FINAL REPORT

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

April 1994

Edwards and Kelcey, Inc.

in association with

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

E D W A R D S   A N D   K E L C E Y ,   I N C .

One Corporate Center, 7401 Metro Boulevard
Minneapolis, Minnesota 55439
Telephone: (612) 835-6411
Fax: (612) 835-7376

Engineers
Planners
Consultants

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.

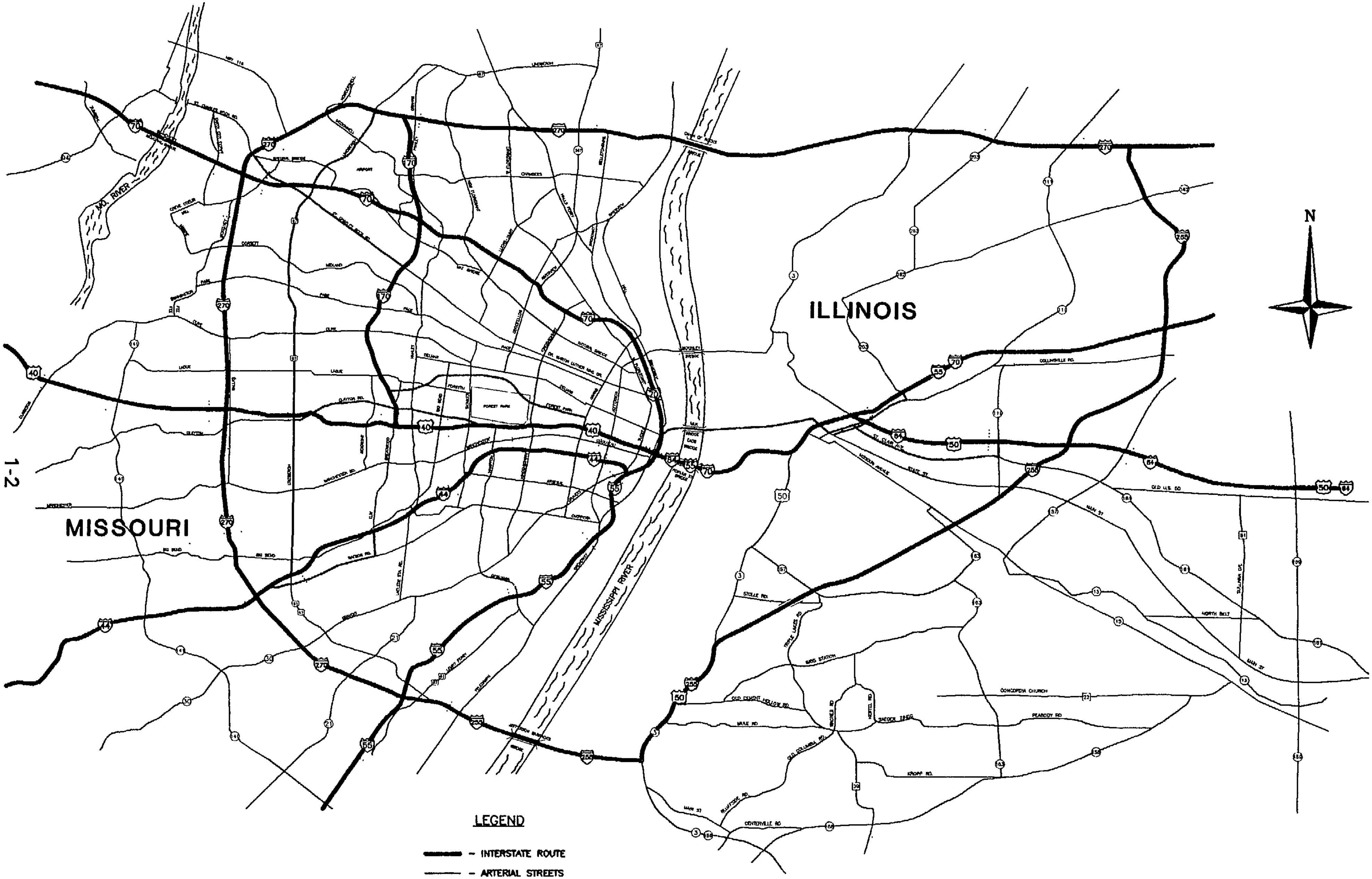
A Strategic Deployment Plan was developed that incorporates proven Intelligent Vehicle-Highway System (IVHS) strategies and technologies that should result in increased vehicle speeds, improved air quality, reduced energy consumption, increased system efficiency, and improved safety. Included in the 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

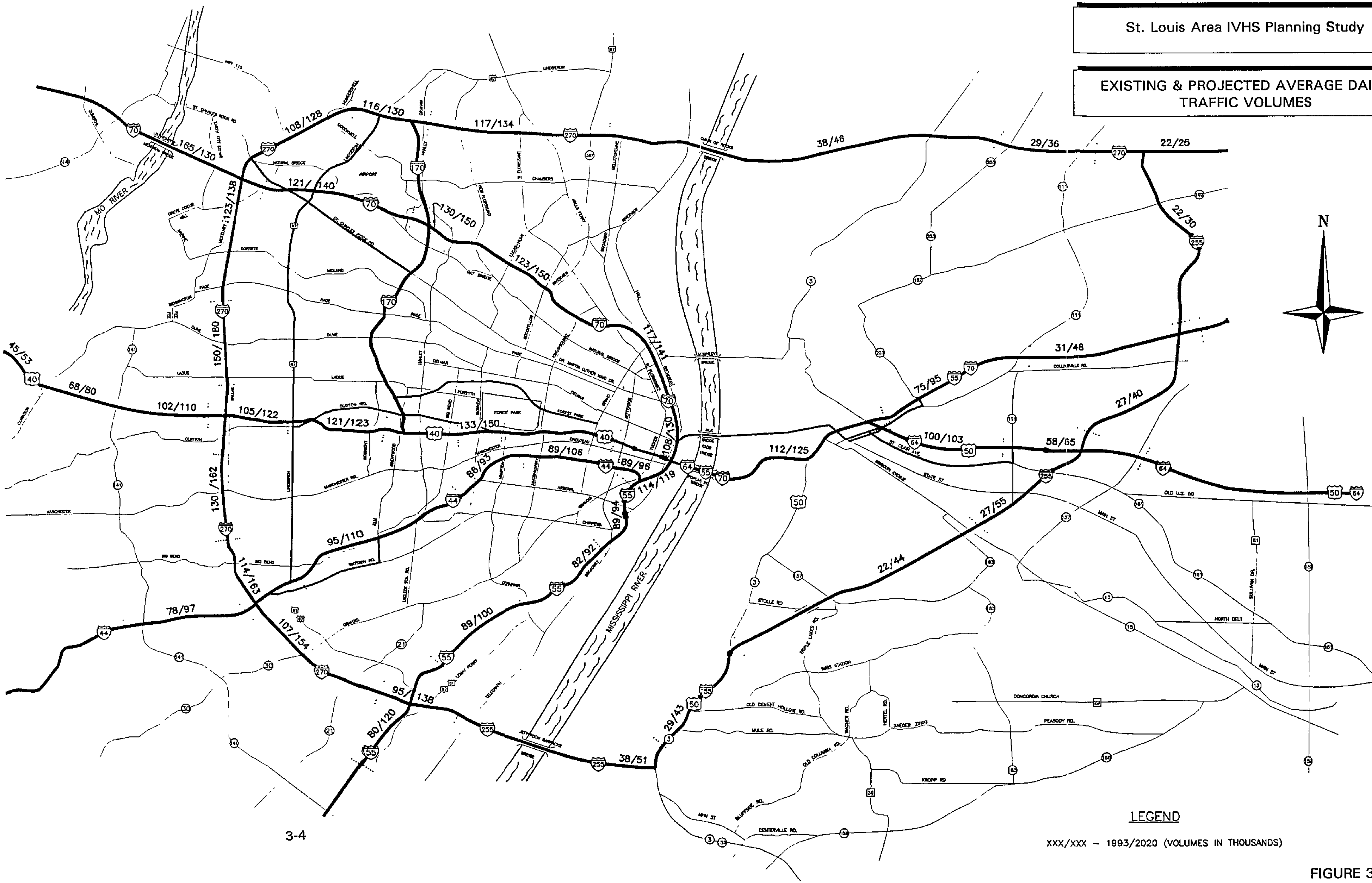


FIGURE 3-2

St. Louis Area IVHS Planning Study

FREEWAY ACCIDENT RATES

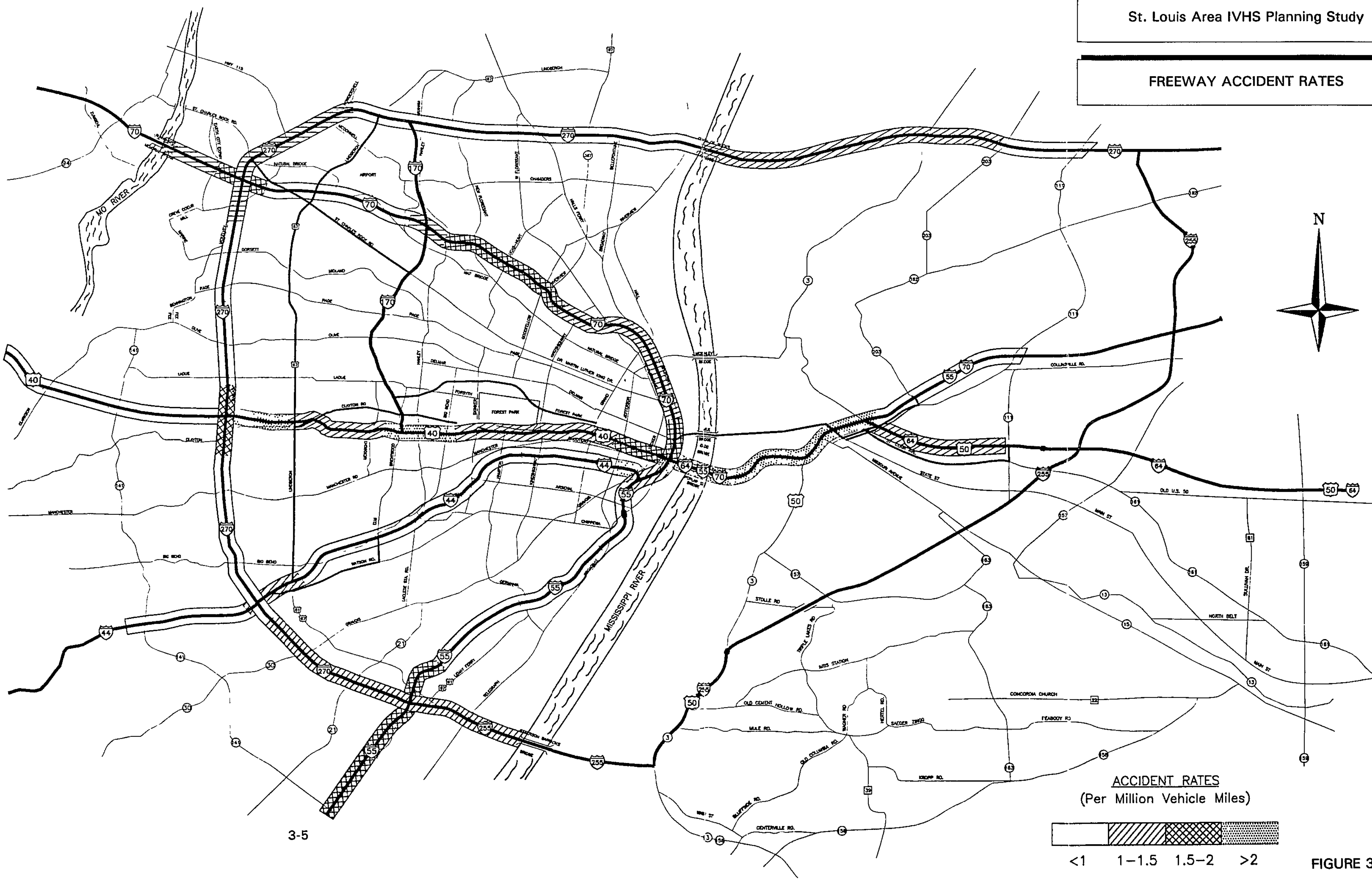


FIGURE 3-3

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

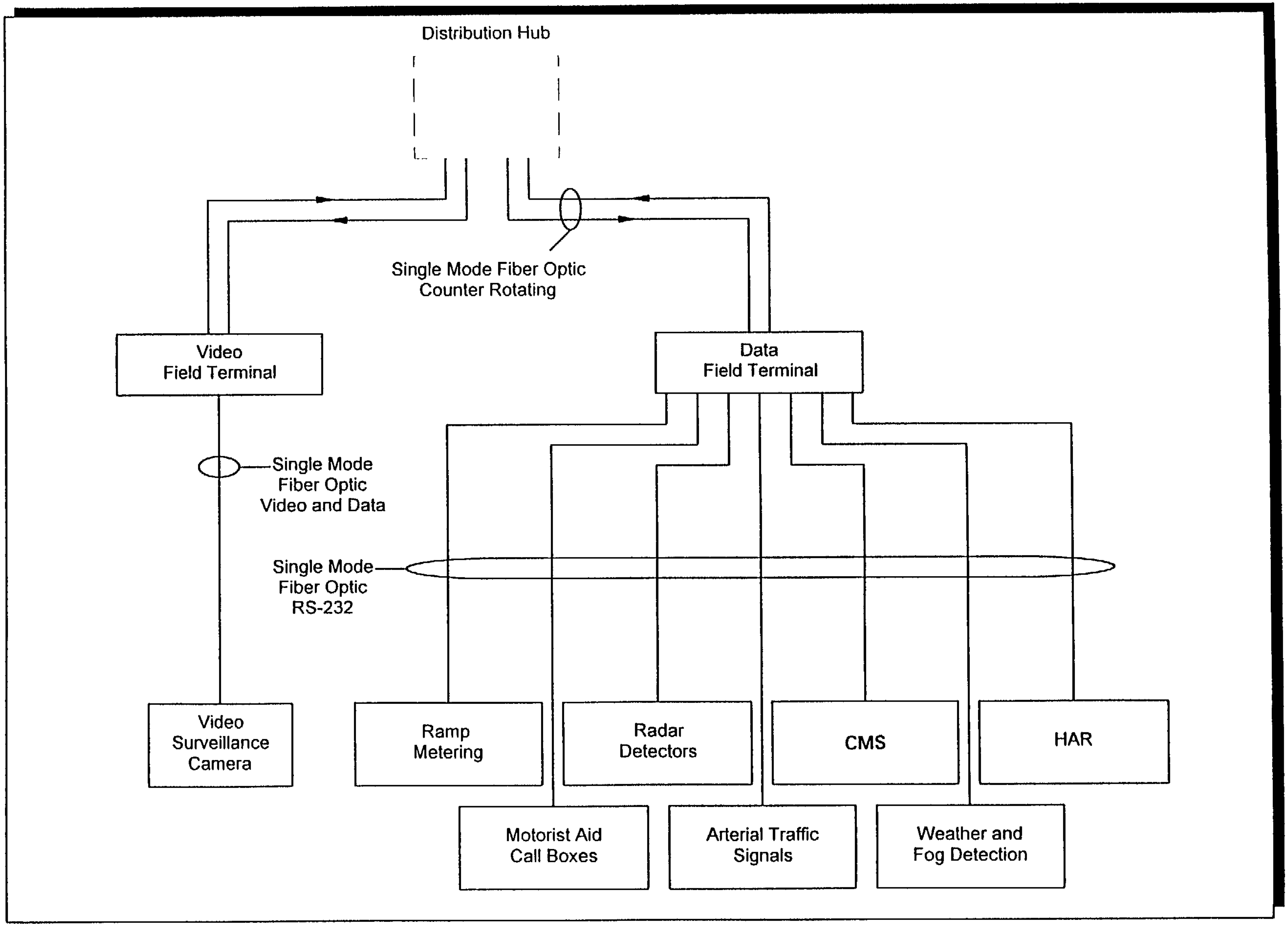
This section presents an overview of the proposed field systems and their components, as recommended in the Technical Memoranda. Figure 4-1 shows the field devices and the proposed communications to link the devices with the regional control centers.

