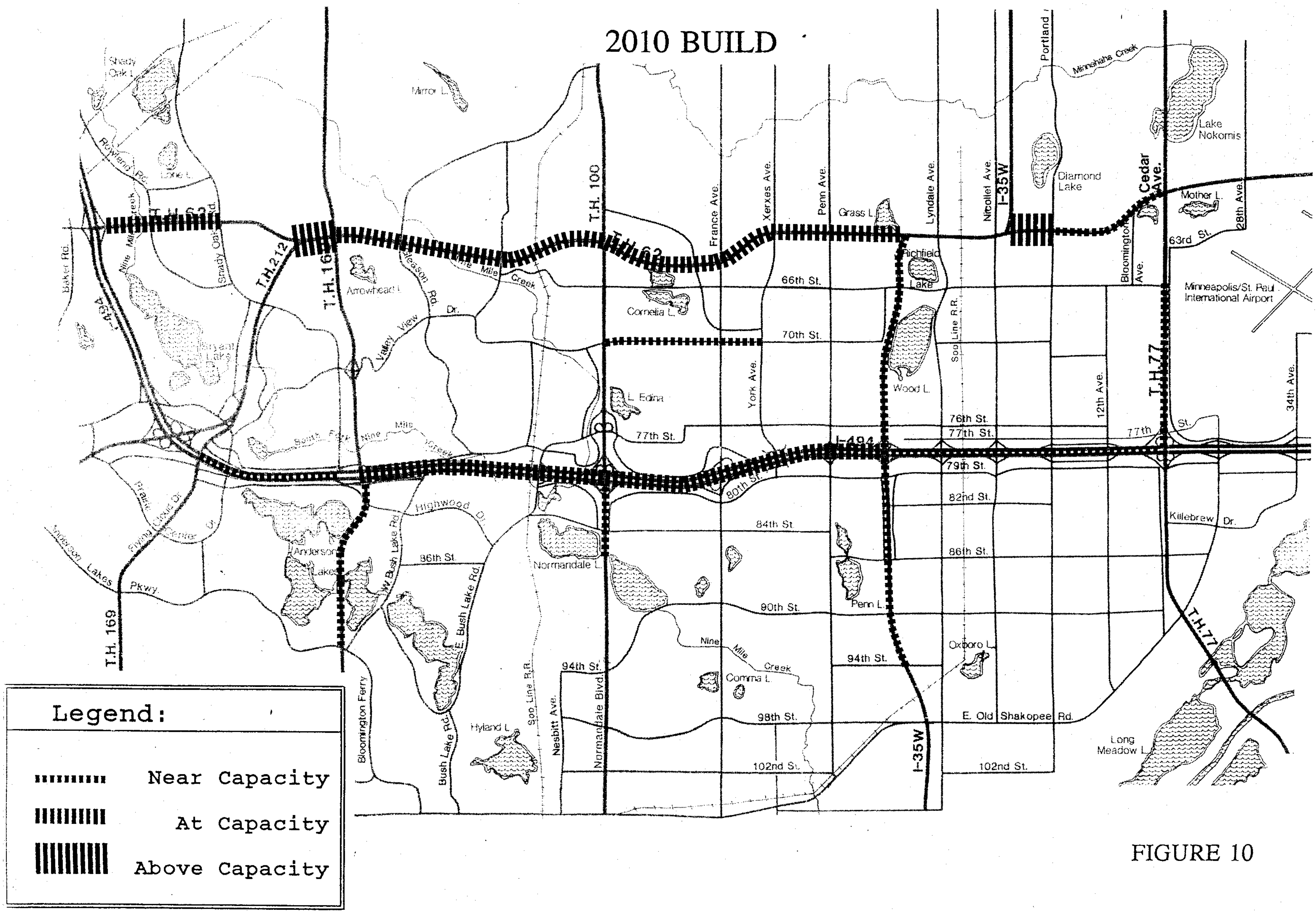
