FINAL REPORT

Bi-State St. Louis Area Intelligent Vehicle Highway System Planning Study

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FINAL REPORT

Bi-State St. Louis Area Intelligent Vehicle Highway System Planning Study

April 1994

Edwards and Kelcey, Inc.

in association with

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April 29, 1994

Mr. Dale L. Ricks, P.E.
Maintenance and Traffic Division
Missouri Highway and Transportation Department
P.O. Box 270
Jefferson City, Missouri 65 102

RE: Bi-State St. Louis Area IVHS Planning Study
MHTD No. IVH-9229 (601) P1

Dear Mr. Ricks:

Pursuant to the terms of the subject agreement, we are pleased to submit this Final Report for the Bi-State St. Louis Area Intelligent Vehicle Highway System (IVHS) Planning Study. This report summarizes a year-long evaluation, culminating with the development of a recommended Strategic Deployment Plan for IVHS freeway management projects throughout the St. Louis metropolitan area. Projects are prioritized for implementation over a multi-year time schedule, ranging from “Early Implementation” projects to be deployed within one year, to “Ultimate Plan” projects to be deployed ten years or more in the future.

We gratefully acknowledge the cooperation and assistance of the Missouri Highway and Transportation Department (MHTD), the Illinois Department of Transportation (IDOT) and the other Federal, State and local agencies for their valuable contributions to this study. We also wish to thank the numerous elected officials, civic leaders and citizens who have contributed for their cooperation and input.

Use of advanced IVHS technologies holds great promise to improve mobility, reduce congestion and better inform the public of actual conditions as they make travel decisions. We trust the results of this study will help the MHTD and IDOT guide the successful deployment of these technologies in the bi-state St. Louis metropolitan area.

Thank you for the opportunity to be of service.

Sincerely,

Walter H. Kraft, P.E.
Project Director

James M. Giblin, P.E.
Project Manager

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Enclosure
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1. PROJECT OVERVIEW

1. 1 INTRODUCTION

This report summarizes the results of a regional study whose general purpose was to develop a practical, deployable freeway management plan for the bi-state St. Louis metropolitan area (Figure 1-1) In Missouri, the study area covered the city of St. Louis and St. Charles, Jefferson, Franklin and St. Louis counties. The Illinois counties of Monroe, St. Clair and Madison were also in the study area. The study was undertaken jointly by the Missouri Highway and Transportation Department and Illinois Department of Transportation.

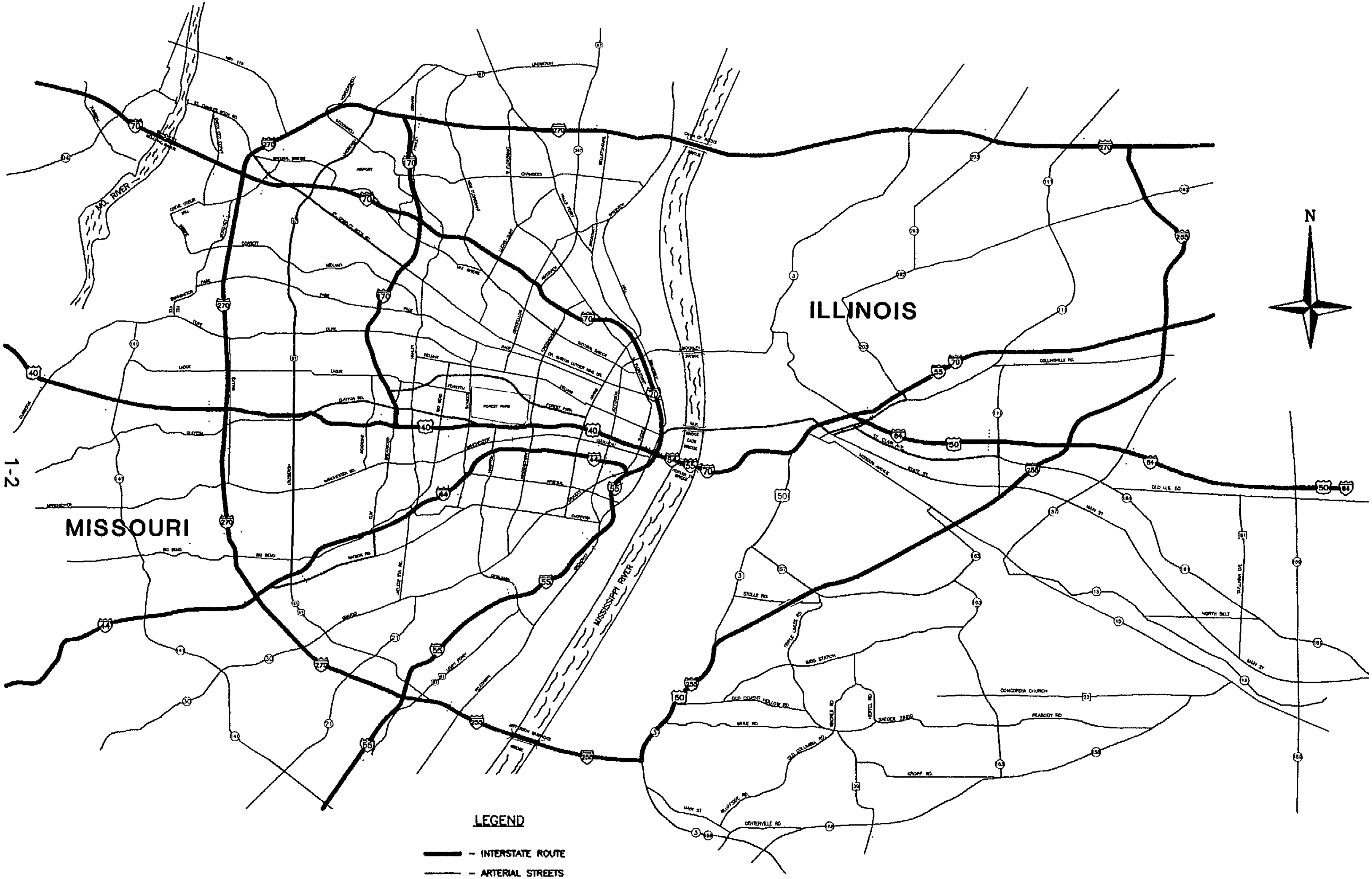
A Strategic Deployment Plan was developed that incorporates proven Intelligent Vehicle-Highway System (IVHS) strategies and technologies that should result in increased vehicle speeds, improved air quality, reduced energy consumption, increased system efficiency, and improved safety. Included in the evaluation were Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) technologies.

Also included in the study were the evaluation and integration of existing roadside motorist aid call boxes, highway advisory radio, motorist assist patrols/emergency patrol vehicles currently operated by the Missouri Highway and Transportation Department (MHTD) and the Illinois Department of Transportation (IDOT), and the new light rail transit system. Specific strategies for the staged implementation of a freeway management plan were developed, along with cost estimates for the various IVHS elements and regional Traffic Information Centers.

A major element of the study involved identifying and inventorying the goals and needs of transportation users in the St. Louis area. The opinions of a wide cross-section of interested and affected parties were solicited by questionnaire and/or personal contact. The final products include a Strategic Deployment Plan and conceptual plans for a freeway management system, which are presented in Chapter 6.

1.2 PARTICIPATING AGENCIES/ORGANIZATIONS/GROUPS

This study was a joint project of the Missouri Highway and Transportation Department (MHTD) and the Illinois Department of Transportation (IDOT), with MHTD administering the project. A Project Guidance Committee (PGC) provided oversight and guidance at regularly scheduled meetings held approximately every other month throughout the entire project. At these meetings, project progress, contents of draft technical memoranda and reports, and preliminary recommendations were reviewed and discussed. In addition to representatives of the local districts and central offices of both MHTD and IDOT, other agencies represented on



St. Louis Area IVHS Planning Study

BI-STATE ST. LOUIS METROPOLITAN AREA

FIGURE 1-1

the PGC were the Federal Highway Administration (Missouri and Illinois divisions) and East-West Gateway Coordinating Council, the metropolitan planning organization for the bi-state St. Louis metropolitan area. A list of PGC members is provided in Appendix A.

About midway between the bi-monthly PGC meetings, informal meetings termed "working sessions" were held between the consultant team and MHTD/IDOT staff. The working sessions were used to discuss technical issues, review alternatives and consider early draft versions of documents to be submitted to the PGC at their next meeting.

Many other agencies, groups and individuals were involved throughout the study by a variety of methods. Two sets of Public Information Meetings were held, on October 19, 1993 and February 9, 1994 (at 2:00 p.m. and 7:30 p.m. on both dates). The purpose of holding these meetings was to explain the project goals, and solicit public input about their transportation goals, needs and priorities in the greater St. Louis area, particularly with respect to the freeway and arterial street systems. Summary notes for each of the four Public Information meetings, along with copies of the meeting handout materials, can be found in Appendix B.

A series of "focus group" meetings were held with various groups to solicit their transportation goals, priorities and needs. Representatives of the following groups or companies were invited to attend a meeting scheduled specifically for each group:

- Comercial Vehicle Operators (truck and air freight, railroad, barge)
- Major Employers
- Transit Operators
- Parking Garage/Lot Operators
- Major/Special Event Generators
- Telecommunications Industry

In addition, meetings were held with the metropolitan area district commanders for the Missouri Highway Patrol and Illinois State Police.

To build community support, meetings were also held with various individuals and groups. They include elected officials or their representatives, community and labor leaders (such as Confluence St. Louis, Civic Progress and the St. Louis Labor Council), and administrators from the University of Missouri-St. Louis.

1.3 PROJECT SCHEDULE

Work on this study began in April, 1993 with an expected duration of one year. The following primary tasks were undertaken, generally in the order listed:

- Inventory Existing Facilities and Data Collection
- Develop Technical Memoranda
- Community Involvement and Consensus Building
- Develop System Architecture
- Prepare Conceptual Plans
- Develop Strategic Deployment Plan
- Benefit/Cost Analysis
- Prepare Final Report

The community involvement and consensus building task was an on-going process, explained above, that took place throughout nearly the entire study. A more detailed discussion of the work efforts undertaken in this task is presented in Chapter 5.

A total of thirteen Technical Memoranda were prepared by the project team to explore and discuss various IVHS technologies that might have application in the bi-state St. Louis metropolitan area. The memoranda provide much greater detail and discussion of the strategies and techniques that are available, and were provided to the PGC early in the study in order to stimulate discussion about the value of each in this particular area. A list of the Technical Memoranda that were prepared is as follows:

1. Detection and Verification Strategies
2. Closed-Circuit Television Systems
3. Highway Advisory Radio
4. Changeable Message Signs
5. Ramp Metering
6. HOV/TSM Applications
7. Route Diversion Technologies
8. Signal System Arterial Integration
9. Communications Systems
10. Incident Management Programs and IVHS Integration
11. Traffic Management Center
    A. Hardware and Software Aspects
    B. Operations
12. Transit Issues and IVHS Integration
13. Data Collection and Analysis

A three-ring binder with numbered dividers was provided to PGC members to organize the Technical Memoranda in a concise, convenient format.

1.4 1991 MISSOURI FREEWAY MANAGEMENT PROPOSAL

In 1991, a committee comprised of MHTD and FHWA staff completed their investigation of the possible implementation of incident and freeway management strategies in both the

Kansas City and St. Louis metropolitan areas. The result was a report titled, "Proposal for Freeway Management in Missouri", that provided useful traffic data and analyses that were incorporated into this study's analyses.

The results and recommendations presented in the 1991 report were reviewed and the analyses expanded and further refined, as necessary. The Illinois portion of the St. Louis metropolitan area was added to the 1991 study area.

2. GOALS AND OBJECTIVES

2. GOALS AND OBJECTIVES

2.1 GOALS

The general goals of this study to develop a freeway traffic management plan for the bi-state St. Louis area are to increase the efficiency of the surface transportation system using IVHS strategies that:

- Will increase vehicle speeds
- Improve air quality
- Reduce energy consumption
- Improve safety

2.2 OBJECTIVES

2.2.1 Study

The primary objective of the study is to develop a freeway traffic management plan that is regional in scope and incorporates proven IVHS technologies primarily in the areas of Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS). Additional specific objectives are as follows:

- Develop strategies for staged implementation of the freeway management plan.
- Define staffing requirements and organizational structure.
- Evaluate and integrate existing roadside call boxes, highway advisory radio, and emergency patrol vehicle service currently operated by IDOT.
- Evaluate the use of High-Occupancy-Vehicle (HOV) lanes.
- Fulfill the requirements of 23 Code of Federal Regulations 655D--Traffic Surveillance and Control as they relate to freeway management planning.
- Address institutional barriers between the affected agencies.
- Identify potential funding sources available to implement the plan.

2.2.2 Short-Term

While the full functionality of an IVHS for the bi-state St. Louis area may not be realized for many years, it is important to phase the implementation such that benefits can be achieved throughout the stages of its development. There are several short-term (within two years) objectives. One is to apply low-cost IVHS applications to help solve (countermeasures) existing problem locations, demonstrating their effectiveness and creating “early winners”.

A related short-term objective is to apply proven, practical, cost-effective measures to mitigate congestion at selected locations. This includes building on existing applications which have shown success, such as motorist aid call boxes, highway advisory radio and motorist assist/emergency patrol services.

2.2.3 Medium-Term

The medium-term objectives are to expand the measures and applications that begin in the short-term in order to cover additional areas and extend system benefits. Medium-term objectives are to be addressed in the 2-10 year time frame.

2.2.4 Long-Term

The objective during the long term phase is to fully complete the system so that benefits can be realized on a regional scale. Again, previous phases will be extended as well as recommending other enhancements that will tie the entire system together and carry it into the future. The long-term objectives will met in the time period of more than 10 years.

2.3 USER SERVICE NEEDS

In developing a freeway management system with IVHS applications for the bi-state St. Louis area, it is important to think in terms of what services need to be provided to the users of the system, not necessarily what new technologies can be incorporated. “Users” can refer to drivers, travelers, transit operators, commercial and emergency vehicle operators, or transportation system management agencies. The user services provided by the system should be the guiding force in developing the overall system concept. The Federal Highway Administration (FHWA) has identified six categories of user services:

- Traveler Information Services
- Traffic Management Services
- Freight and Fleet Management Services
- Public Transportation Services
- Emergency Vehicle Management Services
- Additional Services

From the goals of the various agencies involved with the bi-state St. Louis study and the input received at the Pubic Information Meetings (PIM), three levels of need were defined by the users of the bi-state St. Louis area:

- Strong Need
- Some Need
- Minimal or No Need

In Table 2-1, the three levels of need are shown for each of the six categories of user services and their corresponding functional technology categories. As evident from the table, the strongest needs for the bi-state St. Louis area are in the traveler information and traffic management areas with a secondary need falling under the public transportation, emergency vehicle management, and freight and fleet management. It should be added that while specific user service needs have been identified at this time, the needs should always be revisited and updated.

2.4 TYPICAL BENEFITS

A review of recent reports prepared by MOBILITY 2000, the U.S. General Accounting Office, IVHS America and others provide an insight into typical benefits that can be expected from the implementation of various IVHS strategies.

2.4.1 MOBILITY 2000 Report

The most comprehensive analysis to date of IVHS benefits is a study prepared by MOBILITY 2000 in 1990 titled Intelligent Vehicle Highway Systems: Operational Benefits. The report indicated that significant benefits could be achieved by implementing IVHS in five primary performance areas:

- Safety
- Congestion
- Enhancing Mobility
- Preserving the Infrastructure
- Professional Development

2.4.1.1 Safety

In European studies, the Promtheus project estimates that one-half extra pre-collision second would allow drivers enough evasive action time to avoid 50% of all accidents MOBILITY 2000 then estimated that 14,800 lives lost and $21 billion in accident costs can be prevented annually and lane blocking accidents reduced 11% by 2010. The total accident reduction would be 0.17% by 1995, 1.7% by 2000, and 18.9% by 2010.

2.4.1.2 Congestion

A major purpose of IVHS is to monitor dynamic traffic conditions and reliably and accurately inform the driver. A recent finding is that 56% of all congestion non-recurring. Another estimate is that 39 large US cities incur congestion costs greater than $41 billion annually. Expected IVHS contributions to reducing these loses are:

Table 2- 1

IDENTIFIED USER SERVICE NEEDS

BI -STATE ST. LOUIS METROPOLITAN AREA

USER SERVICES AREAS	FUNCTIONAL TECHNOLOGY CATAGORY						
	Surveillance	Com-munications	Traveler Interface	Control Strategies	Navigation Guidance	Data Processing	In-Vehicle Sensors
TRAVELER INFORMATION							
Traveler Advisory	X	X	X		X	X	
Traveler Service Information		X	X		X	X	
Trip Planning	X	X	X		X	X	
Location Displays			X		X	X	
Route Selection	X	X	X			X	
Route Guidance		X	X		X	X	X
In-Vehicle Signing	X	X	X		X		X
TRAFFIC MANAGEMENT							
Incident Detection and Managmt.	X	X		X		X	
Demand Management		X	X	X		X	
Traffic Network Monitoring	X	X				X	
Traffic Control	X	X		X		X	
Parking Management	X,	X	X	X	X	X	
Construction Management	X	X	X	X		X	
Electronic Toll Collection	X	X		X			
FREIGHT & FLEET MANAGEMENT							
Inter-Modal Transp. Planning		X				X	
Route Planning and Scheduling	X	X	X		X	X	
HAZMAT Monitoring and Tracking	X	X			X	X	X
Vehicle and Cargo Monitoring	X	X			X	X	X
Law Enforcement	X						X
Regulatory Support	X	X					X
PUBLIC TRANSPORTATION & EMERGENCY VEHICLE MANAGEMENT							
planning and Scheduling Systems	X	X	X			X	
Signal Pre-Emption Traffic Control		X		X			
Automatic Payment (Flexible Fares)	X						
Dynamic Ride Sharing			X			X	
Prediction of Arrivals	X	X	X		X	X	X
Emergency Service Sys. Managmt.	X	X	X	X	X	X	
ADDITIONAL SERVICES							
Traveler Safety/Security	X	X	X		X		X
MAYDAY Transmissions		X	X				

Key:

Strong Need	X (shaded)
Some Need	X
Minimal or No Need	X

X: Indicates functional technology catagories applicable to each user services area as identified by FHWA.

- In its simpler forms, IVHS can decrease congestion by 15% at a value of $1.2 billion annually. This provides benefit/cost ratios ranging from 1.3 to 3.2 depending on the size of the city. The Smart Corridor project in Los Angeles estimates a B/C ratio of over 4: 1 after implementation.
- Fully deployed combinations of ATMS and ATIS can produce congestion decreases of 25% to 40%.
- Full automation could virtually eliminate vehicle congestion
- It is possible nationwide to see a 10%, or $75 billion annual improvement by 2010.
- Congestion relief is expected to result in 10% to 50% fuel savings.
- Unchecked traffic congestion is the single most significant contributor to air quality degradation. It is estimated that improvements will be coincident with congestion reduction.
- Congestion relief will benefit transit vehicle operation.

2.4.1.3 Enhancing Mobiiity

Mobility will be improved for many segments of society other than urban residents. Older and disadvantaged drivers can benefit by having specific devices available to offset some of their incapacities. Some of these devices include heads-up displays, infrared imaging, obstacle detection and warning, driver alertness warning, radar braking and steering override, on-board maps and signs, and multi-purpose two-way communications.

IVHS was also predicted to enhance mobility in several other major areas, such as improved access for the economically disadvantaged, improved access for rural residents, improved service for tourists, improved trip planning, enhanced fleet management, and improved transit fleet management.

2.4.1.4 Preserving the Infrastructure

The nations highway system is aging quickly and as travel continues to increase the aging process will accelerate. IVHS includes systems to improve infrastructure facilities management, improve traffic systems management, and enhance traffic demand management. If the highway system is managed better, than more of our scarce resources can be devoted to maintaining the highways rather than expanding them. It is conceivable that billions of dollars could be saved annually by implementing IVHS nationally.

2.4.1.5 Professional Development

A major research program in an exciting area like IVHS would send a signal to the young people of the US that transportation is a field of the future. The cutting edge technology and research grants will likely attract talented people to the transportation profession.

As with many major research programs, it is expected that there will be positive unplanned benefits and side effects.

The MOBILITY 2000 study suggested many optimistic benefits to be incurred upon the implementation of IVHS. However, the development of IVHS has not occurred as quickly as envisioned. Therefore, more recent studies have indicated benefits at a lower level than estimated in MOBILITY 2000.

2.4.2 Recent Studies

A paper by Gardes, May, and Van Aerde, Simulation of IVHS Strategies on the Smart Corridor, indicates an improvement of 11.6% in freeway speeds and a 6.3% increase in overall network speed. The Smart Corridor includes IVHS, HOV lanes on 1-10, and arterial signal improvements.

In a paper presented at IVHS America, Cheslow estimates that national annual fuel savings will be 0.6 billion gallons or 0.9% by the year 2000. By 2010, increased deployment and market penetration will save 3.8 billion gallons of fuel annually, a 5.2% savings.

A study prepared by Peek Traffic in 1993 evaluated two freeway guidance systems in the Netherlands (Rotterdam and Utrecht) covering 35 miles of freeway. The following system performance results were reported: accidents were reduced by 25.5%, secondary accidents were reduced by 46.2%, serious accidents were reduced by 35.3%, persons injured was decreased by 21.1 %, and traffic throughput was increased by 4.5%. The freeway guidance system in this study included variable speed limit for individual lanes which is not currently part of any IVHS proposal in the US.

2.4.3 U.S. General Accounting Office Report

The US General Accounting Office prepared a report to the Chairman, Subcommittee on Transportation, Committee on Appropriations, U.S. Senate titled Smart Highways: An Assessment of Their Potential to Improve Travel in May 1991. This report reviewed 38 IVHS studies conducted over the last decade. The findings are summarized in Tables 2-2 and 2-3.

2.4.4 IVHS America Report

The most recent comprehensive analysis of the benefits of IVHS is a draft report produced by the Benefits, Evaluation, and Costs Committee of IVHS America. The report is titled Will IVHS Transform Transportation System Effectiveness and it was published in early 1993. The findings are summarized in paper by Horan, Toward Adaptive IVHS: The Role of Assessments in Guiding the Development of Advanced Transportation Technologies. The expected impacts are outlined in the following sections.

Table 2-2

REPORTED BENEFITS FROM ATMS OPERATIONAL TESTS

Name of Study	Author	Study Date	Evaluation Methodology	Technology Demonstrated	Reported Benefit
National Signal Timing Optimization Project (11 cities nationwide)	FHWA	1982	Before-after; simulation model	ATMS, improving traffic signal timing plans	For each average intersection: 15,000 vehicle hours of delay saved; 455,000 vehicle stops eliminated; 10,000 gallons of fuel saved; $28,695 average annual benefit; 8.5% improvement in travel time; benefit-cost ratio of 63:1
Fuel-Efficient Traffic Signal Management (FETSIM) (61 cities & 1 County in Calif.)	ITS	1986	Before-after; simulation model; field test	ATMS, improving traffic signal timing plans	15% reduction in vehicle delays; 16% reduction in vehicle stops; 7% reduction in travel times; 8.6% reduction in fuel use; $231 million savings over 3 years; benefit-cost ratio of 58:1; reduced emissions; increased safety; improved public transit operations; improved traffic operations data base.
Automated Traffic Surveillance and Control (ATSAC) (Los Angeles, Calif.)	L. A. Dept. of Trans.	1987	Before-after	ATMS, computer control of traffic signals	13% reduction in travel time; 35% reduction in vehicle stops; 14% increase in average speed; 20% decreased in intersection delay; 12.5% decreased in fuel consumption; 10% decrease in hydrocarbon emissions; 10% decreased in carbon monoxide emissions; benefit-cost ratio of 9.8:1.
Chicago Area Expressway Surveillance and Control Project (Chicago, Ill.)	McDermott et. al.	1979	Before-after	ATMS, large-scale freeway surveillance and control system	30% reduction in peak period congestion; 18% reduction in accidents; decreased travel times; increased average speeds; expedited emergency responses; benefit-cost ratio of 4:1 (ramp metering).

Table 2-3

ESTIMATED BENEFITS OF ATIS FROM SIMULATION STUDIES

Name of Study	Author	Study Date	Estimated Benefit
Smart Corridor for the City of Los Angeles: Demonstration Project Conceptual Design Study	JHK & Associates	1989	Overall corridor effects: travel time reduced by 3.8 to 5.2 million vehicle hours per year (11-15%); fuel consumption decreased by 1.3 million gallons per year (2.5%); annual hydrocarbon emissions reduced by 8%; annual carbon monoxide emissions reduced by 15%; intersection delay reduced nearly 2 million vehicle hours per year (20%); annual savings of $24-32.5 million Individual driver effects: Increased average freeway speeds from 15-35 mph to 40-50 mph; decreased average freeway trip duration of 12%; increased average surface street speeds during peak commute periods from 20mph to 22mph (11%); decreased average surface street trip duration of 13%
Potential Benefits of In-Vehicle Information Systems in a Real Life Freeway Corridor Under Recurring and Incident-Induced Congestion	Al-Deek, et. al.	1988	Travel time savings between 3-10 minutes per freeway trip during nonrecurring, incident-induced congestion
Potential Benefits of In-Vehicle Information Systems:Demand and Incident Sensitivity Analaysis	Al-Deek & May	1988	Travel time savings ranging 0-14 minutes (0-47%) for a 30-minute average trip under different congestion scenarios
Some Theoretical Aspects of the Benefits of En-Route Venhicle Guidance (ERVG)	Al-Deek & Kanafani	1990	Typical travel time savings of 3-4%
Effectiveness of Motorist Information Systems in Reducing Traffic Congestion	Koutaopoulos & Lotan	1990	Modest reduction in travel times up to 4.4%
Study to Show the Benefits of Autoguide on Traffic in London	JMP Consultants	1989	Resource cost savings of 7-9%; travel time savings of 8-11%
Some Possible Effects of Autoguide on Traffic in London	Smith & Russam	1989	Travel time savings ranging from 2.2% for unequipped vehicles to 6.9% for equipped vehicles (10% of vehicles equipped); annual benefits of 170 million pounds; reduction of 400 personal injury accidents

2.4.4.1 Congestion Reduction

Congestion is widely viewed as a major area where IVHS could have positive impacts. The IVHS Strategic Plan suggests that IVHS can reduce congestion costs by 10% in 2001, and by 20% by 2011. The earliest demonstrable benefits are likely to come from the deployment of ATMS in major cities around the country. The Smart Corridor data mentioned previously is the best example to date. While this and similar experiences provide some confidence that near-term IVHS can affect travel flows along congested corridors, the ability to demonstrate regional improvements is more problematic. Recent modeling exercises- particularly in the air quality area- have found difficulty in assessing overall regional gains, and consequently, suggests that near-term IVHS improvements should be viewed with substantial caution.

Other benefits are likely to be more easily shown. For example, reduction in non-recurring congestion is very likely to be improved by ATMS. The impacts of AVI in reducing delay at toll facilities will likely to be easy to show.

2.4.4.2 Safety Enhancement

Safety is also viewed as a major area for IVHS impact. The Strategic Plan estimates that IVHS could reduce the number of fatalities and injuries by 8% annually by 2011 (This compares to the MOBILITY 2000 estimate of 18.9%).

2.4.4.3 Environmental and Energy Effects

The report notes that recent estimates of fuel savings are significantly lower than that predicted by MOBILITY 2000 (Cheslow, 1992). Recent papers at a conference on the environment and IVHS indicated that while ATMS could provide moderate air quality benefits, more dramatic gains would require the marrying of IVHS technologies with other technologies and policies, such as congestion pricing, super-emitter detection, and electric vehicles.

2.4.4.4 Economic Productivity

The economic gains from IVHS are considered vital to its overall success. As has been widely reported, the Strategic Plan estimates that up to 80% of the overall costs of IVHS will come from the private sector and consumer decisions. To the extent that this is realized, IVHS could represent a significant domestic economic activity. The amounts are not yet quantified, but the expectation is that IVHS will lead to productivity growth through reduced costs and improved efficiencies in the transportation sector.

The amount of Federal dollars in funds for IVHS projects and research itself is significant. Over $1 billion is expected to be expended by the year 2000.

2.4.4.5 Social Impacts

The report indicates that a number of groups, such the elderly, handicapped, rural residents, and transit dependent are likely to benefit from the deployment of IVHS.

2.4.4.6 Institutional Impacts

IVHS will depend on as well as impact the various transportation and related public agencies charged with carrying out the program. The transportation industry has traditionally focused on designing, constructing, and maintaining highway and transit facilities. IVHS presents a host of new issues for the industry. The Strategic Plan notes the institutional as well as legal challenges that will confront transportation agencies as they seek to incorporate this information infrastructure into their processes and systems. Among these institutional challenges will be the public/private partnership that are mandated in ISTEA.

Another area of focus is the understanding of the role of IVHS within the context of regional planning. One of the key aspects of the ISTEA legislation was its recognition and reinforcement of regional planning and programming decisions. It remains to be seen how IVHS fits into this policy framework.

These impacts are summarized in Table 2-4. It is expected as ATMS and other IVHS projects are implemented more benefits and benefit/cost analysis will be quantified.

Table 2-4

SUMMARY OF IVHS BENEFIT ISSUES

BENEFIT AREA	SOURCES OF BENEFIT CALCULATIONS			
	Mobility 2000 (1990)	Strategic Plan	Other Data	Focal Areas
Congestion	25-40% reduction in congestion costs by 2010,	15-20% reduce in congestion costs in selected metropolitan areas by 2011	Smart Corridor; inform; Bay Area.	traffic management centers; reduction in non-recurring congestion; mode-change; toll reduction
Safety	reduce annual fatalities by 18.9% by 2011.	reduce annual fatalities by 8% by 2011.	exposure rates; modelling of accident prevention.	Special populations; health care transportation.
Energy and Environment	6.5 billion gallons of fuel saved by 2010	general objective to reduce harmful emissions and fuel wasted.	Mitre: 3.8 billion gallons of fuel saved by 2010.	smoother traffic flows also: super emitters, electric vehicles, etc.
Economic Productivity	not an explicit operational benefit.	general objectives to establish U.S. based industry; estimation that 80% of IVHS cost to be in private sector.	several conflicting studies on relationship between infrastructure spending and productivity.	regional impacts of IVHS investment vis-a-vis other infrastructure investments. commercial applications and analyses.
Social impacts	notes role of IVHS for older driver, impairec traveler, rural residents, etc.	no explicit objectives on social impacts; general statements on range of IVHS effects.	number of people over 75 expected to double by 2000 (to 65 million). 8 million mobility impaired.	special population assessment; broad social impact assessment.
Institutional impacts	not an explicit operational benefit.	general objectives to develop new modes of operation among public and private organizations.	recent research and conference activities highlighting alternative public versus private sector roles	public vs private sector roles; regional technology governance.

3. EXISTING AND FUTURE CONDITIONS

3. EXISTING AND FUTURE CONDITIONS

3.1 INVENTORY EXISTING FACILITIES AND DATA COLLECTION

Critical to supporting an evaluation of possible IVHS measures which could be implemented in the bi-state St. Louis metropolitan area was the assembly of the necessary roadway-related and traffic data. The purpose of this task was not to identify specific measures (or locations) for consideration but, rather to collect and summarize in general terms the data which were available for this planning study. The scope of work did not permit additional data collection.

The next step in this process was the use of the collected data to distinguish those freeway segments (or arterial streets) which had the greatest need for IVHS improvements both now and in the future.

3.1.1 Current Conditions

3.1.1.1 Freeway and Arterial Roadway Network

As illustrated in Figure 3-1, the roadway network that was studied consisted of the entire Interstate system in the bi-state St. Louis metropolitan area. In addition, candidate arterials for freeway traffic diversion were also identified and reviewed.