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

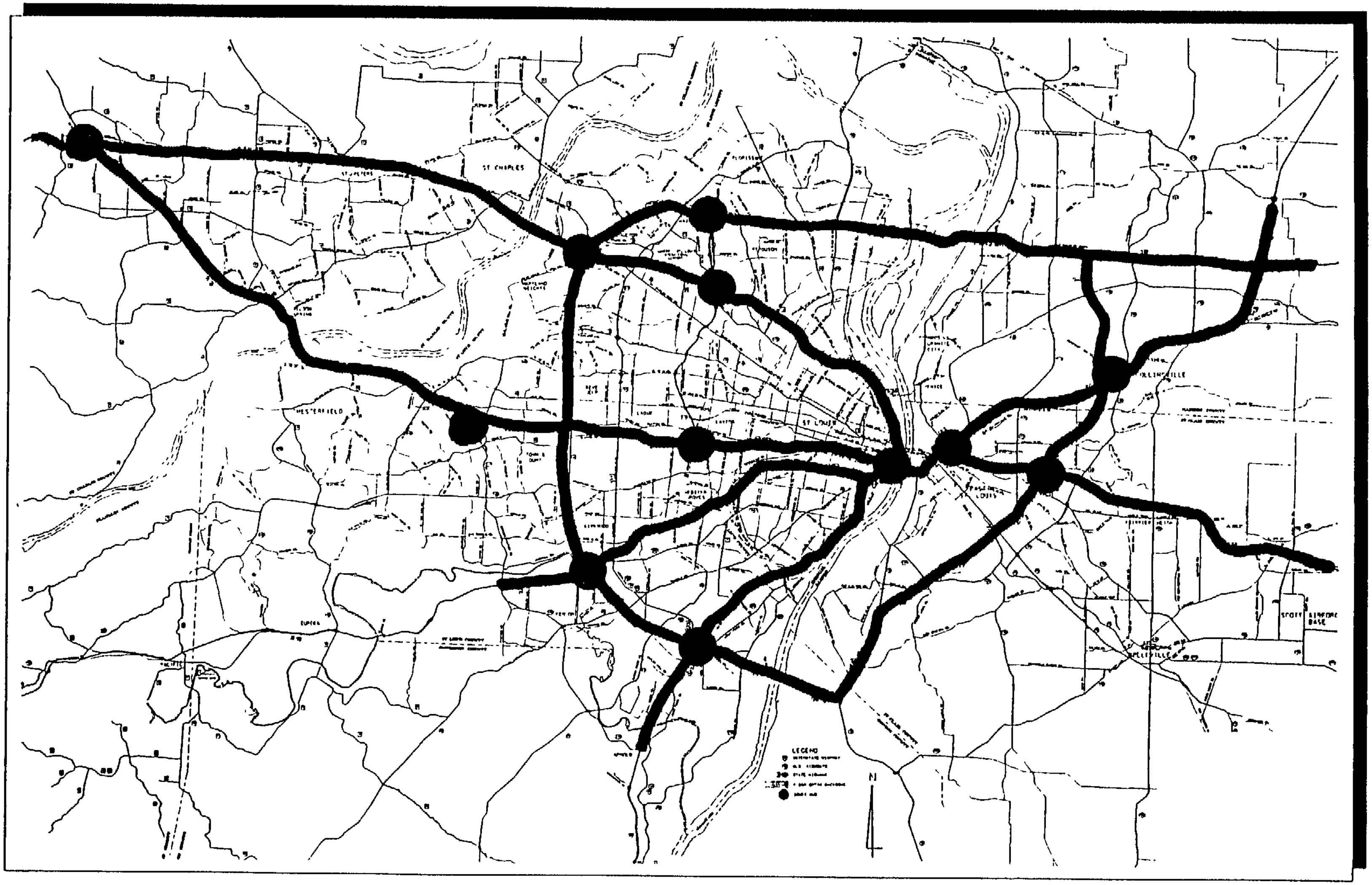
4.2.2.7 Communications

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.

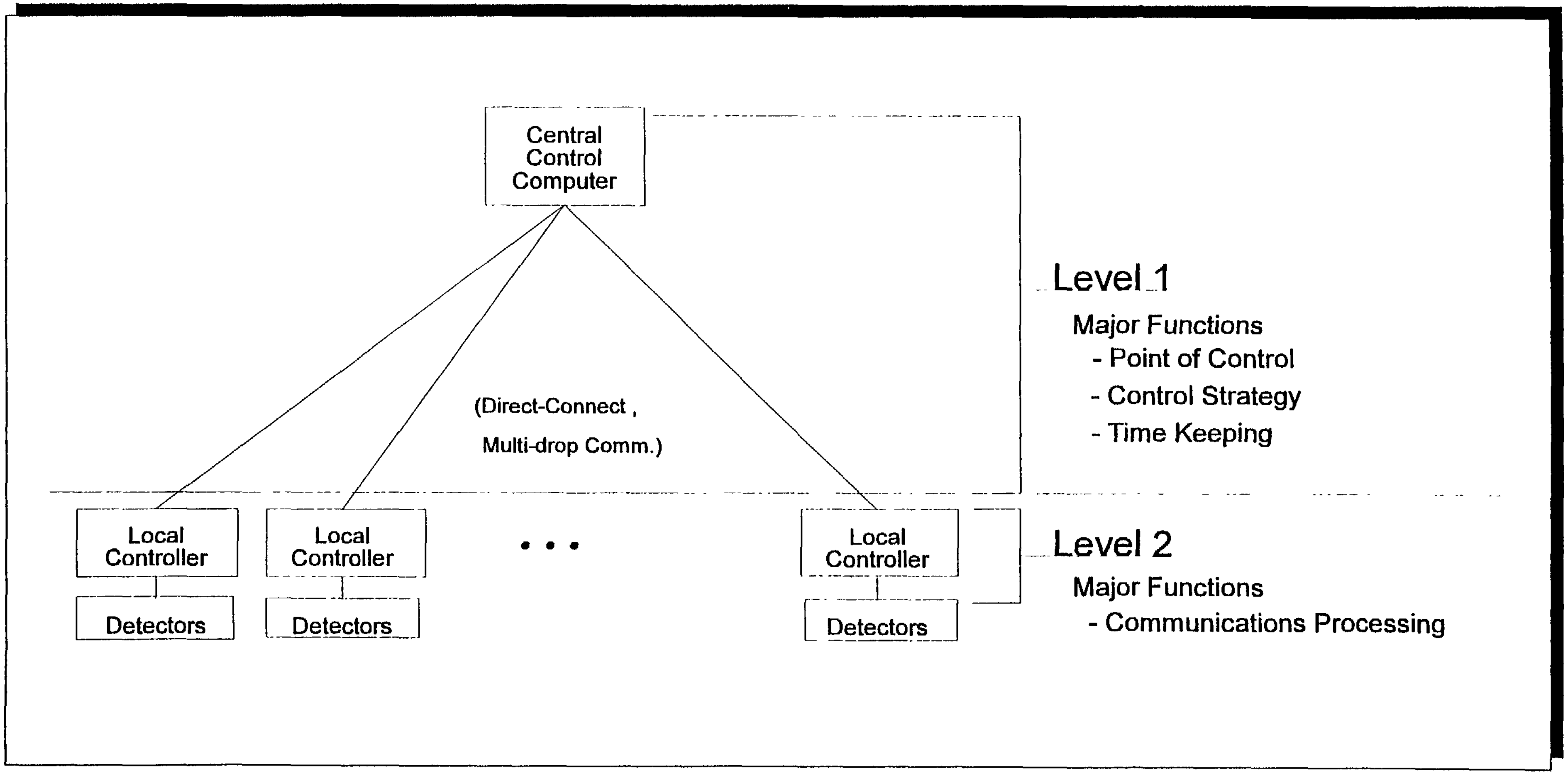
Table 4-1

ADVANTAGES AND DISADVANTAGES OF A CENTRALIZED ARCHITECTURE

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

4.3.2.2 Two-Level Distributed Architecture

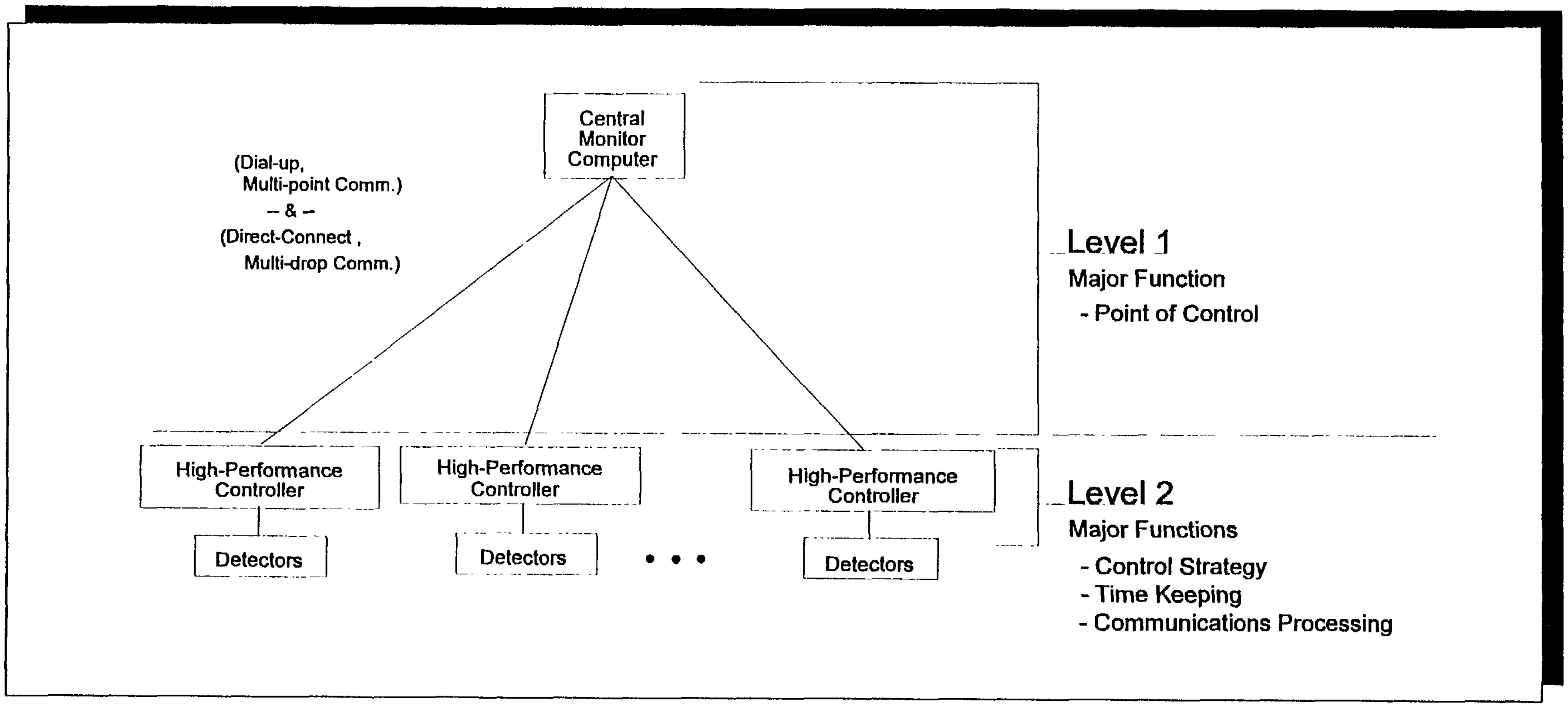
For the Two-level Distributed Architecture, depicted in Figure 4-4, the levels of distribution are dedicated to the central computer and the local controller. The local controller performs the second-by-second microscopic signal control functions which can also include execution of the tactical control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

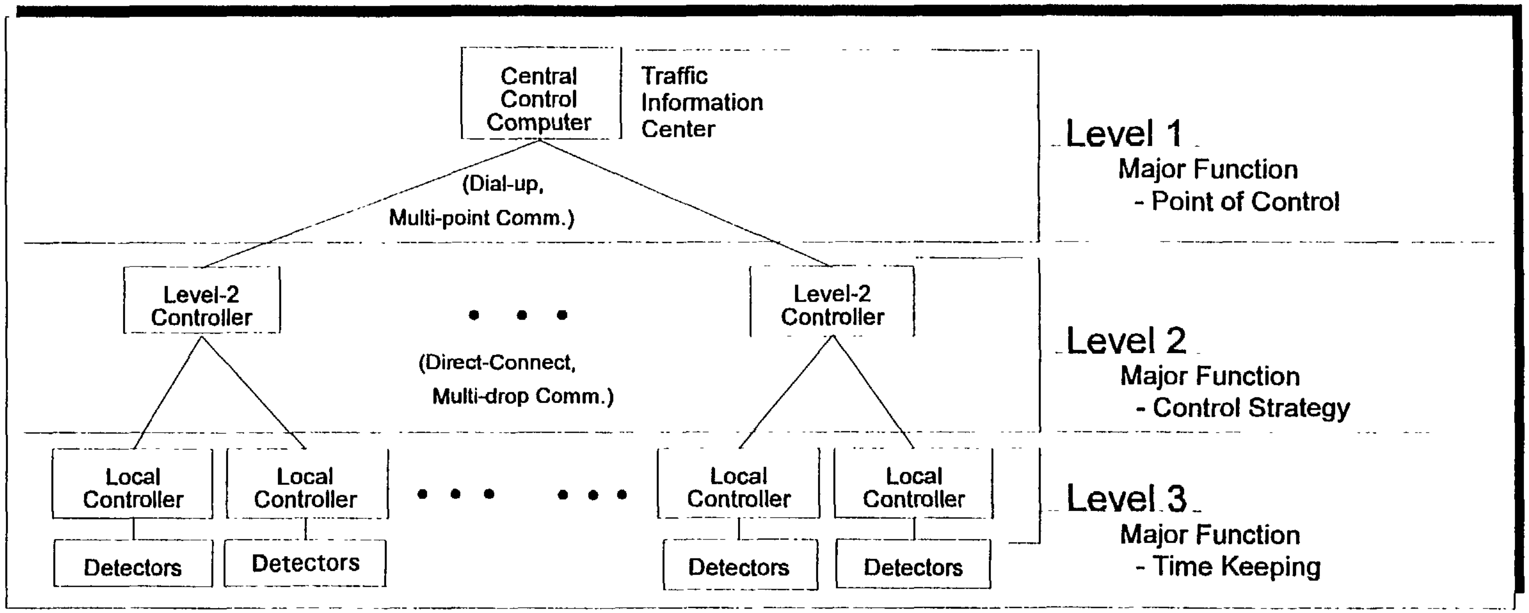
Advantages	Disadvantages
1. Does not depend solely on the central computer subsystem for the system to operate effectively	1. A high performance processor is required within the local controller in order to effectively perform the second by second microscopic adaptive signal control functions
2. The 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 2. Communications requirements between Levels 1 and 2 are minimized 3. Provides for jurisdictions to have independent or coordinated control options	1. Requires additional hardware to perform the Level 2 processing functions 2. Requires more complex communications system.