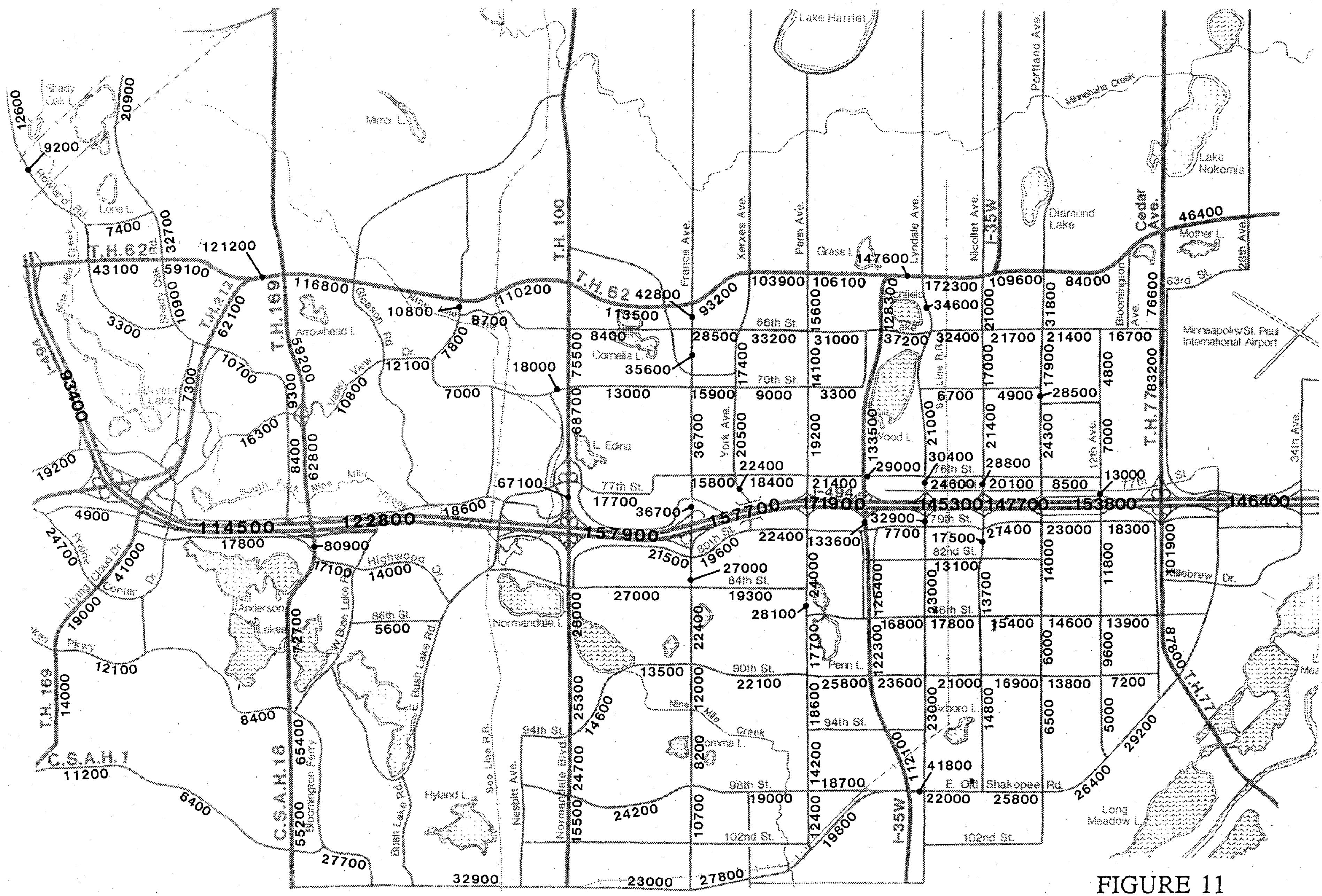