3.1.1.2 Traffic Volumes

The collected traffic volume data were a key indicator of where travel demands are the heaviest and, consequently, where the potential for traffic congestion may be the greatest. The heaviest volumes occur along I-70 between I-270 and the Missouri River, where the current average daily traffic volume (ADT) is approximately 165,000 vehicles. Not surprisingly, this freeway segment also experiences considerable traffic congestion and a large number of traffic accidents and other incidents. Other metropolitan area freeway segments where traffic volumes exceed 100,000 vehicles per day (ADT) are listed below, and also shown in Figure 3-2:

- Interstate 64/40 between Missouri Highway 141 and Tamm Avenue
- Interstate 70 between Zumbehl Road and Interstate 64/US 40 (Downtown)
- Interstate 55 between Interstate 64/US 40 and Interstate 44
- Interstate 270 between Halls Ferry Road and Gravois Road
- Interstate 64/55/70 between the Poplar Street Bridge and Interstate 64
- Interstate 64/50 between Interstate 55/70 and Illinois Highway 111

3.1.1.3 Traffic Accident Data

Traffic accidents are a major contributor to congestion along the metropolitan area freeway system. Even the existence of shoulder-parked vehicles involved in an accident can reduce capacity by 50 percent, or more. Therefore, the information developed through the analysis of accident data has played a key role in designing a freeway management plan using IVHS technologies for the bi-state St. Louis area.

To facilitate review of the accident data, the freeways were divided into segments. Each segment was determined by analyzing the geometric characteristics of the freeway and making breaks where a significant change occurred. For the years four years of 1989 through 1992, the number of accidents was determined for each segment. Accident frequencies (number per mile) were calculated, as well as accident rates (per million vehicle-miles). Figure 3-3 graphically depicts the freeway segments and their respective accident rates. The data were also analyzed to determine the most frequent type of accident which occurred along the various freeway segments. The highest accident segments, which have a rate of at least 1.0 accidents per million vehicle-miles, are summarized in Table 3-1.

The freeway segments exhibiting the two highest accident rates are both on Interstate 55, from the downtown Poplar Street bridge complex south to Chouteau Avenue (in Missouri), and east across the bridge to where I-55/70 and I-64 split (join) in East St. Louis. These segments are congested on a daily basis and, as would be expected, rear-end accidents are the most predominant type of collision. The third highest rate is found on Interstate 44 from Interstate 55 to a point west of Jefferson Avenue. The predominant type of collision in this segment is attributed to vehicles that are “out-of-control”. This accident pattern could be related to large amount of weaving the freeway/interchange design necessitates as motorists choose between exits for the downtown area and exits to travel southbound on Interstate 55.

As is evident in Table 3-1, the predominant type of collision for most freeway segments with high accident rates is the rear-end collision. This pattern is typical because most of these sections are highly congested, at least during weekday morning and afternoon peak hours. By contrast, those freeway sections in the more outlying areas in Illinois, and those sections in Missouri having lower traffic volumes, tend to have a lesser number of rear-end collisions and more fixed object or out-of-control accidents.

3.1.1.4 Incident Data

Vehicle breakdowns which occur along the freeways are often as troublesome as an accident. The blockage of a lane(s) or the mere presence of a stalled vehicle can contribute to significant delays. However, data for motorist breakdowns and other incidents were not as readily available as accident data are. The incident data collected is somewhat limited due to the following conditions:

- The MHTD motorist assist patrol program began in January, 1993 and therefore a limited amount of data is available

St. Louis Area IVHS Planning Study

INTERSTATE & ARTERIAL ROUTES

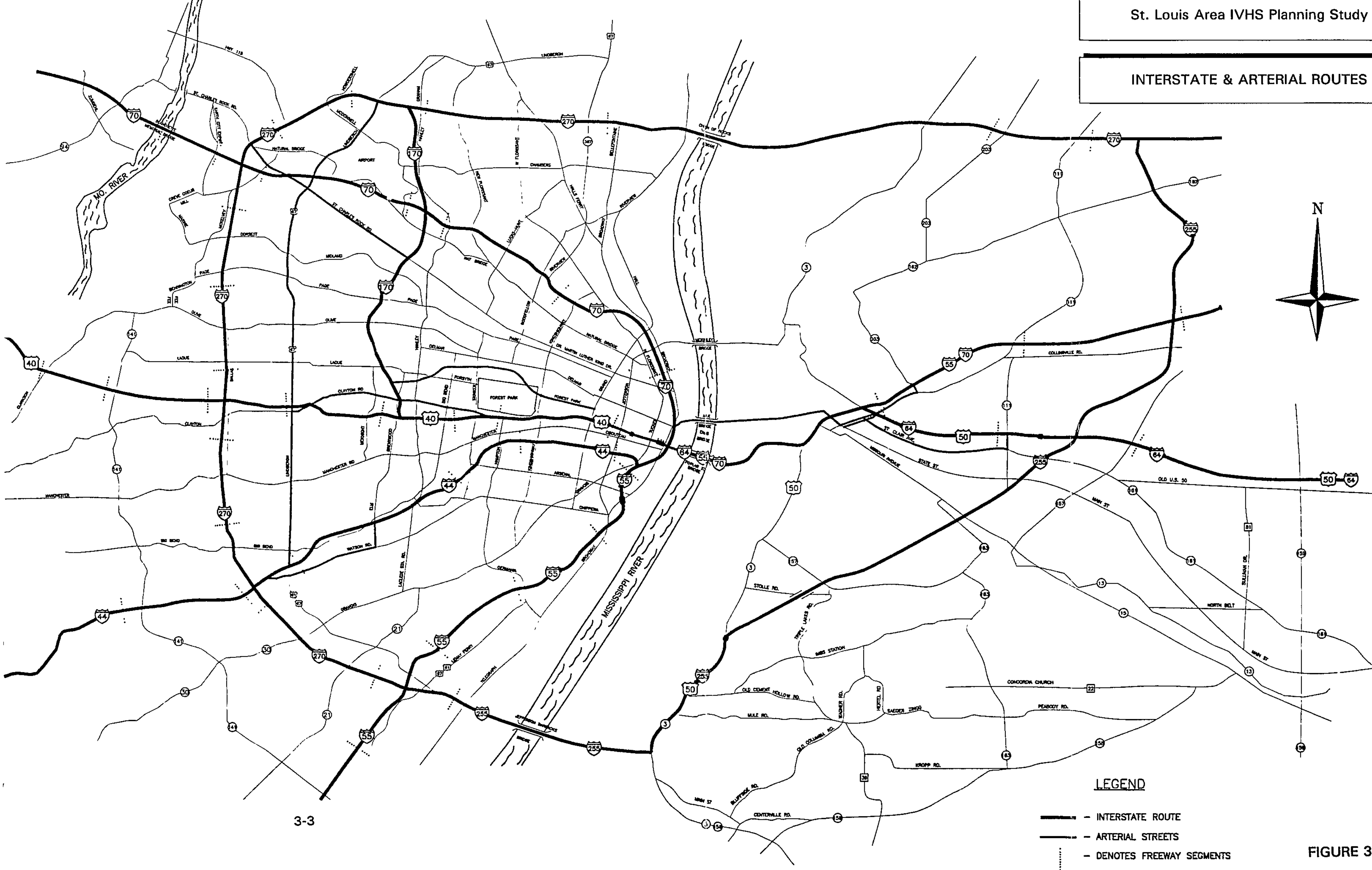
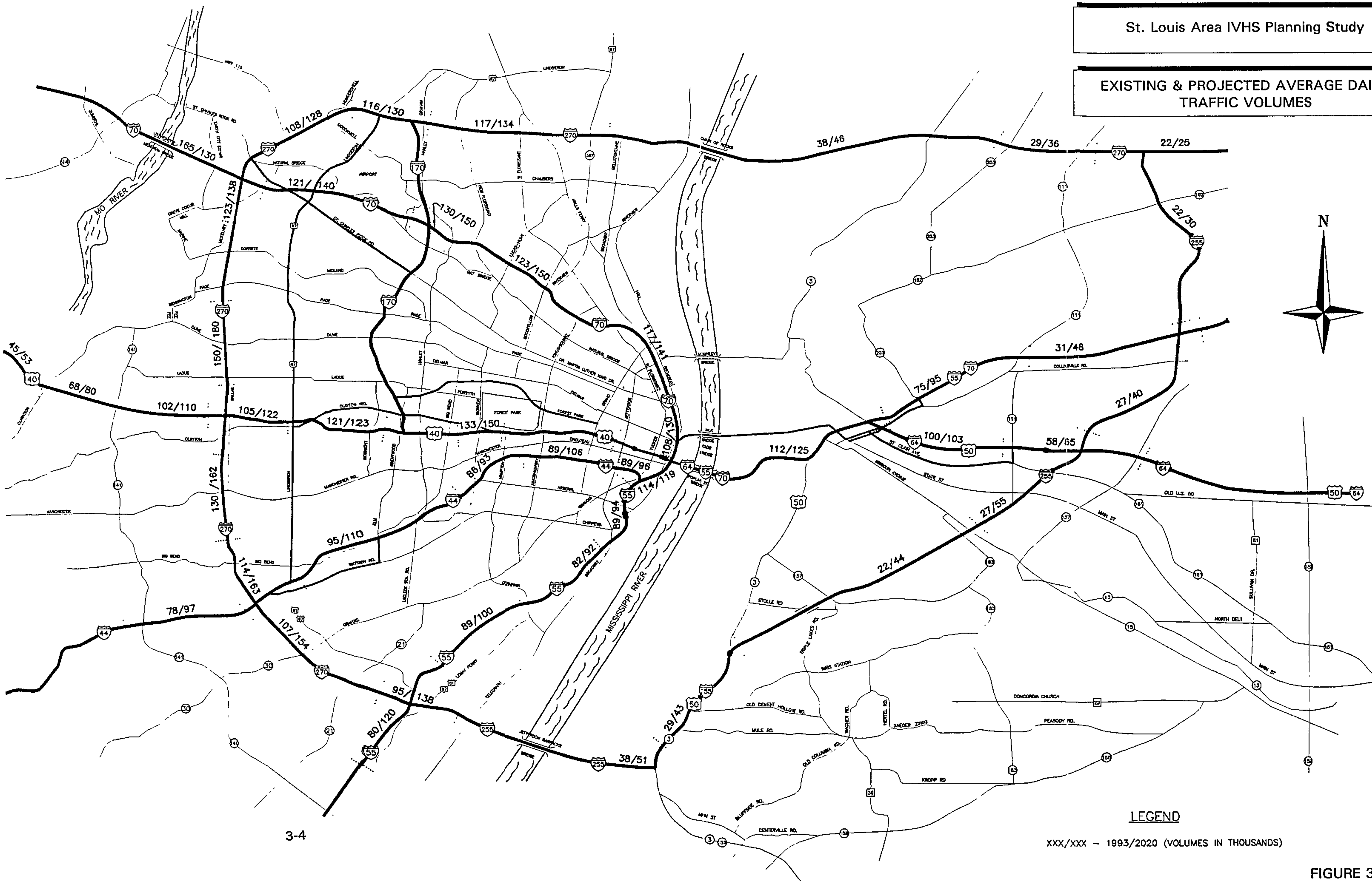


FIGURE 3-1

St. Louis Area IVHS Planning Study

EXISTING & PROJECTED AVERAGE DAILY TRAFFIC VOLUMES



LEGEND

XXX/XXX – 1993/2020 (VOLUMES IN THOUSANDS)

FIGURE 3-2

St. Louis Area IVHS Planning Study

FREEWAY ACCIDENT RATES

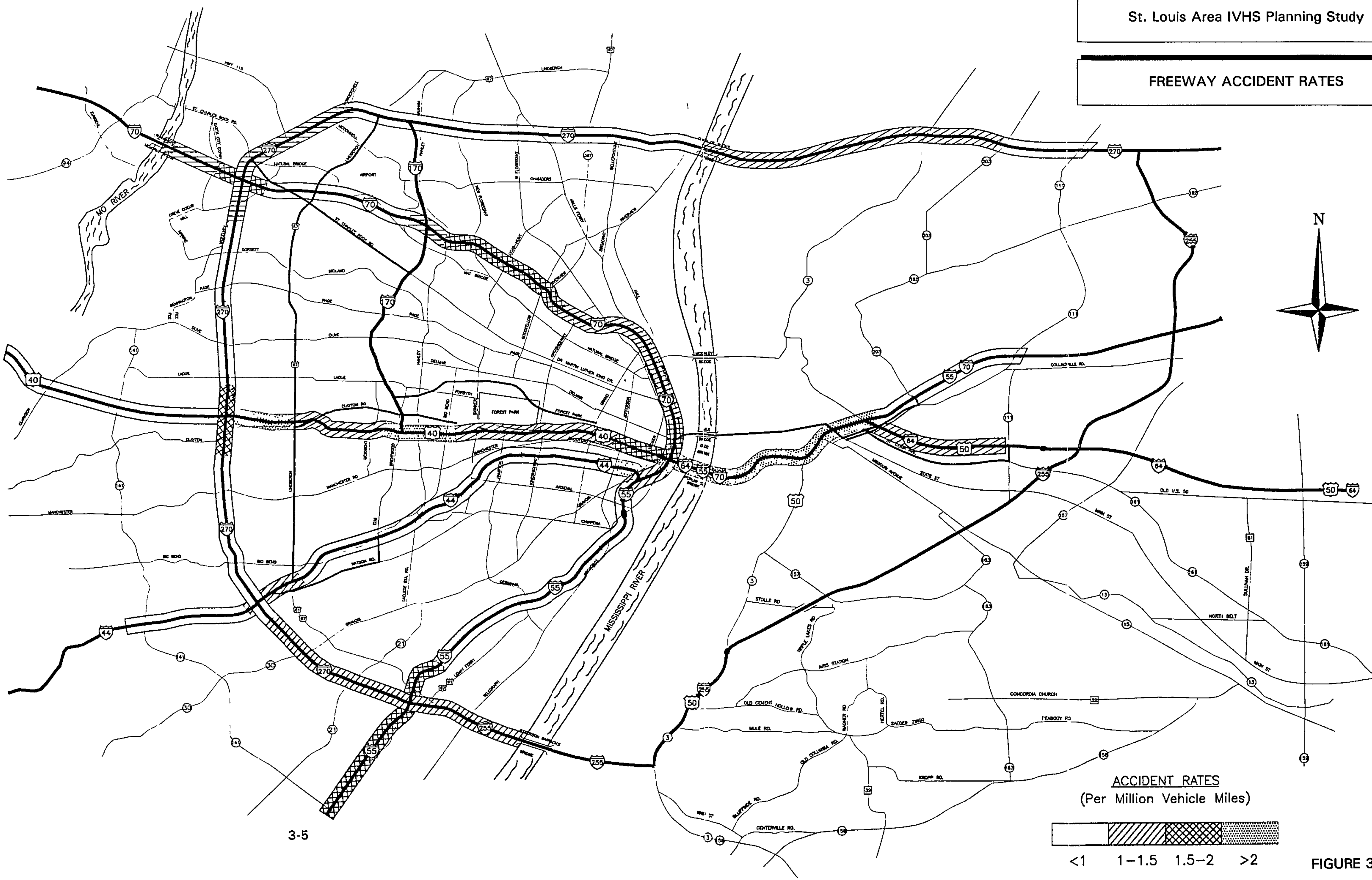


FIGURE 3-3

Table 3-1

HIGHEST ACCIDENT RATES ALONG THE BI-STATE ST. LOUIS AREA FREEWAY SYSTEM

Interstate Route	Segment Description	Total Accidents '89-'92	Accident Fequency (Acc/Mi)	Accident Rate (Million Veh-Mi)	Highest Accident Type
Missouri					
40/64	I-270 to W. of Spoede	691	95	2.48	RE
	W. of Spoede to W. of Brentwood	669	48	1.09	RE
	W. of Brentwood to E. of Big Bend	1020	128	2.66	RE
	E. of Big Bend to W. of Tamm	220	56	1.15	RE
	W. of Tamm to W. of Compton	724	45	1.07	RE/OC
	W. of Compton thru Bridge Complex	433	46	1.63	RE
44	E. of Meramec Rvr. to E. of Lindbergh	441	55	1.44	RE
	E. of Jefferson to I-55	194	87	2.67	OC
55	Poplar St. Bridge to Chouteau	585	293	7.01	RE
	Chouteau to S. of Gravois	300	50	1.21	RE
	N. of Lindbergh to S. of Mattis	499	50	1.71	RE
70	Missouri River to W. of I-270	494	82	1.37	RE
	W. of I-270 to E. of McKelvey	471	79	1.98	RE
	W. of I-170 to W. of Hanley	350	59	1.24	OC
	W. of Hanley to W. End Reversible	1301	72	1.61	RE
	W. End Reversible to W. of Ninth	1230	56	1.36	RE
	W. of Ninth to S. of Market	487	98	2.49	RE
	S. of Market thru Bridge Complex	127	47	1.74	RE
270	I-55 to E. of Tesson Ferry	263	44	1.26	RE
	E. of Tesson Ferry to S. of I-44	573	41	1.05	RE/OC
	S. of Clayton to S. of Ladue	653	82	1.58	RE
	Woodford Way to W. of Lindbergh	516	52	1.31	RE/OC
Illinois					
55	Mississippi River to E. of I-64	1622	135	3.70	RE
64	St. Clair to W. of 111	392	35	1.31	RE/OBJ
270	Mississippi River to W. of 203	250	18	1.11	RE/OBJ

Key:

RE = Rear-End
OC = Out-of-Control
OBJ = Fixed Object

- Only a portion of the Missouri freeway system is served by the MHTD motorist assist patrol program
- The IDOT records system does not provide a summary of motorist assists by location, only system-wide

Though it does not provide a complete picture of the pattern of freeway incidents in the St. Louis metropolitan area, the data collected were useful as a tool in identifying segments which appear to be experiencing the greatest number of incidents. To summarize, Interstate 64 from Lindbergh Boulevard to Big Bend Boulevard, and interstate 70 from the Missouri River to the St. Louis city limits, are experiencing the highest incident rates.

3.1.2 Existing System Operation

3.1.2.1 Current Applications of IVHS Technology

Various traffic information/control elements that fall in the IVHS category are currently in operation in both Missouri and Illinois. IDOT operates a communications center out of the District 8 office in Collinsville. This center is under the management of the Bureau of Operations and is where the IDOT Emergency Patrol Vehicle (EPV) service and Highway Advisory Radio (HAR) system are based.

For more than two decades, the IDOT EPV program has been providing service to motorists on portions of the freeway system. The communications center monitors 310 motorist aid call boxes along other parts of the metropolitan area freeway system (not covered by EPV), and also receives incoming telephone calls from motorists requesting emergency assistance. In turn, dispatchers direct EPV's to the proper location where they provide various services to assist the motorist. In January, 1993 the MHTD also implemented a motorist assist patrol program on a portion of the Missouri metropolitan freeway system.

IDOT's HAR network is currently utilized primarily to provide motorists with bridge crossing traffic information. Nine HAR transmitters (four of which are in Missouri) are operated out of the District 8 communications center.

Although "closed loop" coordinated traffic signal systems do not fall directly in the IVHS category, they become key elements in freeway traffic management once they are integrated into a regional system. MHTD, IDOT and St. Louis County currently operate these types of signal control systems.

3.1.2.2 Mass Transit/LRT

In 1993, the MetroLink light rail transit system (LRT) began service in the St. Louis metropolitan area. Some of the features of the 18-mile system include 19 stations, 31 LRT vehicles (with a capacity of 178 passengers each) and more than 2,000 secured park-and-ride spaces. Operated by the Bi-State Development Agency, the MetroLink system operates each day from 5:30 a.m. until 1:30 a.m. Trains run at 7 W-minute intervals during weekday peak hours, and at 15-minute intervals during off-peak hours. Other schedules apply to late night, weekend, and holiday service.

The Bi-State Development Agency also operates a regional bus system. While this system provides the majority of the transit service in the St. Louis area, some smaller transit authorities also provide additional service to limited portions of the metropolitan area.

3.1.2.3 Jurisdictional Issues

Because the bi-state St. Louis metropolitan area encompasses two states, seven counties, the City of St. Louis and approximately 200 municipalities, jurisdictional issues are an important aspect to effective planning for a regional freeway management system. The varying laws, policies, procedures and enforcement/incident response practices all are key elements to be considered.

3.2 FUTURE PLANS AND CONDITIONS

3.2.1 Forecast Traffic Volumes

In order to plan for IVHS improvements that will not only be effective today, but also in the future, it was important to examine forecast traffic volumes. The traffic volumes used in the analyses were obtained from the East-West Gateway Coordinating Council, and are shown in Figure 3-2.

3.2.2 Transportation Improvement Program/Capital Improvement Program

Data relating to roadway and traffic control improvements planned for the metropolitan area have been extracted from the East-West Gateway Coordinating Council's three-year Transportation Improvement Plan (TIP). These planned improvements include such measures as adding lanes to roadways, new interchange and roadway reconstruction, new traffic signal systems, etc.

As state and local agencies construct improvements to the freeway and arterial street systems, the opportunity exists to coordinate the implementation of freeway management/ IVHS measures into some of these projects. Where this is feasible, it should be possible to achieve a savings in both the time and costs normally associated with bringing these technologies and strategies on line. It is recommended that this information be studied further because it is possible that: 1) some of the planned improvements will alleviate present traffic congestion on a particular freeway; or 2) the projects should be modified to include some type of IVHS measure, thereby giving additional congestion relief on the freeway system.

3.2.3 Mass Transit/LRT

The expansion of both the regional bus and the MetroLink light rail systems is currently under consideration by the Bi-State Development Agency and various levels of government. The bus systems' route structure and levels-of-service provided are part of an on-going initiative to enhance the existing service. For MetroLink, a study is now under way to determine the feasibility of an extension from East St. Louis through St. Clair County to the Scott Air Force Base site.

Other possible MetroLink extensions currently under consideration are a north-south extension, and one west from Lambert-St. Louis Airport to the city of St. Charles in St. Charles County.

4. SYSTEM ARCHITECTURE

4. SYSTEM ARCHITECTURE

4.1 INTRODUCTION

The purpose of this chapter is to present the system architecture requirements for the bi-state St. Louis area freeway management system that is necessary to accommodate existing and future applications of IVHS technologies. This chapter includes a description of the recommended system architecture, including system components, the system framework and inter-jurisdictional communications.

This chapter is based on the evaluation and findings presented in the various Technical Memoranda that were prepared earlier as part of this study. The Technical Memoranda evaluated different technologies for different components of the system, and made recommendations for each of the components. In addition, this chapter takes into account the specific transportation requirements of the study area and the needs of the associated jurisdictions and agencies.

4.1.1 Definition of System Architecture

In order to properly proceed with the development of the system architecture, the term "system architecture" needed to be clearly defined because there are many varying and conflicting definitions in use today. The system architecture can be simply defined as "the structure and relationship among the components of a system." The system architecture provides the framework around which the final report, strategic deployment plan, system design, systemcomponents, specifications, interfaces, and inter-jurisdictional communications are defined.

4.1.2 Objectives of the System Architecture

A well-planned system architecture allows the goals of the transportation system to be easily met, and is flexible so that change, evolution and growth can be accommodated. The flexibility and adaptability of a system architecture for IVHS is especially important, given the rapid pace of changing and developing technologies. The system architecture must also be "open", to allow multiple vendors to supply/maintain the system, and to be able to interface with other systems.

Following is a list of objectives for developing the bi-state St. Louis area System Architecture:

- Provide the overall structure for a transportation management system to improve mobility within the region.
- Strike a balance between using proven, reliable technologies, and the latest state-of-the-art technologies. "Cutting edge" technologies, although offering operational advantages, are often unproven. On the other hand, the technologies used must be recent so that the system is not outdated too quickly. Both proven technologies and state-of-the-art technologies were considered.
- Provide for future regional growth and incorporate advancements in new technologies, with a minimal effort. A system which requires major portions to be discarded as part of an upgrade would not be useful for very long.
- Installation costs for the system should be minimized.
- The architecture should be "open" so that multiple vendors can support the system, which will reduce costs and improve maintenance options.

4.2 SYSTEM ARCHITECTURE DESIGN CONSIDERATIONS

The purpose of this section is to discuss the various components and aspects of the bi-state St. Louis IVHS system and their relationship with the system architecture. The functionality of the components, how the components relate to one another, and institutional issues are all key factors in determining the most appropriate system architecture.

4.2.1 Existing Systems

The bi-state St. Louis region has several existing systems that should be incorporated into the system architecture to the greatest extent possible. Each existing system was reviewed as to whether or not it should be incorporated into the new system, or if the existing system should be upgraded or replaced to fit into the new system. Factors that affected this decision included the age, functionality, and usefulness of the existing system, and the effect on the system architecture that would be imposed by the existing system.

4.2.1.1 Freeway Traffic Management Systems

The Bi-State St. Louis area has the following existing freeway traffic management systems. Each was considered for integration into the system architecture, where practical:

- IDOT Highway Advisory Radio
- IDOT Motorist Aid Call Boxes
- MHTD Motorist Assist Patrol/IDOT Emergency Patrol Vehicles
- I-70 Reversible Lanes (Missouri)

4.2.1.2 Arterial Systems

Technical Memorandum #13 identified a number of arterial roadway systems as potential candidates for diversion routes. Of these arterials, the following have existing signal systems:

Missouri:

- Forest Park Boulevard/Parkway
- Lindbergh Blvd. (US 61/67)
- Watson Road (MO 366)
- St.Charles Rock Road (MO 115/I 80)
- Clayton Road

Illinois:

- State Street
- St. Clair Avenue
- Collinsville Road

Most of these signal systems are a mixture of older and newer equipment. Most of the systems also have a mixture of traffic signal controller manufacturers, which would make direct communications with all of the controllers infeasible. Communications to the systems could be accommodated either by using a remote communications unit (RCU), or by replacing older equipment with new homogeneous controller equipment on each arterial.

4.2.2 Proposed Field Systems Requirements

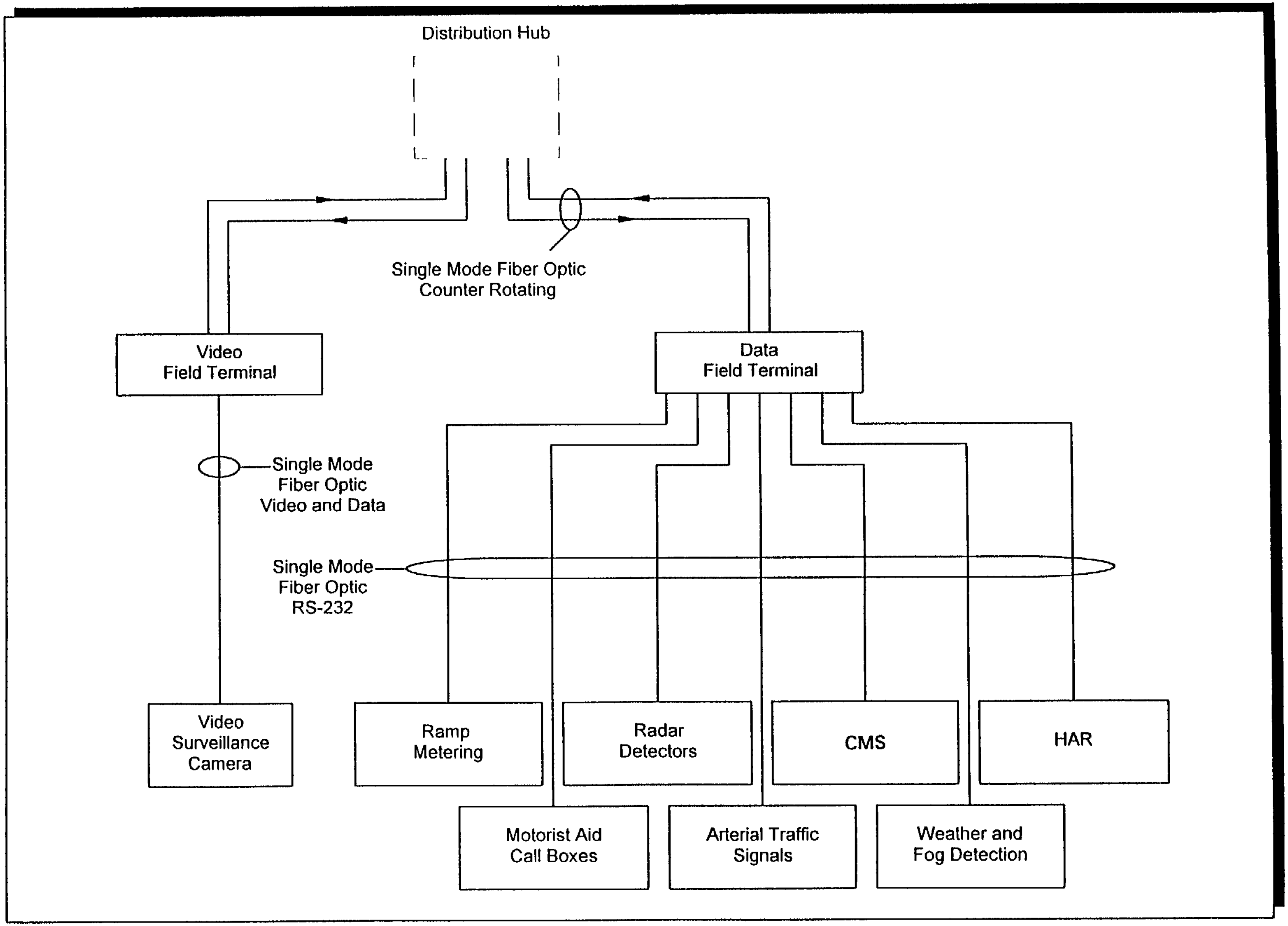
This section presents an overview of the proposed field systems and their components, as recommended in the Technical Memoranda. Figure 4-1 shows the field devices and the proposed communications to link the devices with the regional control centers.

4.2.2.1 Vehicle Detection System

Technical Memorandum #1 recommended the use of radar detectors for system detection. The use of loop detectors, a proven technology, will also be considered for use at selected locations acceptable to MHTD/IDOT. The system architecture will require communications to the detectors and computer hardware/software to process the detector data.

4.2.2.2 Closed Circuit Television System

Technical Memorandum #2 recommended the use of a Closed Circuit Television (CCTV) system for incident detection and verification on the freeway system. The following CCTV system components were considered in the system architecture design:



St. Louis Area IVHS Planning Study

FIELD DEVICES AND COMMUNICATIONS

FIGURE 4-1

- CCTV cameras located throughout the freeway network
- Full motion, color video
- Video matrix switch
- 19" video monitors
- 37" video monitor, which should be mobile
- Fiber optic cable for communications (video and pan/tilt/zoom control)
- IBM/Intel family of video compression hardware/software

4.2.2.3 Highway Advisory Radio System

Technical Memorandum #3 recommended one Highway Advisory Radio (HAR) system for providing traveler information. The recommended HAR system will integrate the existing IDOT HAR sites, with the one exception noted below, and the following components:

- Ten-watt system
- Class D transmitter
- 530 KHz AM transmission
- Vertical whip antenna
- Computer control and digital downloading capabilities
- Live broadcast capability
- Transmitters located throughout the metro area for complete freeway network coverage

The one exception to using the existing IDOT HAR sites is the St. Charles County location near I-70 and State Highway 94. This site does not fit well into a metro-wide HAR network, and should be relocated/replaced by a site further to the southwest along State Highway 94.

4.2.2.4 Changeable Message Sign System

Technical Memorandum #4 recommended two types of Changeable Message Signs (CMS) -- LED/flipped disk, and fiber optic/flipped disk. The system should include these components:

- CMS
- CMS controller
- Field communications
- Computer hardware/software for message generation and monitoring

4.2.2.5 Ramp Metering System

Technical Memorandum #5 provided an overview of ramp metering systems. The components of a ramp metering system include:

- Ramp meter controllers
- Detectors
- Field communications
- Computer hardware/software

The ramp meter controllers would be the Open Architecture (OAC) or Advanced Traffic Controllers (ATC), as recommended in Technical Memorandum #11.