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

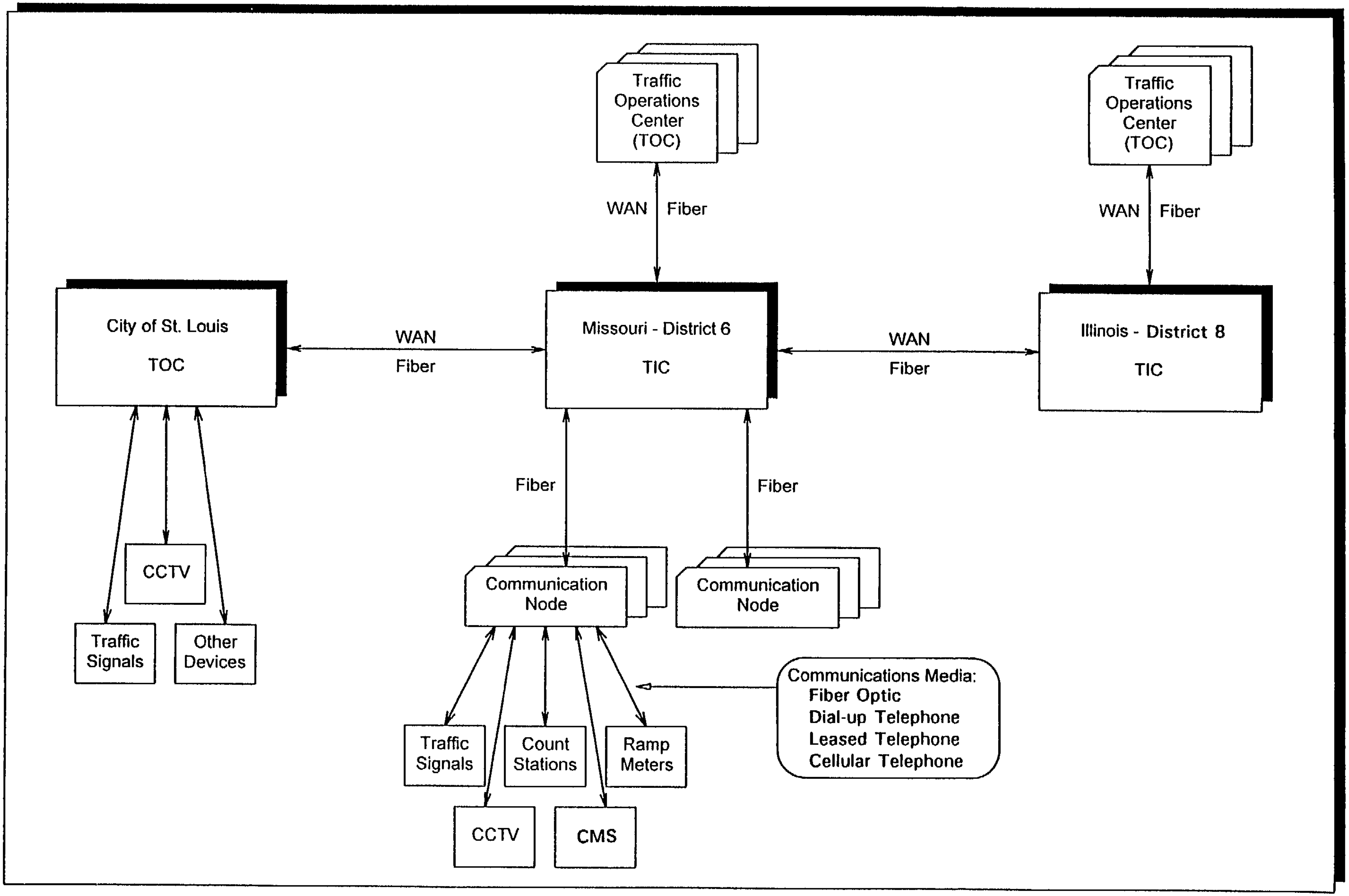
The ultimate recommended system consists of one Traffic Information Center (TIC) in each state which will provide freeway management and other regional operations (see Section 4.2.4.3), and Traffic Operations Centers (TOC) in various major jurisdictions. All of the centers should be designed to provide 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.



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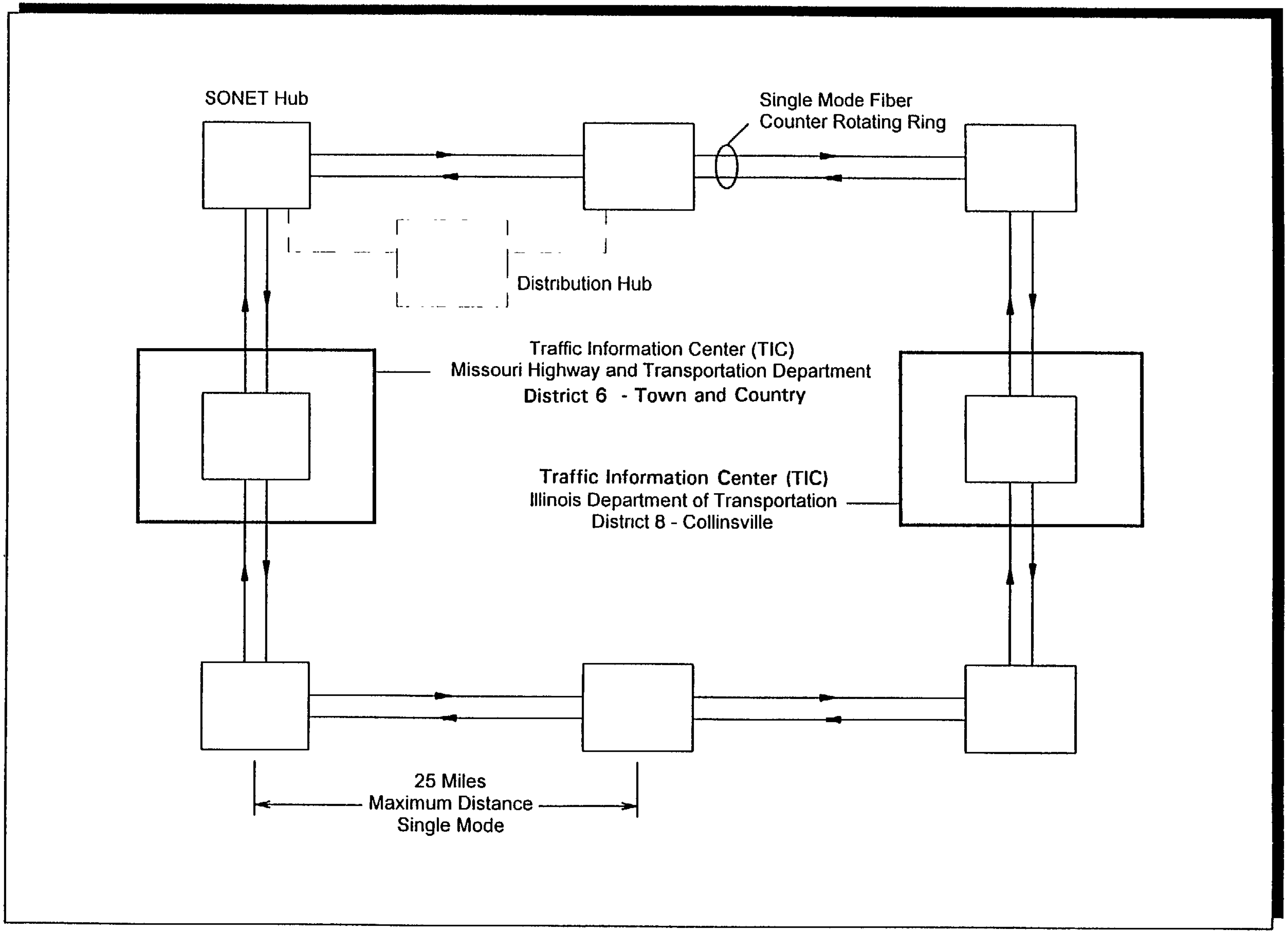
SYSTEM ARCHITECTURE

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.

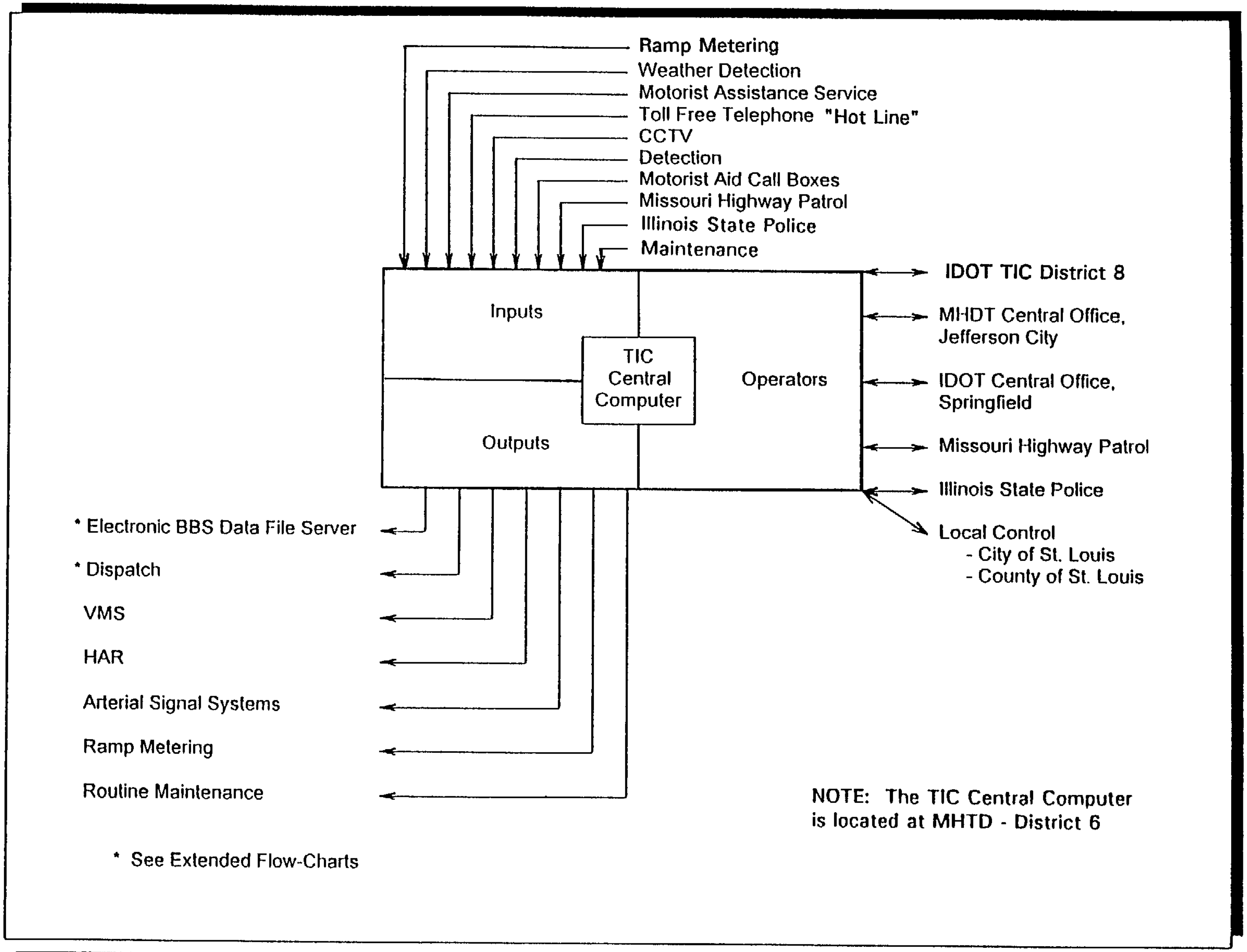
4.4.2 System Software

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

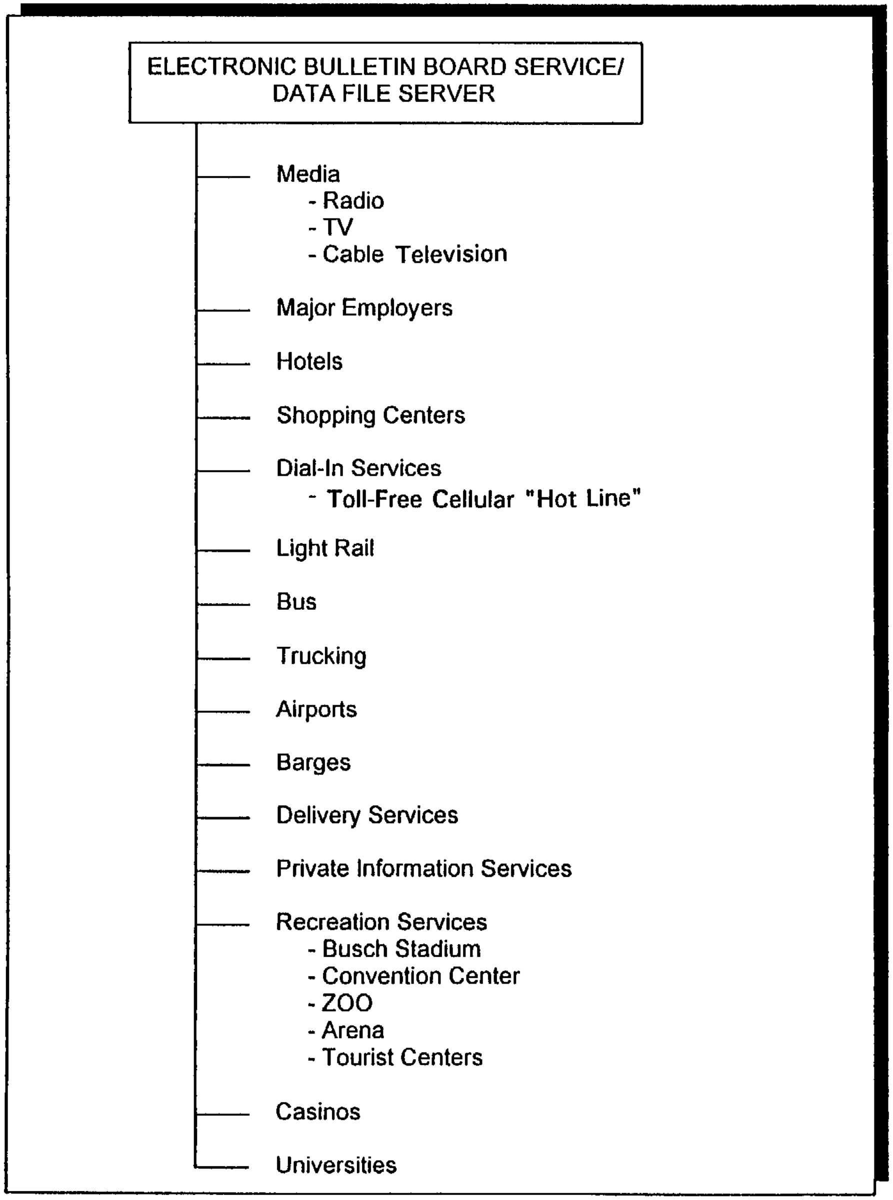
More detailed information on the software and its functionality is contained in Technical Memorandum #11