FIGURE 10

I - 494 FORECASTED AADT

2010



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APPENDIX C

ICTM Construction Projects

TABLE 6

REF	PROJECT	PROJECT COST	YEAR/ MODULE	FHWA	Mn/DOT	HENN COUNTY	City of BLMGTON	City of RICHFIELD	City of EDINA
M-1	I494--Traffic Mgmt Sys @ France								
	Construction Cost	$2,000,000	1996	$1,800,000	$200,000				
	Right-of Way Cost								
	Design/Inspection Cost	$360,000		$324,000	$36,000				
M-2	I494--Minn. River to I394 (Stage 1)								
	Construction Cost	$30,000,000	1997	$27,000,000	$3,000,000				
	Right-of Way Cost								
	Design/Inspection Cost	$5,400,000		$4,860,000	$540,000				
M-3	I494--Replace Ramp Signals (10)								
	Construction Cost	$900,000	1994	$810,000	$90,000				
	Right-of Way Cost								
	Design/Inspection Cost	$162,000		$145,800	$16,200				
M-4	I494--Signals @ Bush Lk Rd								
	Construction Cost	$180,000	1994	$162,000	$18,000				
	Right-of Way Cost								
	Design/Inspection Cost	$32,400		$29,160	$3,240				
R-1	77th St--I35W to Portland (I)								
	Construction Cost	$7,790,000	1993-94	$6,232,000	$1,558,000				
	Right-of Way Cost	$5,868,000	1992-93	$2,828,800	$707,200			$2,332,000	
	Design/Inspection Cost	$843,000	1992	$629,600	$157,400			$56,000	
R-2	77th St--Portland to Cedar Ave (II)								
	Construction Cost	$8,200,000	1994	$6,560,000	$1,640,000				
	Right-of Way Cost	$4,360,000	1993-94	$3,488,000	$872,000				
	Design/Inspection Cost	$955,000	1993	$764,000	$191,000				
R-3	77th St--Cedar Ave to 24th Ave (III)								
	Construction Cost	$10,000,000	1995-96	$8,000,000	$2,000,000				
	Right-of Way Cost	$5,402,000	1994-95	$4,321,600	$1,080,400				
	Design/Inspection Cost	$1,800,000		$1,440,000	$360,000				
H-1	Penn Ave--75th to 80th								
	Construction Cost	$2,734,000	1993			$1,499,000	$636,000	$600,000	
	Right-of Way Cost	$2,500,000				$1,250,000	$450,000	$800,000	
	Design/Inspection Cost	$492,120				$269,820	$114,480	$108,000	
H-2	Penn Ave--80th to Dixon (Pav't rehab)								
	Construction Cost	$115,000	1994			$115,000			
	Right-of Way Cost								
	Design/Inspection Cost	$20,700				$20,700			
E-1	Indust Blvd--W Bush Lk Rd to TH 100								
	Construction Cost	$572,000	1995						$572,000
	Right-of Way Cost								
	Design/Inspection Cost	$102,960							$102,960
E-2	W 77th-- TH 100 to Minn Dr								
	Construction Cost	$590,000	1996-97						$590,000
	Right-of Way Cost								
	Design/Inspection Cost	$106,200							$106,200
B-1	W 80th--Thomas Ave to Morgan Ave								
	Construction Cost	$4,940,000	1993				$4,940,000		
	Right-of Way Cost								
	Design/Inspection Cost	$889,200					$889,200		
B-2	W 80th/79th--Morgan Ave to Bryant Ave								
	Construction Cost	$9,400,000	1997	$4,000,000	$3,500,000		$1,900,000		
	Right-of Way Cost								
	Design/Inspection Cost	$1,692,000		$720,000	$630,000		$342,000		
B-3	W 79th--Bryant Ave to Pleasant Ave								
	Construction Cost	$9,000,000	1996	$7,200,000			$1,800,000		
	Right-of Way Cost								
	Design/Inspection Cost	$1,620,000		$1,296,000			$324,000		
B-4	E 79th--Pleasant Ave to 5th Ave								
	Construction Cost	$9,000,000	1994	$7,200,000			$1,800,000		
	Right-of Way Cost								
	Design/Inspection Cost	$1,620,000		$1,296,000			$324,000		
B-5	E 79th--5th Ave to TH 77								
	Construction Cost	$7,000,000	1995	$5,600,000			$1,400,000		
	Right-of Way Cost								
	Design/Inspection Cost	$1,260,000		$1,008,000			$252,000		
B-6	E 80th --24th Ave to 34th Ave								
	Construction Cost	$1,800,000	1996				$1,800,000		
	Right-of Way Cost								
	Design/Inspection Cost	$324,000					$324,000		
	TOTALS	$140,030,580		$97,714,960	$16,599,440	$3,154,520	$17,295,680	$3,896,000	$1,371,160
	PERCENT OF TOTAL PROJECT COSTS			69.78%	11.85%	2.25%	12.35%	2.78%	0.98%

REF	PROJECT
M-1	**I494--Traffic management system at France Avenue.** Includes: 1) Reconstruction of the entrance ramps at the I494/France interchange and meter bypasses for all entrance ramps. 2) Traffic management system including new communications medium, fiber optics cable, meters, cabinets, etc. **Cost:** **Construction:** $2,000,000 in 1996(90% Federal/10% State). **R/W:** None required. **Design/Inspection:** 18% of construction cost.
M-2	**I494--Minnesota River to I394.**--Major reconstruction, includes grading, surfacing and bridges. **Cost:** **Construction:** $30,000,000 in 1997 (90% Federal/10% State). **R/W:** **Design/Inspection:** 18% of the construction cost.
M-3	**I494--Signal Construction.** Includes replacement of: 1) Two ramp signals at 12th Avenue 2) Two ramp signals at Portland Avenue 3) Two ramp signals at Nicolett Avenue 4) Two ramp signals at Lyndale Avenue 5) Two ramp signals at Penn Avenue. **Cost:** **Construction:** $90,000/signal--Total $900,000 in 1994 (90% Federal/10% State). **R/W:** None required. **Design/Inspection:** 18% of construction cost.
M-4	**I494--Signal construction at East Bush Lake Road.** **Cost:** **Construction:** $90,000/signal--Total $180,000 in 1994 (90% Federal/10% State). **R/W:** None required. **Design/Inspection:** 18% of the construction cost.