4.2.2.6 Traffic Signal Systems

Technical Memorandum #8 discussed the benefits of integrating freeway and arterial traffic control, especially where the arterial is a local route for diverting freeway traffic during an incident. The components of a traffic signal system include:

- Signal controllers
- Detectors
- Field communications
- Computer hardware/software

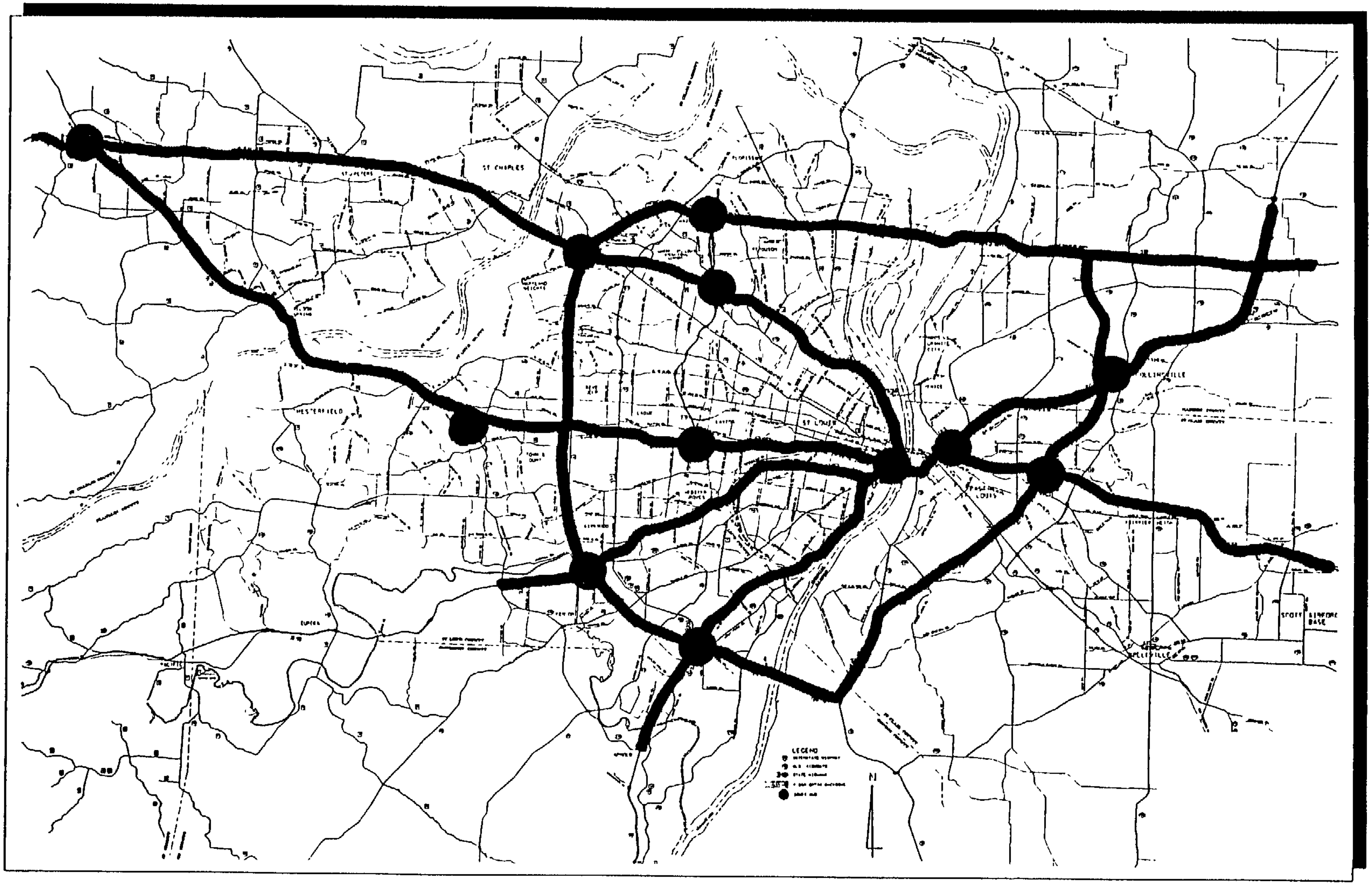
4.2.2.7 Communications

Technical Memorandum #9 discussed the communications system and presented recommendations for a multi-level distributed communications network. The network will consist of a fiber optic backbone, with distributed processing/multiplexing contained at communications nodes (e.g., SONET hubs) throughout the region. This recommended communications architecture forms the basis for the system architecture. Figure 4-2 shows the proposed fiber optic backbone routing and SONET hub locations.

4.2.2.8 Traveler Information Services

Although not expressly identified in a separate Technical Memorandum, traveler information services will be a major function of the freeway management system. Several of the components discussed above are also part of the traveler information network, including CMS's and HAR. Other components of traveler information services include:

- Toll-free Cellular "Hotline"/Highway Advisory Telephone
- Motorist Aid Call Boxes
- Electronic bulletin board service (BBS), to provide information to the media (commercial radio and television) and others (see below)
- Information kiosks in major transportation stations, major employment centers and traffic generators (sports stadium/arena, shopping centers, etc.)
- Cable TV transportation channel



St. Louis Area IVHS Planning Study

Fiber Optic Backbone
& SONET Hub Locations

FIGURE 4-2

4.2.3 Transportation Management Requirements

This section presents an overview of the proposed transportation management systems and functions, as recommended in the Technical Memoranda. The type of functions that are recommended for the system, both initially and for the future, also affect the system architecture. The recommended transportation management functions are as follows:

- Monitoring (surveillance) functions, including the collection and analysis of traffic flow data, system performance evaluation, and provision for incident detection/verification
- High Occupancy Vehicle (HOV) applications, including dissemination of information to the public, and monitoring of HOV lanes
- Route guidance/diversion
- Ramp metering of selected freeway access ramps
- Arterial/freeway traffic control systems integration
- Incident management, including incident detection/verification, incident response, and dissemination of information to the public
- Other functions, including the monitoring of system components, maintenance and inventory

4.2.4 Inter-Jurisdictional/Agency Coordination Requirements

The bi-state St. Louis area has many different jurisdictions and agencies that should be involved in the management of the regional transportation system. How these jurisdictions are organized, how they communicate with one another, who controls what traffic control devices, and other such issues need to be resolved. This section discusses the different jurisdictions and agencies involved, their transportation management needs, the needs of the regional system, and makes recommendations for an organizational framework.

4.2.4.1 Identification of Involved Jurisdictions and Agencies

The following is a partial list of the major involved jurisdictions within the study area:

- Missouri Highway and Transportation Department
- Illinois Department of Transportation
- East-West Gateway Coordinating Council
- Missouri Counties of St. Louis, St. Charles, Jefferson and Franklin
- Illinois Counties of Monroe, Madison and St. Clair
- City of St. Louis
- City of Bridgeton
- City of Chesterfield
- City of Clayton
- City of Creve Coeur

- City of East St. Louis
- City of Kirkwood
- City of Ladue
- City of Maryland Heights
- City of Richmond Heights
- City of O'Fallon
- City of St. Charles
- City of St. Peters

The following is a list of agencies that have major transportation responsibilities within the study area:

- Missouri Highway and Transportation Department
- Illinois Department of Transportation
- Missouri Counties of St. Louis, St. Charles, Jefferson and Franklin
- Illinois Counties of Monroe, Madison and St. Clair
- City of St. Louis
- East-West Gateway Coordinating Council (MPO)
- Bi-State Development Agency (transit/light rail agency)
- City of St. Louis Airport Authority
- Various Emergency Medical Service and Fire Department Authorities
- Missouri Highway Patrol, Illinois State Police and various local police agencies
- Several smaller cities that control/maintain their own signals and other equipment

Major employers in the metropolitan area are also critical players in developing the organizational framework,

4.2.4.2 Relationships Between Jurisdictions and Agencies

Although there are already good working relationships between all of the parties involved in the study, there are still some institutional issues that needed to be addressed before the system architecture design could be completed. Primarily, these dealt with the operation of the system, maintenance of the system components, and issues that will likely be encountered in the future as the system expands in functionality. How jurisdictions communicate with one another, and the level of control each has, has a significant impact on the system architecture.

Operational issues to be resolved included how information is transmitted from one jurisdiction to another to coordinate signal operations, diversion routes, incident responses, and other situations. For example, during a major incident, it is advantageous for the regional agency to be able to take over temporary control of a local jurisdiction's signals to coordinate and facilitate the traffic diverted from the freeway. How and when this could take place is dependent on numerous factors, including:

- The willingness of the local agency to relinquish control
- The nature of the incident and volume of diverted traffic involved
- The staffing level and hours of operation of the local traffic center
- The staffing level and hours of operation of the regional traffic center
- The level of input that the local jurisdictions have to the regional center
- The amount and accuracy of information that is available to each center

Because of the complexity of some system components (e.g. fiber optics, CCTV), not all jurisdictions are able (or willing) to cost-effectively maintain such high technology equipment. Thus, how the system will be maintained, whether internally by joint maintenance agreements between agencies or through external maintenance contracts, has to be addressed.

Other issues involved in operating the system that cross jurisdictional boundaries include:

- Standardization of system components and software
- Funding and staffing responsibilities
- Maintenance responsibilities, especially for shared facilities like the communications infrastructure
- Operational policies, from messages that are displayed on CMS's to common time references
- Political and public issues, such as CCTV and privacy rights, diverting freeway traffic onto local streets, and others
- Private sector issues, including sharing of information, joint use of facilities (e.g. telephone lines), and others

4.2.4.3 Jurisdictions that Should Have a Traffic Information/Operations Center

Before discussing whether there is a need for a "Traffic Information Center" (TIC), the definition of a TIC must be clarified. TIC's can range from a fully functional control center in a large room with full time, round-the-clock staff, that houses communications and computer equipment and other support devices, to a small office with just a personal computer and a modem. The fully functional TIC's can control equipment, collect, process and disseminate information, and coordinate regional transportation/incident response activities. In this report, the term "Traffic Operations Center" (TOC) refers to the small office described above. A TOC would be able to access information, get updates on maps and status, and be able to transmit information and messages to others in the system.

TIC candidates are usually the state transportation/highway departments, while TOC candidates typically include large cities, emergency response authorities (police, fire, medical), and large counties. Examples include:

- Missouri Highway and Transportation Department--District 6, Town and Country (TIC)
- Illinois Department of Transportation--District 8, Collinsville (TIC)
- City of St. Louis Department of Streets (TOC)
- St. Louis County Department of Highways and Traffic (TOC)

- Regional police, fire, and emergency response authorities or teams (TOC)
- Bus, rail and airport transit agencies (TOC)

Other TOC candidates could be smaller cities and counties, and other transit authorities.

4.2.5 Future IVHS Technology Requirements

The initial system will be the building block for future IVHS applications within the region. As such, the design of the system and system architecture should be open, flexible, and adaptable to accommodate future IVHS functions. The system should not preclude these functions, nor should it require extensive modification to grow with future developments in IVHS technologies. This section presents an overview of some of the foreseeable applications of IVHS, in both the near and long-term future.

4.2.5.1 Traveler Information

Other functions related to Advanced Traveler Information Systems (ATIS), beyond the HAR and CMS that will be provided initially, could include:

- Traveler Advisories
- Traveler Service Information
- Trip Planning
- Location Determination/Display
- Route Selection
- Route Guidance
- In-Vehicle Signing

4.2.5.2 Traffic Management

Traffic management features that will be included in the initial system include incident detection/management, and traffic control. Additional traffic management features could include:

- Demand Management
- Traffic Network Management
- Adaptive Traffic Control
- Parking Management
- Construction Management

4.2.5.3 Freight and Fleet Management

Freight and fleet management includes commercial vehicle operations (CVO) and could include the following functions:

- Inter-modal Transportation Planning
- Route Planning and Scheduling
- Hazardous Materials (HAZMAT) Monitoring and Tracking
- Vehicle and Cargo Monitoring
- Law Enforcement
- Regulatory Support

4.2.5.4 Public Transportation and Emergency Vehicle Management

Public transportation and emergency vehicle management falls under the IVHS category of Advanced Public Transportation Systems, and could include the following functions:

- Planning and Scheduling Systems
- Signal Preemption and/or Signal Priority
- Automatic Payment, Flexible Fares
- Dynamic Ride Sharing
- Prediction of Arrivals
- Emergency Services System Management
- Traveler Safety/Security
- MAYDAY Transmissions

4.2.5.5 Advanced Vehicle Control Systems

Advanced vehicle control systems are long-term future IVHS technologies which could include:

- Driver Aided Vehicle Control
- Adaptive Cruise Control
- Autonomous Vehicle Control
- Collision Alert Warning
- Collision Avoidance Control
- Driver Condition and Performance
- Intersection Hazard Warning
- Vision Enhancement
- Vehicle Condition and Performance Monitoring

4.2.5.6 Automated Highway System

Automated Highway Systems are also a long-term IVHS application, which could include such features as:

- Automated Check-in/out
- Lateral Control
- Longitudinal Control
- Malfunction Control
- Traffic Regulation

4.3 SYSTEM ARCHITECTURE ALTERNATIVES

There are many different possible system architectures, each with their own advantages and drawbacks. In addition, there are two major portions of the system architecture that must be analyzed concurrently--the structure of the regional communications network and inter-agency operations (the institutional architecture) and the structure of the hardware and software components (the operational system architecture). The following sections describe the types of architectures that were examined.

4.3.1 Potential Institutional Architecture Candidates

The institutional architecture of the system defines the structure of how different agencies and jurisdictions will work together to manage the region's transportation system. It is very important that the many institutional issues, described herein and in the Technical Memoranda, be discussed and addressed before system implementation.

There are a wide variety of possible institutional architectures for the system. The preliminary investigations considered a number of potential architectures, including:

- Keeping the status quo--the null, or no build, alternative
- Independent systems--which would consist of each of the jurisdictions/agencies upgrading their systems, but without any linkages or advanced communications
- Independent systems linked through time-based coordination--which is the same as above, but with some linkages between systems, including a common time reference, and the ability to share some data
- Networked systems--which would include provisions for a wide area network to interconnect all of the region's systems, and allow for direct communications, sharing of information, and passing of control
- A single centralized system--which would consist of one agency being responsible for the control and command of the entire region

The recommended institutional architecture is discussed in Section 4.4.

4.3.2 Potential Operational System Architecture Candidates

The traffic management systems that exist today can be categorized into three general types:

- Centralized Systems
- Two-level Distributed Systems
- Multi-level Distributed Systems

Each of these systems, along with its advantages and disadvantages, is discussed below.

4.3.2.1 Centralized Architecture

The Centralized Architecture, depicted in Figure 4-3, is the traditional approach used with most large scale Urban Traffic Control System (UTCS) type traffic control applications. The second-by-second, real-time monitoring and control of local controllers is performed by a multi-processing central computer located at a traffic operations center. The local controllers have minimal processing requirements beyond the basic detector and communication functions.

Centralized architecture systems are mandatory for any system requiring second-by-second control of field devices. The advantages and disadvantages of such a design are detailed in Table 4-1.

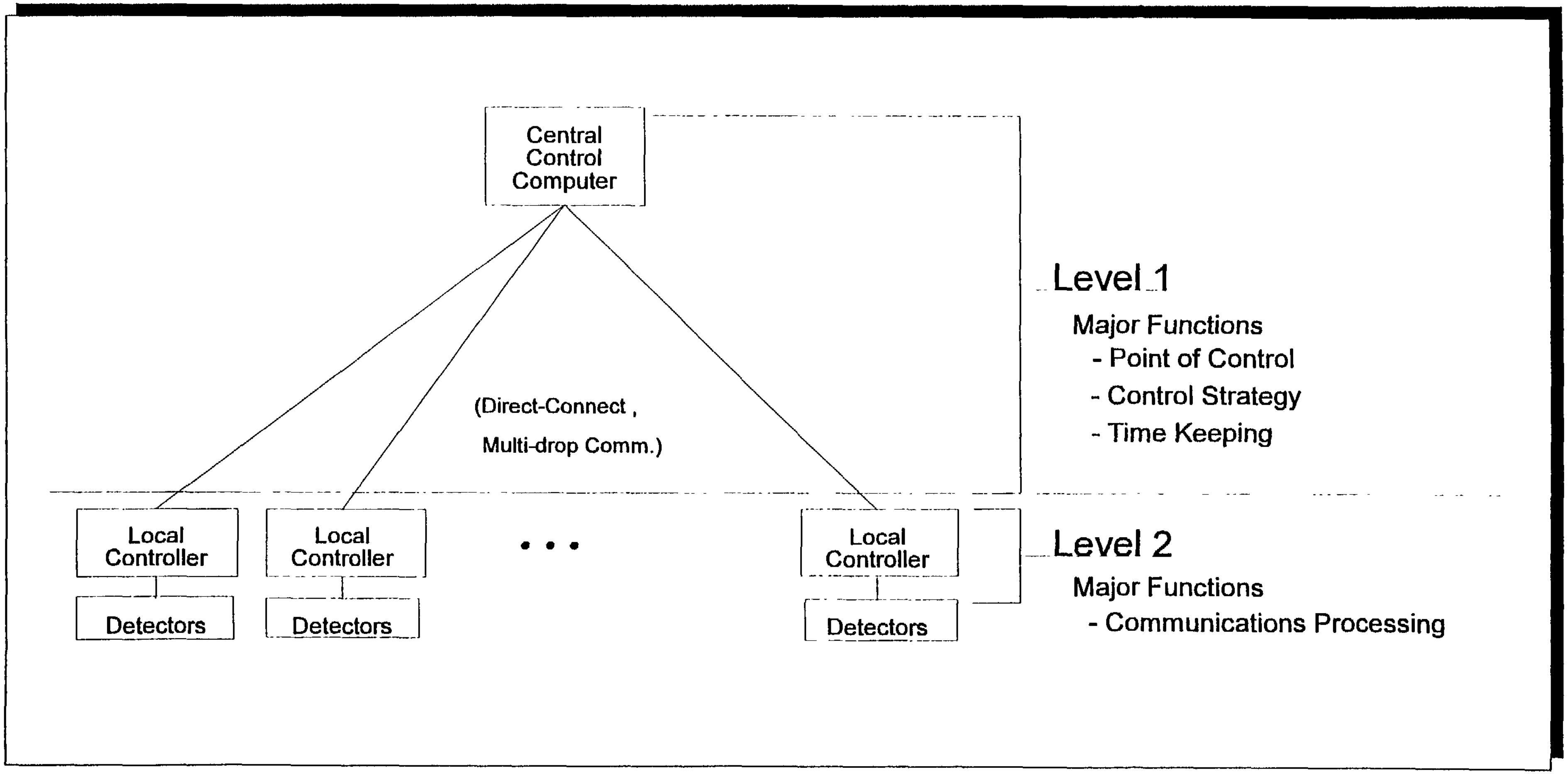
Table 4-1

ADVANTAGES AND DISADVANTAGES OF A CENTRALIZED ARCHITECTURE

Advantages	Disadvantages
1. Straightforward design	1. Heavy dependency and cost associated with dedicated communications links
2. Allows use of existing controllers	2. Heavy processing requirements due to high communications loads
3. Isolates the majority of the software and hardware requirements to the central computer	3. Single point of failure

4.3.2.2 Two-Level Distributed Architecture

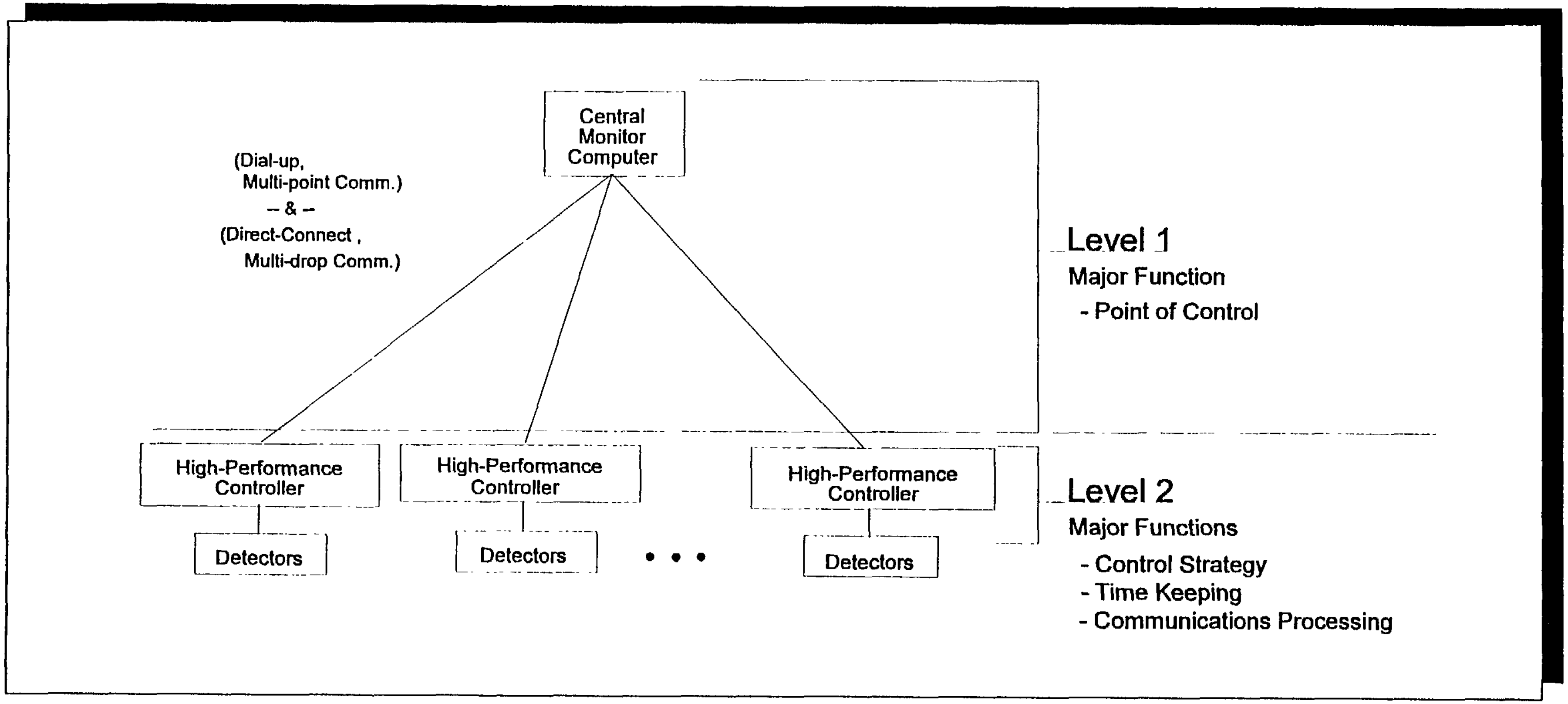
For the Two-level Distributed Architecture, depicted in Figure 4-4, the levels of distribution are dedicated to the central computer and the local controller. The local controller performs the second-by-second microscopic signal control functions which can also include execution of the tactical control strategy. The central computer performs the remote controlling of the



St. Louis Area IVHS Planning Study

Centralized Architecture

FIGURE 4-3



St. Louis Area IVHS Planning Study

Two-Level Distributed Architecture

FIGURE 4-4

local algorithm's operation and monitors its effectiveness. Additional capabilities could be provided by the central computer such as the high level macroscopic adaptive signal control functions.

The advantages and disadvantages of this design are presented in Table 4-2.

Table 4-2

ADVANTAGES AND DISADVANTAGES OF THE TWO-LEVEL DISTRIBUTED ARCHITECTURE

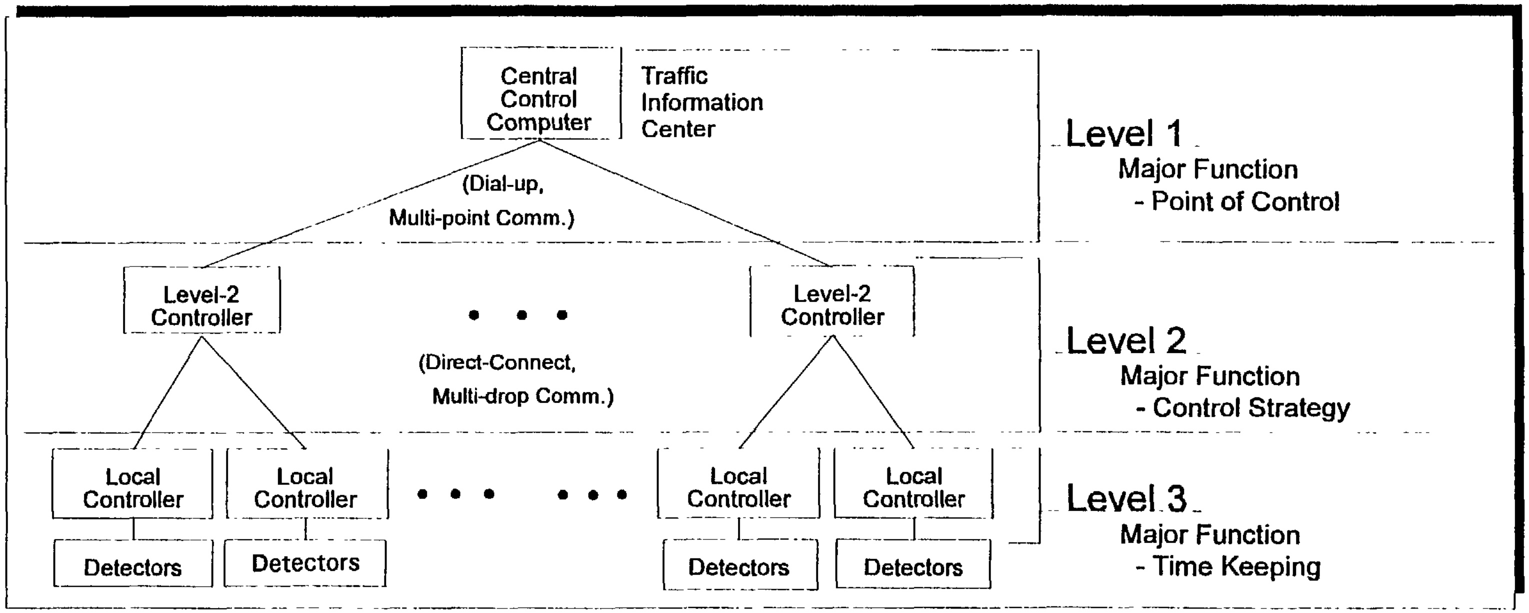
Advantages	Disadvantages
1. Does not depend solely on the central computer subsystem for the system to operate effectively	1. A high performance processor is required within the local controller in order to effectively perform the second by second microscopic adaptive signal control functions
2. The communications requirement are more flexible, since there exists no real-time data exchange between the local controllers and central computer	2. Loss of flexibility in the control algorithm design due to the limited ability of intersections to exchange data

4.3.2.3 Multi-Level Distributed Architecture

In a Multi-level Distributed Architecture, depicted in Figure 4-5, monitoring and control processing functions are shared between mid-level computers and a central computer. This architecture can also be a geographically distributed architecture in which the central computer serves as a repository for summary data, and as a network hub that ties together satellite processors.

Closed Loop Systems are a good example of this architecture. These field distributed systems feature a central microcomputer that communicates with local area masters using either dedicated or dial-up communications facilities. The local area masters are connected to the intersection controllers using dedicated communications facilities. This architecture is the type that is being implemented in the Atlanta Regional ATMS project, and at several other ATMS projects throughout the country.

The major advantages and disadvantages of this system are highlighted in Table 4-3.



St. Louis Area IVHS Planning Study

Multi-Level Distributed Architecture

FIGURE 4-5

Table 4-3

ADVANTAGES AND DISADVANTAGES OF THE MULTI-LEVEL DISTRIBUTED ARCHITECTURE

Advantages	Disadvantages
1. Interaction between controllers is accommodated by the Level 2 processor	1. Requires additional hardware to perform the Level 2 processing functions
2. Communications requirements between Levels 1 and 2 are minimized	2. Requires more complex communications system.
3. Provides for jurisdictions to have independent or coordinated control options	

3.2.4 Example Systems for the Various Architectures

There are several existing examples of all four basic system architecture types in use today.

Table 4-4 summarizes the distribution of functions for a variety of existing systems.

Table 4-4

DISTRIBUTION OF FUNCTIONS FOR SAMPLE SYSTEMS

Architecture	***Examples***	***Location of Functions***		
		Point of Control	***Control Strategy***	***Time Keeping***
Isolated	Full-Actuated OPAC (no comm.)	Local	Local	Local
Central (Old Tech.)	UTCS SCOOT SCATS	Central	Central	Central
Central/Two-Level Hybrid (New Tech.)	MIST Series 2000 MONARC	Central	Central	Local Controller
Two-level Distributed	UTOPIA OPAC (with comm.) RT-TRACS (future)	Central	Local Controller	Local Controller
Multi-level Central Distributed	UTCS (DC) SCATS (WAN)	Supervisor and/or Area Computer	Area Computer	Area Computer
Multi-level Field Distributed	Closed Loop Systems	Central	Master Controller	Local Controller

The location of functions shown in Table 4-4 above are defined as follows.

- ***Point of control:*** Identifies where the primary operator interface is executed and where an operator can control the system. In most cases, the point of control is at the central computer.

- ***Control strategy:*** Identifies where the system performs the processing of system algorithms such as plan selection or split allocation.

- ***Time keeping:*** Identifies the location where clocks are maintained for timing the system and local intersection operations according to the parameters set by the other function levels as indicated above.

Table 4-4 shows that there are a variety of existing systems using the different system architectures. Furthermore, the type of architecture chosen is typically dependent on the prevailing conditions at the location where the system is to be installed, including:

- The quality, age and reliability of existing equipment
- Local desires regarding the type of signal control
- Budget constraints

The type of communications system used for each of the example systems also varies depending upon the installation location. The UTCS, SCOOT, SCATS, SERIES 2000, MONARC and MIST systems are variants of centralized systems which require dedicated communication links between central and the local controllers. Even though these systems require a dedicated communications link, the mechanisms of communication varies, as shown in the Table 4-5 below.

UTCS and SCOOT (as well as a number of other proprietary systems not shown in Table 4-4) actually perform controller time-keeping (cycle, split, and offset) at the central computer. Historically, systems which require once-per-second communications perform this high polling due to the time-keeping functions being performed at central, or due to the requirement to receive real-time detector data for a highly responsive system. SCOOT is the only system which requires the high polling rate for both reasons.

Table 4-5

COMMUNICATIONS REQUIREMENTS FOR SAMPLE SYSTEMS

System	*Controllers per Channel*	*Maximum Detectors Re turned*	*Polling Frequency per Intersection*	*Time Keeping*	*Compatible Controllers*	*Typical Baud Rate*
UTCS	8	8	once per second	Central	Type 170 NEMA w/ RCU	1200
SCOOT	10	8	once per second	Central	Type 170	1200
SCATS	1	24	continuous	Local Controller	Type 170	300
SERIES 2000	8	8	once per second	Local Controller	Type 170 NEMA w/RCU	1200
MONARC				Local Controller	Type 170 Eagle Series NEMA w/RCU	1200
MIST v1.3	30	24	once every 30 seconds	Local Controller	Type 170 TCT Series Eagle EPAC NEMA w/RCU	1200

4.4 RECOMMENDED SYSTEM ARCHITECTURE

Based on the design considerations of the system and the alternatives presented above, a recommended architecture for the system was selected. The most appropriate institutional architecture for the system is a multi-level distributed architecture, with each of the agencies connected together via a wide area network (WAN) over a fiber optic communications network. The operational system architecture should also be a multi-level distributed design, with processing distributed at the field devices, communications nodes and at the control centers.