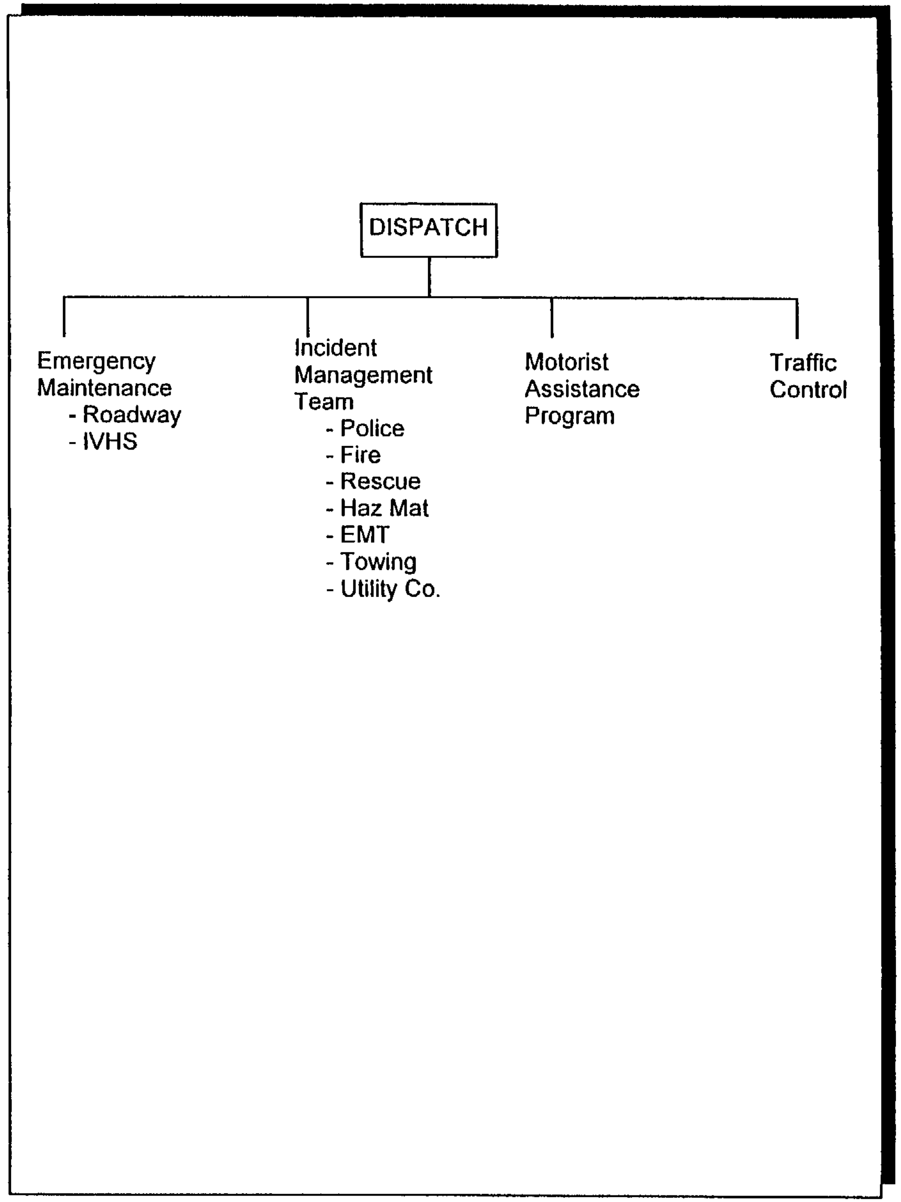


St. Louis Area IVHS Planning Study

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.

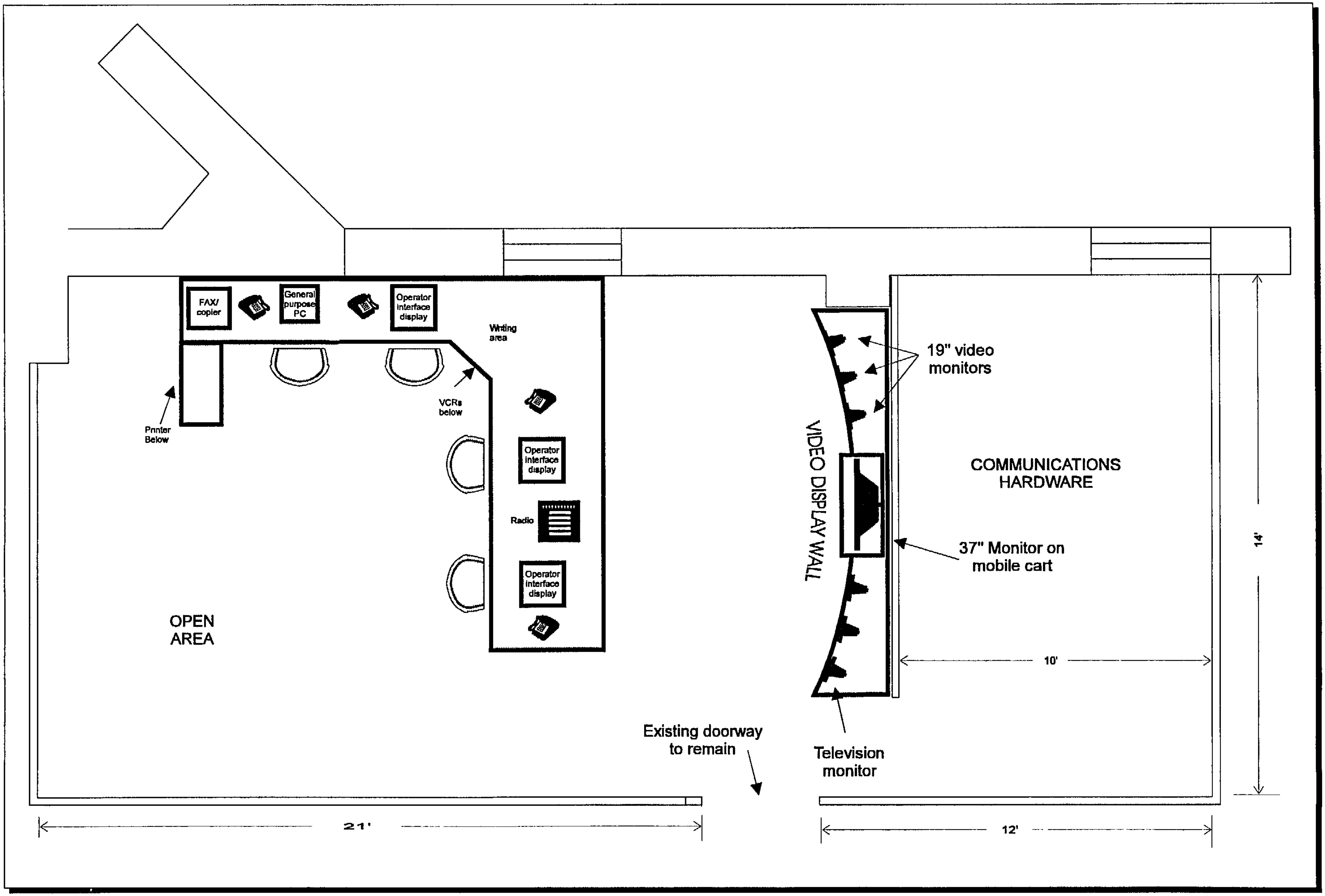
The TIC would be located at the MHTD District 6 offices in Town and Country, in the first floor space that has been set aside for this purpose. Given the rectangular shape of the room and its two glass walls, three possible room layouts appear feasible (refer to the three figures, "TIC Schematic Layout," 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

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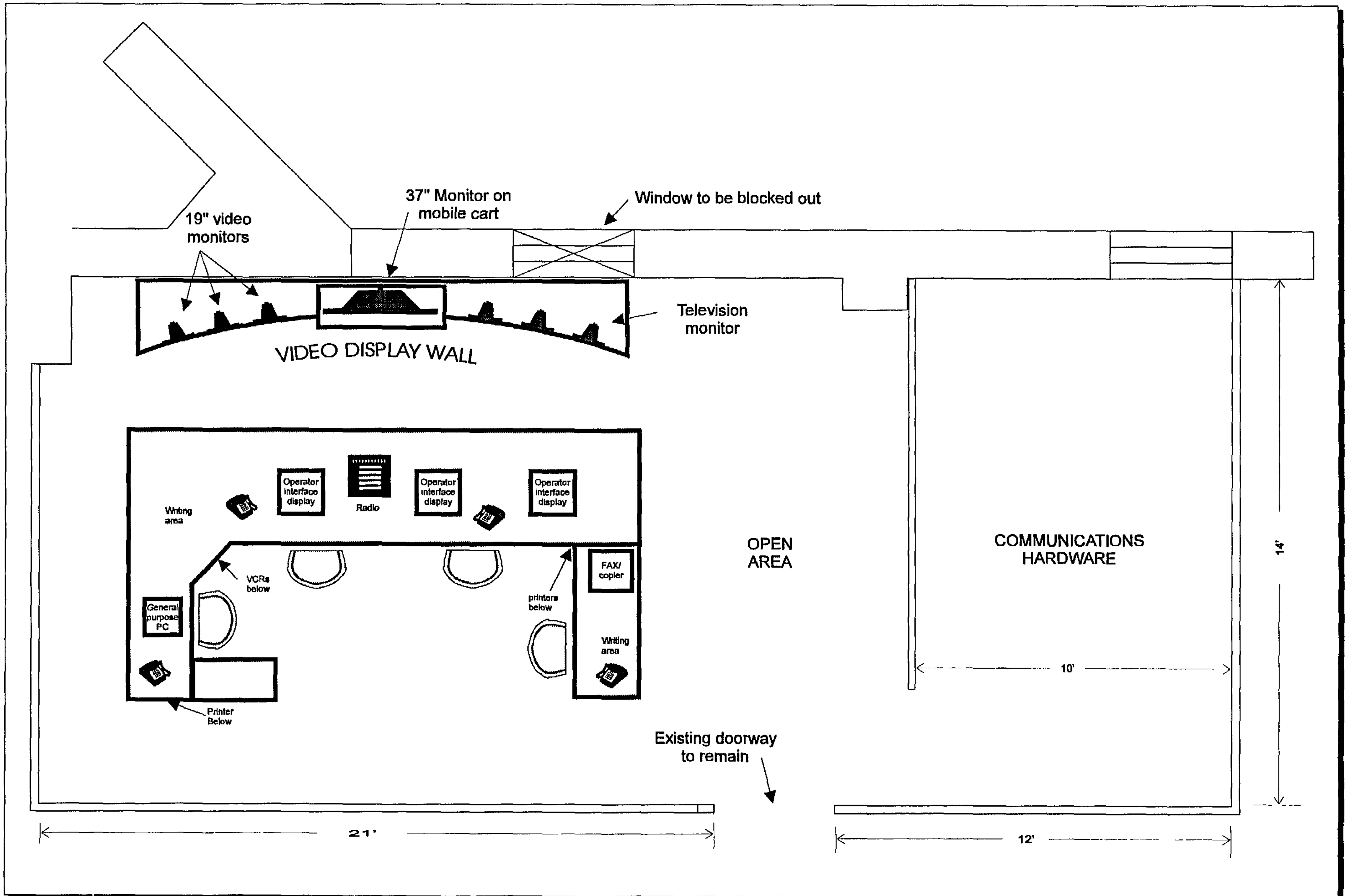
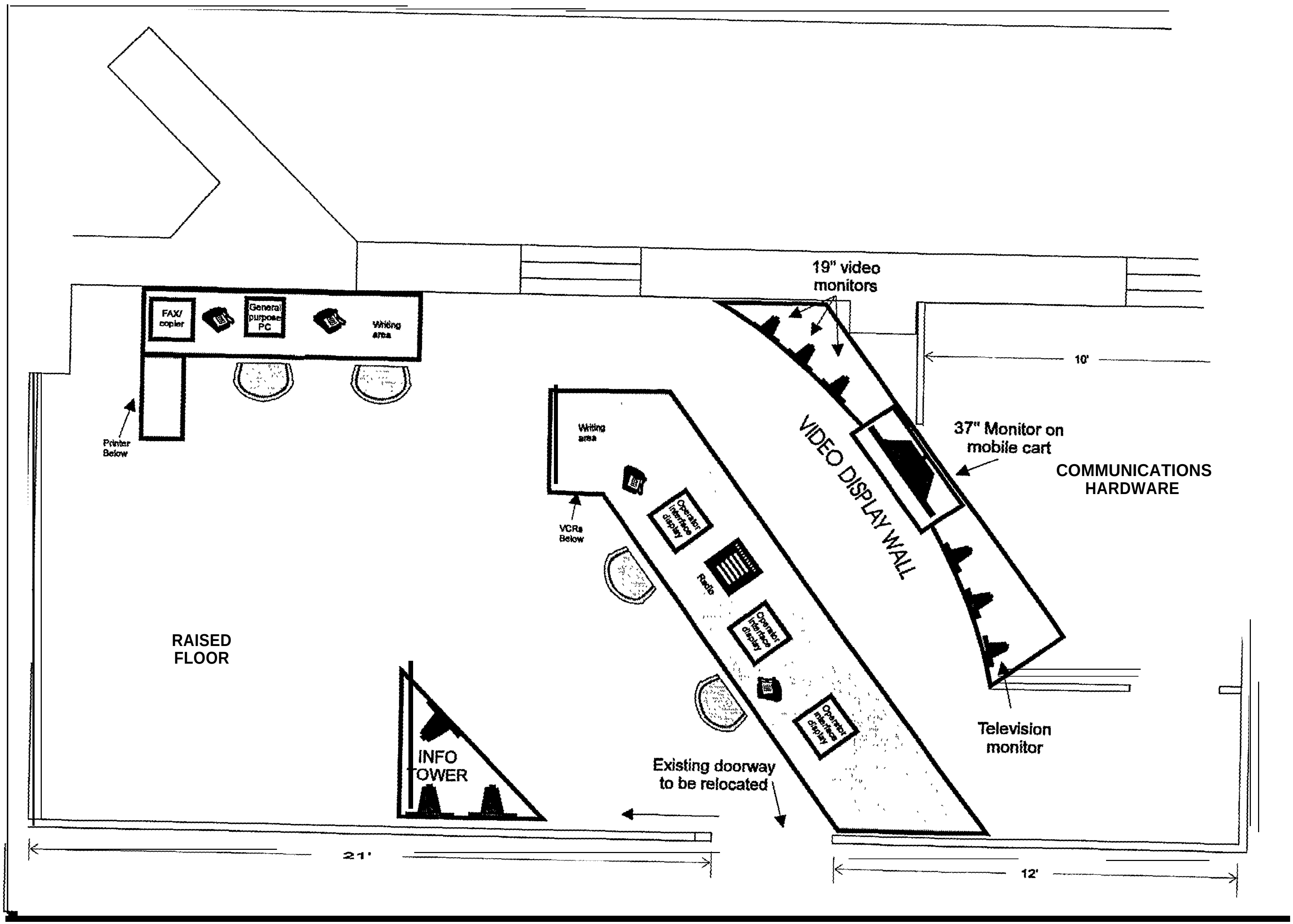
FIGURE 6-1



TIC Schematic Layout - option B

St. Louis Area IVHS Planning Study

FIGURE 6-2



TIC Schematic Layout - option C

St. Louis Area IVHS Planning Study

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 <u>Construction Cost Estimate</u>

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 <u>Engineering Costs</u>

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 MO	QUANTITY BY STATE IL	COST BY STATE MO	COST BY STATE IL	TOTAL QUANTITY	TOTAL COST
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: Benefit Package:			$ 657,000 $ 394,200		$ 35,775 $ 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.