R-1	**77th Street construction project--Phase I.** Major reconstruction of 77th Street from I35W to Portland Avenue. **Cost:** **Construction:** $7,790,000 estimated in 1993 (80% Federal/20% State). **R/W:** $2,332,000 spent for R/W in 1992 (Richfield MSAS funds). $3,536,000 spent in 1993 (80% Federal/20% State). **Design/Inspection:** $787,000 (80% Federal/20% State) spent on preliminary engineering in 1992. An additional $56,000 was spent by the City of Richfield (MSAS funds).
R-2	**77th Street construction project--Phase II.** Major reconstruction of 77th Street from Portland Avenue to TH 77. Funding is not yet secured for this project. **Cost:** **Construction:** $8,200,000 in 1994 (80% Federal/20% State). **R/W:** $4,360,000 in 1993 and 1994 (80% Federal/20% State). **Design/Inspection:** $955,000 (estimated) for preliminary design in 1993 (80% Federal/20% State).
R-3	**77th Street construction project--Phase III** Major reconstruction of 77th Street from TH 77 to 24th Avenue. Includes an underpass under TH 77. Funding is not yet secured for this project. **Cost:** **Construction:** $10,000,000 in 1995 and 1996 (80% Federal/20% State). **R/W:** $5,402,000 in 1994 and 1995 (80% Federal/20% State). **Design/Inspection:** 18% of the construction cost.
H-1	**Penn Avenue from 75th Street to 80th Street.** Grading, surfacing, bridge widening and rehabilitation, and signal construction and interconnect. **Cost:** **Construction:** $2,734,000 in 1994 ($1,499,000 from Hennepin County, $636,000 from Bloomington and $599,000 from Richfield). **R/W:** $2,500,000 ($800,000 from Richfield). **Design/Inspection:** 18% of the construction cost.

H-2	**Penn Avenue from 80th Street to Dixon Avenue.** Pavement rehabilitation. **Cost:** **Construction:** $115,000 in 1993 (Hennepin County). **R/W:** None required. Design/Inspection: 18% of the construction cost.
E-1	**Industrial Boulevard from West Bush Lake Road to TH 100.** Project includes: grading, surfacing and signal upgrades. **Cost:** **Construction:** $572,000 in 1995. **R/W:** **Design/Inspection:** 18% of the construction cost.
E-2	**West 77th Street from TH 100 to Minnesota Drive.** Project includes: Regrading, surfacing and signal upgrades. **Cost:** **Construction:** $590,000 in 1996 and 1997. **R/W:** **Design/Inspection:** 18% of the construction cost.
B-1	**West 80th Street from Thomas Avenue to Morgan Avenue.** **Cost:** **Construction:** $4,940,000 in 1993. (100% Bloomington). **R/W:** **Design/Inspection:** 18% of the construction cost.
B-2	**West 79th and 80th Streets from Morgan Avenue to Bryant Avenue.** **Cost:** **Construction:** $9,400,000 in 1997 ($4,000,000 Federal, $3,500,000 State, $1,900,000 Bloomington. **R/W:** **Design/Inspection:** 18% of the construction cost.
B-3	**West 79th Street from Bryant Avenue to Pleasant Avenue.** **Cost:** **Construction:** $9,000,000 in 1996 ($7,200,000 Federal, $1,800,000 Bloomington). **R/W:** **Design/Inspection:** 18% of the construction cost.
B-4	**East 79th Street from Pleasant Avenue to 5th Avenue** **Cost:** **Construction:** $9,000,000 in 1994 ($7,200,000 Federal, $1,800,000 Bloomington). **R/W:** **Design/Inspection:** 18% of the construction cost.

B-5	**East 79th Street from 5th Avenue to TH 77.** **Cost:** **Construction:** $7,000,000 in 1995 ($5,600,000 Federal, $1,400,000 Bloomington). **R/W:** **Design/Inspection:** 18% of the construction cost.
B-6	**East 80th Street from 24th Avenue to 34th Avenue.** **Cost:** **Construction:** $1,800,000 in 1996 (100% Bloomington). **R/W:** **Design/Inspection:** 18% of the construction cost.