4.4.1 Overall System Architecture

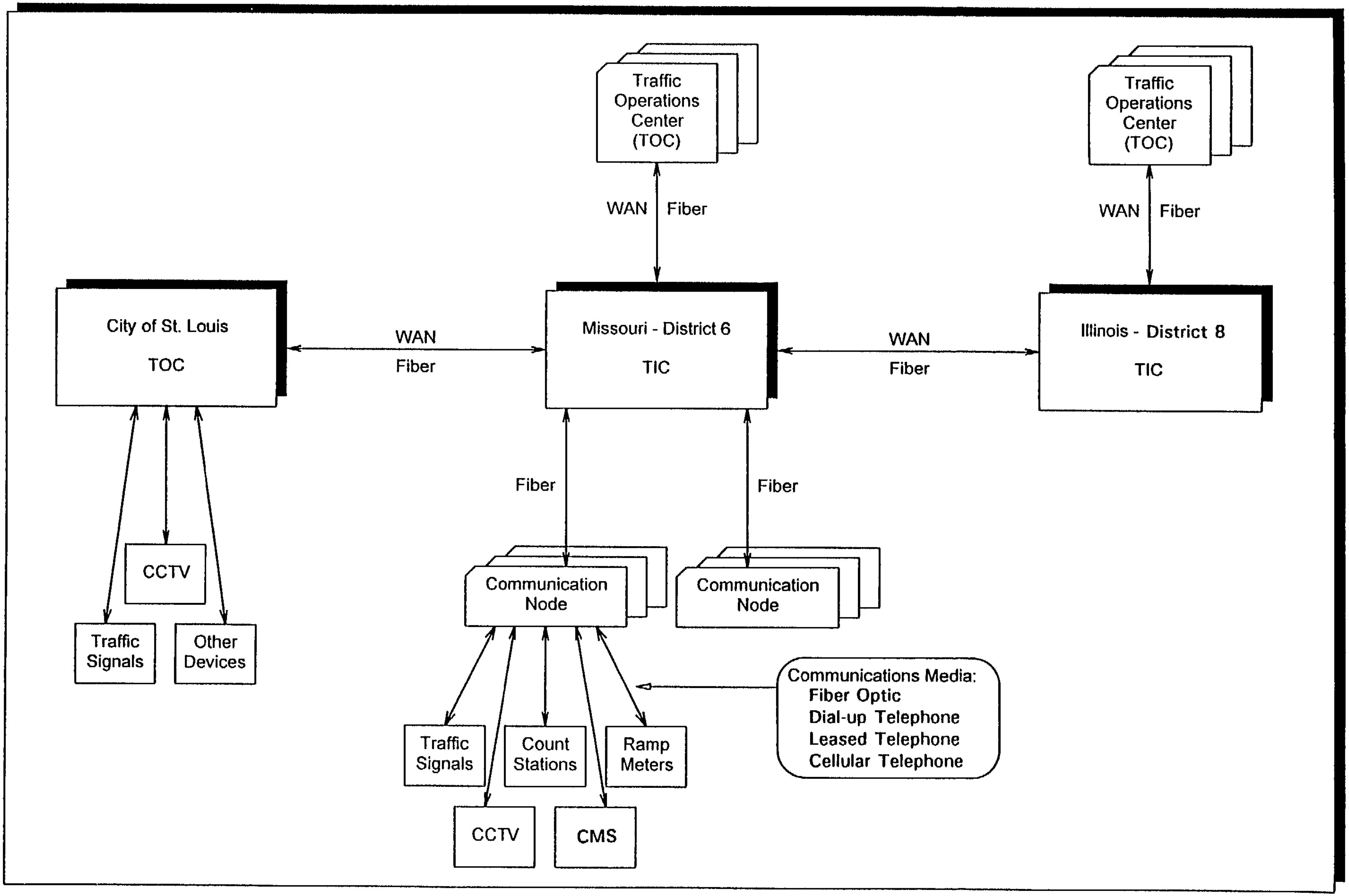
The ultimate recommended system consists of one Traffic Information Center (TIC) in each state which will provide freeway management and other regional operations (see Section 4.2.4.3), and Traffic Operations Centers (TOC) in various major jurisdictions. All of the centers should be designed to provide expansion capability for the foreseeable future, and use a modular design for both the hardware and software to allow easy maintenance and future upgrades. This design will allow for new functions to be added to the system in the future, including those that may be desired for freeway traffic management and the traveler information system. Figure 4-6 shows the structure of the recommended system.

Each of the traffic centers will be connected to the regional wide-area computer network (WAN) using the fiber optic communications backbone network. Figure 4-7 shows the proposed system communications network.

The WAN will provide for the complete integration of all of the region's traffic systems in a single environment. Although each agency will have ultimate control over all of its signals and operations, the system will permit:

- The controlling agency to defer control of all, or any group of, signals to another authorized agency, presumably the TIC, within the controlling agency's specified constraints
- An agency to monitor system operation of any system in the region
- Messages to be passed back and forth between operators and other personnel of the connected agencies

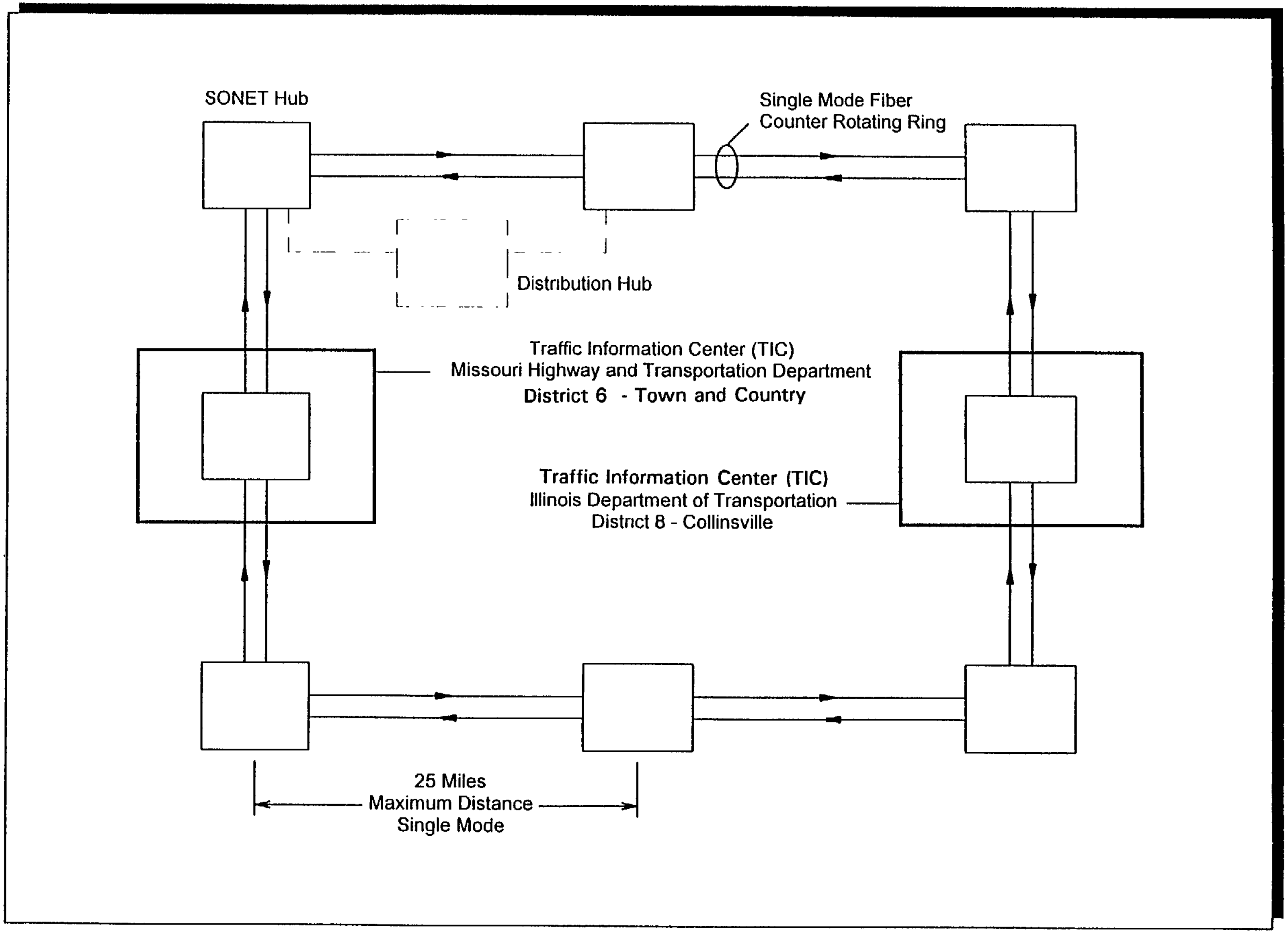
It is expected that the two TIC's, defined as the regional control centers, would control the arterial traffic signals on diversion routes (possibly only in their respective states) when conditions demanded regional, not local, control (e.g. a major freeway incident). Each of the individual TOC's would perform the basic data acquisition and control functions for all of its signals (i.e. communications, failure monitoring, system detector processing, etc.). However, the TIC will always be capable of monitoring all of the signals that are connected to the regional system.



St. Louis Area IVHS Planning Study

SYSTEM ARCHITECTURE

FIGURE 4-6



St. Louis Area IVHS Planning Study

FIBER OPTIC BACKBONE COMMUNICATIONS LOOP

FIGURE 4-7

The recommended design will provide virtually unlimited expansion capabilities. New systems, including freeway management and other types of systems, can be integrated into the central system by connecting them to the WAN. Dynamic cross-jurisdictional coordination can be provided through the automatic generation of messages between agencies when management plan or signal timing changes are needed.

The processing requirements of the system will be distributed at four levels, as follows:

- TIC level
- TOC level
- Communication node level
- Field equipment level

This design allows for transparent signal processing and allows for uninterrupted future growth and expansion. In addition, the processing criteria can be established on each level separately, and can be optimized for maximum operating effectiveness.

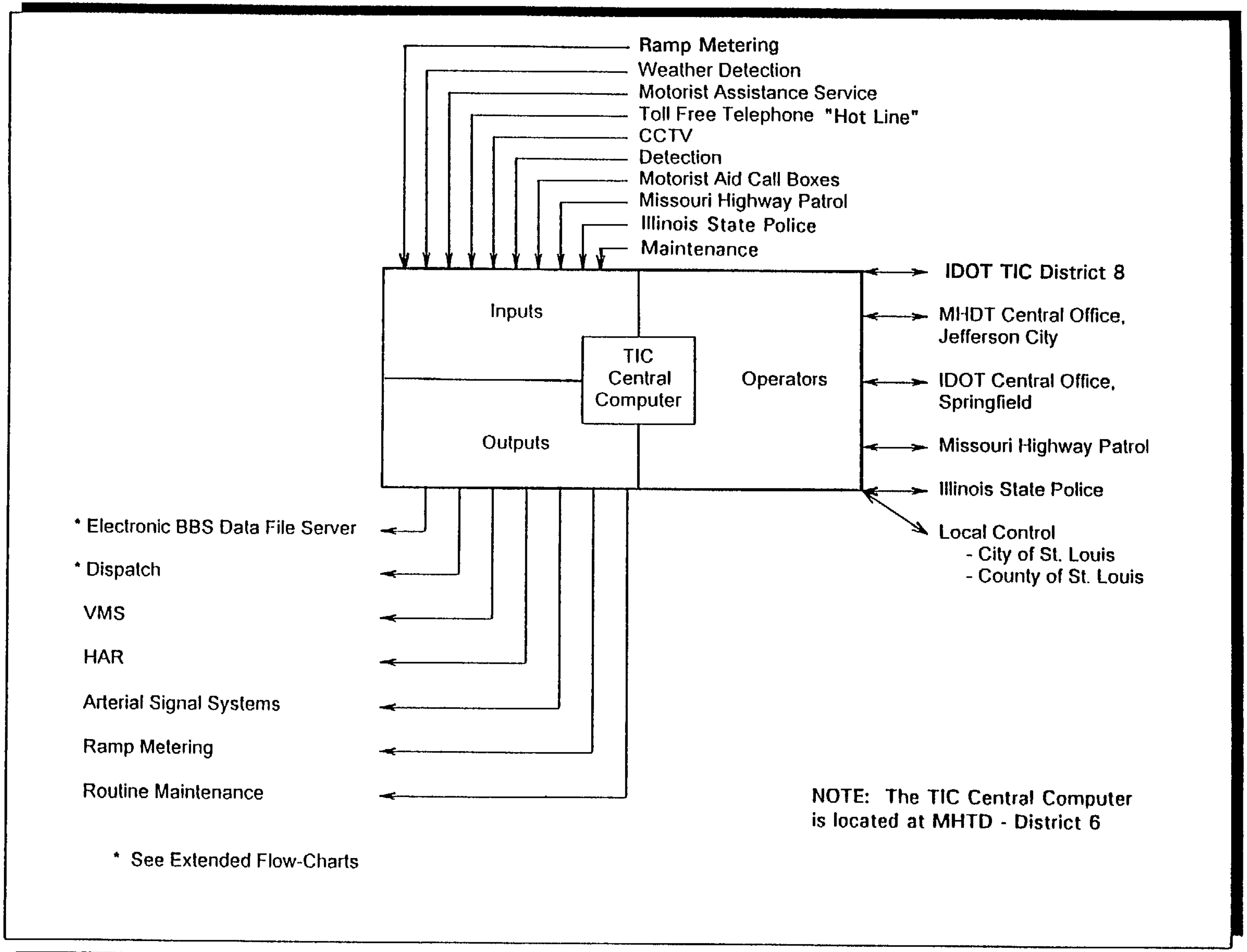
4.4.2 System Software

The recommended system will require that all of the systems use software that shares a common protocol for data exchange. As there is not currently such a standard for traffic control software, it will likely require that all agencies use the same software for signal control, or be equipped with an additional layer of software that would translate messages from one system to another. Because the additional layer would complicate the system and add unnecessary levels of software, it is strongly recommended that all agencies use the same software package.

Figures 4-8 and 4-8a show the typical data flow process and control points of a TIC. The data flow is a classic systems process, simply involving input, analysis and output. The process can be structured into the following:

- Inputs, such as traffic data from the detectors
- Processing in the control center, a decision-making process carried out by the software/operator, and an action or response performed by the software/operator
- The corresponding output, to control devices and/or disseminate information

More detailed information on the software and its functionality is contained in Technical Memorandum #11



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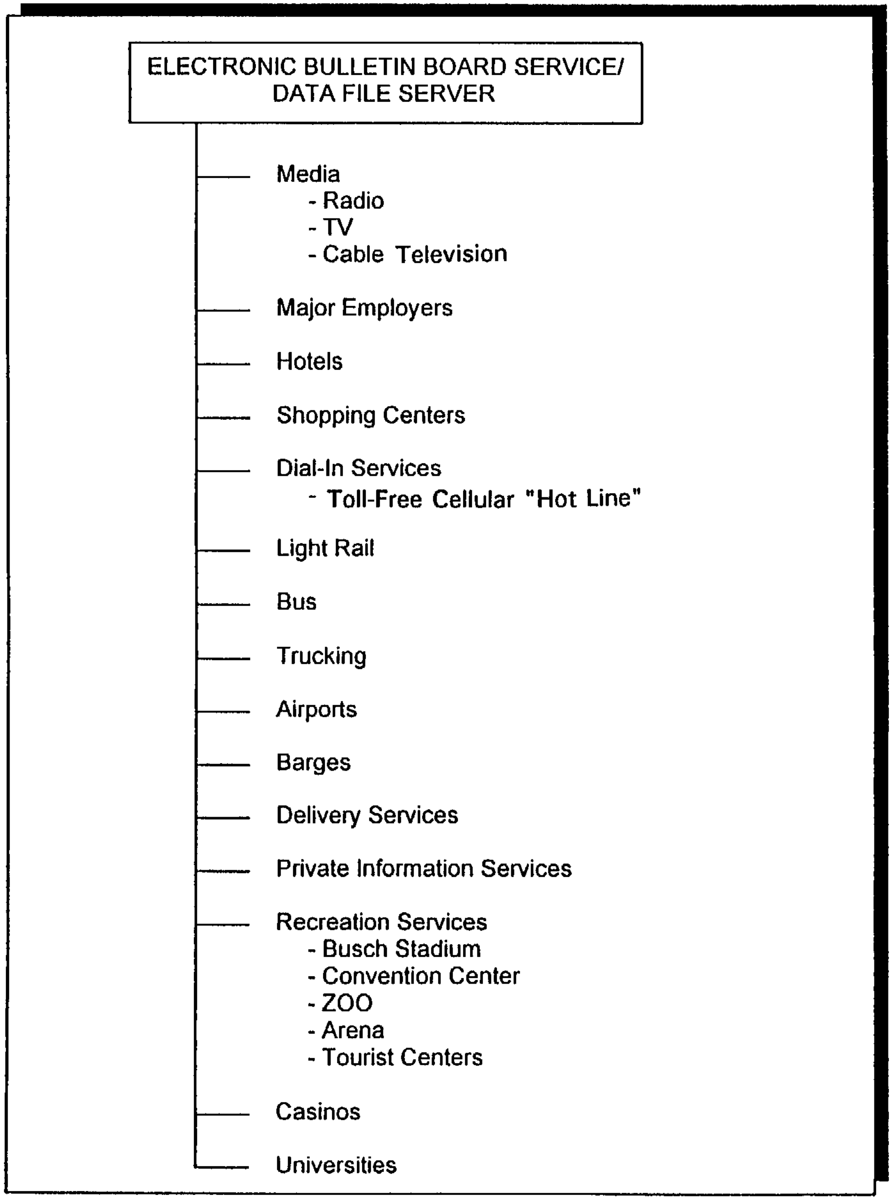
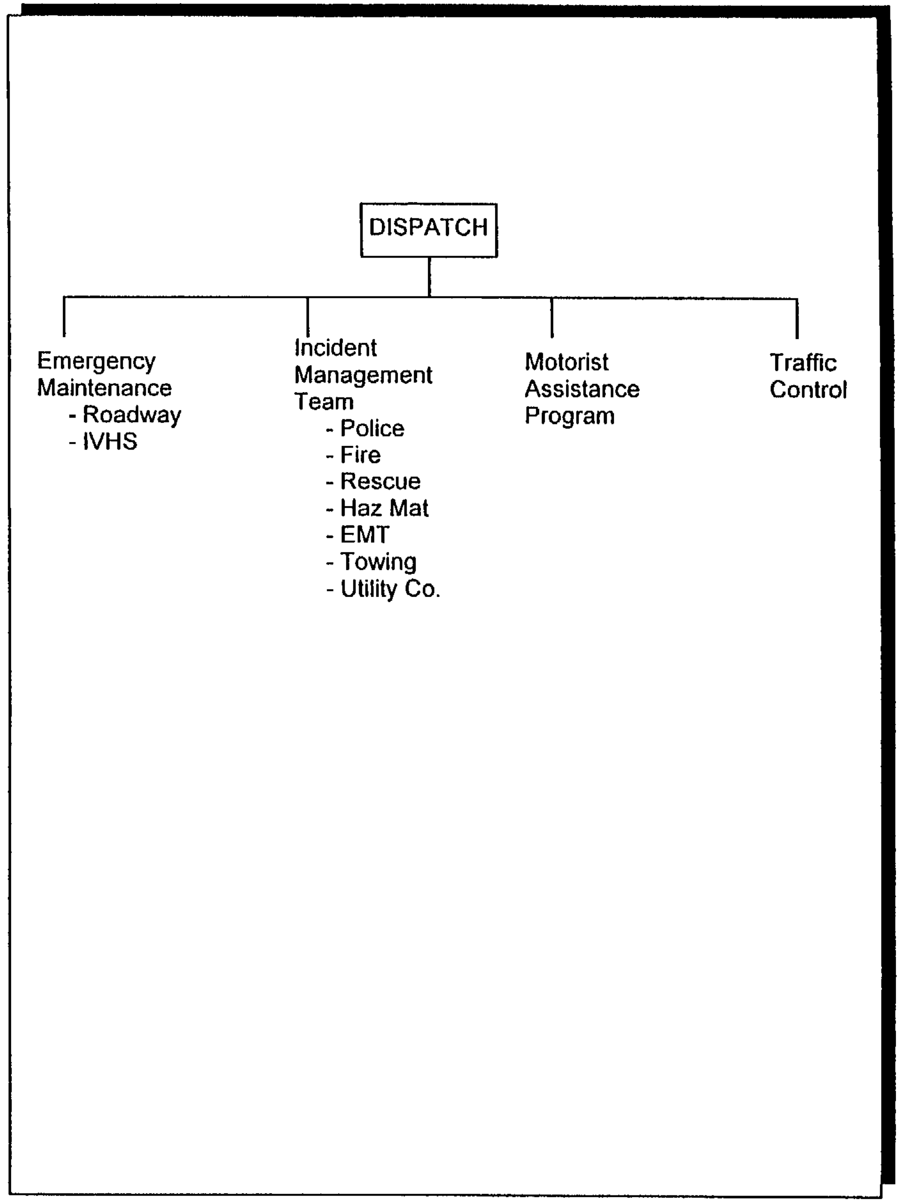
SYSTEM DATA FLOW

FIGURE 4-8





St. Louis Area IVHS Planning Study

SYSTEM DATA FLOW (BBS & DISPATCH)

FIGURE 4-9

4.4.3 Field Equipment

Most of the field equipment recommendations have been identified in the Technical Memoranda. However, one issue that warrants discussion in the final report is choosing between NEMA controllers and Type 170 controllers for the control of traffic signals.

4.4.3.1 Traffic Signal Controller Type

The general trend in the microprocessing industry is to provide for an "open architecture" type of equipment. In the desktop computer market, for example, this has resulted in a multitude of manufacturers producing virtually identical machines meeting the IBM-PC and MS-DOS standards. As a result, it is relatively easy and inexpensive to upgrade computer hardware and system software for these standard pieces of equipment.

Unfortunately, the same broad-based standardization has not occurred in the transportation controller industry. There are two general standards for transportation controllers that are currently available: NEMA and Type 170. Both have their advantages and disadvantages.

- ***NEMA Controllers***

The NEMA controller standard only provides for the standardization of the basic timing features. Coordination features, as well as more advanced functions, are not addressed by the NEMA standard, other than to allow the manufacturers to supply them if they desire. This effectively prevents the interchanging controllers from one manufacturer to another (and sometimes even one model to another) without significant extra effort. Further, the design of the timing parameters vary between the different makes. For example, some controllers measure the offset from the start of yellow in seconds, while others measure it from the start of green in percent. As a result, systems are usually designed with one specific make of controller, and often the agency/jurisdiction will commit to one specific manufacturer's equipment in order to minimize maintenance problems and costs.

The traditional method of overcoming these drawbacks is to use a remote communications unit (RCU), which provides a common interface between the system and the controller. This allows for multiple controllers to be supported by the system, but adds another piece of proprietary equipment to purchase and maintain.

A recent development that will make the use of NEMA controllers more attractive is the ongoing work of the NEMA protocol committee. The committee is developing a standard protocol that can be used for systems communications by all NEMA manufacturers. This protocol will enable a system to easily connect to a different NEMA manufacturer's controllers (or even Type 170 controllers) and still have access to system coordination functions and other standard features. The committee expects to have the protocol finalized in 1994. It is very important that the system hardware and software that is used in the St. Louis system be compatible with, and contain, the standard protocol developed for systems communication.

- ***Type* 170 *Controllers***

The Type 170 controller is rigidly standardized, allowing the user to interchange the program module, such that all Type 170 controllers will be able to look alike and operate in the same manner. Unfortunately, there is a significant price to pay for this standardization. The Type 170 controller is not nearly as user-friendly, nor as powerful, as the latest NEMA controllers. For example, instead of having a 4x40 character display, which is a de facto standard on the NEMA controller, the Type 170 has a five character display. Further, the processor and memory in the Type 170 is not nearly as powerful as those in the NEMA controllers.

A few other controllers have been developed in an attempt to overcome these problems with the Type 170. The first product, developed by New York State, was the 179 controller. This controller was taken a step further with the Type 17OSC (Southern California) and the Type 170E (Extended--California) controllers. These models provided slightly improved processor, memory and modem capabilities over the Type 170, but are still lacking compared to the NEMA controllers. However, the Type 170 update efforts are ongoing, and the latest conceptual designs indicate that the Type 170 and NEMA markets are merging.

- ***Open Architecture Controllers and the* 2070**

The most recent efforts to improve the Type 170 controller have focused on developing an Open Architecture Controller (OAC), or Advanced Traffic Controller (ATC). Although final standards are not yet completed, the first permanent installations of these machines will take place this year in the states of New Jersey and Washington.

CALTRANS is actively pursuing the development of their version of the specifications, and has indicated a willingness to team with other agencies interested in finalizing the design. This model, called the Advanced Transportation Management System Controller Model 2070, will likely come standard with a 4x40 display, a NEMA TS2 Port, a Type 170 CI port, a Motorola 680X0 chip and at least three expansion slots. The expansion slots will work in a similar manner to a desktop PC--simply slide a card in, configure and use. This will enable the controller to not only be used for signal control, but for other advanced functions that will be required in a regional transportation management system.

Although these new controllers are still not standardized, they are scheduled to be in production within the next year. The cost will be within the same price range as the current Type 170 controller (about $2,500).

- ***Controller Recommendations***

For the St. Louis metropolitan area, the most appropriate choice for a region-wide standard is the NEMA controller. Its long-time use in the region and the resulting familiarity with these controllers, as well as their advanced features and better display capabilities, are all positive aspects of using the NEMA controller. Furthermore, with the nearly complete development of the protocol standard, the single major drawback of the NEMA controller (lack of a communications standard, and thus swap-out capabilities) will be eliminated in the near future.

It is difficult to currently recommend regional standardization for traffic signal control using the Model 2070, or any other OAC/ATC, for the following reasons:

- Standards are not yet finalized
- It is still unproven in a permanent field installation for traffic signal control
- Available software for it is limited

However, since this controller provides valuable features that may be used in future applications, consideration should be given to installing a testbed for these controllers. By the time such an installation would take place, many, if not most, of the above issues will likely be resolved.

Given the desire to keep using, in the St. Louis area, many of the more advanced traffic control features supplied by the NEMA controllers, the conventional Type 170 controller is also not a realistic option. One of the newer versions of the Type 170 may supply some of the desired features, but the five-character display limitation and staff unfamiliarity with the controller still are obstacles to its selection.

4.4.3.2 Other Field Device Controllers

Controllers will be required for other field devices, including ramp meters, CMS' s, and count stations. To simplify the maintenance of these devices, a common controller should be selected. This standardization will minimize the problems associated with:

- Communicating with various controllers with different protocols
- Maintaining controllers of various models and manufacturers
- Utilizing controllers that have different database layouts
- Replacing field controllers from a limited inventory

For these devices, a NEMA controller will not work. It is recommended that the Open Architecture/Advanced Traffic Controller (OAC/ATC) be used, as discussed in Technical Memorandum #11. Although these devices have some drawbacks for traffic signal control, they are being used successfully for freeway applications in many locations, where the software and control functions are not as complex.

4.4.4 Communications Network

The structure of the recommended communications network is described in detail in Technical Memorandum #9. The communications network will consist of a fiber optic cable backbone, with distributed processing/multiplexing contained at communications nodes throughout the region, as shown in Figure 4-1.

The type of media used for communication from the nodes to the field equipment can vary, depending upon the specific situational requirements. For instance, the media could be fiber optic, copper twisted wire pair, spread spectrum radio, microwave, or other appropriate technology. The media could even be the re-use of existing interconnect cable from an existing signal system. The recommended communications media for connection of field equipment is fiber optic cable.

Further information about this subject can be found in Appendix C, which contains reports detailing alternative field equipment communications requirements and interfaces.

4.5. SUMMARY

This chapter presents the recommended system architecture for the bi-state St. Louis area freeway management system and its IVHS elements. The recommended architecture is a multi-level distributed system, with processing and control functions distributed to four different levels. The architecture for the different agencies in the region is also distributed, with primary device control residing at each jurisdiction and supervisory capabilities provided for each state agency. All of the agencies will be interconnected through a wide-area network to facilitate communications and sharing of traffic information. The preferred communications network is fiber optic cable for both the backbone and between the nodes and field equipment.

5. CONSENSUS BUILDING

5. CONSENSUS BUILDING

5.1 EFFORTS TO BUILD A COALITION OF SUPPORT

Community involvement and consensus building were critical elements throughout the process of developing a recommended freeway management plan that incorporates IVHS technologies and strategies. A major element of the study involved identifying and inventorying the goals and needs of transportation users in the St. Louis area. The opinions of a wide cross-section of interested and affected parties were solicited by questionnaire and/or contact in person or on the telephone.

In early meetings of the Project Guidance Committee (PGC), a list of agencies and public/private groups and organizations to contact was developed. It was decided to meeting individually with many of these "focus groups" to solicit their transportation goals, priorities and needs, explain the study and build support. Letters of invitation and telephone contacts were made with representatives of the following groups or companies requesting that they attend a focus group meeting:

- Commercial Vehicle Operators (truck and air freight, railroad, barge)
- Major Employers
- Transit Operators
- Parking Garage/Lot Operators
- Major/Special Event Generators
- Telecommunications Companies

Law enforcement agencies are important members of the system implementation team. Meetings were held with the metropolitan area district commanders for the Missouri Highway Patrol and Illinois State Police to explain the project goals, learn their approach to incident management, and solicit their views. A presentation about this study was also made at the first "St. Louis Regional Incident Management Conference" held in June, 1993. The conference objectives were to create an awareness and understanding of the need for incident management, and emphasize how a pro-active incident management program can reduce traffic congestion and delay, improve safety and save taxpayers' money.

To reach out to the general public, two sets of Public Information Meetings (PIM) were held, on October 19, 1993 and February 9, 1994 (at 2:00 p.m. and 7:30 p.m. on both dates). The purpose of holding these meetings was to explain the project goals, and solicit public input about their transportation goals, needs and priorities in the greater St. Louis area, particularly with respect to the freeway and arterial street systems. A questionnaire was prepared for distribution at the first set of PIM's, and attendees were asked to rank IVHS user services at the second set of PIM's. Summary notes for each of the four Public Information meetings, along with copies of the meeting handout materials, can be found in Appendix B.

Individual or small group meetings were also held with area elected officals (or their representatives) and community and labor leaders to brief them on the project and build a consensus. These meetings included:

- Administrative Assistant to the St. Louis Mayor
- Administrative Assistant to the St. Louis County Executive
- District Representative for Congressman Richard Gephardt
- President of Civic Progress
- President of the St. Louis Labor Council
- Infrastructure Implementation Committee of Confluence St. Louis
- Several Administrators at the University of Missouri-St. Louis

5.2 CONCLUSIONS DRAWN FROM PUBLIC AND AGENCY CONTACTS

The many contacts with agency officials, the focus groups and the public indicate support for implementing a freeway management system tailored to the needs of transportation users in the bi-state St. Louis metropolitan area.

Based on the Public Information Meetings, focus group meetings and meetings with community, labor and civic leaders, the primary transportation goals and concerns of the users appear to be:

- Traffic congestion
- Improving public transit
- Providing a good linkage between automobiles and transit
- Government management of high-tech solutions
- Getting reliable traffic information so that people can make their own travel decisions
- Accommodating pick-up and drop-off commercial and industrial deliveries
- Minimizing lost time at weigh stations
- Providing good traffic control through construction and maintenance work zones

Attendees at the second set of Public Information Meetings were asked to rank the three most important elements to be included in an Early Implementation Plan, with the following overall results:

1. Regional Traffic Information Center
2. Expanded Motorist Assist Patrol/Emergency Patrol Vehicle service
3. Additional Motorist Aid Call Boxes

A summary of the questionnaire rankings for each of the February, 1994 public information meetings can be found in Appendix B, as part of the meeting summaries.

6. STRATEGIC DEPLOYMENT PLAN

6. STRATEGIC DEPLOYMENT PLAN

6.1 PROJECT DEVELOPMENT FRAMEWORK

6.1.1 Geographical Area Covered

In developing the recommended Strategic Deployment Plan, the entire study area has been considered. This includes the City of St. Louis, the Missouri counties of St. Charles, Jefferson, Franklin and St. Louis, and the Illinois counties of Monroe, St. Clair and Madison.

6.1.2 Interagency Cooperation and Operational Agreements

The manner in which this project was conceived and administered has been unlike many other projects. All of the major agencies have been involved, demonstrating a high degree of interagency coordination. Though the Missouri Highway and Transportation Department has been the lead agency, the Illinois Department of Transportation, Federal Highway Administration and East-West Gateway Coordinating Council (St. Louis area metropolitan planning organization) have all been actively involved in project guidance and oversight.