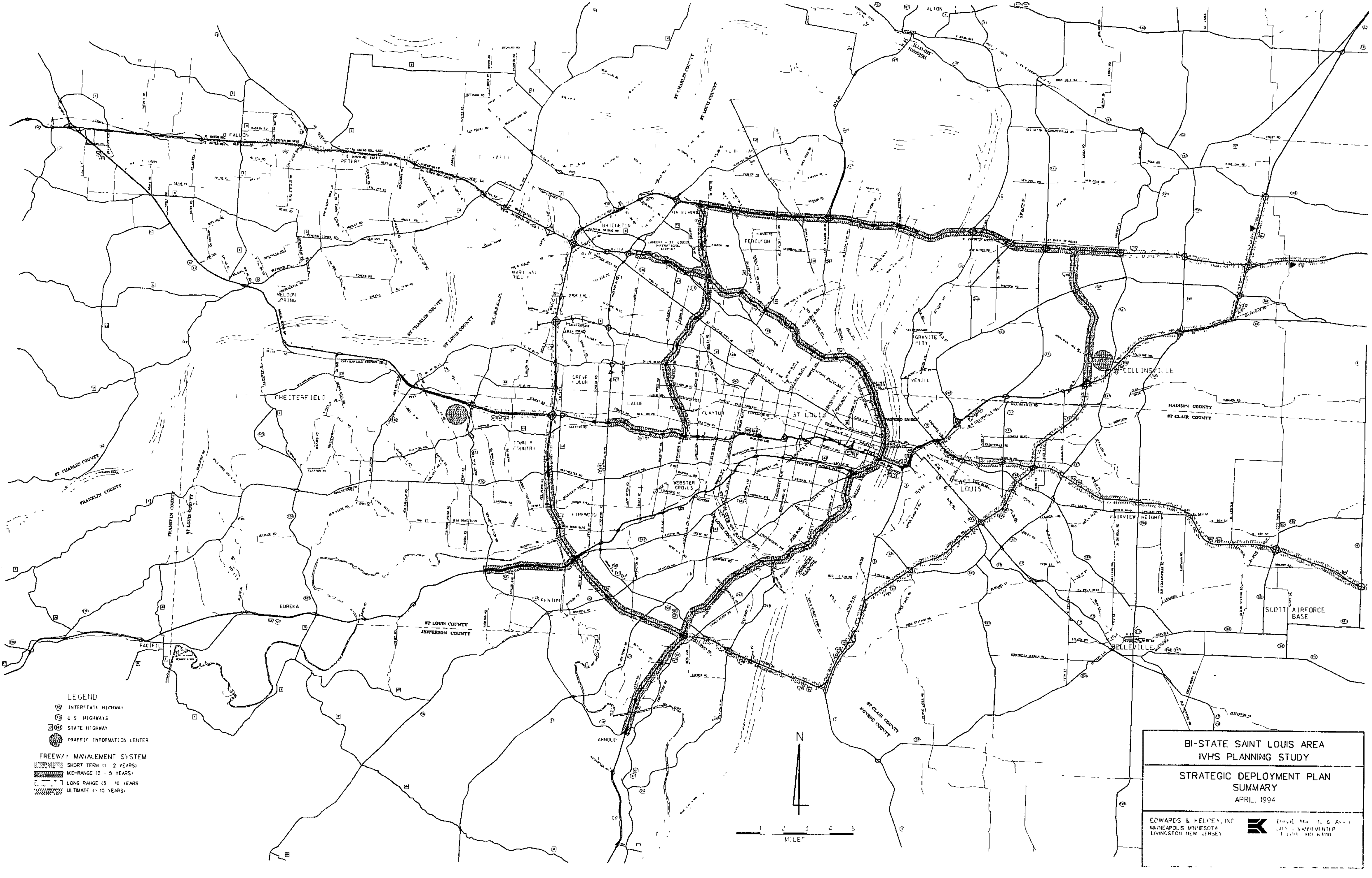
6.3.2 Installation Options

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.


BI-STATE SAINT LOUIS AREA
IVHS PLANNING STUDY
STRATEGIC DEPLOYMENT PLAN
SUMMARY
APRIL, 1994
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LIVINGSTON NEW JERSEY
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TRAFFIC INFORMATION CENTER
FREEWAY MANAGEMENT SYSTEM
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MID-RANGE (2 - 5 YEARS)
LONG RANGE (5 - 10 YEARS)
ULTIMATE (> 10 YEARS)
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CLAYTON
WEBSTER GROVES
KIRKWOOD
FENTON
EUREKA
PACIFIC
ARNOLD
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CREVE COEUR
LADUE
BRIDGETON
FERGUSON
GRANITE CITY
VENICE
COLLINSVILLE
EAST ST LOUIS
FAIRVIEW HEIGHTS
BELLEVILLE
SCOTT AIRFORCE BASE
MADISON COUNTY
ST CLAIR COUNTY
ST CHARLES COUNTY
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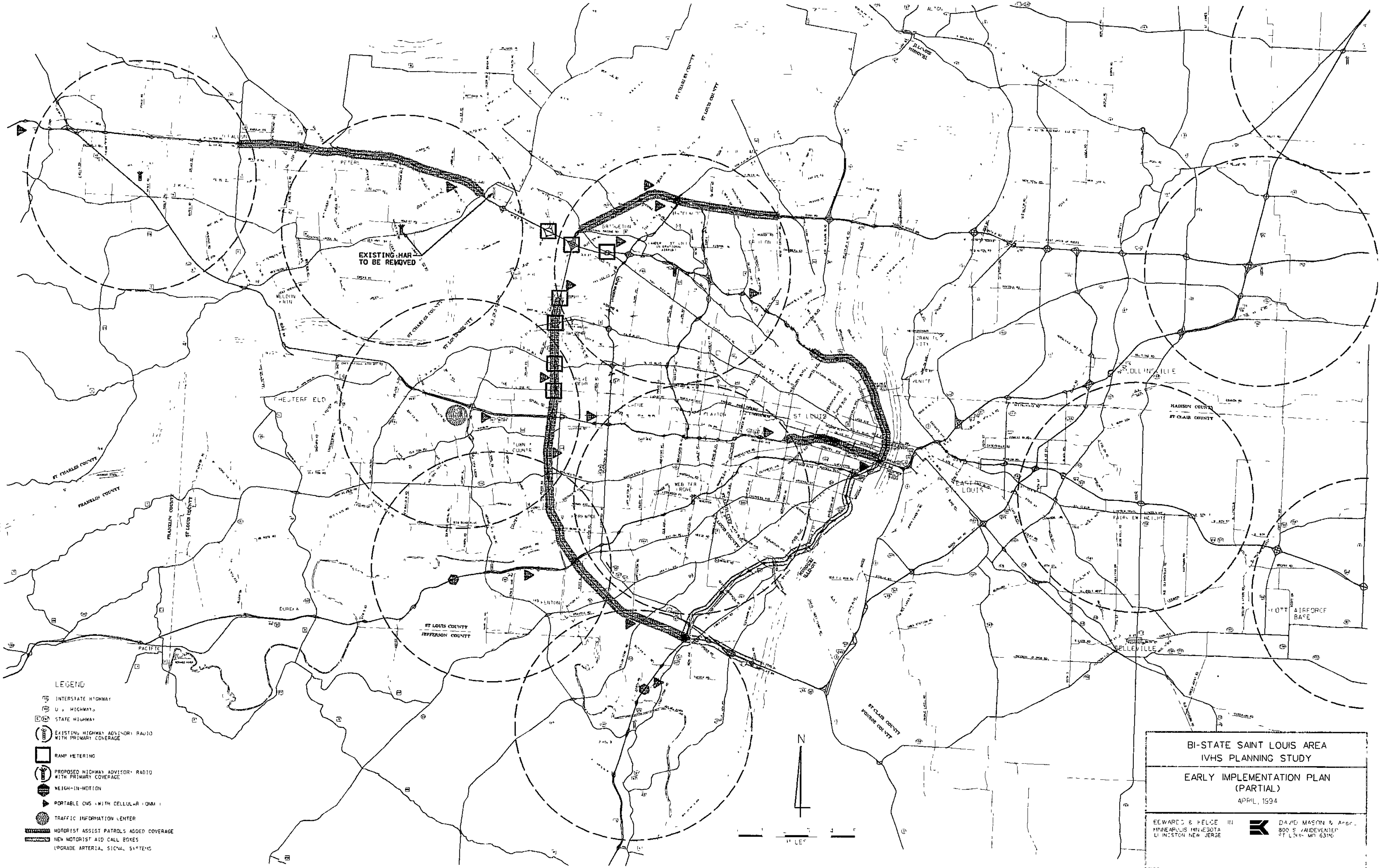
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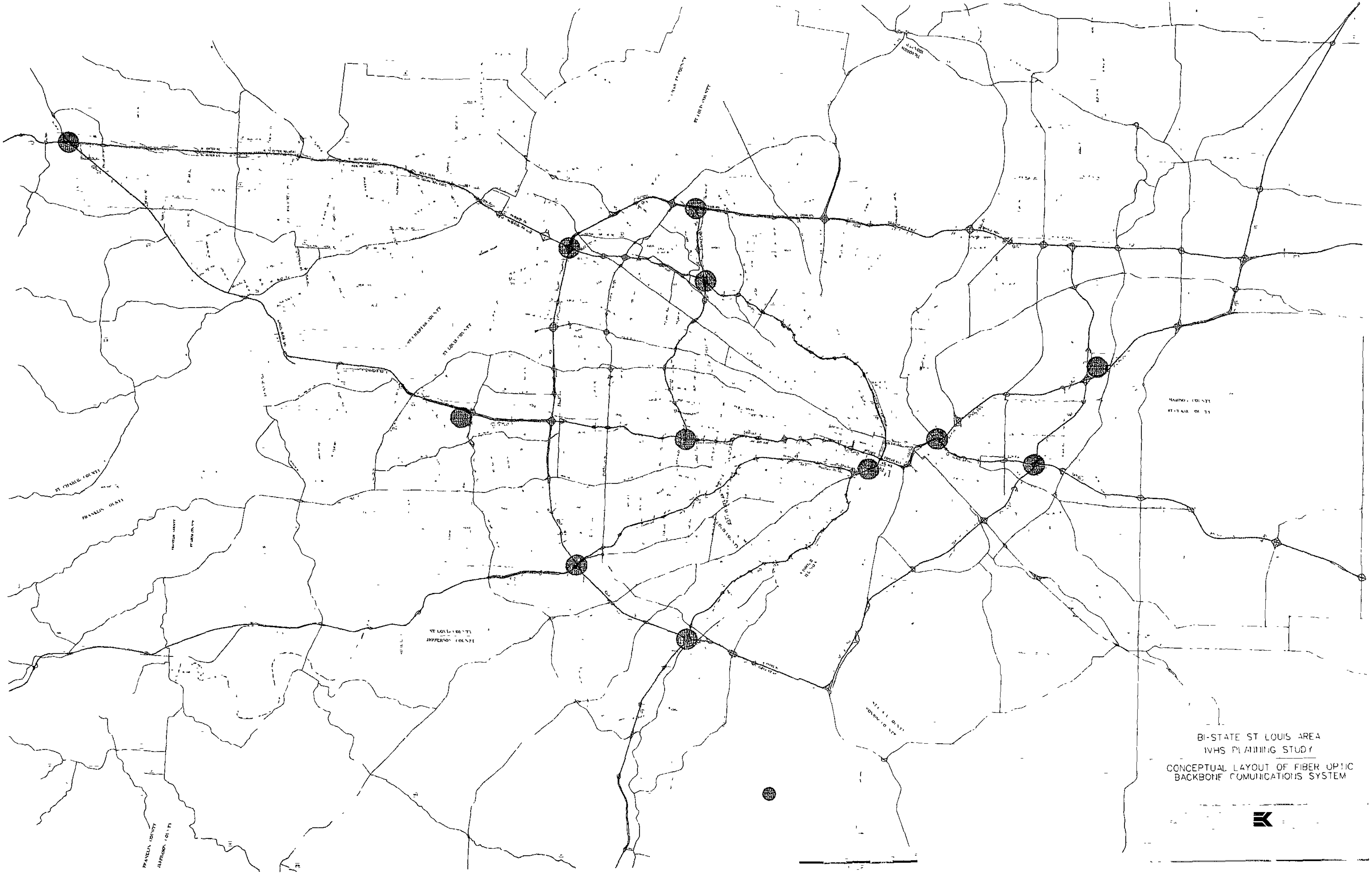
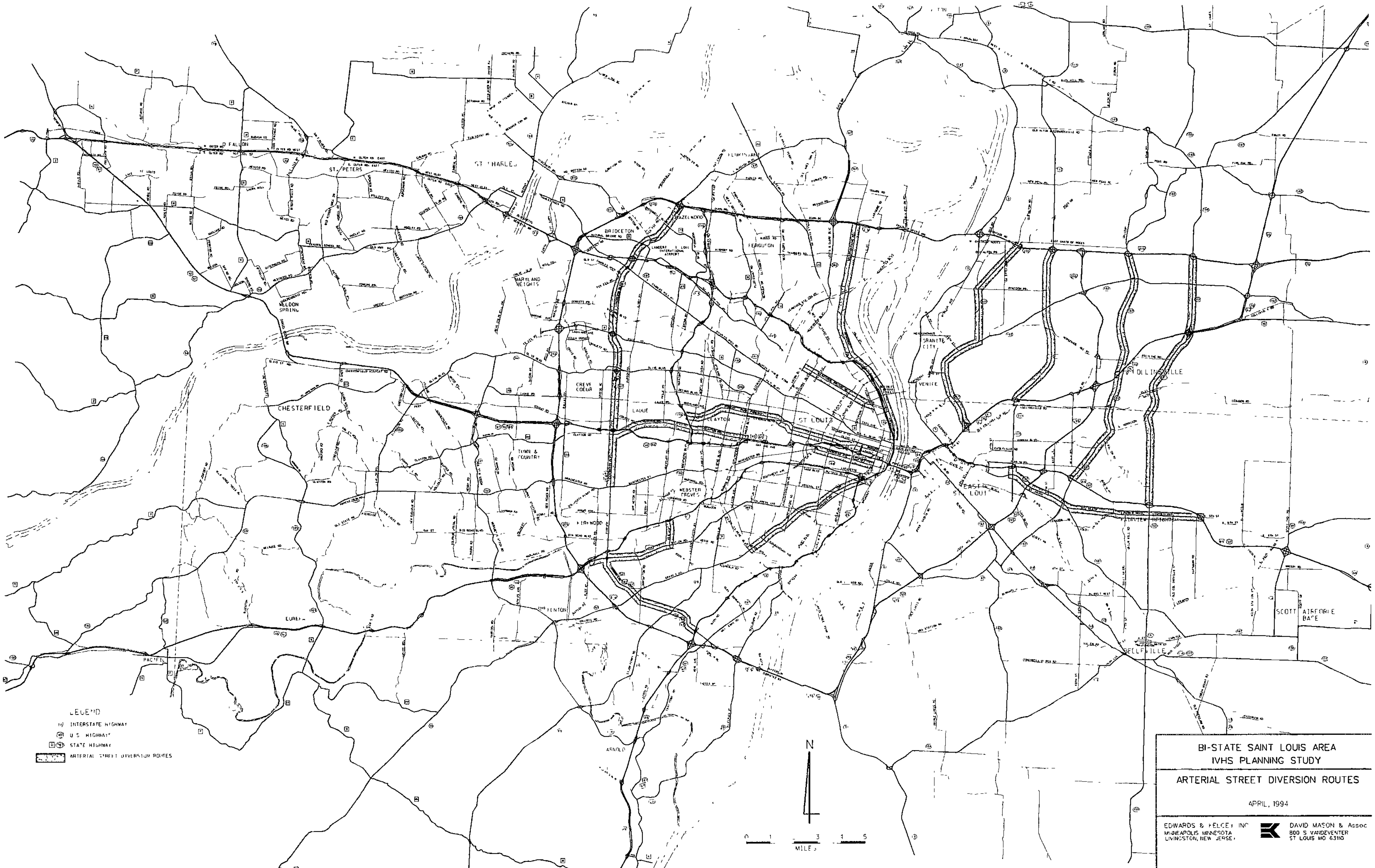
INTERSTATE HIGHWAY
U.S. HIGHWAYS
STATE HIGHWAY
EXISTING HIGHWAY ADVISORY RADIO WITH PRIMARY COVERAGE
RAMP METERING
PROPOSED HIGHWAY ADVISORY RADIO WITH PRIMARY COVERAGE
WEIGH-IN-MOTION
PORTABLE CMS (WITH CELLULAR COMM.)
TRAFFIC INFORMATION CENTER
MOTORIST ASSIST PATROLS ADDED COVERAGE
NEW MOTORIST AID CALL BOXES
UPGRADE ARTERIAL SIGNAL SYSTEMS
N
MILES
BI-STATE SAINT LOUIS AREA
IVHS PLANNING STUDY
EARLY IMPLEMENTATION PLAN
(PARTIAL)
APRIL, 1994
DAVID MASON & Assoc.