Operational agreements will need to be executed during the design phase. Since the Strategic Deployment Plan involves many agencies and groups throughout the bi-state St. Louis area, a regional organization should have the administrative responsibility for such agreements.

6.1.3 Recommended Changes in Laws, Regulations and Policies

In order for the overall freeway management system, and incident management in particular, to operate most efficiently, two changes in current Missouri laws and/or enforcement practices are strongly recommended.

The Missouri Highway Patrol (MHP) should patrol the entire metropolitan area freeway system in Missouri, just as the Illinois State Police currently does in Illinois. This will greatly simplify communications and coordination, and should reduce response times to reported incidents and increase the likelihood that the correct emergency equipment is dispatched in a timely manner. Currently, the MHP does not routinely patrol the freeway system inside Interstate 270; rather, local police agencies patrol short pieces of freeways that are located within their city limits. Primary freeway patrol coverage should be the province of the MHP, with back-up provided by local authorities. MHP is presently not staffed to assume the added responsibility this change would involve, so an increase in, or reallocation of, MHP resources will be required.

The second recommended change involves enacting legislation governing the prompt removal of disabled vehicles from traffic lanes, and abandoned vehicles, on Missouri freeways. At present, authority to promptly remove such vehicles from Missouri freeways is lacking. The Incident Management Coalition that has been meeting regularly should continue its work towards this and the related goal of developing incident management strategies. The legislation should also clearly define a lead agency (which has the responsibility and authority) to manage and clear an incident, as recommended by the Incident Management Coalition.

6.2 PROPOSED PROJECTS/ACTIONS AND DEPLOYMENT SCHEDULE

The Strategic Deployment Plan for the bi-state St. Louis area Intelligent Vehicle - Highway System (IVHS) freeway management plan is comprised of sub-plans covering five time frames:

- ***Early Implementation Plan*** - Initial (foundation) projects and actions which can be implemented within about one year of making the decision to proceed.

- ***Short-Term Plan*** - Projects/actions which can be implemented in a time span of one to to two years.

- ***Mid-Range Plan*** - Projects/actions to be implemented two to five years in the future.

- ***Long-Range Plan*** - Projects/actions to be implemented in a time span of five to ten years.

- ***Utimate Plan*** - Projects/actions which complete the freeway management system and would be implemented more than ten years in the future.

A series of maps have been prepared to graphically depict the various projects and actions that are recommended to implement the freeway management system. The following maps can be found at the end of this chapter:

- Strategic Deployment Plan (22” x 34” and folded in a pocket)
- Strategic Deployment Plan - Summary (11" x 17”)
- Early Implementation Plan (Partial) (11" x 17”)
- Conceptual Layout of Fiber Optic Backbone Communications System (11” x 17”)
- Arterial Street Diversion Routes (11” x 17”)

A series of tables have been prepared that provide a summary of quantities, by state, and detail preliminary cost estimates for equipment, construction, engineering operations, and maintenance (Tables 6-1 to 6-1.1). A table has also been prepared that summarizes the recommended timetable for upgrading signal timing on the arterials which could be used for diverting freeway traffic during a major incident (Table 6-1.2).

6.2.1 Early Implementation Plan

The Early Implementation Plan (EIP) includes those measures that can give the greatest benefits, at a relatively low cost, in a short amount of time. The projects/actions recommended for implementation within approximately one (1) year, if possible, are:

6.2.1.1 Regional Traffic Information Center

Establish and promote a regional Traffic Information Center (TIC), with electronic bulletin board service and a toll-free cellular "hotline" phone number for motorists.

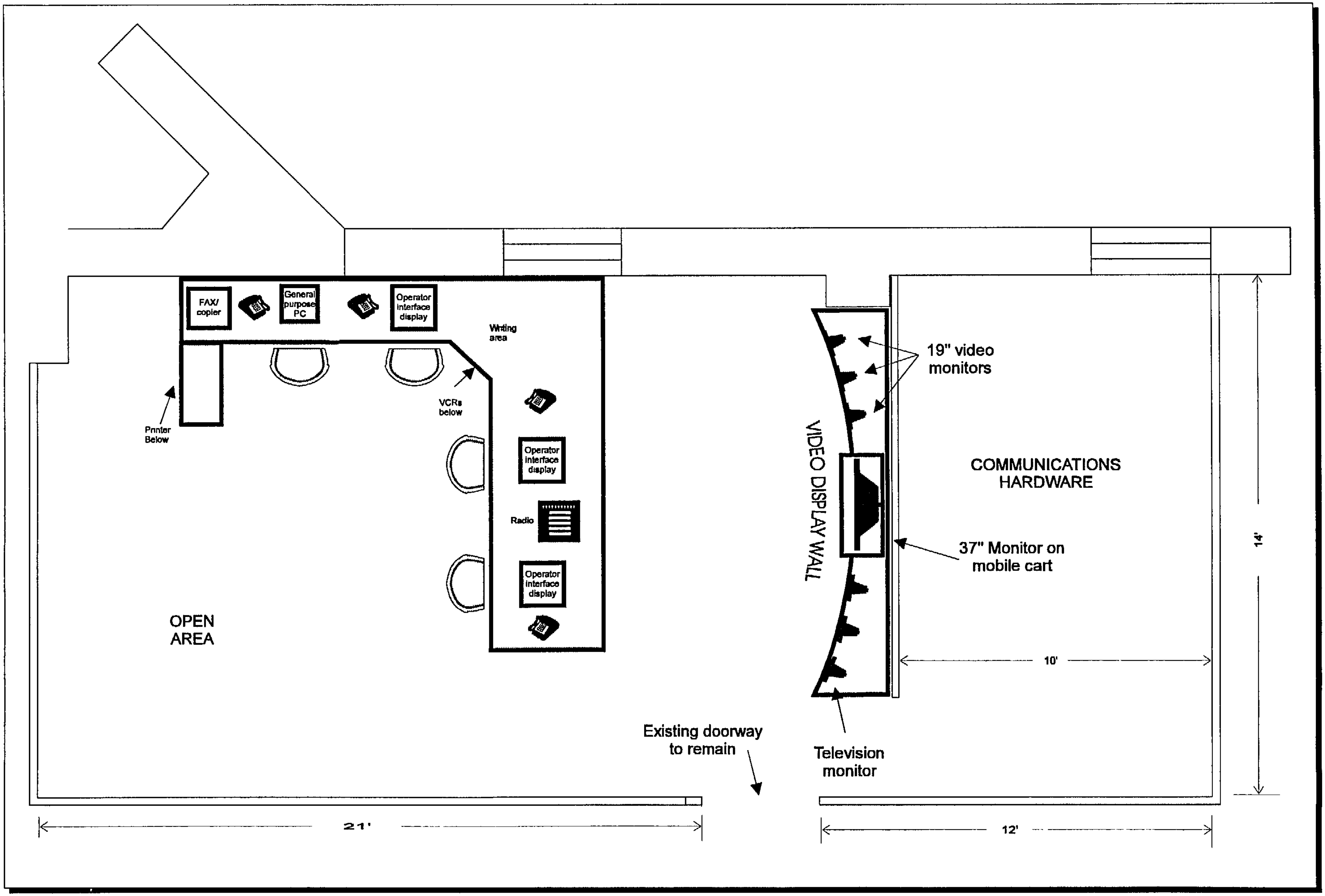
The TIC would be located at the MHTD District 6 offices in Town and Country, in the first floor space that has been set aside for this purpose. Given the rectangular shape of the room and its two glass walls, three possible room layouts appear feasible (refer to the three figures, "TIC Schematic Layout," options A, B and C). The existing room is small and it would be beneficial if this room could be enlarged; the extra space would be used for the communications hardware (for option C, enlargement is necessary and the existing doorway should be relocated). Initially, the recommended hours of normal operation are 5:00 a.m. to 9:00 p.m. (16 hours per day) on weekdays only.

NOTE: Included in the Mid-Range Plan (2 - 5 years) is the establishment of an equally functional TIC at the site of /DOT District 8 offices in Collinsville. In the same time frame, a direct communications link would be established between the MHTD TIC and the new IDOT TIC. Refer to the Mid-Range Plan Section for additional discussion.

The electronic bulletin board service (BBS) and toll-free cellular "hotline" are both traveler information services. The BBS data file server will provide radio and television stations, cable TV, major employers, shopping centers and many others with access to the system, and disseminate real-time traffic data to them. It will also provide this data to the traffic information kiosks described in a later section. The toll-free cellular "hotline" will permit callers to call in traffic-related information to an outside service (not the TIC operators), which will serve as a clearinghouse to direct the traffic information to the TIC operator and/or law enforcement dispatcher, if appropriate, or to the appropriate agency or person. Only one telephone number should be used for travelers in the bi-state St. Louis metropolitan area.

6.2.1.2 Public-Private Partnerships

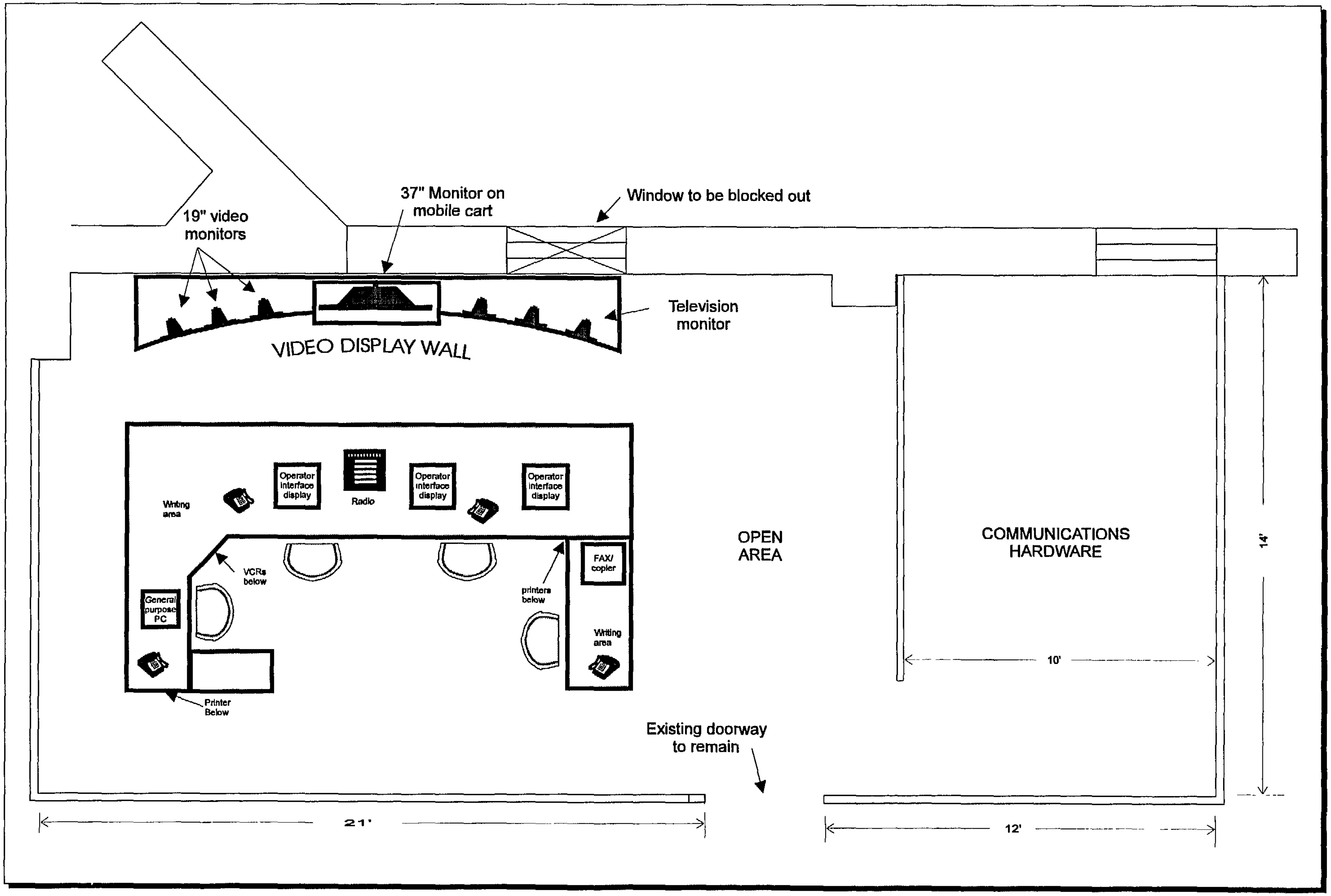
Establish public-private partnerships that implement part of the freeway management system wherever possible. An excellent application would be for the installation of fiber optic cable to form the backbone communications system (see the attached map). MHTD is currently exploring this avenue by soliciting proposals from communications companies interested in installing and maintaining an exclusive, buried fiber optic communications system in freeway rights-of-way along the freeway mainline. In exchange, MHTD would have use of the communications system for its own needs.



TIC Schematic Layout - option A

St. Louis Area IVHS Planning Study

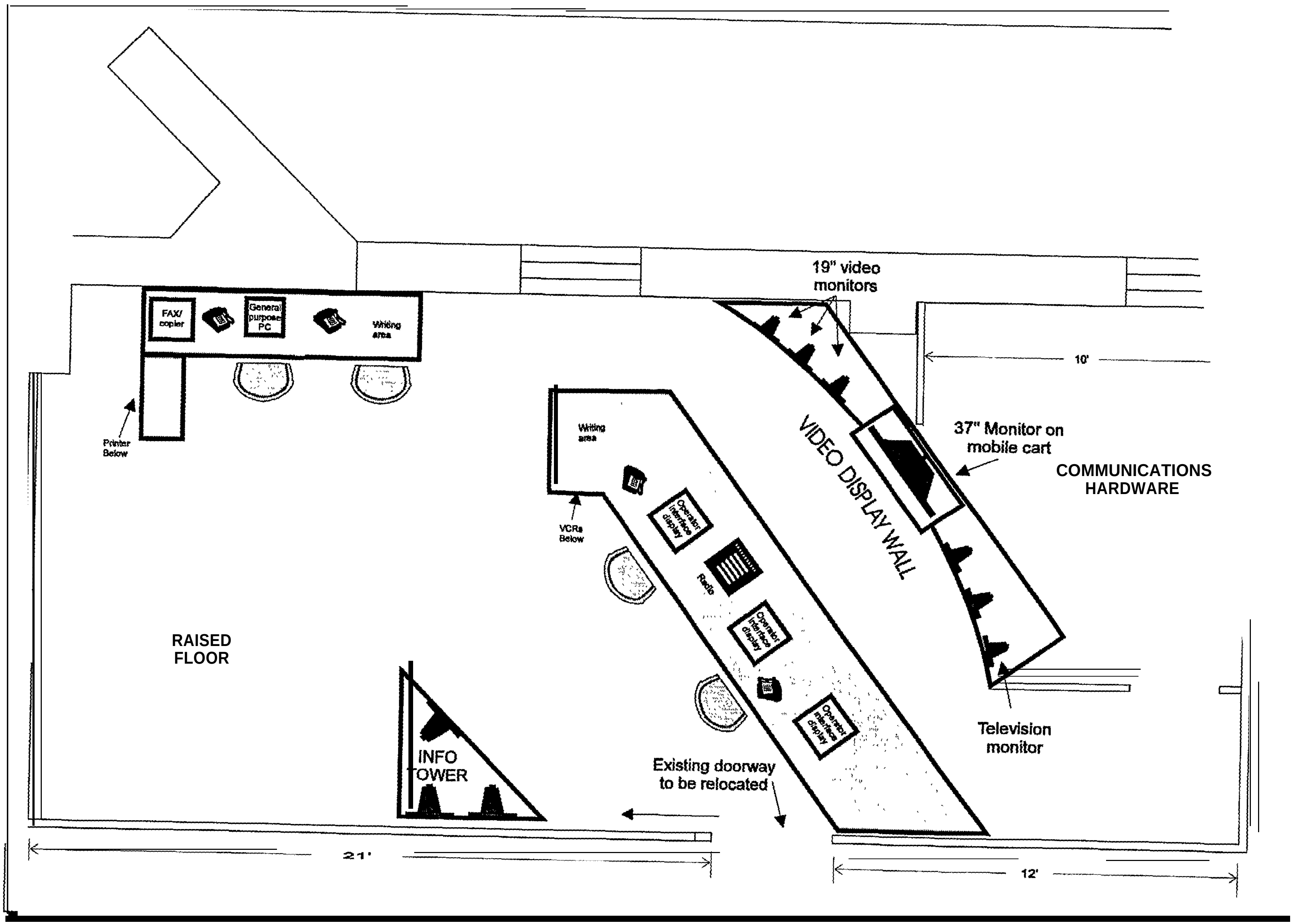
FIGURE 6-1



TIC Schematic Layout - option B

St. Louis Area IVHS Planning Study

FIGURE 6-2



TIC Schematic Layout - option C

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6.2.1.3 Motorist Assist Patrol Expanded Coverage

Expand coverage of the "Motorist Assist Patrol" program on Missouri freeways by adding approximately 48 miles of coverage. Refer to the Early Implementation Plan and Strategic Deployment Plan maps for the recommended locations of added coverage. The coverage area of the long-established, successful "Emergency Patrol Vehicle" (EPV) service in Illinois is sufficient, and expansion of its coverage area is not recommended.

6.2.1.4 Regional Highway Advisory Radio System

Design and implement a regional Highway Advisory Radio (HAR) system capable of providing continuous traffic information that integrates the existing IDOT HAR network into the regional system and covers the entire metropolitan area. Seven new HAR transmitters will be required (four in Missouri, three in Illinois) where shown in the Early Implementation Plan map. All of the existing IDOT HAR transmitters will be used, with one possible exception. The site in St. Charles County near the I-70/State Highway 94 interchange would either be removed and replaced (by one of the new Missouri sites) or the equipment relocated to the new site further to the southeast, along State Highway 94.

Refer to the Early Implementation Plan and Strategic Deployment Plan maps for the existing (shown in black) and recommended new HAR locations (shown in green). The dotted circles represent the primary coverage area (a radius of five miles), and even though the circles do not always overlap, HAR coverage should be continuous within the metropolitan area.

To improve the value of the HAR system, two types of related signs are recommended for installation. One sign will alert motorists that they should tune to the HAR frequency when yellow lights incorporated into the sign are flashing (activated by cellular communications). These signs will be installed on all freeways entering the metropolitan area, and at key locations within the metro area (in the general area shown on the Strategic Deployment Plan map), a total of about 50 such signs. The second type of sign will be installed on freeways where motorists are exiting the metro area, informing them that they are leaving the HAR coverage area (seven signs total).

6.2.1.5 Portable Changeable Message Signs

Establish Interstate-to-Interstate diversion routing capability by placing portable (mobile) changeable message signs (CMS) with cellular communications on freeways approaching major driver decision points. A total of 23 portable CMS sites are recommended (refer to the Early Implementation Plan and Strategic Deployment Plan maps for the recommended locations).

6.2.1.6 Peak Period Traffic Impacts of Construction Projects

Establish a construction project database covering the entire metropolitan area. An MHTD task force is currently in the process of developing a database system that includes construction information. Good communications between the two states is critical to its success. Also, develop or revise existing MHTD and IDOT policies and procedures governing construction and maintenance work lane closures to minimize peak period traffic impacts.

6.2.1.7 Motorist Aid Call Boxes

Install a network of voice-type motorist aid call boxes using cellular communications and solar power on portions of two Missouri freeways: I-55 between I-44 and I-270, and I-255 between I-55 and the Mississippi River. A total of 34 call boxes will be required. (Note: IDOT has had extensive call box coverage on its metro area freeways for many years, in conjunction with its Emergency Patrol Vehicle program. Coverage areas for both are shown on the detailed Strategic Deployment Plan map.)

6.2.1.8 Weigh-in-Motion Facility

Design and construct one or two weigh-in-motion (WIM) facilities for commercial vehicle operations (CVO) for sampling purposes only, not enforcement. Two WIM facilities have been included, though whether one or two such facilities are constructed in this phase will depend on the results of MHTD's CVO study that is in progress. The recommended locations for the two WIM facilities are in Missouri: on I-44 between I-270 and Route 109; and on I-55 between I-270 and Route 141. The depiction of both sites on the Strategic Deployment and Early Implementation maps is schematic; the exact location of each WIM facility, within these two freeway segments, will be determined by MHTD after further study.

6.2.1.9 Ramp Metering

A test of entrance ramp metering during peak traffic flow hours in the metropolitan area should be implemented at selected locations where it shows the most promise to be successful. The two recommended freeway segments for such a test consist of four consecutive interchanges along highly-congested I-270, between I-70 and I-64/US 40, and three interchanges along I-70 between US 67 (Lindbergh Blvd.) and the Missouri River.

The four interchanges along I-270 are Dorsett Road, Page Blvd., Olive Blvd., and Ladue Road. A total of ten ramps would be metered (two entrance ramps to I-270 at the three diamond interchanges, and four at the one cloverleaf interchange). Along I-70, only selected ramps at two of the three interchanges would be metered. At the Route 180 interchange, only the westbound entrance ramp would be metered; and at the I-270 directional interchange, only the southbound I-270 to westbound I-70 ramp would be metered. The Earth City Expressway cloverleaf interchange would have ramp meters installed on all four entrance ramps. A total of 16 different entrance ramps are involved.

With the very high peaks in traffic flow here and the many existing two lane entrance ramps (for queue storage), these sections of freeway appear to be good locations to experiment with ramp metering. They also include different interchange configurations (diamond, cloverleaf and freeway-to-freeway directional). Another advantage of using this portion of I-270 for a "test section" is the presence of a relatively good parallel alternative route, US 67 (Lindbergh Blvd). The recurrent congestion on I-70 in this vicinity is well documented, particularly eastbound (approaching I-270) in the morning and westbound (leading to the Blanchette bridge) in the afternoon.

Initially, the ramp metering would take place without constructing specialized bus and high-occupancy vehicle (HOV) bypass lanes. Bypasses are highly desirable features that encourage carpooling and transit usage; bypass construction at the above locations would follow a successful demonstration of ramp metering's effectiveness, and would be included with the installation of ramp metering at additional locations beyond those noted above. In subsequent phases, a limited number of additional ramp metering installations have been included in the quantities and cost estimates; the exact locations for future installations will be determined at a later date.

6.2.1.10 Arterial Signal Systems Upgrade

The process of upgrading arterial signal systems along alternative routes begins in the Early Implementation Plan and continues throughout all phases. It is important that the upgrading begin early on arterial corridors where such improvements have potentially significant benefits. Two such arterial corridors to be upgraded in this early phase are Lindbergh Blvd. (US 67), between I-270 and I-64/US 40, and Forest Park Boulevard/Parkway between I-170 and Grand Avenue.

The selection of this part of Lindbergh Blvd. is related to its role as the primary alternative route for a ramp metering operational test section (see item 9 above). The existing signals on Lindbergh Blvd. should be reviewed, the control equipment upgraded and new coordinated timing plans developed as necessary, to encourage the peak period use of this route as a good alternative to congested I-270. Similar efforts should be undertaken for Forest Park Parkway, which serves as an alternative route to I-64/US 40 west of downtown St. Louis. Between the two arterials, a total of 36 signalized intersections would be involved.

6.2.1.11 Remote Terminals

Four remote terminals that can access the regional Traffic Information Center (TIC) by dial-up telephone have been included in the system plan. The MHTD central office in Jefferson City, and the IDOT central office in Springfield, should both have the dial-up capability to call into their respective TIC and obtain traffic related data and the system status. Both locations are scheduled for the same plan phase as the establishment of their respective TIC.

The other two recommended remote terminal locations are both in the Short-Term Plan phase. One site is the office of the City of St. Louis Traffic Engineer (Department of Streets), and the other is the offices of the St. Louis County Department of Highways and Traffic in Clayton. With the recommended signal system upgrades and their responsibility for traffic operations of many major arterial roadways, these two agencies need to have communications capability to the TIC. The City and County terminals will, in effect, enhance the "Traffic Operations

Center" capabilities for monitoring signal system timing and traffic flows on their own roadways. They will also be used during major freeway incidents involving traffic diversion to arterial roadways.

Additional locations for a remote terminal may be identified in the future. Possible sites may include emergency response authorities (MO Highway Patrol, IL State Police,local police, fire, medical); bus, rail and airport authorities; and other counties/cities within the metro area.

6.2.1.12 Traffic Information Kiosks

Traffic information kiosks should be installed in major office buildings and employment centers, shopping centers, and where they would benefit transit users. The monitors in the kiosks would provide detailed and timely traffic information that is received directly from the Traffic information Center (TIC). The kiosks would include either a passive color traffic condition map or an active touch-screen monitor that can be queried for specific route information. For transit users, kiosks should be installed at park and ride lots, MetroLink stations, and high-volume bus stops.

6.2.1.13 Event Management Plans

Where they do not exist, event management plans should be prepared to address the traffic congestion that can result from sporting events and special events. Existing traffic management plans should be reviewed and updated, as necessary. These event management plans should be prepared in close cooperation with stadium and arena operators with the goal of avoiding starting and/or ending events during periods of recurrent congestion. Traffic information kiosks should be used to supplement the event management plans by providing up-to-date traffic information to event patrons as they leave the site.

6.2.1.14 Advanced Traffic Information Area Oragnizations

Strategies that reduce peak period single-occupant vehicle trips should be pursued. One recommended approach is establishing what could be called "Advanced Traffic Information Area" (ATIA) organizations in three high-density activity centers, such as: downtown St. Louis; Clayton; and the Central West End/Hospitals areas. Oversight for these ATIA groups should be provided by the East-West Gateway Coordinating Council, though the actual administration would likely be better provided by agencies/organizations involved in rideshare programs or existing business or employer groups.

The primary goals of the ATIAs would be to help their members decide how best to reduce congestion by promoting ridesharing and reducing peak period single-occupant automobile trips in their area. ATIA organizations would disseminate current traffic information through the use of information kiosks with touch-screen monitors that would be furnished to each ATIA member. The kiosks would be provided at no cost to ATIA members, with funding for their purchase and maintenance provided by the MHTD.

6.2.2 General Information About the Regional System

The overall development of the recommended regional freeway management system for the bi-state St. Louis metropolitan area gets underway with this plan phase. It is recommended that implementation of the entire system be characterized as occurring in four general phases, corresponding to the specific time frames explained earlier. Implementation will take longer, probably much longer, than ten years to complete. The attached Strategic Deployment Plan maps will be helpful in understanding the various system elements, their locations and the proposed implementation schedule.

Of course, a number of assumptions had to be made in developing the recommended Strategic Deployment Plan. When constructing those portions of the fiber optic backbone communications system that are included in each phase, it has been assumed that permanent changeable message signs (CMS), system detection and closed circuit television (CCTV) cameras will be installed along that particular freeway segment at the same time.

When complete, the communications system will consist of an estimated 255 miles of fiber optic backbone and a total of 12 SONET communications hubs, as depicted in the attached map, Conceptual Layout of Fiber Optic Backbone Communications System. Detector stations will be placed (to cover both directions of the freeway) at a one-half mile spacing, resulting in an estimated 515 total detector stations required. Approximately 81 CCTV cameras will be needed, but only at critical interchanges and locations, not to provide continuous freeway video coverage. Permanent changeable message signs (CMS) will be installed at 23 locations to replace the portable CMS deployed in the Early Implementation Plan. Also, a weather detection station is planned for each of the 12 SONET hubs.

Also attached is a map depicting candidate arterial street diversion routes which could be used, most likely one or two at a time, to divert traffic from the freeway during a major incident. Routes were selected on the basis of there being available capacity during the peak traffic flow periods. Refer to the attached map, Arterial Street Diversion Routes. The signalized intersections/systems on several of these diversion routes are recommended for upgrading in each of the four plan phases (refer to the attached table, Upgrade Phasing of Freeway Traffic Diversion Arterials. In general, the priority ranking has been based on replacing the oldest signal control equipment first. As the upgrading takes place, it is envisioned that these arterial signal systems would communicate with the TIC's via a remote circuit (such as with leased telephone lines, existing twisted wire pairs or new fiber optic).

6.2.3 Short-Term Plan (1 - 2 years)

The Short-Term Plan phase begins the design and construction of the freeway management system with the most critical freeway segments. The two most important tasks are to establish the MHTD District 6 TIC in Town and Country, and to provide freeway management for the highly congested I-70 corridor near and west of I-270. The specific freeway segments included in the Short-Term Plan phase total approximately 39 miles, as follows (refer also to the Strategic Deployment Plan maps):

- Interstate 64/US 40 from the MHTD TIC to US 67 (Lindbergh Blvd.)
- Interstate 270 between Interstate 170 and a point approximately two miles to the south of Interstate 64/US 40
- Interstate 70 between Lindbergh Blvd. and Highways K and M (in St. Charles County)

The following arterial signals/signal systems are to be upgraded and communications established to the MHTD TIC in this phase:

- Natural Bridge Avenue between Tucker Blvd. and Union Ave.
- Market Street between downtown St. Louis and Grand Ave.
- Chouteau Avenue between Tucker Blvd. and Vandeventer

It has been assumed that the ramp metering installed in the Early Implementation Plan will be successful and accepted by the public. Therefore, an additional 12 ramp metering locations in Missouri have been included in the quantities and cost estimate for this plan phase. Their exact locations will be determined at a later date.

6.2.4 Mid-Range Plan (2 - 5 years)

The Mid-Range Plan includes the establishment of an equally functional (to the MHTD Traffic Information Center) TIC at the site of IDOT District 8 offices (this building is leased from the City of Collinsville). In the same time frame, a communications link would be established between the MHTD TIC and the new IDOT TIC. There are two options for establishing the IDOT TIC: find space within the existing facility, or construct a new building at the same site. It is not evident that there is available space in the existing facility, and there are inefficiencies and difficulties in retrofitting existing buildings. As such, the best approach is often construction of a separate building (which would be adjacent to the current District offices) designed expressly for TIC functions. At this point, it is uncertain which approach would be best under these circumstances.

The Mid-Range Plan phase will also include the design and construction of the same elements implemented in the Short-Term Plan, on the following freeway segments:

- Interstate 255 between Interstate 270 and the IDOT TIC
- Interstate 270 between Interstate 170 and Illinois State Highway 157
- Interstate 170 between Interstate 270 and Interstate 64/US 40
- Interstate 70 between US 67 (Lindbergh Blvd.) and the interchange at the west end of the Poplar Street Bridge
- Interstate 64/US 40 between Interstate 170 and US 67 (Lindbergh Blvd.)

- Interstate 55 between State Highway 141 and the interchange at the west end of the Poplar Street Bridge
- Interstate 270 between Interstate 55 and a point approximately two miles south of Interstate 64/US 40
- Interstate 44 between Interstate 270 and State Highway 141

The following arterial signals/signal systems are to be upgraded and communications established to the TIC's in this phase:

- Broadway between downtown St. Louis and Interstate 270
- Clayton Road between Skinker Blvd. and US 67 (Lindbergh Blvd.)

As a continuation of the previous plan phase, an additional 12 ramp metering locations (eight in Missouri and four in Illinois) have been included in the quantities and cost estimate for this phase. Their exact locations will be determined at a later date.

In about the same time frame as the Mid-Range Plan, a national or state program for tracking the transportation of hazardous materials (HAZMAT) being transported by truck may be implemented. This issue is continues to be the subject of much discussion and debate. As currently envisioned, a national/state database of HAZMAT shipments would be kept. Within the St. Louis metropolitan area, the freeway management system could be used to help track HAZMAT shipments. An electronic identification device called a HAZMAT transponder or transceiver, placed on every vehicle transporting HAZMAT, could be "read" by detectors on designated freeway HAZMAT transportation routes. But because of the uncertainties surrounding the format such a program may take, no cost estimate could be prepared for this subject.

6.2.5 Long-Range Plan (5 - 10 years)

The Long-Range Plan phase will consist of design and construction of the same elements implemented in the Short-Term and Mid-Range Plans, on the following freeway segments:

- Interstate 55/64/70 between the interchange at the west end of the Poplar Street Bridge and the IDOT TIC
- Interstate 64/US 40 between Interstate 170 and the interchange at the west end of the Poplar Street Bridge
- Interstate 44 between Interstate 270 and Interstate 55
- Interstate 70 between Highways K and M (in St. Charles County) and a point approx. two miles west of the interchange with US 40/6l/future Interstate 64
- US 40/61/future Interstate 64 between Interstate 70 and the MHTD TIC

The following arterial signals/signal systems are to be upgraded and communications established to the TIC's in this phase:

- Elm-Watson Road between Interstate 44 and Interstate 270

As a continuation of the previous plan phases, an additional 12 ramp metering locations (in Missouri) have been included in the quantities and cost estimate for this phase. Their exact locations will be determined at a later date.

The Long-Range Plan is probably the first phase for which it is appropriate to consider high-occupancy vehicle (HOV) lanes, or an HOV system. A detailed, in-depth analysis of the potential roadway corridors where HOV is feasible and implementable is essential but beyond the scope of this study. At a cost of up to $15 million per mile, HOV lanes are obviously expensive. As such, major roadway corridors that are being planned or scheduled for reconstruction should be considered for HOV in order to reduce the cost. An added factor to consider in St. Louis is the MetroLink light rail line; they may be an opportunity to combine HOV construction with a MetroLink extension. Whether any HOV facilities would be implemented in this time frame, or the later Ultimate plan phase, is uncertain. For these reasons, no HOV facilities have been included in the quantities and cost estimate tables.

Two corridors (or portions thereof) appear to have the potential for successful HOV lanes. One is Interstate 70 from downtown St. Louis into St. Charles County (shown on the Strategic Deployment Plan map as terminating at State Highway 79). HOV construction would likely be scheduled along with major reconstruction of this aging freeway, or possibly with the MetroLink extension into St. Charles County. The existing reversible lanes on I-70 east of Kingshighway would be removed as part of HOV construction because the peak period directional split in traffic flow that justified it has since changed; inbound and outbound traffic is now nearly balanced. The second potential HOV facility would be on the new downtown Mississippi River bridge, or on a nearby existing bridge. This possibility is, appropriately, currently under study.

6.2.6 Ultimate Plan (> 10 years)

The Ultimate Plan consists of the last implementation phase in the regional bi-state St. Louis area freeway management system, as well as other enhancements that will carry the system into the future. The Ultimate Plan phase will consist of design and construction of the same elements implemented in the Short-Term, Mid-Range and Long-Term Plans, on the following freeway segments:

- Interstate 64 between Interstate 55/70 and Illinois State Highway 4
- Interstate 55/70 between Interstate 255 and Interstate 270
- -- Interstate 255 between Interstate 55 and Interstate 55/70
- Interstate 270 between Illinois State Highway 157 and Interstate 55/70
- Interstate 55 between Interstate 70/270 and Illinois State Highway 143
- Interstate 70 between Interstate 55/270 and a point approximately two miles to the east

The following arterial signals/signal systems are to be upgraded and communications established to the TIC's in this phase:

- Gravois-Chippewa between Tucker Blvd. and Hampton Ave.
- Illinois State Highway 203 between Interstate 270 and Interstate 55
- Illinois State Highway 111 between Interstate 270 and Interstate 55
- St. Clair Avenue/Lincoln Highway between Illinois State Highway 111 and Interstate 64
- Illinois State Highway 157 between Interstate 270 and Interstate 64
- Illinois State Highway 159 between Interstate 270 and Interstate 64

6.2.7 System Quantity and Cost Estimates

Preliminary quantity and cost estimates have been prepared for the freeway management system recommended in the Strategic Deployment Plan. A quantity summary table has been prepared which shows each system element, the deployment plan phase(s), and the quantity of elements in each state (Table 6-1).

Included in the other tables are capital construction costs, engineering costs, software development costs, and operations and maintenance costs for the various IVHS elements (Tables 6-2 to 6-l 1). All of the costs are shown in current, 1994 dollars.

6.2.7.1 Construction Cost Estimate

Construction cost estimates for each major element of construction of the Strategic Deployment Plan are shown by phase -- as well as for the Plan as a whole -- in Tables 6-2 to 6-7.

The "miscellaneous" line item in the construction cost estimate covers a variety of items. For example, included are such items as mobilization, field office set-up and maintenance, final clean-up, work zone traffic control devices and their maintenance during the work, performance bond and payment bond, etc.

The total estimated construction cost for all Strategic Deployment Plan phases is approximately $103 million.

6.2.7.2 Engineering Costs

Engineering design is estimated to cost about 12 percent of the total construction cost, while engineering services during construction are estimated to be in the range of six (6) percent. This results in an engineering cost estimate for all Strategic Deployment Plan phases of approximately $18.5 million.

Table 6-1

QUANTITIES SUMMARY FOR IVHS ELEMENTS

ELEMENT	UNIT	PLAN PHASES: EARLY IMPLEM.		SHORT TERM		MID RANGE		LONG RANGE		ULTIMATE		TOTALS BY STATE		GRAND TOTALS
		MO	IL	MO	IL	MO	IL	MO	IL	MO	IL	MO	IL	
MHTD Traffic Information Center with Electronic Bulletin Board and Toll-Free Cellular Hotline	EA	1	0	–	–	–	–	–	–	–	–	1	0	1
IDOT Traffic Information Center	EA	–	–	–	–	0	1	–	–	–	–	0	1	1
Expand Motorist Assist Patrol	MI	48	0	–	–	–	–	–	–	–	–	48	0	48
Establish Regional Highway Advisory Radio (HAR) System including integration of existing IDOT system	EA	4	0	0	3	–	–	–	–	–	–	4	3	7
"HAR When Flashing" Sign	EA	38	0	0	16	–	–	–	–	–	–	38	16	54
"Leaving HAR Area" Sign	EA	4	0	0	3	–	–	–	–	–	–	4	3	7
Portable Changeable Message Signs with Cellular Communications Capabilities	EA	16	0	0	7	–	–	–	–	–	–	16	7	23
Establish Construction Scheduling Database	EA	1	0	0	1	–	–	–	–	–	–	1	1	2
Motorist Aid Call-Boxes	EA	34	0	–	–	–	–	–	–	–	–	34	0	34
Weigh-In-Motion Facility	EA	2	0	–	–	–	–	–	–	–	–	2	0	2
Ramp Metering Operational Test	RAMP	16	0	12	0	8	4	12	0	12	4	60	8	68
Arterial Signal System Upgrade (early implement.)	SIG	36	0	–	–	–	–	–	–	–	–	36	0	36
Arterial Signal System Upgrade (future phases)	SIG	–	–	33	0	45	0	13	0	27	78	118	78	196
Remote Terminals	EA	–	–	3	0	0	1	–	–	–	–	3	1	4
Detector Stations	EA	–	–	80	0	140	30	110	30	5	120	335	180	515
Closed Circuit Televison Cameras	EA	–	–	17	0	31	4	14	6	1	8	63	18	81
Permanent Changeable Message Signs	EA	–	–	9	0	5	2	2	1	0	4	16	7	23
Fiber Optic Communication Backbone	MI	–	–	39	0	70	15	54	15	2	60	165	90	255
Fiber Optic Communication to IVHS elements	MI	–	–	22	0	28	10	27	9	3	37	80	56	136
SONET Communication Hubs	EA	–	–	2	0	4	1	3	1	0	1	9	3	12
Weather Detection Stations	EA	–	–	2	0	4	1	3	1	0	1	9	3	12
Power Distribution to IVHS elements	EA	4	0	100	3	170	40	130	30	15	110	419	183	602
Traffic Information Kiosks	EA	40	0	0	10	–	–	–	–	–	–	40	10	50
Event Management Plans	LS	1	0	–	–	–	–	–	–	–	–	1	0	1
Advanced Traffic Information Area Organizations	EA	3	0	–	–	–	–	–	–	–	–	3	0	3

Table 6-2

COST ESTIMATE: CONSTRUCTION, ENGINEERING AND SOFTWARE DEVELOPMENT

EARLY IMPLEMENTATION PHASE

ELEMENT	UNIT	UNIT COST	QUANTITY BY STATE		COST BY STATE		TOTAL QUANTITY	TOTAL COST
			MO	IL	MO	IL		
MHTD Traffic Information Center with:	EA	$954,160	1	0	$1,384,160	$0	1	$1,384,160
Electronic Bulletin Board,	EA	$90,000						
Toll-Free Cellular Hotline	EA	$340,000						
IDOT Traffic Information Center	EA	$750,000	–	–	$0	$0	0	$0
Expand Motorist Assist Patrol	MI	$15,000	48	0	$720,000	$0	48	$720,000
Establish Regional Highway Advisory Radio (HAR) System including integration of existing IDOT system	EA	$19,295	4	0	$77,180	$0	4	$77,180
"HAR When Flashing" Sign	EA	$2,500	38	0	$95,000	$0	38	$95,000
"Leaving HAR Area" Sign	EA	$500	4	0	$2,000	$0	4	$2,000
Portable Changeable Message Signs with Cellular Communications Capabilities	EA	$35,000	16	0	$560,000	$0	16	$560,000
Establish Construction Scheduling Database	EA	$90,000	1	0	$90,000	$0	1	$90,000
Motorist Aid Call-Boxes	EA	$7,800	34	0	$265,200	$0	34	$265,200
Weigh-In-Motion Facility	EA	$70,000	2	0	$140,000	$0	2	$140,000
Ramp Metering Operational Test	RAMP	$22,595	16	0	$361,520	$0	16	$361,520
Arterial Signal System Upgrade (early implement.)	SIG	$25,095	36	0	$903,420	$0	36	$903,420
Arterial Signal System Upgrade (future phases)	SIG	$25,095	–	–	$0	$0	0	$0
Remote Terminals	EA	$15,000	–	–	$0	$0	0	$0
Detector Stations	EA	$24,025	–	–	$0	$0	0	$0
Closed Circuit Televison Cameras	EA	$35,365	–	–	$0	$0	0	$0
Permanent Changeable Message Signs	EA	$145,095	–	–	$0	$0	0	$0
Fiber Optic Communication Backbone	MI	$129,220	–	–	$0	$0	0	$0
Fiber Optic Communication to IVHS elements	MI	$49,729	–	–	$0	$0	0	$0
SONET Communication Hubs	EA	$151,060	–	–	$0	$0	0	$0
Weather Detection Stations	EA	$78,750	–	–	$0	$0	0	$0
Power Distribution to IVHS elements	EA	$19,200	4	0	$76,800	$0	4	$76,800
Traffic Information Kiosks	EA	$15,000	40	0	$600,000	$0	40	$600,000
Event Management Plans	LS	$75,000	1	0	$75,000	$0	1	$75,000
Advanced Traffic Information Area Organizations	EA	$75,000	3	0	$225,000	$0	3	$225,000
SUBTOTAL 1					$5,575,280	$0		$5,575,280
MISCELLANEOUS WORK ITEMS (20%)					$1,115,056	$0		$1,115,056
SUBTOTAL 2					$6,690,336	$0		$6,690,336
ENGINEERING (12%)					$802,840	$0		$802,840
CONSTRUCTION SERVICES (6%)					$401,420	$0		$401,420
SOFTWARE DEVELOPMENT (LS)					$450,000	$0		$450,000
SUBTOTAL 3					$8,344,596	$0		$8,344,596
CONTINGENCY (15%)					$1,251,689	$0		$1,251,689
TOTAL					$9,596,286	$0		$9,596,286
TOTAL ESTIMATED COST EARLY IMPLEMENTATION PHASE					*$9,600,000*	*$0*		*$9,600,000*

ALL COSTS IN 1994 DOLLARS

Table 6-3

COST ESTIMATE: CONSTRUCTION, ENGINEERING AND SOFTWARE DEVELOPMENT

SHORT TERM PHASE

ELEMENT	UNIT	UNIT COST	QUANTITY BY STATE		COST BY STATE		TOTAL QUANTITY	TOTAL COST
			MO	IL	MO	IL		
MHTD Traffic Information Center with:	EA	$954,160	–	–	$0	$0	0	$0
Electronic Bulletin Board,	EA	$90,000						
Toll-Free Cellular Hotline	EA	$340,000						
IDOT Traffic Information Center	EA	$750,000	–	–	$0	$0	0	$0
Expand Motorist Assist Patrol	MI	$15,000	–	–	$0	$0	0	$0
Establish Regional Highway Advisory Radio (HAR) System including integration of existing IDOT system	EA	$19,295	0	3	$0	$57,885	3	$57,885
"HAR When Flashing" Sign	EA	$2,500	0	16	$0	$40,000	16	$40,000
"Leaving HAR Area" Sign	EA	$500	0	3	$0	$1,500	3	$1,500
Portable Changeable Message Signs with Cellular Communications Capabilities	EA	$35,000	0	7	$0	$245,000	7	$245,000
Establish Construction Scheduling Database	EA	$90,000	0	1	$0	$90,000	1	$90,000
Motorist Aid Call-Boxes	EA	$7,800	–	–	$0	$0	0	$0
Weigh-In-Motion Facility	EA	$70,000	–	–	$0	$0	0	$0
Ramp Metering Operational Test	RAMP	$22,595	12	0	$271,140	$0	12	$271,140
Arterial Signal System Upgrade (early implement.)	SIG	$25,095	–	–	$0	$0	0	$0
Arterial Signal System Upgrade (future phases)	SIG	$25,095	33	0	$828,135	$0	33	$828,135
Remote Terminals	EA	$15,000	3	0	$45,000	$0	3	$45,000
Detector Stations	EA	$24,025	80	0	$1,922,000	$0	80	$1,922,000
Closed Circuit Televison Cameras	EA	$35,365	17	0	$601,205	$0	17	$601,205
Permanent Changeable Message Signs	EA	$145,095	9	0	$1,305,855	$0	9	$1,305,855
Fiber Optic Communication Backbone	MI	$129,220	39	0	$5,039,580	$0	39	$5,039,580
Fiber Optic Communication to IVHS elements	MI	$49,729	22	0	$1,094,038	$0	22	$1,094,038
SONET Communication Hubs	EA	$151,060	2	0	$302,120	$0	2	$302,120
Weather Detection Stations	EA	$78,750	2	0	$157,500	$0	2	$157,500
Power Distribution to IVHS elements	EA	$19,200	100	3	$1,920,000	$57,600	103	$1,977,600
Traffic Information Kiosks	EA	$15,000	0	10	$0	$150,000	10	$150,000
Event Management Plans	LS	$75,000	–	–	$0	$0	0	$0
Advanced Traffic Information Organizations	EA	$75,000	–	–	$0	$0	0	$0
SUBTOTAL 1					$13,486,573	$641,985		$14,128,558
MISCELLANEOUS WORK ITEMS (20%)					$2,697,315	$128,397		$2,825,712
SUBTOTAL 2					$16,183,888	$770,382		$16,954,270
ENGINEERING (12%)					$1,942,067	$92,446		$2,034,512
CONSTRUCTION SERVICES (6%)					$971,033	$46,223		$1,017,256
SOFTWARE DEVELOPMENT (LS)					$750,000	$50,000		$800,000
SUBTOTAL 3					$19,846,987	$959,051		$20,806,038
CONTINGENCY (15%)					$2,977,048	$143,858		$3,120,906
TOTAL					$22,824,035	$1,102,908		$23,926,944
TOTAL ESTIMATED COST SHORT TERM PHASE					***$22,800,000***	***$1,100,000***		***$23,900,000***

ALL COSTS IN 1994 DOLLARS

Table 6-4

COST ESTIMATE: CONSTRUCTION, ENGINEERING AND SOFTWARE DEVELOPMENT

MID RANGE PHASE

ELEMENT	UNIT	UNIT COST	QUANTITY BY STATE		COST BY STATE		TOTAL QUANTITY	TOTAL COST
			MO	IL	MO	IL		
MHTD Traffic Information Center with	EA	$954,160	–	–	$0	$0	0	$0
Electronic Bulletin Board.	EA	$90,000						
Toll–Free Cellular Hotline	EA	$340,000						
IDOT Traffic Information Center	EA	$750,000	0	1	$0	$750,000	1	$750,000
Expand Motorist Assist Patrol	MI	$15,000	–	–	$0	$0	0	$0
Establish Regional Highway Advisory Radio (HAR) System including integration of existing IDOT system	EA	$19,295	–	–	$0	$0	0	$0
"HAR When Flashing" Sign	EA	$2,500	–	–	$0	$0	0	$0
"Leaving HAR Area" Sign	EA	$500	–	–	$0	$0	0	$0
Portable Changeable Message Signs with Cellular Communications Capabilities	EA	$35,000	–	–	$0	$0	0	$0
Establish Construction Scheduling Database	EA	$90,000	–	–	$0	$0	0	$0
Motorist Aid Call–Boxes	EA	$7,800	–	–	$0	$0	0	$0
Weigh–In–Motion Facility	EA	$70,000	–	–	$0	$0	0	$0
Ramp Metering Operational Test	RAMP	$22,595	8	4	$180,760	$90,380	12	$271,140
Arterial Signal System Upgrade (early implement.)	SIG	$25,095	–	–	$0	$0	0	$0
Arterial Signal System Upgrade (future phases)	SIG	$25,095	45	0	$1,129,275	$0	45	$1,129,275
Remote Terminals	EA	$15,000	0	1	$0	$15,000	1	$15,000
Detector Stations	EA	$24,025	140	30	$3,363,500	$720,750	170	$4,084,250
Closed Circuit Televison Cameras	EA	$35,365	31	4	$1,096,315	$141,460	35	$1,237,775
Permanent Changeable Message Signs	EA	$145,095	5	2	$725,475	$290,190	7	$1,015,665
Fiber Optic Communication Backbone	MI	$129,220	70	15	$9,045,400	$1,938,300	85	$10,983,700
Fiber Optic Communication to IVHS elements	MI	$49,729	28	10	$1,392,412	$497,290	38	$1,889,702
SONET Communication Hubs	EA	$151,060	4	1	$604,240	$151,060	5	$755,300
Weather Detection Stations	EA	$78,750	4	1	$315,000	$78,750	5	$393,750
Power Distribution to IVHS elements	EA	$19,200	170	40	$3,264,000	$768,000	210	$4,032,000
Traffic Information Kiosks	EA	$15,000	–	–	$0	$0	0	$0
Event Management Plans	LS	$75,000	–	–	$0	$0	0	$0
Advanced Traffic Information Area Organizations	EA	$75,000	–	–	$0	$0	0	$0
SUBTOTAL 1					$21,116,377	$5,441 ,180		$6,557,557
MISCELLANEOUS WORK ITEMS (20%)					$4,223,275	$1,088,236		$5,311,511
SUBTOTAL 2					$25,339,652	$6,529,416		$31,869,068
ENGINEERING (12%)					$3,040,758	$783,530		$3,824,288
CONSTRUCTION SERVICES (3%)					$1,520,379	$391,765		$1,912,144
SOFTWARE DEVELOPMENT (LS)					$50,000	$200,000		$250,000
SUBTOTAL 3					$29,950,790	$7,904,711		$37,855,501
CONTINGENCY (15%)					$4,492,618	$1,185,707		$5,678,325
TOTAL					$34,443,408	$9,090,418		$43,533,826
TOTAL ESTIMATED COST MID RANGE PHASE					*$34,400,000*	*$9,100,000*		*$43,500,000*

ALL. COSTS IN 1994 DOLLARS

Table 6-5

COST ESTIMATE: CONSTRUCTION, ENGINEERING AND SOFTWARE DEVELOPMENT

LONG RANGE PHASE

ELEMENT	UNIT	UNIT COST	QUANTITY BY STATE		COST BY STATE		TOTAL QUANTITY	TOTAL COST
			MO	IL	MO	IL		
MHTD Traffic Information Center with:	EA	$954,160		- -	$0	$0	0	$0
Electronic Bulletin Board,	EA	$90,000						
Toll-Free Cellular Hotline	EA	$340,000						
IDOT Traffic Information Center	EA	$750,000	-	-	$0	$0	0	$0
Expand Motorist Assist Patrol	MI	$15,000	-	-	$0	$0	0	$0
Establish Regional Highway Advisory Radio (HAR) System including integration of existing IDOT system	EA	$19,295	–	–	$0	$0	0	$0
"HAR When Flashing" Sign	EA	$2,500	–	–	$0	$0	0	$0
"Leaving HAR Area" Sign	EA	$500	–	–	$0	$0	0	$0
Permanent Changeable Message Signs with Cellular Communications Capabilities	EA	$35,000	–	–	$0	$0	0	$0
Establish Construction Scheduling Database	EA	$90,000	–	–	$0	$0	0	$0
Motorist Aid Call–Boxes	EA	$7,800	–	–	$0	$0	0	$0
Weigh–In–Motion Facility	EA	$70,000	–	–	$0	$0	0	$0
Ramp Metering Operational Test	RAMP	$22,595	12	0	$271,140	$0	12	$271,140
Arterial Signal System Upgrade (early implement.)	SIG	$25,095	–	–	$0	$0	0	$0
Arterial Signal System Upgrade (future phases)	SIG	$25,095	13	0	$326,235	$0	13	$326,235
Remote Terminals	EA	$15,000	–	–	$0	$0	0	$0
Detector Stations	EA	$24,025	110	30	$2,642,750	$720,750	140	$3,363,500
Closed Circuit Televison Cameras	EA	$35,365	14	6	$495,110	$212,190	20	$707,300
Permanent Changeable Message Signs	EA	$145,095	2	1	$290,190	$145,095	3	$435,285
Fiber Optic Communication Backbone	MI	$129,220	54	15	$6,977,880	$1,938,300	69	$8,916,180
Fiber Optic Communication to IVHS elements	MI	$49,729	27	9	$1,342,683	$447,561	36	$1,790,244
SONET Communication Hubs	EA	$151,060	3	1	$453,180	$151,060	4	$604,240
Weather Detection Stations	EA	$78,750	3	1	$236,250	$78,750	4	$315,000
Power Distribution to IVHS elements	EA	$19,200	130	30	$2,496,000	$576,000	160	$3,072,000
Traffic Information Kiosks	EA	$15,000	–	–	$0	$0	0	$0
Event Management Plans	LS	$75,000	–	–	$0	$0	0	$0
Advanced Traffic Information Area Organizations	EA	$75,000	–	–	$0	$0	0	$0
SUBTOTAL 1					$15,531,418	$4,269,706		$19,801,124
MISCELLANEOUS WORK ITEMS (20%)					$3,106,284	$853,941		$3,960,225
SUBTOTAL2					$18,637,702	$5,123,647		$23,761,349
ENGINEERING (12%)					$2,236,524	$614,838		$2,851,362
CONSTRUCTION SERVICES (6%)					$1 ,118,262	$307,419		$1,425,681
SOFTWARE DEVELOPMENT (LS)					$125,000	$125,000		$250,000
SUBTOTAL 3					$22,117,488	$6,170,904		$28,288,392
CONTINGENCY (15%)					$3,317,623	$925,636		$4,243,259
TOTAL					$25,435,111	$7,096,539		$32,531,650
TOTAL ESTIMATED COST LONG TERM PHASE					***$25,400,000***	***$7,100,000***		***$32,500,000***

ALL COSTS IN 1994 DOLLARS

Table 6-6

COST ESTIMATE: CONSTRUCTION, ENGINEERING AND SOFTWARE DEVELOPMENT

ULTIMATE PHASE

ELEMENT	UNIT	UNIT COST	QUANTITY BY STATE		COST BY STATE		TOTAL QUANTITY	TOTAL COST
			MO	IL	MO	IL		
MHTD Traffic Information Center with:	EA	$954.160	-	-	$0	$0	0	$0
Electronic Bulletin Board	EA	$90,000						
Toll-Free Cellular Hotline	EA	$340,000						
IDOT Traffic Information Center	EA	$750,000	–	–	$0	$0	0	$0
Expand Motorist Assist Patrol	MI	$15,000	–	–	$0	$0	0	$0
Establish Regional Highway Advisory Radio (HAR) System including integration of existing IDOT system	EA	$19,295	–	–	$0	$0	0	$0
"HAR When Flashing" Sign	EA	$2,500	–	–	$0	$0	0	$0
"Leaving HAR Area" Sign	EA	$500	–	–	$0	$0	0	$0
Portable Changeable Message Signs with Cellular Communications Capabilities	EA	$35,000	–	–	$0	$0	0	$0
Establish Construction Scheduling Database	EA	$90,000	–	–	$0	$0	0	$0
Motorist Aid Call–Boxes	EA	$7,800	–	–	$0	$0	0	$0
Weigh–In–Motion Facility	EA	$70,000	–	–	$0	$0	0	$0
Ramp Metering Operational Test	RAMP	$22,595	12	4	$271,140	$90,380	16	$361,520
Arterial Signal System Upgrade (early implem.)	SIG	$25,095	–	–	$0	$0	0	$0
Arterial Signal System Upgrade	SIG	$25,095	27	78	$677,565	$1,957,410	105	$2,634,975
Remote Terminals	EA	$15,000	–	–	$0	$0	0	$0
Detector Stations	EA	$24,025	5	120	$120,125	$2,883,000	125	$3,003,125
Closed Circuit Televison Cameras	EA	$35,365	1	8	$35,365	$282,920	9	$318,285
Permanent Changeable Message Signs	EA	$145,095	0	4	$0	$580,380	4	$580,380
Fiber Optic Communication Backbone	MI	$129,220	2	60	$258,440	$7,753,200	62	$8,011,640
Fiber Optic Communication to IVHS elements	MI	$49,729	3	37	$149,187	$1,839,973	40	$1,989,160
SONET Communication Hubs	EA	$151,060	0	1	$0	$151,060	1	$151,060
Weather Detection Stations	EA	$78,750	0	1	$0	$78,750	1	$78,750
Power Distribution to IVHS elements	EA	$19,200	15	110	$288,000	$2,112,000	125	$2,400,000
Traffic Information Kiosks	EA	$15,000	–	–	$0	$0	0	$0
Event Managment Plans	LS	$75,000	–	–	$0	$0	0	$0
Advanced Traffic Information Area Organizations	EA	$75,000	–	–	$0	$0	0	$0
SUBTOTAL 1					$1,799,822	$17,729,073		$19,528,895
MISCELLANEOUS WORK ITEMS (20%)					$359,964	$3,545,815		$3,905,779
SUBTOTAL 2					$2,159,786	$21,274,888		$23,434,674
ENGINEERING (12%)					$259,174	$2,552,987		$2,812,161
CONSTRUCTION SERVICES (6%)					$129,587	$1,276,493		$1,406,080
SOFTWARE DEVELOPMENT (LS)					$125,000	$125,000		$250,000
SUBTOTAL 3					$2,673,548	$25,229,367		$27,902,915
CONTINGENCY (15%)					$401,032	$3,784,405		$4,185,437
TOTAL					$3,074,580	$29,013,772		$32,088,353
TOTAL ESTIMATED COST ULTIMATE PHASE					$3,100,000	$29,000,000		$32,100,000

ALL COSTS IN 1994 DOLLARS

Table 6-7

COST ESTIMATE: CONSTRUCTION, ENGINEERING AND SOFTWARE DEVELOPMENT

ALL PHASES

ELEMENT	UNIT	UNIT COST	TOTAL QUANTITY BY STATE		COST BY STATE ALL PHASES		TOTAL QUANTITY	TOTAL COST
			MO	IL	MO	IL		
MHTD Traffic Information Center with:	EA	$954,160	1	0	$1,384,160	$0	1	$1,384,160
Electronic Bulletin Board,	EA	$90,000						
Toll-Free Cellular Hotline	EA	$340,000						
IDOT Traffic Information Center	EA	$750,000	0	1	$0	$750,000	1	$750,000
Expand Motorist Assist Patrol	MI	$15,000	48	0	$720,000	$0	48	$720,000
Establish Regional Highway Advisory Radio (HAR) System including integration of existing IDOT system	EA	$19,295	4	3	$77,180	$57,885	7	$135,065
"HAR When Flashing" Sign	EA	$2,500	38	16	$95,000	$40,000	54	$135,000
"Leaving HAR Area" Sign	EA	$500	4	3	$2,000	$1,500	7	$3,500
Portable Changeable Message Signs with Cellular Communications Capabilities	EA	$35,000	16	7	$560,000	$245,000	23	$805,000
Establish Construction Scheduling Database	EA	$90,000	1	1	$90,000	$90,000	2	$180,000
Motorist Aid Call-Boxes	EA	$7,800	34	0	$265,200	$0	34	$265,200
Weigh-In-Motion Facility	EA	$70,000	2	0	$140,000	$0	2	$140,000
Ramp Metering Operational Test	RAMP	$22,595	60	8	$1,355,700	$180,760	68	$1,536,460
Arterial Signal System Upgrade (early implement.)	SIG	$25,095	36	0	$903,420	$0	36	$903,420
Arterial Signal System Upgrade (future phases)	SIG	$25,095	118	78	$2,961,210	$1,957,410	196	$4,918,620
Remote Terminals	EA	$15,000	3	1	$45,000	$15,000	4	$60,000
Detector Stations	EA	$24,025	335	180	$8,048,375	$4,324,500	515	$12,372,875
Closed Circuit Televison Cameras	EA	$35,365	63	18	$2,227,995	$636,570	81	$2,864,565
Permanent Changeable Message Signs	EA	$145,095	16	7	$2,321,520	$1,015,665	23	$3,337,185
Fiber Optic Communication Backbone	MI	$129,220	165	90	$21,321,300	$11,629,800	255	$32,951,100
Fiber Optic Communication to IVHS elements	MI	$49,729	80	56	$3,978,320	$2,784,824	136	$6,763,144
SONET Communication Hubs	EA	$151,060	9	3	$1,359,540	$453,180	12	$1,812,720
Weather Detection Stations	EA	$78,750	9	3	$708,750	$236,250	12	$945,000
Power Distribution to IVHS elements	EA	$19,200	419	183	$8,044,800	$3,513,600	602	$11,558,400
Traffic Information Kiosks	EA	$15,000	40	10	$600,000	$150,000	50	$750,000
Event Management Plans	LS	$75,000	1	0	$75,000	$0	1	$75,000
Advanced Traffic Information Area Organizations	EA	$75,000	3	0	$225,000	$0	3	$225,000
SUBTOTAL 1					$57,509,470	$28,081,944		$85,591,414
MISCELLANEOUS WORK ITEMS (20%)					$11,501,894	$5,616,389		$17,118,283
SUBTOTAL 2					$69,011,364	$33,698,333		$102,709,697
ENGINEERING (12%)					$8,281,364	$4,043,800		$12,325,164
CONSTRUCTION SERVICES (6%)					$4,140,682	$2,021,900		$6,162,582
SOFTWARE DEVELOPMENT (LS)					$1,500,000	$500,000		$2,000,000
SUBTOTAL 3					$82,933,410	$40,264,033		$123,197,442
CONTINGENCY (15%)					$12,440,011	$6,039,605		$18,479,616
TOTAL					$95,373,421	$46,303,638		$141,677,059
TOTAL ESTIMATED COST ALL PHASES					***$95,400,000***	***$46,300,000***		***$141,700,000***

ALL COSTS IN 1994 DOLLARS

Table 6-8(a)

COST ESTIMATE: OPERATIONS AND MAINTENANCE

Traffic Information Center (TIC), 1 Each Missouri and Illinois

Personnel

Personnel		Regular Shift Operations		Yearly Overtime Operations	
Title	Annual Salary	Number of Personnel	Hourly Rate	Hours at 9 G/person	Overtime, Hourly rate
Director	$ 46,000	1	$ 22.12	0	$ 33.17
Shift Supervisor /Manager	$ 39,000	3	$ 18.75	288	$ 28.13
System Operator	$ 25,000	6	$ 12.02	576	$ 18.03
Software Programmer	$ 38,000	1	$ 18.27	0	$ 27.40
Communications Specialist	$ 38,000	1	$ 18.27	0	$ 27.40
Technician, Control Center	$ 30,000	1	$ 14.42	0	$ 21.63
Subtotal:		13	$ 201.44	864	NA
Annual Total, unloaded:			$ 419,000		$ 18,485
Benefit Package:	60%		$ 251,400	0%	$ 0
Annual Total:			$ 670,400		$ 18,485

Total Personnel Operations Cost for a Year: $ 689,000

Notes:

Overtime Operations are 12 Holidays during the normal work year at 8 hours per person per Holiday.