BI-STATE ST LOUIS AREA
IVHS PLANNING STUDY

CONCEPTUAL LAYOUT OF FIBER OPTIC
BACKBONE COMUNICATIONS SYSTEM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BI-STATE SAINT LOUIS AREA
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ST LOUIS MO 63110

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	$686,769	$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		$1,181,938	$4,729,284	$337,806

Average savings per mile $502,000

Table 7-2

RECURRENT PEAK PERIOD ESTIMATED TRAVEL TIME SAVINGS CONGESTED SECTIONS

Corridor/Location Limits	Direction/ Period	2 Hour Volume (V)	Dist. (MI)	2 Hr. Peak Current: Travel Speed (MPH)	2 Hr. Peak Current: Veh. Trav. Time (VHR) Daily	2 Hr. Peak Current: Veh. Trav. Time (VHR) Annually	2 Hr. Peak with 5 MPH Speed Increase: Veh. Trav. Time (VHR) Daily	2 Hr. Peak with 5 MPH Speed Increase: Veh. Trav. Time (VHR) Annually	2 Hr. Peak with 5 MPH Speed Increase: Savings (VHR) Annually	2 Hr. Peak with 10 MPH Speed Increase: Veh. Trav. Time (VHR) Daily	2 Hr. Peak with 10 MPH Speed Increase: Veh. Trav. Time (VHR) Annually	2 Hr. Peak with 10 MPH Speed Increase: 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

Assumptions:

(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

				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)	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

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)	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
TABLE OF CONTENTS

A. PROJECT GUIDANCE COMMITTEE MEMBERSHIP

PROJECT GUIDANCE COMMITTEE MEMBERSHIP

Dale L. Ricks, Project Manager	MHTD-Jefferson City
Jimmie D. Plumb	MHTD-Jefferson City
Steven A. McDonald	MHTD-Jefferson City
Lisa M. Thimmesch	MHTD-District 6, Town and Country
Joseph E. Crowe, Jr.	IDOT-District 8, Collinsville
Michael D. Pritchett	IDOT-District 8, Collinsville
Lawrence W. Gregg	IDOT-Springfield
Tom Brooks	FHWA-Missouri Division
Peter L. Olson	FHWA-Illinois Division
Marty Altman	East-West Gateway Coordinating Council
Donna Day	East-West Gateway Coordinating Council

B. MEETING SUMMARIES FOR THE OCTOBER 19, 1993 AND FEBRUARY 9, 1994 PUBLIC INFORMATION MEETINGS

E D W A R D S   A N D   K E L C E Y ,   I N C .

One Corporate Center, 7401 Metro Boulevard
Minneapolis, Minnesota 55439

Telephone: (612) 835-6411
Fax: (612) 835-7376

Engineers
Planners
Consultants

BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

PUBLIC INFORMATION MEETING SUMMARY
2:00 p.m., October 19, 1993

This public information meeting was held on Tuesday, October 19, 1993 at the Missouri Highway and Transportation Department IMHTD) District 6 office in Town and Country. A total of 20 people registered (see attached sign-in sheet) and picked up the handout materials (attached).

PART A - PROJECT OVERVIEW

MHTD District 6 Engineer J.T. Yarnell began the meeting at 2:10 p.m. by welcoming everyone. He expressed MHTD's strong support of efforts to improve the freeway system in the greater St. Louis metropolitan area and introduced MHTD Project Manager Dale Ricks, who explained the goals and schedule for the project, the Bi-State St. Louis Area Intelligent Vehicle Highway Systems (IVHS) Planning Study. Ricks explained that a consultant team headed by Edwards and Kelcey, Inc. had been hired and would be conducting today's meetings. After a short presentation, most of the meeting would be devoted to comments and questions from the audience.

Ricks then introduced Leonard Levine, Assistant to the President of Edwards and Kelcey and former Commissioner of the Minnesota Department of Transportation, who chaired the meeting. Levine explained that a short presentation about the project would be made first, followed by comments/questions from the audience. He described his experiences in Minnesota, a recognized leader in the IVHS area, and stressed how important public input is to the project and how it will be used in developing recommendations. Levine introduced Edwards and Kelcey Project Manager James Giblin, who introduced the other consultant team members who were also present:

Gary Rylander	Edwards and Kelcey
David Roper	Roper & Associates
William Bunte	Crawford, Bunte, Brammeier
William Heyse	David Mason & Associates

Giblin then gave a brief explanation of what "traffic engineering" and "IVHS" are, and that it is not all "star wars" high technology but rather mostly common sense. He and Roper then gave a slide presentation covering: a project overview; goals and schedule; IVHS in general; incident management; motorist information; the need to move people rather than just (mostly) single-occupant vehicles; volume/capacity ratio for freeways; delays at flow breakdown and the drop in capacity from 2,000 vehicles per hour per lane to around 1,300; and how each minute of lane blockage/restriction causes 4-5 minutes of delay in off-peak periods (the ratio is several hundred, or more, to one in peak traffic periods).

Giblin indicated that IVHS can help improve air quality, noting that the St. Louis area is an ozone non-attainment area. He noted that construction and maintenance work can seriously affect traffic flow and that IVHS can be used to improve operations. The handout materials (attached yellow papers), which consisted of a one-page IVHS overview, a listing of the 27 IVHS user services and sub-services, and a St. Louis area map of freeway and arterial routes, were discussed. He explained that a strategic plan will be developed by next spring, and that would include an early deployment plan--actions that can be taken relatively quickly and should yield significant benefits. He noted that the next set of public information meetings, at which some preliminary recommendations will be made, will be held on Wednesday, January 5, 1994.

Donna Day of the East-West Gateway Coordinating Council gave an overview of the council's role as the metropolitan planning organization, and that this project was consistent with their ongoing transportation planning efforts for the St. Louis metropolitan area. Giblin then went over, in detail, the one-page IVHS/freeway management summary in the handout materials, describing the various system components and the role they play in the overall strategy. Ricks noted that national statistics show that 60 percent of traffic congestion is due to incidents, while 40 percent is recurring. Roper commented that most of that 60 percent is due to minor incidents such as stalled vehicles and minor fender-benders, not the spectacular crashes typically covered by the media.

PART B- COMMENTS AND QUESTIONS FROM THE AUDIENCE

At this point, Levine opened the floor to comments and questions from the audience. For ease of reference, each has been numbered and presented in sequential order. As these are summary notes and not a verbatim transcript, all remarks have been paraphrased.

1. I feel the initial focus should be on large problems resulting from incidents because it would be more cost-effective. I am a member of an incident management group and want to see how well that works, prior to getting into big dollars for addressing recurring congestion. RESPONSE: Incident management is a major focus of this study. MHTD is now trying motorist assist patrols (IDOT has had them for many years). Potential solutions will be ranked by cost and short-medium-long term recommendations will be made.

2. How much of what the Traffic Information Center (TIC) will do is available now in the area, and why are these things not being done now? RESPONSE: There is no focal point now for the many types of traffic data now available, and much simply isn't available. We want to get everyone on board and get a broad dissemination of the information. FOLLOW-UP: My community is now forming a Traffic Management Authority (TMA) that will be the first in the state. We can't get MHTD to re-time some traffic signals along a really congested route, and we don't know why. We would like

data on how it can be done. RESPONSE: Re-timing traffic signals is very labor intensive and can be a costly process. While re-timing can often result in a 20-25 percent improvement, that isn't always true, particularly if traffic demand far exceeds capacity. Ricks commented that congestion management is a new role for MHTD; there previously hasn't been much money available for operations, though the federal ISTEA legislation now authorizes additional funds.

3. What have other states' success ratio been with incident management? RESPONSE: The program is aimed at congestion relief, not safety per se. The number of incidents has not been significantly reduced, but the resulting delay has been greatly reduced. Typical benefit/cost ratios for motorist assist patrols have been 10:1 to 15:1, despite their high cost. Levine commented that accident investigation sites in Minneapolis have been very successful, though they are education intensive.

4. How can ramp volume/access control work well--doesn't it back traffic onto the arterial street and create greater/equal problems there? RESPONSE: With ramp metering, more traffic is handled on both the entrance ramp and the freeway mainline that without it--even though it may not seem that way. A coordinated decision making effort to accommodate the diverted traffic has worked well in other areas.

5. Are the effects of freeway closure due to an incident taken into account in the planning process? RESPONSE: The computer evaluates the alternative diversion routes and selects where the traffic should be routed. It then monitors conditions on the diversion route(s) and makes real-time adjustments as needed.

6. I agree that cooperation among agencies is essential. Local communities are willing to work to deal with recurring congestion. My city monitors one interchange with a camera and puts it on cable television. RESPONSE: That's good; by creating a focal point for metro area traffic data, many others can receive current traffic information.

7. My question concerns network optimization versus demand modeling. Local research shows < 10 percent gain in capacity due to ramp metering. Constraints placed on the model show that some arterials are not well utilized. How is this taken into account? RESPONSE: The computer evaluates many possible routes and after real-time polling, it selects the route(s) to use. Routes can change as needed so as to not overload any one route. There is no longer a "typical day" for traffic flow, but 90 percent of the time the diverted traffic can be handled. FOLLOW-UP: But no one knows what the driver is going to do--this is the weak link in modeling. RESPONSE: True, we can't be sure what drivers will do, but demand can be fairly well estimated; the critical thing is managing the traffic demand. FOLLOW-UP: Will the optimization routine algorithm be static and therefore need to be revisited regularly? RESPONSE: No, because the control is real-time and demand responsive, it will adjust for long-term changes such the relocation of a major employer.

8. An approach to "ratchet" capacity upward may work, but why not increase auto occupancy? Wouldn't that be the most cost-effective? Isn't cheap parking downtown a major cause of low auto occupancy? RESPONSE: Yes, increasing auto occupancy is important and very cost-effective if it can be done; there has been limited and spotty success because it is very difficult to change attitudes towards ridesharing and transit usage. The personal automobile is very difficult to compete with, offering convenience, flexibility, security and status/image. Many people want to have their car available during the day even though they rarely, if ever, use it. In Los Angeles, high-occupancy vehicle (HOV) lanes have in some locations increased auto occupancy to 1.48-1.6 persons/vehicle from 1.18, so it can be done. But Los Angeles is much different from St. Louis, of course. With respect to increasing parking fees, it should be carefully considered because in other cities it has driven businesses from downtown to the suburbs.

9. I have concerns about high-occupancy vehicle (HOV) lanes. Elsewhere, there have been many violations in HOV lanes and ridesharing in St. Charles County is dropping. I believe that an HOV lane on I-70 will not work. RESPONSE: Violation rates for HOV lanes vary around the country, the highest incidence being where the lane is a standard freeway lane not physically separated from the mixed traffic lanes. In Washington, DC and Minneapolis-St. Paul, for example, HOV compliance has been very good. In Minneapolis, parking garages were built over the I-394 freeway with direct ramp connections and carpools using that freeway pay only $10/month for parking. Criteria for selecting freeways where HOV lanes should be successful are being developed as a part of this study.

10. Last year, the Poplar Street Bridge was resurfaced and there were major delays. Many inter-city truck drivers still used the bridge, despite advance signing and HAR advisories, even though they could have bypassed downtown. Why? Also, can a higher speed limit be posted on an HOV lane as an incentive to rideshare? RESPONSE: Why the trucks did not bypass the congestion is a good question. As far as speeds in an HOV lane, experience shows that traffic will travel as fast as it wants to, irrespective of the posted limit. The key to a successful HOV lane is to keep it free flowing at all times while the adjoining mixed lanes are congested. To really get people's attention and get encourage their use, the HOV lane has to save people at least 8 minutes.

11. What is the timetable for this project? RESPONSE: The planning study will be completed by the end of April, 1994. There is no implementation schedule yet--funding needs to be secured. At this point, we would guess that implementation could begin sometime in 1996, if funding is available.

12. Has Bi-State Development, operator of the new Metrolink light rail transit (LRT) line, been contacted for input to this study? Bi-State has no money, so how could they implement any recommendations? RESPONSE: Yes, Bi-State is a part of the study. We will be looking at possible funding sources. FOLLOW-UP: Also, HOV lanes in Houston have decreased travel times and been successful. RESPONSE: There are numerous

success stories around the country. The key is to keep in mind that there is no simple solution--rather, a family of solutions is needed, tailored to the specific metropolitan area.

13. How will this study impact highway construction? RESPONSE: Basically, highway construction has stopped. High costs, environmental regulations and changes in public attitudes have effectively changed things forever. For example, the Century Freeway was just opened in Los Angeles, decades in the making (and many years in court). It is very likely the last new urban freeway to ever be built in the U.S. Freeway rehabilitation and reconstruction which promotes ridesharing and transit use, but not single-occupant vehicles, is the current policy and that will continue. The public must understand this, and MHTD has a good public affairs group that will be helpful in getting this message out. Roper stressed that congestion management works, and as an example he cited CALTRANS' successful experience with an extensive congestion management program during the 1984 Olympics in Los Angeles; despite peak period traffic counts being down only about two percent, the freeways were essentially congestion free.

14. Has any comparison of accident rates been done in Los Angeles in order to lower auto insurance rates? RESPONSE: No such study has been done. In LA, they found that the AM peak shifted 35 minutes earlier, while the PM peak is unchanged. Truck volumes are down and that helped reduce accidents, as well. Ricks commented that, on a national basis, IVHS can reduce accidents--projections of a 20 percent reduction look promising. FOLLOW-UP: One signalized intersection in Creve Coeur has a bad accident problem, and the new TMA is intended to get everyone involved in helping solve the problem.