This table is for a 16 Hour Operation Control Center.

All costs in 1994 dollars.

Table 6-8(b)

COST ESTIMATE: OPERATIONS AND MAINTENANCE

Traffic Information Center (TIC), 1 Each Missouri and Illinois

Physical Plant

	Unit Costs	Size or Quantity	Yearly Cost
Monthly Building Operating Costs:			
Rent (yearly)	$ 10 /Sq.Ft.	1400 Sq.Ft.	$ 14,000
HVAC & Electric (daily)	$ 0.085 /KW	341.98 KW /day	$ 10,610
Maintenance	$ 1,000 /month	12 months	$ 12,000
General Supplies	$ 200 /month	12 months	$ 2,400
Communications, Telephone General:			
Regular Phone Service	$ 333 /month	3 units	$ 12,000
Celluar Phones	$ 500 /month	3 units	$ 18,000
800 Number Service	$ 1,000 /month	1 number	$ 12,000
Communications, MODEM Links:			
Dial-up	$ 20 /drop /month	15 locations	$ 3,600
Leased Lines	$ 100 /drop /month	30 agencies	$ 36,000
Computers:	$ 200,000 initial cost		
Supplies	$ 605 /month	12 months	$ 7,260
Maintenance	10% /year	1 year	$ 20,000
Replacements	10% /year	1 year	$ 20,000
Miscellaneous:			
Monthly Vehicle Costs	$ 0.50 /mile	2500 Avg Miles /month	$ 15,000
Total Physical Plant Operations Cost for a Year:			$ 183,000

All costs in 1994 dollars.

Table 6-9(a)

COST ESTIMATE: OPERATIONS AND MAINTENANCE

Field Hardware - Missouri

Personnel

Personnel		Regular Shift Operations		5% Overtime Operations	
Title	Hourly Rate	Number of Personnel	Salary Cost	Number of Personnel	Salary cost
Foreman, Field	$ 17.31	1	$ 17	1	$ 26
Technician, Field	$ 13.46	2	$ 27	2	$ 40
Technician, Electronics, Field	$ 16.83	2	$ 34	2	$ 51
Subtotal (Hourly):			$ 78		$ 117
Subtotal Yearly: Benefit Package:			$ 162,000 $ 97,200		$ 12,150 $ 0
Subtotals:			$ 259,200		$ 12,150

Total Personnel Operations Cost for a Year: **$ 271,000**

Physical Plant

	Unit Costs	Size or Quantity	Yearly Cost
Electric Power:			
Electric (daily)	$ 0.09 IKW	852 KW /day	$311,000
Sign HVAC (daily)	$ 0.09 /KW	138 KW /day	$ 50,500
Vehicle Costs, Initial:			
High Bucket, 65'	$ 55,000 purchase	1 @ 8 years Life Span	$ 9,625
Bucket Truck/Van	$ 35,000 purchase	2 @ 8 years Life Span	$12,250
Equipment/Splicing Van	$ 40,000 purchase	1 @ 8 years Life Span	$ 7,000
Vehicle Costs, Monthly Operations:			
High Bucket, 65'	$ 0.50 /mile	1 @ 600 Miles /month	$ 3,600
Bucket Truck/Van	$ 0.50 /mile	2 @ 600 Miles /month	$ 7,200
Equipment/Splicing Van	$ 0.50 /mile	1 @ 600 Miles /month	$ 3,600
Hardware Maintenance/Supplies:			
All Field Equipment	$ 75,000 /month	12 months	$ 900,000

Total Physical Plant Operations Cost for a Year: **$ 1,305,000**

All costs in 1994 dollars.

Table 6-9(b)

COST ESTIMATE: OPERATIONS AND MAINTENANCE

Field Hardware - Illinois

Personnel

Personnel		Regular Shift Operations		5% Overtime Operations	
Title	Hourly Rate	Number of Personnel	Salary Cost	Number of Personnel	Salary cost
Foreman, Field	$ 17.31	1	$17	1	$ 26
Technician, Field	$ 13.46	2	$ 27	2	$ 40
Technician, Electronics, Field	$ 16.83	2	$ 34	2	$ 51
Subtotal (Hourly):			$ 78		$117
Subtotal Yearly: Benefit Package:			$ 162,000 $ 97,200		$ 12,150 $ 0
Subtotals:			$ 259,200		$ 12,150

Total Personnel Operations Cost for a Year: $ 271,000

Physical Plant

	Unit Costs	Size or Quantity	Yearly Cost
Electric Power:			
Electric (daily)	$ 0.09 /KW	348 KW /day	$ 127,000
Sign HVAC (daily)	$ 0.09 /KW	60 KW /day	$ 22,000
Vehicle Costs, Initial:			
High Bucket, 65'	$ 55,000 purchase	1 @ 8 years Life Span	$ 9,625
Bucket Truck/Van	$ 35,000 purchase	2 @ 8 years Life Span	$12,250
Equipment/Splicing Van	$ 40,000 purchase	1 @ 8 years Life Span	$ 7,000
Vehicle Costs, Monthly Operations:			
High Bucket, 65'	$ 0.50 /mile	1 @ 600 Miles /month	$ 3,600
Bucket Truck/Van	$ 0.50 /mile	2 @ 600 Miles /month	$ 7,200
Equipment/Splicing Van	$ 0.50 /mile	1 @ 600 Miles /month	$ 3,600
Hardware Maintenance/Supplies:			
All Field Equipment	$ 30,000 /month	12 months	$ 360,000

Total Physical Plant Operations Cost for a Year: $ 552,000

All costs in 1994 dollars.

Table 6-10(a)

COST ESTIMATE: OPERATIONS AND MAINTENANCE

Incident Management Response - Missouri

Personnel

Personnel		Regular Shift Operations		5% Overtime Operations	
Title	Hourly Rate	Number of Personnel	Salary Cost	Number of Personnel	Salary cost
Shift Supervisior / Manager	$ 18.75	3	$ 56	3	$ 84
Foreman, Field	$ 17.31	5	$ 87	5	$ 87
Technician, Highway (Hourly)	$ 14.42	12	$ 173	12	$ 173
State Police	$ 0	0	$ 0	0	$ 0
HAZMAT	$ 0	0	$ 0	0	$ 0
Medical	$ 0	0	$ 0	0	$ 0
Fire	$ 0	0	$ 0	0	$ 0
Towing	$ 0	0	$ 0	0	$ 0
Subtotal (Hourly):			$ 316		$ 344
Subtotal Yearly:			$ 657,000		$ 35,775
Benefit Package:			$ 394,200		$ 0
Subtotals:			$ 1,051,200		$ 35,775

Total Personnel Operations Cost for a Year: **$ 1,087,000**

Physical Plant

	Unit Costs	Size or Quantity	Yearly Cost
Communications, Telephone General:			
Celluar Phones	$ 500 /month	4 units	$ 24,000
Vehicle Costs, Initial:			
Dump Truck	$ 40,000 purchase	2 @ 8 years Life Span	$ 14,000
Pickup Truck with Arrow	$ 35,000 purchase	2 @ 8 years Life Span	$ 12,250
Vehicle Costs, Monthly Operations:			
Dump Truck	$ 0.50 /mile	2 @ 500 Miles /month	$ 6,000
Pickup Truck with Arrow	$ 0.50 /mile	2 @ 500 Miles /month	$ 6,000

Total Physical Plant Operations Cost for a Year: **$ 62,000**

All costs in 1994 dollars.

Table B-10(b)

COST ESTIMATE: OPERATIONS AND MAINTENANCE

Incident Management Response - Illinois

Personnel

Personnel		Regular Shift Operations		5% Overtime Operations	
Title	Hourly Rate	Number of Personnel	Salary Cost	Number of Personnel	Salary cost
Shift Supervisior / Manager	$ 18.75	3	$ 56	3	$ 84
Foreman, Field	$ 17.31	3	$ 52	3	$ 87
Technician, Highway (Hourly)	$ 14.42	6	$ 87	6	$ 173
State Police	$ 0	0	$ 0	0	$ 0
HAZMAT	$ 0	0	$ 0	0	$ 0
Medical	$ 0	0	$ 0	0	$ 0
Fire	$ 0	0	$ 0	0	$ 0
Towing	$ 0	0	$ 0	0	$ 0
Subtotal (Hourly):			$ 195		$ 223
Subtotal Yearly:			$ 405,000		$ 23,175
Benefit Package:			$ 243,000		$ 0
Subtotals:			$ 648,000		$ 23,175

Total Personnel Operations Cost for a Year: **$ 671,000**

Physical Plant

	Unit Costs	Size or Quantity	Yearly Cost
Communications, Telephone General:			
Celluar Phones	$ 500 /month	3 units	$ 18,000
Vehicle Costs, Initial:			
Dump Truck	$ 40,000 purchase	1 @ 8 years Life Span	$ 7,000
Pickup Truck with Arrow	$ 35,000 purchase	1 @ 8 years Life Span	$ 6,125
Vehicle Costs, Monthly Operations:			
Dump Truck	$ 0.50 /mile	1 @ 300 Miles /month	$ 1,800
Pickup Truck with Arrow	$ 0.50 /mile	1 @ 300 Miles /month	$ 1,800

Total Physical Plant Operations Cost for a Year: **$ 35,000**

All costs in 1994 dollars.

Table 6-11

COST ESTIMATE: OPERATIONS AND MAINTENANCE

Summary

Actual Costs

	MISSOURI	ILLINOIS	TOTAL
Traffic information Center (TIC):			
Personnel	$ 689,000	$ 689,000	$ 1,378,000
Physical Plant	$ 183,000	$ 183,000	$ 366,000
Field Hardware:			
Personnel	$ 271,000	$ 271,000	$ 542,000
Physical Plant	$ 1,305,000	$ 552,000	$ 1 ,857,000
Incident Management Response:			
Personnel	$ 1,087,000	$ 671,000	$ 1 ,758,000
Physical Plant	$ 62,000	$ 35,000	$ 97,000
Total:	$ 3,600,000	$ 2,400,000	$ 6,000,000

All costs in 1994 dollars.

Table 6-12

UPGRADE PHASING OF FREEWAY TRAFFIC DIVERSION ARTERIALS

ARTERIAL	LIMITS	AGENCY	SIGNALIZED INTERSECTIONS	UPGRADE PHASE
Lindbergh Blvd.	I-270 to I-64/40	St. Louis County	18	Early Implementation
Forest Park Parkway	Grand Ave. to I-170	St. Louis County	18	Early Implementation
Natural Bridge Ave.	Tucker Blvd. to Union Ave.	St. Louis City	14	Short Term
Market St.	CBD to Grand Ave.	St. Louis City	7	Short Term
Chouteau Ave.	Tucker Blvd. to Vandeventer Ave.	St. Louis City	12	Short Term
Broadway	CBD to I-270	St. Louis City	30	Mid Range
Clayton Rd.	Skinker Blvd. to Lindbergh Blvd.	St. Louis County	15	Mid Range
Elm-Watson Rd.	I-44 to I-270	St. Louis County	13	Long Range
Illinois Route 203	I-270 to I-55	Illinois	18	Ultimate
Illinois Route 111	I-270 to I-55	Illinois	7	Ultimate
St. Clair Ave. / Lincoln Hwy.	Illinois Route 111 to I-64	Illinois	21	Ultimate
Gravois-Chippewa	Tucker Blvd. to Hampton Ave.	St. Louis City	27	Ultimate
Illinois Route 157	I-270 to I-64	Illinois	15	Ultimate
Illinois Route 159	I-270 to I-64	Illinois	17	Ultimate

6.2.7.3 Software Development Costs

In order to operate the freeway management system and its various IVHS elements, as well as provide the required communications capabilities (such as to the IDOT TIC, other agencies traffic information kiosks, etc.), computer software needs to be written and/or existing software modified. This is a large task, and the vast majority of the work is required early in the implementation process.

The total estimated cost of software development over all plan phases is $2 million.

6.2.7.4 Total Capital Costs

The total estimated capital cost for construction, engineering and software development for all Strategic Deployment Plan phases, including a 15 percent contingency, is approximately $142 million.

6.2.7.5 Operations and Maintenance Costs

Operations and maintenance cost estimates were prepared for the proposed Traffic Information Centers, field hardware, and incident management response components. Included are estimated costs for:

- Operations Personnel
- Building Operations and Maintenance
- Computer Maintenance
- Utilities and Communications
- Maintenance Equipment

The incident management response component (Tables 6-10(a) and(b) reflects costs for a separate team specifically trained and equipped for this role, with specialized heavy-duty equipment that can handle difficult problems such as overturned semi-trailer trucks and hazardous material spills. As shown, this component is “optional” in the sense that this important function could be provided in many different ways. The St. Louis Incident Management Coalition that has been established is an excellent means by which to develop an incident management program and address how this critical function will be provided; the coalition’s recommendations in this regard, when finalized, should be the basis for implementation.

The total annual system cost for operations and maintenance, including incident management response, is estimated to be just over $6 million.

6.3 PROCUREMENT AND INSTALLATION OPTIONS

6.3.1 Procurement Options

Every agency or Department of Transportation (DOT) purchasing high-tech IVHS equipment faces a variety of alternatives. In most cases, initial procurement and installation costs must be weighted against future recurring costs for compatibility, operation and maintenance. Maintenance personnel requirements must also be considered, particularly in view of the increasing electronic sophistication of IVHS equipment. Agencies should select equipment that can be feasibly operated and maintained within their present and anticipated financial and personnel capabilities.

Most current IVHS equipment is purchased using the "low bid" procurement concept made popular by the FHWA. This has resulted in DOT's and agencies having a wide variety of equipment models from many different manufacturers and obsolete or outdated equipment, which requires varied maintenance procedures and repair capabilities. As a result, the training and deployment of maintenance staff and servicing of equipment is often difficult and inefficient, and excessively large parts inventories are often required.

There are three basic procurement methods available for the installation of IVHS technologies and systems. A brief description of each procurement option follows:

- "LOW BID" - Designed in-house or by a consultant and constructed by a contractor who selects the equipment based ont he specifications. Responsibility for initial system operation is vague and subject to interpretation.

- "DESIGN-BUILD" - A contractor designs the system, selects the equipment,m and is responsible for construction and proper initial system operation.

- "SYSTEM INTEGRATOR" - A consultant designs the system, purchases the equipment (hardware and software), and installs the equipment. A contractor constructs the traditional civil engineering components (e.g., conduit, structures, foundations). The consultant is responsible for initial system operation.

The "low bid" procurement concept may reduce costs initially, but usually results in higher maintenance costs during the life of the equipment. Another disadvantage in IVHS applications is that even if the equipment and its installation meets the specifications, it may not function as needed. The responsibility for making the system function properly rests with the contractor, who is usually a general electrical contractor not versed in IVHS technologies.

The "design-build" approach has usually been undertaken under limited circumstances. This work is usually performed by either a major contractor or a large engineering firm or equipment manufacturer/supplier. The most common application has been where there is an on-going source of revenue after construction, such as for toll roads and toll bridges. Another situation in which it has been used is with public-private partnerships for the design and construction of a fiber-optic communications system. A potential disadvantage is that this approach can restrict the public agency's future options because design-build contracts can run for several years, even decades. This approach may also not qualify for federal funding, depending upon the circumstances.

The "system integrator" method is a relatively new concept that is gaining widespread acceptance and use. It provides continuity from design through system operation and maintenance by making the consultant responsible for all of these phases. The consultant designs the system, purchases the best equipment for the project and is responsible for making the system work. These is no uncertainty. Other major project advantages are the consultant's practice of billing the government agency for the equipment at their cost (no markup), and developing software programs that are specifically tailored to that equipment and the project. Because the software is written and tested for that specific equipment, it will perform the functions that are required (e.g., all changeable message sign controllers are not the same) or the consultant is responsible to get it working properly.

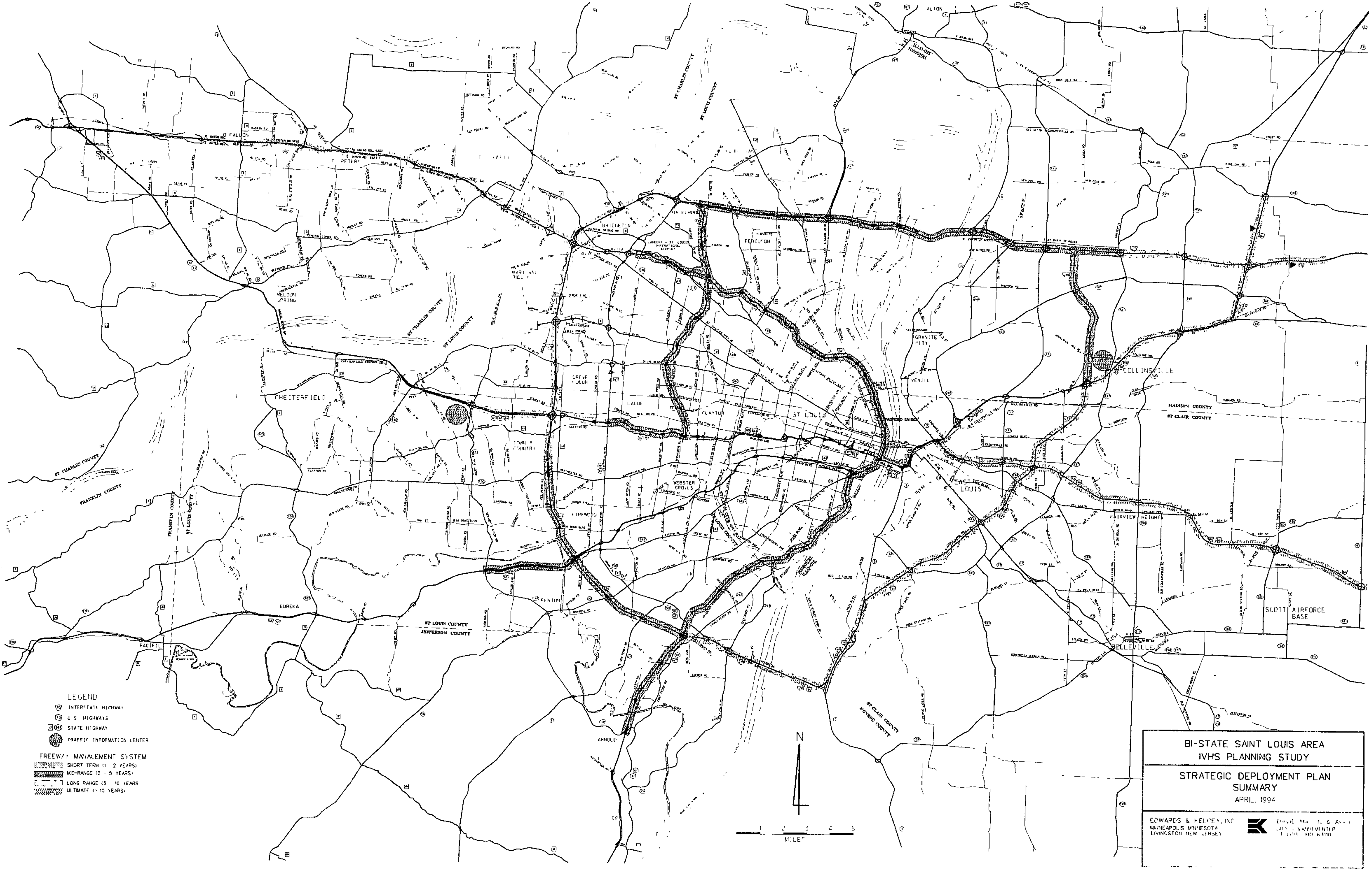
6.3.2 Installation Options

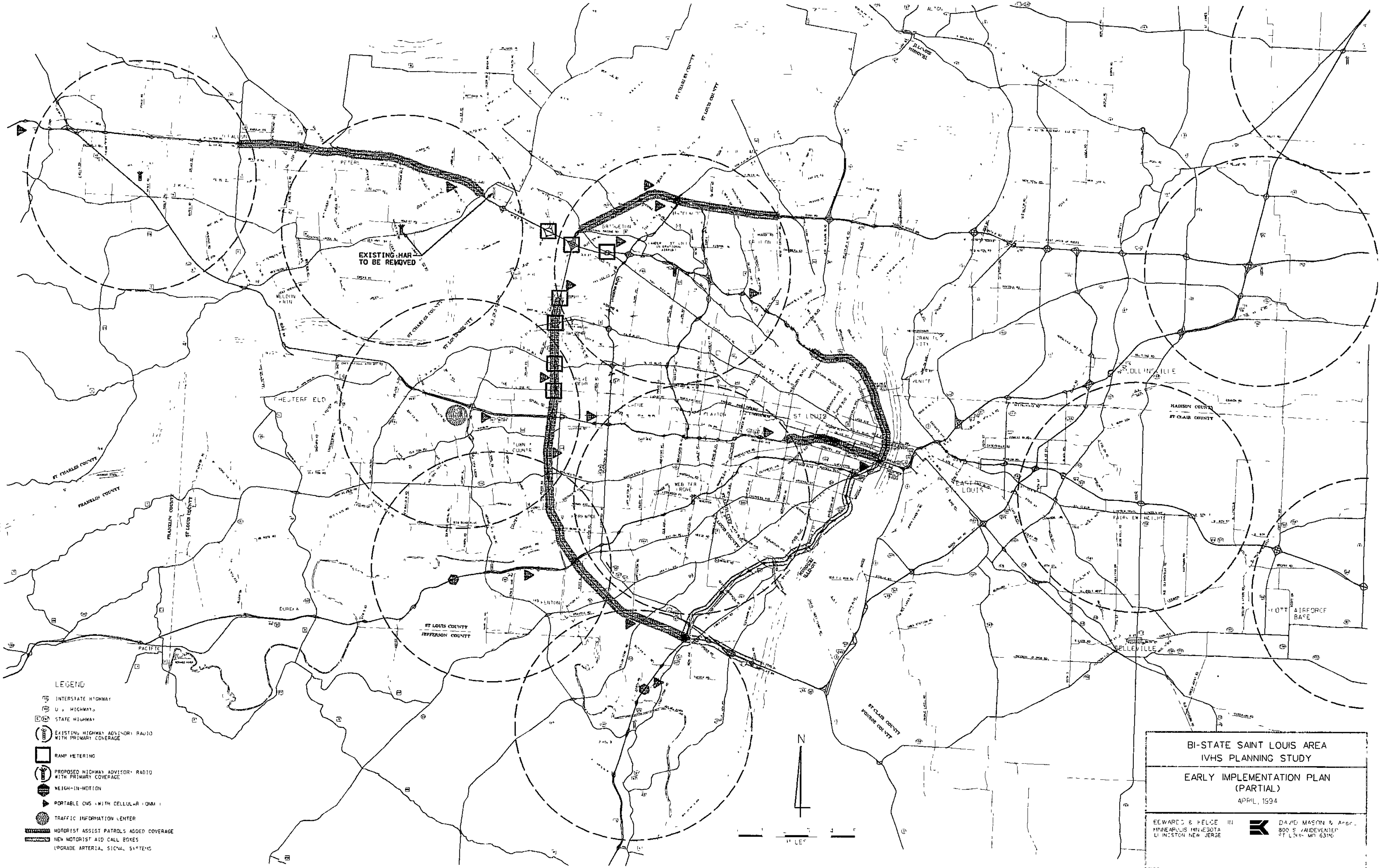
Success during the system installation phase is, to a large degree, dependent on the quality of the work which preceded it. Thorough planning, coupled with complete and definitive plans and specifications, are essential to the installation of a successful traffic system. Good contract management and thorough construction inspection are essential to a system's success, since the biggest errors, longest delays and largest cost overruns have taken place during system installation. Unless the installation phase is properly managed, it can break a project and turn the system into an operational failure and maintenance nightmare.

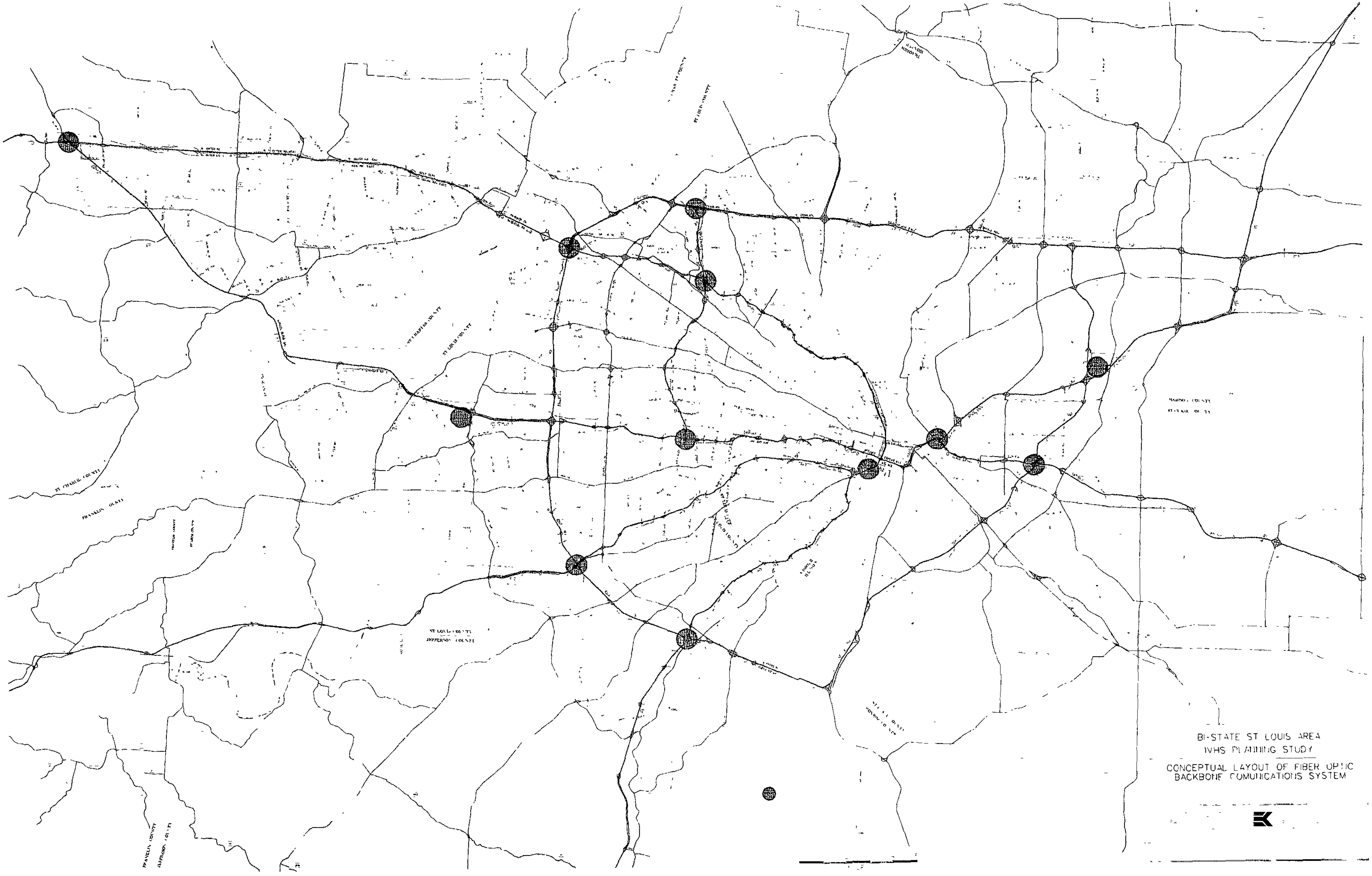
IVHS installation depends on effective construction contract administration and supervision, close cooperation among all parties involved, careful attention to plan details and good workmanship. Good installation procedures and practices can make installation easier, avoid construction delays, minimize future operational problems and maintenance requirements, and reduce the risk of future liability.

A detailed description of system installation options and recommendations is contained in Appendix D. Subjects addressed are:

- Preconstruction administration, supervision and coordination activities.
- Effective record keeping during construction.
- A construction inspection checklist to avoid common problems and facilitate good workmanship.
- Guidelines for final project inspection and acceptance.