15. What would the cost of a simple, minimumIVHS program be? RESPONSE: Levine suggested that dollars not be cited at this meeting because it is so early in the process, and out of context could hurt the chances for implementation. Giblin stated that if put in the context of new freeway construction, the costs are low. Roper pointed out that the new Century Freeway in Los Angeles cost about $100 million per mile. It was noted that a recent study estimates that delay now costs motorists in the St. Louis metro area about $1 million per day, whereas the construction cost for IVHS averages about $1 million per mile (costs for maintenance and operations control are additional). Roper noted that there are low-tech strategies and techniques that can be employed initially, such as compiling incident reports by cellular phone and using expanded motorist service patrols (80 percent of incidents in Chicago are reported by these patrols).

16. What does it cost to re-time a traffic signal? RESPONSE: If current turning movement count data are available, it could be done for around $1,000 per intersection. But chances are this intersection is interconnected with other nearby signals, and the system has to be look at as a whole. Ricks mentioned that sometimes traffic demand so far exceeds capacity that re-timing has no significant effect. FOLLOW-UP: There is a privately funded (Monsanto) traffic signal near Olive Blvd. and I-270 that stops the

mainline whenever anyone approaches on the private road. This doesn't make any sense, but we can't get the timing changed. It's been counted and studied by East-West Gateway, but nothing changes and we're very frustrated. RESPONSE: Ricks indicated that he did not know the history but would like to discuss this situation with the questioner after the meeting.

There being no further comments or questions from the audience, Levine thanked everyone for attending and indicated that a summary of this meeting will be prepared so that it could be taken into account in the study. He noted that another public information meeting would be held this evening at 7:30 p.m. Levine also reminded everyone that a second set of public information meetings would be held on Wednesday, January 5, 1994, at which some preliminary recommendations would be presented. Notices will be sent and a newpaper ad placed, with the exact times and location, in December.

The meeting concluded at 4:15 p.m.

Prepared by,

Gary F. Rylander
Edwards and Kelcey, Inc.

Attachments

PUBLIC INFORMATION MEETINGS
October 19, 1993
2:00 p.m. and 7:30 p.m.

On behalf of the Missouri Highway and Transportation Department (MHTD) and Illinois Department of Transportation (IDOT), the Edwards and Kelcey project team is pleased to welcome you to today's public information meeting regarding this regional study.

BI-STATE ST. LOUIS AREA INTELLIGENT VEHICLE-HIGHWAY SYSTEM PLANNING STUDY

FOR FURTHER INFORMATION

Two St. Louis-based engineering firms are assisting Edwards and Kelcey with the study: Crawford, Bunte, Brammeier; and David Mason & Associates. Also a part of the project team is Farradyne Systems, Inc. of Rockville, Maryland. For further information, please contact:

William F. Bunte or
Cynthia L. Borchers
Crawford, Bunte, Brammeier
(314) 878-6644

James M. Giblin
Edwards and Kelcey, Inc.
(800) 253-9527 ext. 315

BACKGROUND

Over recent years, roadways in the greater St. Louis area have become more congested. The need for a traffic management system is more acute today due to:

- Congestion due to Inadequate Capacity
- Limited Ability to Build New Highway Lanes
- Greater Competition for Limited Funds

The most common remedy for congestion has been to build additional lanes on existing highways. Widening a roadway often requires the purchase of additional right-of-way, utility relocations, and certain agency permits (e.g. wetlands; stream encroachment; hazardous waste) which are often difficult and time consuming to obtain. Instead, management of congestion can be achieved by enacting a well-planned control and monitoring system.

The freeway management plan to be developed in this study will incorporate proven Intelligent Vehicle-Highway System (IVHS) strategies and technologies that will result in increased vehicle speeds, improved air quality, reduced energy consumption, increased system efficiency, and improved safety.

Included in the evaluation will be Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) technologies, as well as high-occupancy vehicle (HOV) lanes. Also included in the study are the evaluation and integration of the existing roadside call boxes, highway advisory radio and emergency traffic patrols currently operated by IDOT and/or MHTD. Specific strategies for the staged implementation of a freeway management plan will be developed, along with staffing requirements and a recommended organizational structure. Potential new funding sources will also be identified.

A major element of the study involves identifying and inventorying the goals and expectations of transportation users in the greater St. Louis area. In order to prepare a plan around which a broad consensus of support can be developed, the opinions of a wide cross-section of interested and affected parties are being solicited by questionnaire, public meetings and/or personal contact. The final products include a strategic deployment plan and conceptual plans for the freeway management plan.

FREEWAY TRAFFIC MANAGEMENT SYSTEM

A freeway traffic management system is comprised of guiding, informing and controlling components which are interconnected to a Traffic Information Center (TIC) by the latest in communications technology. Benefits include:

- Better use of available roadways.
- Diverting traffic to alternate roadways with sufficient excess capacity.
- Timely dissemination of current traffic information to the public.
- Improved air quality.

Simply stated, freeway traffic management systems are typically comprised of 8 distinct elements that interrelate as follows. If an incident (crash, stalled vehicle, etc.) occurs, the **Detection System** recognizes an increase or decrease in vehicle flow and speeds. This information is sent, via the **Communications System**, to an operator at the **Traffic Information Center.** The operator uses the **Video Monitoring System** to look at the roadway and visually identify the incident. The operator then sends messages to the **Variable Message Signs** and **Highway Advisory Radio.** These messages alert motorists to the situation and suggest diverting to alternate route(s). The operator then arranges for the timing of **traffic signals along diversion routes** to be adjusted for the added traffic and **Ramp Metering** rates to be adjusted, as necessary. The system components are explained below.

Traffic Information Center (TIC) - The TIC is the focal point of the freeway management system. It houses the computers, communications equipment, video switching equipment and display monitors that are required to operate the system. When an incident is detected and verified, a scenario of different re-routing patterns will be presented to the operator by the master computer. The operator will then activate the appropriate response plan, and if necessary, send the proper emergency response equipment to the scene of the incident.

Detection System - The Detection System monitors the volume and speed of traffic along the freeways and other affected roadways. Two types of detectors are often used: loops and radar. Loop detection uses inductive loops that are laid into cuts in the roadway surface, while radar detectors are mounted on bridges, signs and pole. Speeds and the number of vehicles are measured and transmitted to the TIC. A sudden increase/decrease in levels may signify that an incident has taken place.

Communications System - The communications cable is the "backbone" of the system. Fiber optic cable is typically used to provide the high-capacity communication of data and video. A glass or plastic fiber carries a signal generated by light-emitting diodes or lasers.

Video Monitoring System (CCTV) - Closed Circuit Television (CCTV) cameras are mounted on 40-55 foot poles strategically placed to survey the roadway, allowing the TIC operators to identify the nature of a reported incident. The operator can then notify the appropriate response teams (fire, ambulance, etc.), thus reducing the length of time that the incident adversely affects traffic.

Variable Message Sign (VMS) System - Variable Message Signs (VMS) are traffic control devices used for traffic warning, regulation, routing and management, and are designed to inform motorists of important information of traffic conditions. Placed at key locations, all VM signs are connected to the TIC via the Communications System.

Highway Advisory Radio (HAR) System - HAR utilizes low power transmission signals that will be broadcast to motorists along designated sections of freeway. Motorists are advised when up-to-date information is available and what station they should listen to for that information.

Control of Traffic Signals Along Diversion Routes - When a diversion plan is required, the TIC will either adjust (or communicate with the appropriate agency that controls) the operation of signalized intersections along the diversion route so that the signals can better accommodate the added traffic being diverted from the freeway.

Ramp Metering System - The primary goal of a ramp metering system is to manage the flow of vehicles entering the freeway. The ramp metering system consists of installing traffic signals to "meter" the flow of traffic onto the freeway at critical entrance ramps, thus reducing congestion and travel time, increasing speeds, improving safety on the freeway and improving air quality.

BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

IVHS USER SERVICES AND SUB-SERVICES

1. Pre-Trip Travel Information (transit, driver and ridesharing)
2. En Route Driver Information
   - Driver Information
   - In-Vehicle Signing
3. En Route Transit Information
4. Traveler Services Information (yellow pages, etc.)
5. Route Guidance (includes general service plus commercial vehicle and HAZMAT-specific guidance; does not include emergency vehicle-specific)
6. Ride Matching and Reservation (car/van pool, HOV control, etc.)
7. Incident Management (excludes emergency vehicle management service)
8. Travel Demand Management (regulatory, mode change, parking control, emissions detection, etc.)
9. Traffic Control (includes transit priority and HOV priority)

BI-STATE ST. LOUIS AREA
IVHS PLANNING STUDY

IVHS USER SERVICES AND SUB-SERVICES

10. Electronic Payment Services (parking, transit fares, toll collection, congestion and highway pricing, etc.)
11. Commercial Vehicle Pre-clearance (includes roadside access to carrier, vehicle and driver records, International Border Pre-clearance)
12. Automated Roadside Safety Inspections (automated inspection facilities)
13. Commercial Vehicle Administrative Processes
    - Electronic Purchase of Credentials
    - Automated Mileage and Fuel Reporting and Auditing
14. On-Board Safety Monitoring (includes driver, vehicle and cargo)
15. Commercial Fleet Management (includes motor carrier and intermodal terminal operations)
16. Public Transportation Management
    - Operations of Vehicles and Facilities
    - Planning and Scheduling Services
    - Personnel Management

IVHS USER SERVICES AND SUB-SERVICES

17. Personalized Public Transit (paratransit, route deviations, etc.)
18. Emergency Notification and Personal Security
    - Driver and Personal Security
    - Automated Collision Notification
    - HAZMAT Incident Notification
19. Public Travel Security
20. Emergency Vehicle Management
    - Fleet Management
    - Route Guidance
    - Signal Priority
21. Longitudinal Collision Avoidance
    - Rear-End Crash Warning and Control
    - Autonomous Intelligent Cruise Control
    - Cooperative Intelligent Cruise Control
    - Head-On Crash Warning and Control
    - Passing Warning (on two-lane roads)
    - Backing Crash Warning

BI-STATE ST. LOUIS AREA
IVHS PLANNING STUDY

IVHS USER SERVICES AND SUB-SERVICES

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22. Lateral Collision Avoidance
    - Lane Change/Blind Spot Crash Warning and Control
    - Lane Keeping Warning and Control
23. Interstate Crash Warning and Control
24. Vision Enhancement for Crash Avoidance (inclement weather and at night)
25. Impairment Alert
    - Impaired Driver Warning and Control Override
    - Vehicle Condition Warning
    - In-Vehicle Infrastructure Condition Warning (infrastructure-based warning in En Route Travel Advisory service)
    - Integrated Warning Systems
26. Pre-Crash Restraint Deployment
27. Fully Automated Vehicle Operation (Automated Highway System)

PLEASE SIGN IN

10-19-93 PUBLIC INFORMATION MEETING 2:00 p.m.

Name	Representing	Telephone
[illegible signature]	EWGCC	314-421-4220
Jim Plumb	MHTD	(314) 526-2906
BRUCE LARSON	UNION ELECTRIC	314 554-2631
Pati Trout	TMA Creve Coeur	314-569-9336
JILL MILLER	SWB TELEPHONE	314-957-1773
Fred Schwartz	Benns & McDonnell	816 822-3872
A. Chris Chiodini	MHTD-Planning	314-526-3502
TOM OXLER	SOUTHWESTERN BELL	314-949-1301
Joe Pasponie	Dept of Highways + Traffic	314-854 6522
Ed Hendricks	Ret.	968 1987
Dale L. Haudsdell	City of St. Peters	447-4440 Ext 302
Ken Kohl	St. Louis Traffic	768-2806
DONNA DAY	EAST-WEST GATEWAY	421-4220
J.T. YARNELL	MHTD	340-4200
Mike Pritchett	IDOT	(618) 346-3223
LINDA GETZ	SEN FRANC FLOTRON	434 2115
TEE BAUR	BAUR PROP.	434-3700
ROD HAFEMEISTER	BELLEVILLE NEWS-DEMOCRAT	(618) 234-1004 EXT 563
Ken Coy	MHTD	340-4317
Chris Hensley (CHRIS HINSLEY)	PFRC	553-5845

E D W A R D S A N D K E L C E Y , I N C .

One Corporate Center, 7401 Metro Boulevard
Minneapolis, Minnesota 55439

Telephone: (612) 835-6411
Fax: (612) 835-7376

Engineers
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BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

PUBLIC INFORMATION MEETING SUMMARY
7:30 p.m., October 19, 1993

This public information meeting was held on Tuesday, October 19, 1993 at the Missouri Highway and Transportation Department (MHTD) District 6 office in Town and Country. A total of 18 people registered (see attached sign-in sheet) and picked up the handout materials (attached).

PART A - PROJECT OVERVIEW

MHTD Project Manager Dale Ricks began the meeting at 7:35 p.m. by welcoming everyone. With one exception, the remainder of the “Project Overview” presentation was the same as the 2:00 p.m. meeting earlier in the day (refer to that meeting summary for details). Donna Day of the East-West Gateway Coordinating Council was unable to attend this meeting, so Ricks gave an overview of the Council’s role as the metropolitan planning organization and explained that this project was consistent with their ongoing transportation planning efforts for the St. Louis metropolitan area.

PART B - COMMENTS AND QUESTIONS FROM THE AUDIENCE

At this point, Levine opened the floor to comments and questions from the audience. For ease of reference, each has been numbered and presented in sequential order. As these are summary notes and not a verbatim transcript, all remarks have been paraphrased.

1. People are going to be opposed to auto tagging, like credit card tracking. The most successful approach is to keep the private sector involved as much as possible--not government. RESPONSE: We are seeing more public-private partnerships and that is very much the case with IVHS, so you can expect that to be the case here.

2. Were the air pollution reductions shown in the slides for New Jersey’s MAGIC project actually achieved? St. Louis only has an ozone problem, and that was not shown on the slide. RESPONSE: Since the MAGIC system is just now being installed, the values shown are forecast reductions, not measured values.

3. The St. Louis area has many local units of government. Ladue and Creve Coeur, for example, simply will not permit diversion from the freeways to their arterials. There are very few parallel arterials in the area, as well. The many river crossings also limit options. How will you deal with this? RESPONSE: The St. Louis constraints and problems you describe really are similar to those in other metropolitan areas. It’s not just a question of diversion; rather, by getting the word to motorists at home and at

work, demand can be lowered so there is less traffic to divert. In Los Angeles, CALTRANS met with every city to cooperatively work out alternative routes. Some communities were more receptive than others, but by taking the time to communicate and explain the situation these things were worked out. With respect to the limited number of alternative routes, that makes planning even more important than when there are many routes available, and makes behavior modification more critical. Teamwork is critical, and a Minneapolis-St. Paul reconstruction example was cited, where 96 different agencies were involved.

4. I have an asthma problem--why not have vehicles with dual carburetors that would permit natural gas to be burned? The federal government hasn't suggested this, but a tax credit could be used to encourage it. Also, maybe local governments should give credit to firms that use staggered work hours. And why not use a rubber-tired train that runs on the freeway, rather than light rail transit where fixed, steel tracks are used? RESPONSE: Burning natural gas has not been economical. Tax breaks have been used to promote various strategies, though the implementation of staggered work hours has not been one of them.