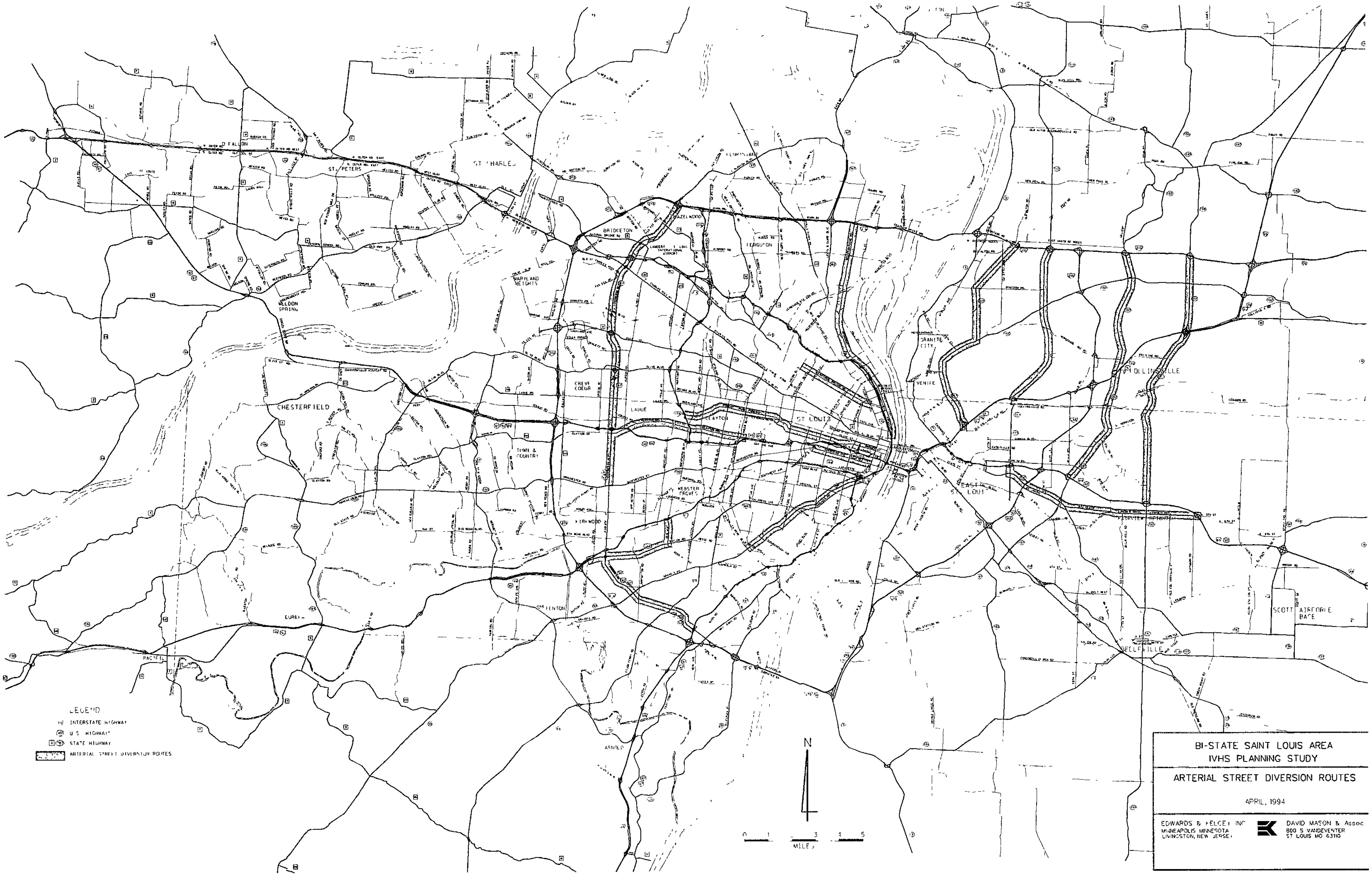

LEGEND
INTERSTATE HIGHWAY
U S HIGHWAYS
STATE HIGHWAY
TRAFFIC INFORMATION CENTER
FREEWAY MANAGEMENT SYSTEM
SHORT TERM (1 2 YEARS)
MID-RANGE (2 - 5 YEARS)
LONG RANGE (5 10 YEARS
ULTIMATE (> 10 YEARS)
N
MILES
ST CHARLES COUNTY
ST LOUIS COUNTY
FRANKLIN COUNTY
JEFFERSON COUNTY
MADISON COUNTY
ST CLAIR COUNTY
MONROE COUNTY
CHESTERFIELD
EUREKA
PACIFIC
ARNOLD
FENTON
KIRKWOOD
WEBSTER GROVES
CLAYTON
ST LOUIS
GRANITE CITY
VENICE
COLLINSVILLE
EAST ST LOUIS
FAIRVIEW HEIGHTS
BELLEVILLE
SCOTT AIRFORCE BASE
BRIDGETON
FERGUSON
ALTON
BI-STATE SAINT LOUIS AREA
IVHS PLANNING STUDY
STRATEGIC DEPLOYMENT PLAN
SUMMARY
APRIL, 1994
MINNEAPOLIS MINNESOTA
LIVINGSTON NEW JERSEY


BI-STATE SAINT LOUIS AREA
IVHS PLANNING STUDY
EARLY IMPLEMENTATION PLAN
(PARTIAL)
APRIL, 1994
EDWARDS & KELCEY INC
MINNEAPOLIS MINNESOTA
LIVINGSTON NEW JERSEY
DAVID MASON & Assoc.
800 S VANDEVENTER
ST LOUIS MO 63110
LEGEND
INTERSTATE HIGHWAY
U.S. HIGHWAYS
STATE HIGHWAY
EXISTING HIGHWAY ADVISORY RADIO WITH PRIMARY COVERAGE
RAMP METERING
PROPOSED HIGHWAY ADVISORY RADIO WITH PRIMARY COVERAGE
WEIGH-IN-MOTION
PORTABLE CMS (WITH CELLULAR COMM.)
TRAFFIC INFORMATION CENTER
MOTORIST ASSIST PATROLS ADDED COVERAGE
NEW MOTORIST AID CALL BOXES
UPGRADE ARTERIAL SIGNAL SYSTEMS
EXISTING HAR TO BE REMOVED
ST LOUIS
EAST ST. LOUIS
CHESTERFIELD
EUREKA
PACIFIC
FENTON
BELLEVILLE
COLLINSVILLE
GRANITE CITY
VENICE
ALTON
FAIRVIEW HEIGHTS
SCOTT AIRFORCE BASE
MADISON COUNTY
ST CLAIR COUNTY
ST LOUIS COUNTY
JEFFERSON COUNTY
ST CHARLES COUNTY
FRANKLIN COUNTY
ILLINOIS
MISSOURI
N
MILES



BI-STATE ST LOUIS AREA
IVHS PLANNING STUDY

CONCEPTUAL LAYOUT OF FIBER OPTIC
BACKBONE COMUNICATIONS SYSTEM



BI-STATE SAINT LOUIS AREA
IVHS PLANNING STUDY

ARTERIAL STREET DIVERSION ROUTES

APRIL, 1994

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7. BENEFIT/COST ANALYSIS

7. BENEFIT/COST ANALYSIS

Costs to fully implement the proposed Strategic Deployment Plan for the Bi-State St. Louis Area are expected to total nearly $140 million, as described in the preceding chapter. In addition, a fully deployed program is expected to cost approximately $6 million annually to maintain. Offsetting these costs are the substantial benefits to the motorist, the general public and the operating agencies from IVHS deployment. Typical benefits from such systems, based on experience in other sections of the country and abroad, were discussed in Chapter 2.

In this chapter, traveler, public and agency benefits are estimated for the St. Louis Area, drawing upon the typical benefits experienced to date in other areas. Where possible, the approximate dollar value of such benefits have been quantified, to allow direct benefit to cost comparison. Since actual experience with such technologies is relatively limited, the benefit estimates should be used with caution. However, they do provide a good indication of the relative magnitude of benefits versus costs that can be expected.

To provide a conservative approach, all motorist/travel related benefits have been estimated based on current traffic volume levels. Since traffic in St. Louis Area freeways is currently growing at a rate of approximately 3%, actual motorist benefits can also be expected to increase in future years.

Conversely, since the Strategic Deployment Plan is expected to be implemented in various stages over a number of years, not all the benefits will be immediately realized. However, both capital and operating costs will be also phased in over a multi-year period. For practical reasons, therefore, all costs and benefits for benefit/cost comparison were assumed on a basis of current 1994 dollars and traffic conditions.

Anticipated benefits of the Proposed Strategic Deployment Plan for the St. Louis area can be grouped into five primary areas:

- Incident Management Benefits
- Recurrent Peak Period Congestion Reduction Benefits
- Accident Reduction Benefits
- Arterial Signal System Upgrade Benefits
- Other Benefits

The following five sections describe the methodology and estimated benefits in eachcategory. A sixth section summarizes the combined annual benefits in comparison to anticipated annual costs. The scope of work did not permit supplemental data collection. The benefit/cost methodology was developed using existing data and relative case histories.

7.1 INCIDENT MANAGEMENT BENEFITS

Benefits from the proposed Incident Management Program (IMP) portion of the Strategic Deployment Plan were estimated drawing upon the studies described in the "Typical Benefits" section of Chapter 2 and a document produced by FHWA titled Freeway Incident Management Handbook. The benefits of an incident management system include time cost savings, savings in fuel consumption, accident reduction, and savings in air pollutant emissions.

Time cost and fuel consumption savings are described in detail in the Freeway Incident Management Handbook, based on a benefit/cost analysis performed by the Ontario Ministry of Transportation in 1987 for a section of Highway 401 in Toronto. A number of assumptions were made as a part of the Ontario analysis:

- Typical duration of a single lane blocking incident with the Incident Management Program (IMP) is 17 minutes
- Duration of a single lane blocking incident without IMP is 38 minutes
- Peak hour volume on HW 401 for a three lane section is 5220 v/h
- Capacity for the same section is 6000 v/h
- Capacity for the same section with a single lane blocking incident is 4000 v/h
- Traffic stream is composed of 88% passenger vehicles and 12% commercial vehicles
- Cost of fuel is $1 per gallon
- A stationary vehicle will use 0.85 gallons of fuel per hour
- The time cost of a stationary passenger vehicle is $6/hr and for a commercial is $25/hr

The Ontario Ministry of Transportation performed a traffic simulation analysis for the freeway section. The study found that the 38 minute blockage would result in a maximum queue length of 1.44 miles. The queue would take 58 minutes to dissipate after the incident was cleared. The total delay is calculated as 610 vehicle hours. The society cost of this delay was computed as follows: (0.88 passenger veh x $6/hr + 0.12 commercial veh x $25/hr + 0.85 gallons x $1/gallon) x 610 veh hrs = $5566. With the Incident Management Program in place, the 17 minute single lane blocking incident would result in a maximum queue length of 0.64 miles. The queue would take 26 minutes to dissipate after the incident was cleared. The total delay is calculated as 122 veh hrs and has a society cost of $1113.

The Missouri HTD has estimated that the delay cost for a passenger vehicle is $10 per hour. This cost factor would raise the cost per incident without an IMP to $7717. Using the same factor of $10/hr.the cost per incident with an IMP is $1543, producing a cost savings of $6173 per incident.

Using data reported in Technical Memorandum No. 13, the number of accidents and motorist assists is known for three segments of the St. Louis freeway system. This information provides the best available indicator of the frequency of incidents on the most heavily traveled segments of the St. Louis freeway system. The cost per incident both with and without incident management was calculated for three freeway segments. The results are shown in

Table 7-1. The annual savings per mile with an incident management program was found to average $502,000. It should be noted that the peak hour volumes for the freeway sections in St. Louis are similar to the study freeway section in Toronto, therefore it is reasonable to expect that queue lengths and queue dissipation times will also be similar.

Approximately 93 miles of the 269-mile St. Louis area freeway system carry average daily traffic volumes of over 100,000 vehicles per day. In general, these sections also have the highest accident rates and represent that portion of the system where the majority of the Incident Management Program benefits will accrue. Estimated travel time and fuel savings for the 93 mile portion would be 93 mi. x $502,000/mil = approximately $46.7 million per year. Based on this analysis, a conservative savings estimate for the overall St. Louis metropolitan area freeway system is approximate/y $50 million per year. Additional savings due from accident and emissions reduction are discussed in the following sections.

7.2 RECURRENT PEAK PERIOD CONGESTION REDUCTION

In addition to incident reduction, the Strategic Deployment Plan is also expected to reduce recurrent weekday peak period congestion on the freeway system. Currently, approximately 50 miles of the freeway system experience daily average travel speeds of less than 45 miles per hour during either morning or afternoon peak hours.

Increasing average travel speeds for these sections alone during the peak periods (two hour AM or PM periods) by 5 to 10 miles per hour would produce annual vehicle travel time savings of approximately 800,000 to 1,400,000 hours, as shown in Table 7-2. Considering that projects such as the Los Angeles SMART corridor produced average freeway speed increases from a before level of 15-35 mph to an after level of 40-50 mph; a 5 to 10 mph estimated increase in currently congested locations can be considered a conservative benefit estimate for the St. Louis Plan.

At a delay cost of $10 per hour for automobiles and $25 per hour for commercial vehicles, the total annual recurrent congestion savings would be in the range of $9 to $15 million

For the range of operating speeds involved, the estimated speed improvements would not produce significant incremental fuel consumption savings. Accident and emissions benefits are considered in the following sections.

7.3 ACCIDENT REDUCTION BENEFITS

The proposed Strategic Deployment Plan is expected to reduce both the number and severity of accidents by providing warnings of incidents or congestion ahead to drivers. Accident data reported in Technical Memorandum No. 13 shows that there were approximately 6500 accidents per year on the St. Louis area freeways in the 1989-1992 period. Analysis of

Table 7–1

ANNUAL SAVINGS WITH AN INCIDENT MANAGEMENT PROGRAM

INTERSTATE ROUTE	DESCRIPTION	MILES	1992 ACCIDENTS	1992 ASSISTS	1992 TOTAL INCIDENTS	ADT	PEAK HOUR VOLUME	W/O IM COST INCIDENT	W/O IM ANNUAL SOCIETY COST	W/O IM ANNUAL COST /MILE	WITH IM COST/ INCIDENT	WITH IM ANNUAL SOCIETY COST	ANNUAL SAVINGS WITH IM	ANNUAL SAVINGS PER MILE
I–64 (US 40)	W. of Hwy 141 to W. of I–270	1 5	52	37	89	102,000	8160	$7,717	$666,769	$457,846	$1,543	$137,327	$549,442	$366,294
	W of I–270	1 17	43	13	56	102,000	8160	$7,717	$432,124	$369,337	$1,543	$86,408	$345,716	$295,484
	I–270 to W. of Spoede	1 82	203	25	228	105,000	8400	$7,717	$1,759,362	$966,682	$1,543	$351,804	$1,407,558	$773,384
	W. of Spoede to W of Brentwood	3 5	119	203	322	121,000	9680	$7,717	$2,484,713	$709,918	$1,543	$496,846	$1,987,867	$567,962
	W. of Brentwood to E of Big Bend	2	256	110	366	133,000	10640	$7,717	$2,824,239	$1,412,120	$1,543	$564,738	$2,259,501	$1,129,751
	E. of Big Bend to W of Tamm	1	43	34	77	133,000	10640	$7,717	$594,171	$594,171	$1,543	$118,811	$475,360	$475,360
	W of Tamm to W of Compton	4	128	85	213	133,000	10640	$7,717	$1,643,615	$410,904	$1,543	$328,659	$1,314,956	$328,739
	TOTALS	14.99	844	507	1351				$10,424,992	$695,463		$2,084,593	$8,340,399	$556,397
I–70	Missouri River to W of I–270	1 5	121	114	235	165,000	13200	$7,717	$1,813,495	$1,208,997	$1,543	$362,605	$1,450,890	$967,260
	W of I–270 to E of McKelvey	1 5	73	75	148	121,000	9680	$7,717	$1,142,116	$761,411	$1,543	$228,364	$913,752	$609,168
	E of McKelvey to W of I–170	5	167	234	401	121,000	9680	$7,717	$3,094,517	$618,903	$1,543	$618,743	$2,475,774	$495,155
	W of I–170 to W of Hanley	1 5	72	73	145	130,000	10400	$7,717	$1,118,965	$745,977	$1,543	$223,735	$895,230	$596,820
	W. of Hanley to W. end reversible	4 5	282	254	536	130,000	10400	$7,717	$4,136,312	$919,180	$1,543	$827,048	$3,309,264	$735,392
	W end reversible to W. of 9th	5 5	248	69	317	123,000	9840	$7,717	$2,446,289	$444,780	$1,543	$489,131	$1,957,158	$355,847
	W. of 9th to S. of Market	1 25	117	32	149	117,000	9360	$7,717	$1,149,833	$919,866	$1,543	$229,907	$919,926	$735,941
	TOTALS	20.75	1080	851	1931				$14,901,527	$718,146		$2,979,533	$11,921,994	$574,564
I–270	N of Big Bend to S of Clayton	4	92	1	93	130,000	10400	$7,717	$717,681	$179,420	$1,543	$143,499	$574,182	$143,546
	S. of Clayton to S of Ladue	2	153	14	167	130,000	10400	$7,717	$1,288,739	$644,370	$1,543	$257,681	$1,031,058	$515,529
	S. of Ladue to S. of Page	2 5	63	48	111	150,000	12000	$7,717	$856,587	$342,635	$1,543	$171,273	$685,314	$274,126
	S. of Page to S. of McKelvey	3	119	94	213	123,000	9840	$7,717	$1,643,721	$547,907	$1,543	$328,659	$1,315,062	$438,354
	S. of Mckelvey to Woodford Way	2.5	82	100	182	123,000	9840	$7,717	$1,404,494	$561,798	$1,543	$280,826	$1,123,668	$449,467
	TOTALS	14	509	257	766				$5,911,222	$422,230		$1,181,936	$4,729,284	$337,806

Average savings per mile $502,000

Table 7–2

RECURRENT PEAK PERIOD ESTIMATED TRAVEL TIME SAVINGS CONGESTED SECTIONS

				2 Hr. Peak Current			2 Hr. Peak with 5 MPH Speed Increase			2 Hr. Peak with 10 MPH Speed Increase		
Corridor/Location Limits	Direction/ Period	2 Hour Volume (V)	Dist. (MI)	Travel Speed (MPH)	Veh. Trav. Time (VHR) Daily	Veh. Trav. Time (VHR) Annually	Veh. Trav. Time (VHR) Daily	Veh. Trav. Time (VHR) Annually	Savings (VHR) Annually	Veh. Trav. Time (VHR) Daily	Veh. Trav. Time (VHR) Annually	Savings (VHR) Annually
I–44; Bowles Avenue to Route 61/67	EB/AM	10428	3.77	34.2	1150	298875	1003	260753	38122	889	231256	67619
I–55; Meramec Bottom to Railroad Overpass	NB/AM	9075	2.90	25.8	1020	265215	854	222161	43054	735	191133	74082
I–55/70; North B&O to West end Poplar St. Brdg.	WB/AM	9279	3.48	17.5	1845	479751	1435	373140	106611	1174	305296	174455
I–64; I–170 to Bellevue	EB/AM	11779	1.71	20.0	1007	261847	806	209478	52369	671	174565	87282
I–64; Oakland to I–170	WB/AM	8397	2.37	29.5	675	175398	577	149978	25420	504	130993	44404
I–64; I–170 to State Line	EB/PM	8489	9.05	23.7	3242	842811	2677	695980	146831	2280	592719	250092
I–64; State Line to I–170	WB/PM	10930	9.07	35.4	2800	728111	2454	637998	90113	2184	567734	160377
I–70; Cave Springs to Earth City	EB/AM	14804	5.14	24.1	3157	820916	2615	679865	141051	2231	580178	240738
I–70 Exit Ramp; I–70 to I–270	EB/SB/AM	5863	1.46	17.9	478	124335	374	97188	27147	307	79770	44564
I–70; East Grand to Broadway	EB/PM	8727	2.47	36.6	589	153128	518	134723	18405	463	120268	32860
I–70; Union to Jennings Sta.	WB/PM	11564	1.51	34.1	512	133139	447	116113	17025	396	102948	30190
I–70; Earth City to Fairgrounds	WB/PM	14658	2.50	23.4	1566	407167	1290	335482	71684	1097	285260	121906
I–270; I–64/40 to Route AB	EB/NB/AM	15128	1.17	26.2	676	175646	567	147498	28148	489	127125	48521
I–270; Hanley/Graham to Route N	EB/PM	5533	0.97	34.5	156	40447	136	35327	5120	121	31358	9089
I–270 Exit Ramp; I–270 to I–70	NB/WB/PM	3936	1.74	34.6	198	51464	173	44966	6498	154	39925	11539

ANNUAL TRAVEL TIME SAVINGS – VEHICLE HOURS (VHR) TOTAL 817600 TOTAL 1397720

ANNUAL COST SAVINGS $8.9 Million $15.2 Million

<u>Assumptions:</u>

(1) Annual estimate based on 260 annual weekdays.

(2) Delay costs = $10 per hour for passenger vehicles, $25 per hour for commercial vehicles.

(3) 94% passenger vehicles; 6% commercial vehicles during peak hours

severity data indicates that approximately 18% of the accidents involved injuries (including fatalities); the remaining 82% involved property damage only.

As described under "Typical Benefits" in Chapter 2 of this report, a study of similar freeway surveillance and control in the Chicago area reported a reduction in accidents of 18% after project implementation. An 18% reduction in freeway accidents in St. Louis would reduce annual accidents by approximately 1170. The Missouri Highway and Transportation Department has compiled a Manual on Identification, Analysis and Correction of High-Accident Locations. Average costs of accidents are identified as:

Fatal/injury accidents on Interstate Freeways . . . $73,900
Property damage only accident . . . . $ 4,000

Using these costs, and the 18% injury/ 82% property damage mix, the annualsavings for an 18% accident reduction would be approximately $19 million. Because the severity of accidents can also be expected to drop, the $19 million estimate can be considered conservative.

7.4 ARTERIAL SIGNAL SYSTEMS UPGRADE

Another element of the St. Louis Strategic Deployment Plan is the upgrading of several arterial corridors to provide coordinated computer-controlled signal systems where freeway traffic may be diverted. The ultimate plan provides for upgrading 232 intersections.

The National Signal Timing Optimization project review by FHWA for 11 cities nationwide showed annual savings per intersection of 15,000 vehicle travel hours and 10,000 gallons of fuel when signal systems were coordinated, retimed and computer-controlled. As an indicator of benefits achievable for proposed St. Louis upgrades, such typical savings would produce an annual time cost savings of approximately $35 million at $10 per hour, and a fuel cost savings of approximate/y $2 million at $1 per gallon.

Other benefits likely to be provided by signal system upgrades include reduction in the number of accidents, reduction in air pollutant emissions, improvement in bus transit operations, and reduction in signal maintenance costs.

7.5 OTHER BENEFITS

7.5.1 Air Pollutant Emissions Reduction

Experience in other areas has shown that fully deployed traffic information and management systems can reduce peak period congestion by up to 40 percent and thereby significantly reduce air pollutant emissions. Air pollutant reduction estimates for the proposed Strategic

Deployment Plan were prepared for the approximate 50 miles of freeway segments currently experiencing either morning or afternoon peak period congestion. These sections are the same sections used for estimating recurrent congestion travel time benefits (Section 7.2).

As shown in Tables 7-3 to 7-5, peak period travel speed improvements of 5 to 10 mph in these congested locations would reduce carbon monoxide (CO) and hydrocarbon (HC) emissions by approximately 12 to 25 percent. CO emissions would be reduced by some 575 to 955 thousand Ibs/year; HC emissions by 60 to 100 thousand Ibs/year. Nitrous Oxide (NOx) emissions would remain relatively unaffected by the speed changes--increasing slightly in some segments while decreasing in others--with a small overall increase expected.

All the above estimates are based on current traffic volume levels. They are not intended to represent accurate pollutant calculations for the entire St. Louis area freeway system. Rather, they are provided to illustrate the order of magnitude of emissions benefits that implementation of IVHS technologies can have in the suggested segments of the freeway system. As traffic volumes increase in the future, the potential benefits of such strategies increase further. A discussion of such implications, along with additional descriptions of the methods used to produce the estimates, can be found in Appendix E.

7.5.2 Other Enhancements

As described in Chapter 2, deployment of IVHS technologies in other areas has produced such benefits as:

- enhanced mobility
- improved service for tourists
- improved transit fleet management
- professional development
- infrastructure preservation
- improved interagency cooperation and information sharing

No attempts have been made to quantify or assign a dollar value to such benefits for the proposed Bi-State St. Louis Strategic Deployment Plan. Rather, such benefits can be viewed as providing additional justification for implementing a freeway management plan that uses IVHS technologies.

Table 7-3

RECURRENT PEAK PERIOD ESTIMATED CARBON MONOXIDE (CO) EMISSIONS CHANGE CONGESTED SECTIONS

Corridor/Location Limits	Direction/ Period	2 Hour Volume (V)	Dist. (MI)	2 Hr. Peak Current: Travel Speed (MPH)	2 Hr. Peak Current: CO Emissions (LBS) Daily	2 Hr. Peak Current: CO Emissions (LBS) Annually	2 Hr. Peak with 5 MPH Speed Increase: CO Emissions (LBS) Daily	2 Hr. Peak with 5 MPH Speed Increase: CO Emissions (LBS) Annually	2 Hr. Peak with 5 MPH Speed Increase: Change (LBS) Annually	2 Hr. Peak with 10 MPH Speed Increase: CO Emissions (LBS) Daily	2 Hr. Peak with 10 MPH Speed Increase: CO Emissions (LBS) Annually	2 Hr. Peak with 10 MPH Speed Increase: Change (LBS) Annually
I-44; Bowles Avenue to Route 61/67	EB/AM	10428	3.77	34.2	866	225160	769	199940	-25220	706	183560	-41600
I-55; Meramec Bottom to RR Overpass	NB/AM	9075	2 90	25.8	752	195520	635	165100	-30420	555	144300	-51220
I-55/70; N. B&O to W. end Poplar St. Brdg.	WB/AM	9279	3.48	17.5	1313	341380	1052	273520	-67860	868	225680	-115700
I-64; I-170 to Bellevue	EB/AM	11779	1.71	20.0	734	190840	593	154180	-36660	498	129480	-61360
I-64; Oakland to I-170	WB/AM	8397	2.37	29.5	500	130000	433	112580	-17420	387	100620	-29380
I-64; I-170 to State Line	EB/PM	8489	9.05	23.7	2381	619060	1982	515320	-103740	1707	443820	-175240
I-64; State Line to I-170	WB/PM	10930	9.07	35.4	2190	569400	1894	492440	-76960	1752	455520	-113880
I-70; Cave Springs to Earth City	EB/AM	14804	5.14	24.1	2321	603460	1938	503880	-99580	1673	434980	-168480
I-70 Exit Ramp; I-70 to I-270	EB/SB/AM	5863	1.46	17.9	342	88920	274	71240	-17680	227	59020	-29900
I-70; East Grand to Broadway	EB/PM	8727	2.47	36.6	446	115960	403	104780	-11180	375	97500	-18460
I-70; Union to Jennings Sta.	WB/PM	11564	1.51	34.1	384	99840	342	88920	-10920	314	81640	-18200
I-70; Earth City to Fairgrounds	WB/PM	14658	2.50	23.4	1150	299000	955	248300	-50700	821	213460	-85540
I-270; I-64/40 to Route AB	EB/NB/AM	15128	1.17	26.2	498	129480	422	109720	-19760	369	95940	-33540
I-270; Hanley/Graham to Route N	EB/PM	5533	0.97	34.5	117	30420	104	27040	-3380	96	24960	-5460
I-270 Exit Ramp; I-270 to I-70	NB/WB/PM	3936	1.74	34.6	149	38740	133	34580	-4160	122	31720	-7020

ANNUAL CARBON MONOXIDE (CO) EMISSIONS SAVINGS (LBS) TOTAL -575640 TOTAL -954980

PERCENT CHANGE -16% -26%

Assumptions:

(1) Annual estimate based on 260 annual weekdays.

Table 7-5

RECURRENT PEAK PERIOD ESTIMATED NITROUS OXIDE (NOx) EMISSIONS CHANGE CONGESTED SECTIONS

Corridor/Location Limits	Direction/ Period	2 Hour Volume (V)	Dist. (MI)	2 Hr. Peak Current			2 Hr. Peak with 5 MPH Speed Increase			2 Hr. Peak with 10 MPH Speed Increase		
				Travel Speed (MPH)	NOx Emissions (LBS) Daily	NOx Emissions (LBS) Annually	NOx Emissions (LBS) Daily	NOx Emissions (LBS) Annually	Change (LBS) Annually	NOx Emissions (LBS) Daily	NOx Emissions (LBS) Annually	Change (LBS) Annually
I-44; Bowles Avenue to Route 61/67	EB/AM	10428	3 77	34.2	191	49660	190	49400	-260	195	50700	1040
I-55; Meramec Bottom to RR Overpass	NB/AM	9075	2.90	25.8	124	32240	125	32500	260	126	32760	520
I-55/70; N. B&O to W. end Poplar St. Brdg.	WB/AM	9279	3.48	17.5	158	41080	153	39780	-1300	152	39520	-1560
I-64; I-170 to Bellevue	EB/AM	11779	1.71	20.0	96	24960	95	24700	-260	95	24700	-260
I-64; Oakland to I-170	WB/AM	8397	2.37	29.5	94	24440	95	24700	260	96	24960	520
I-64; I-170 to State Line	EB/PM	8489	9 05	23.7	364	94640	363	94380	-260	365	94900	260
I-64; State Line to I-170	WB/PM	10930	9 07	35.4	472	122720	480	124800	2080	498	129480	6760
I-70; Cave Springs to Earth City	EB/AM	14804	5.14	24.1	360	93600	360	93600	0	362	94120	520
I-70 Exit Ramp; I-70 to I-270	EB/SB/AM	5863	1.46	17.9	42	10920	41	10660	-260	40	10400	-520
I-70; East Grand to Broadway	EB/PM	8727	2.47	36 6	103	26780	105	27300	520	109	28340	1560
I-70; Union to Jennings Sta.	WB/PM	11564	1 51	34.1	83	21580	84	21840	260	87	22620	1040
I-70; Earth City to Fairgrounds	WB/PM	14658	2 50	23.4	174	45240	173	44980	-260	174	45240	0
I-270; I-64/40 to Route AB	EB/NB/AM	15128	1.17	26.2	84	21840	84	21840	0	85	22100	260
I-270; Hanley/Graham to Route N	EB/PM	5533	0.97	34.5	26	6760	26	6760	0	27	7020	260
I-270 Exit Ramp; I-270 to I-70	NB/WB/PM	3936	1 74	34.6	33	8580	33	8580	0	34	8840	260

ANNUAL NITROUS OXIDE (NOx) EMISSIONS INCREASE (LBS) TOTAL 780 TOTAL 10660

PERCENT CHANGE 0% 2%

Assumptions:

(1) Annual estimate based on 260 annual weekdays.

Table 7-4

RECURRENT PEAK PERIOD ESTIMATED HYDRO CARBON (HC) EMISSIONS CHANGE CONGESTED SECTIONS

				2 Hr. Peak Current			2 Hr. Peak with 5 MPH Speed Increase			2 Hr. Peak with 10 MPH Speed Increase		
Corridor/Location Limits	Direction/ Period	2 Hour Volume (V)	Dist. (MI)	Travel Speed (MPH)	HC Emissions (LBS) Daily	HC Emissions (LBS) Annually	HC Emissions (LBS) Daily	HC Emissions (LBS) Annually	Change (LBS) Annually	HC Emissions (LBS) Daily	HC Emissions (LBS) Annually	Change (LBS) Annually
I-44; Bowles Avenue to Route 61/67	EB/AM	10428	3.77	34.2	121	31460	107	27820	-3640	98	25480	-5980
I-55; Meramec Bottom to RR Overpass	NB/AM	9075	2.90	25.8	96	24960	85	22100	-2860	76	19760	-5200
I-55/70; N. B&O to W. end Poplar St. Brdg.	WB/AM	9279	3.48	17.5	159	41340	130	33800	-7540	107	27820	-13520
I-64; I-170 to Bellevue	EB/AM	11779	1.71	20.0	88	22880	75	19500	-3380	66	17160	-5720
I-64; Oakland to I-170	WB/AM	8397	2.37	29.5	66	17160	58	15080	-2080	54	14040	-3120
I-64; I-170 to State Line	EB/PM	8489	9.05	23.7	299	77740	261	67860	-9880	233	60580	-17160
I-64; State Line to I-170	WB/PM	10930	9.07	35.4	290	75400	264	68640	-6760	243	63180	-12220
I-70; Cave Springs to Earth City	EB/AM	14804	5.14	24.1	292	75920	256	66560	-9360	228	59280	-16640
I-70 Exit Ramp; I-70 to I-270	EB/SB/AM	5863	1.46	17.9	41	10660	34	8840	-1820	30	7800	-2860
I-70; East Grand to Broadway	EB/PM	8727	2.47	36.6	62	16120	56	14560	-1560	52	13520	-2600
I-70, Union to Jennings Sta.	WB/PM	11564	1.51	34.1	52	13520	48	12480	-1040	44	11440	-2080
I-70; Earth City to Fairgrounds	WB/PM	14658	2.50	23.4	144	37440	125	32500	-4940	112	29120	-8320
I-270; I-64/40 to Route AB	EB/NB/AM	15128	1.17	26.2	64	16640	57	14820	-1820	51	13260	-3380
I-270; Hanley/Graham to Route N	EB/PM	5533	0.97	34 5	17	4420	14	3640	-780	13	3380	-1040
I-270 Exit Ramp, I-270 to I-70	NB/WB/PM	3936	1.74	34.6	20	5200	18	4680	-520	17	4420	-780

ANNUAL HYDRO CARBON (HC) EMISSIONS SAVINGS (LBS) TOTAL -57980 TOTAL -100620

PERCENT CHANGE -12% -21%

Assumptions:

(1) Annual estimate based on 260 annual weekdays.

7.6 BENEFIT / COST COMPARISON

Quantifiable annual benefits, as described in the previous sections can be summarized as:

	Estimated Annual Benefits (Million)
Incident Management	$ 50
Recurrent Peak Period Congestion Reduction	12
Accident Reduction	19
Arterial Signal Systems Upgrade	35
TOTAL	$ 116

Annual costs for the proposed Strategic Deployment plan, assuming a 15 year service life for all elements with no salvage value, and a 10% interest rate are:

	Estimated Annual Costs (Million)
Capital Recovery ($142 Million)	$ 19
Annual Operations and Maintenance	6
TOTAL	$ 25

The resultant Benefit / Cost Ratio is 116 : 25, or approximately 4.6 : 1.

All benefits and costs for the above comparison are in 1994 dollars. While both costs and benefits are expected to occur incrementally as the various components of the plan are implemented in stages, for practical reasons and ease of comparison both have been assumed to be incurred in 1994. As previously described, conservative assumptions have generally been made for estimating benefits. Also, many non-quantifiable benefits that would increase the benefit/cost ratio are anticipated. Similarly, the assumption of no salvage value and 10% interest for capital cost recovery constitutes a conservative approach to the benefit/cost comparison. Thus, actual benefits can be expected to exceed the 4.5 : 1 benefit/cost ratio.

FINAL REPORT

APPENDICES

Bi-State St. Louis Area
Intelligent Vehicle Highway System
Planning Study

April 1994

Edwards and Kelcey, Inc. B

in association with

Farradyne Systems, Inc.
Crawford, Bunte, Brammeier
David Mason & Associates, Inc.

APPENDICES
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