5. There's lots of stuff on the shelf, we should see if they'll work here. HOV lanes, toll roads, etc. work well elsewhere and I'm happy to see it coming here. I would like to know what's happening five miles down the road. Allen Barkledge is the only one we can get traffic information from, but it isn't always reliable. I'm a charter bus operator and just this morning they told of an incident and blockage near me, but it wasn't there when I got there. RESPONSE: Accurate, timely information is critical. Outdated or inaccurate data leads to a loss of credibility. Advance motorist information is one of the most important elements of this plan. The traffic data can be sent over phone lines to anyone with a computer. There would no charge for the data; the only cost would be the hook-up charge. The data can also be targeted to specific users with only the data they find useful, such as for buses. By organizing all of the data at a central point, the system and the users are both benefiting. In construction zones, MHTD is now using changeable message signs programmed by cellular telephone in order to get real-time traffic information out to motorists.

6. When HOV lanes have been proposed for St. Charles County in the past, the reaction from MHTD has been a negative one. I have heard presentations from East-West Gateway about how to achieve air quality attainment. Why is IVHS not being touted by others as a means to obtain attainment, and how long would it take to achieve attainment--how much benefit would there be? RESPONSE: MHTD is very interested in looking at the "big picture" and where HOV lanes fit. In 1989-90, MHTD undertook a study of HOV facilities, but found that the need then was not very strong, particularly compared to other metropolitan areas (where congestion is much worse). But now, congestion in the St. Louis area is costing an estimated $1 million per day and MHTD is firmly committed to reducing congestion. A strong consensus of support needs to be present in order to proceed, both with specific projects and in order to obtain funding from the legislature. Air quality modeling in conjunction with East-West Gateway is being done, but it's very expensive. FHWA requires such work for before and after analyses, but at this point there are no specifics.

7. I am not an engineer but a freeway user. Just what has MHTD been doing? On I-270, why not put a changeable message sign on the Blanchette Bridge? Missouri is so backward that it won't be easy explaining to people what to do. Don't put speed limits on signs--paint them on the pavement--older people are always looking down at the road. In Pennsylvania, there are signs when you enter the state warning of the penalties for speeding--why not here? RESPONSE: None required.

8. How much did the Minnesota IVHS program cost? RESPONSE: The first federal grant was for $1 million, then a second grant for $3-4 million was obtained. There are too many elements to easily count. For example, the very successful highway helper program is funded out of several different budgets.

9. How do you calculate cost-effectiveness? Test beforehand? The number of additional people moved? Drop in pollution levels? RESPONSE: The key is a reduction in delay, with fewer secondary accidents and lower fuel consumption. The benefits of these types of improvement are hard to track because the benefits go to the citizens and are not revenue to some government agency. The experience in Los Angeles is similar to that in other metro areas, benefit/cost ratios of 15:1 to 16:1. Motorist service/assist patrols have been found to be 14:1 to 18:1. There are models to predict cost-effectiveness. We will obtain an accurate breakdown for the Minnesota IVHS experience and make it available.

10. Is this an isolated analysis, or will other non-capital intensive options that might be more cost-effective (such as carpooling, vanpooling, staggered work hours) be evaluated? RESPONSE: Incentives to shift travel modes are important to examine. For example, in Los Angeles HOV lanes can be justified based only on carpool usage; having transit use the lanes is a plus. The important principle is that HOV lanes must always be free-flowing, to encourage diversion from congested mixed use lanes.

11. Rush hour traffic will always be a problem as long as it's free. Envisions a file server with dial-up option. Cable companies could use it to target geographical areas. Someone else might customize data in other ways and home computers could also gain access. RESPONSE: All of this can be done now, the technology exists. A computer can also be programmed to call you at home to advise you of delays along your regular travel route. TV stations in some cities show graphic displays in the morning rush hour. In Los Angeles, a map of traffic conditions is sent by fax to major employers so it can be posted on the board as people head home. And in Great Britain, there is a pager unit that punches up the latest data and beeps when it receives a change in information.

12. Is there a timetable for this project? RESPONSE: The project is a 12-month study, with updates about every two months for a project guidance committee. The final report will be completed in late April, 1994, and is 90% federally funded. The project is not tied to the federal funding cycle, but will be implemented in stages, most likely starting in 1995 or 1996. The St. Louis area will really benefit from the latest computer technology--it is much cheaper and more powerful than even a few years ago, and has shrunk in size so that the Traffic Information Center (TIC) can occupy a relatively small room. Another advantage is that system architecture design can start with basically a

"clean sheet", rather than having to integrate a myriad of conflicting and competing elements that are incompatible technically. Very few states have spent large sums of money for regional IVHS planning studies, and it shows--MHTD and IDOT are taking the best approach for St. Louis, which will be on the "cutting edge" of IVHS but not the "bleeding edge". Ricks commented that MHTD and Kansas DOT are in the preliminary stages of a similar study for the Kansas City metropolitan area, which should start in early 1994.

13. CB radio was a big deal in the 1970's. What would be wrong with having everybody on a specific highway tune to a different channel to get traffic information. There would be conflict and each route would have information specifically tailored to it. RESPONSE: CB radio is not a realistic option, for several reasons. Not everyone has a CB radio, while there is an AM radio in nearly every vehicle. Many motorists travel more than one freeway and would have to change back and forth on a CB radio. Also, many people would have to be trained. AM radio has proven to be one of the most cost-effective methods of disseminating traffic information, when gathered at a central point, the TIC. For more route specific data, highway advisory radio (HAR) can used (and is used today in the St. Louis area). The important point is that no one specific means can be used to solve this problem--rather, the solution will be a integrated mixture of various strategies, techniques and technology.

14. I have tried tuning my car radio to 5:30 AM, and it is usually unintelligible (a second person in the audience agreed). What's the problem? RESPONSE: IDOT's HAR system which uses the 5:30 AM frequency is not easy for them to monitor and maintain. In other parts of the country, HAR works very well. This study will look at how to modify and improve the use of HAR in the St. Louis area.

There being no further comments or questions from the audience, Levine thanked everyone for attending and indicated that a summary of this meeting will be prepared so that it could be taken into account in the study. He also reminded everyone that a second set of public information meetings would be held on Wednesday, January 5, 1994, at which time some preliminary recommendations would be presented. Notices will be sent and a newspaper ad placed, with the exact times and location, in December.

The meeting concluded at 9:40 p.m.

Prepared by,

Gary F. Rylander
Edwards and Kelcey, Inc.

Attachments

PLEASE SIGN IN

10-19-93 PUBLIC INFORMATION MEETING 7:30 p.m.

Name	Representing	Telephone
Chuck Gross	State Rep, Dist. 18	947-7893
Rod Sechtleben	Kenneth Balk & Assoc	576-2021
Thomas C. Tucker	Chesterfield Police	537-3000
DWIGHT McCOMB	FHWA	708 206-3226
Leonard Bradley	A.T.S.S.	(314) 389-7445
Bill Schierholz	ChemTech	314 966 9801
Bob Olson	FHWA	217-492-4634
ARNOLD O FINK		741 77-[illegible]
DARAN CHURCVICH	CONSOLIDATED COMMUNICATIONS	217-235-4435
Tom DARNOLD	Sverdrup	436-7600
Ray L. Wilshire	Kimley-Horn	214/770-1300
Eric Harris	Self & L&C TWP LP	314 838 1776
THOMAS E. BARTA	FRED WEBER INC	314 344 0070
T. Joseph Markering	Burns & McDonnell	314/821-9016
GARY ECKWESTAD	ST. CHARLES COUNTY	(314) 441-7186
[illegible]	HCI	314 427-2227
Harold G Brooks	Public	314-256-9564
G.O. SANDSTEDT	COMMERCIAL DATA, INC	314-776-1130

E D W A R D S A N D K E L C E Y , I N C .

One Corporate Center, 7401 Metro Boulevard
Minneapolis, Minnesota 55439

Telephone: (612) 835-6411
Fax: (612) 835-7376

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BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

PUBLIC INFORMATION MEETING SUMMARY
2:00 p.m., February 9, 1994

This public information meeting was held on Wednesday, February 9, 1994 at the Engineer's Club of St. Louis, 4359 Lindell Blvd., St. Louis. A total of 30 people were in the audience, though only 28 registered (see attached sign-in sheet), and picked up the handout materials (attached).

PART A - PROJECT OVERVIEW

MHTD Project Manager Dale Ricks began the meeting at 2:05 p.m. by welcoming everyone. He explained the goals and schedule for the project, the Bi-State St. Louis Area Intelligent Vehicle Highway Systems (IVHS) Planning Study. He explained that the project final report may be delayed from April, 1994 to May due to a potential public-private partnership in the communications area that is being explored.

Ricks explained that a consultant team headed by Edwards and Kelcey, Inc. (EK) had been selected to undertake the study and would be conducting today's meetings. He noted that after a short presentation, most of the meeting would be devoted to comments and questions from the audience. Ricks then introduced Jim Giblin, EK Project Manager who chaired the meeting, and Gary Rylander, EK Deputy Project Manager. Giblin explained that a short presentation about the project would be made first, followed by comments/questions from the audience and an opportunity for everyone to state their opinions on priorities.

Giblin gave a brief explanation of "traffic engineering" and "IVHS", and noted that urban areas can no longer build enough roadways to eliminate congestion. A freeway management plan is being developed in order to better manage traffic. He explained how IVHS technologies collect traffic data and that information is used to determine how well traffic is moving and to locate incidents. The traffic data is also made available to the public to help them plan their trips, through the media, cable TV, traffic information kiosks in office buildings and shopping centers, etc. He discussed how incidents and accidents have a major impact on traffic safety and flow, and for this reason having an incident management plan is important.

PART B - COMMENTS AND QUESTIONS FROM THE AUDIENCE

At this point, Giblin opened the floor to comments and questions from the audience. For ease of reference, each has been numbered and presented in sequential order. As these are summary notes and not a verbatim transcript, remarks have been paraphrased. Responses are by Giblin unless noted otherwise.

1. On I-55 north of Butler, there is a bridge construction sign that is not clear. RESPONSE: Giblin gave an example of how a changeable message sign would help guide traffic in the area.

2. Why would this IVHS technology be better than a traffic helicopter? RESPONSE: The time required to detect an incident is much shorter than it would be by helicopter or airplane, which fly fixed routes and are restricted near the airport. Detectors can identify an incident in two minutes or less; it also is not difficult to tell the difference between recurring (regular) congestion and incident-related congestion. The other advantage of IVHS technology is that prompt visual confirmation gets the proper emergency response equipment on the scene faster.

3. How far can a closed circuit television (CCTV) camera see? RESPONSE: Usually about two and one-half miles in each direction when mounted 40-55 feet in the air. Pan-tilt-zoom control allows the operator to the camera as required. Color CCTV camera technology has been improving rapidly and are they now becoming the standard.

4. How much IVHS technology is currently in place? RESPONSE: A limited amount--IDOT has had highway advisory radio, motorist aid call boxes, and emergency patrol vehicle service for many years; MHTD has recently begun limited motorist assist patrol service. Ricks commented that there really isn't only one solution; rather, a group of actions tailored to the St. Louis area is what will work.

5. Is this a standard system architecture so it works across the country? RESPONSE: Yes, this is similar to other applications. The automobile manufacturers are also involved.

At this point, Giblin used an overhead transparency of handout material to explain the project schedule, that public information meetings were held on October 19, 1993, and a series of focus group meetings were held in January, 1994.

6. Has anyone looked at blending modes? For example, someone would drive a car onto a smart highway or rail line, like with cargo distribution. RESPONSE: Yes, it is being explored, but it is many years off.

7. I drive I-55 north, and crossing Lindbergh Blvd. traffic is driving at high speed. It seems that all of the problems are at exits. RESPONSE: These concerns can be addressed by the freeway management system and enforcement.

8. I think ramp metering is a bad idea, a big thumbs down. Diamond interchanges are problems. RESPONSE: Experience elsewhere has shown that ramp metering can be very effective in improving freeway capacity and reducing accidents.

At this point, Giblin used an overhead transparency of handout material to discuss the public concerns that were expressed at the October public information meetings.

9. I don't know why anyone would want to use transit. It's slow as molasses and not convenient. RESPONSE: It is difficult to get people to use transit if they have an automobile available. IVHS technologies can be used to improve information about transit schedules, when the next bus/train will arrive, etc.

10. Traffic laws have high violation rates around here. "No Turn on Red" violations are common, for example. What can government do about this? RESPONSE: This is a difficult enforcement issue.

11. Why don't people use turn signals? Why do they drive 45 mph in the left lane? RESPONSE: None required.

12. Do carpool lanes really work? Where, besides California? RESPONSE: They can work, and do in high congestion parts of the country. Carpool, or HOV, lanes need to be segregated from mixed traffic lanes to work well; this increases HOV capacity and reduces violations. An HOV-3 (persons required) example was given.

At this point, Giblin used overhead transparencies of handout material to explain the concerns expressed in the focus group meetings and the types of IVHS user services related to the Early Implementation Plan (EIP). He went over each item listed on the questionnaire, and used overhead transparencies of Figures 8 and 8a of the draft System Architecture document to explain how the communications would be structured and traffic data would be disseminated free of charge.

13. Why not charge for the traffic data? Let truckers pay for it. RESPONSE: People are paying for it, one way or another, but it is to everyone's advantage to make the information widely available. The best way to do that is to make it "free" to use. We all benefit if truckers are able to avoid congested routes.

14. Isn't the Traffic Information Center (TIC) the heart of the system? RESPONSE: Yes. Some system elements would work without the TIC, but would be less efficient.

15. We have heard about the Los Angeles success story of carpooling during the 1984 Olympics, but you can't force people to rideshare. RESPONSE: No, we can't, but ridesharing should be made as attractive as possible to encourage people to do so.

At this point, Giblin asked attendees to take ten minutes to fill out the EIP questionnaire by ranking the top three IVHS user service categories, from their perspective. The questionnaires were collected and tabulated, with the following results:

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

A complete summary of the rankings, showing the number of votes for first, second and third priority, is attached.

16. How far down the list was ridesharing? RESPONSE: Well down the list, about eighth.

17. How can you tell how cost-effective the system implementation turns out to be? RESPONSE: "Before" and "after" studies are required and will be conducted.

18. Let's not just talk about this--can it be done? RESPONSE: Yes it can, if the funding can be secured. The EIP includes elements that can be implemented within about a six month period.

19. Isn't it less safe to four people in one car? Doesn't increase your potential liability? RESPONSE: Having four people in a car means there are fewer vehicles out on the road, making fewer trips. Therefore, there are fewer conflicts and less exposure.

There being no further comments or questions from the audience, Ricks thanked everyone for attending and indicated that a summary of this meeting will be prepared so that it could be taken into account in the study. He noted that another public information meeting would be held this evening at 7:30 p.m.

The meeting concluded at 3:45 p.m.

Prepared by,

Gary F. Rylander
Edwards and Kelcey, Inc.

Attachments

BI-STATE ST. LOUIS AREA
IVHS PLANNING STUDY

PROJECT SCHEDULE

- PUBLIC INFORMATION MEETINGS HELD OCTOBER 19, 1993
- FOCUS GROUP MEETINGS HELD IN JANUARY AND FEBRUARY, 1994
  - SPECIAL EVENT OPERATORS
  - COMMERCIAL VEHICLE OPERATORS
  - MAJOR EMPLOYERS
  - COMMUNICATIONS COMPANIES
  - PARKING GARAGE/LOT OPERATORS
  - TRANSIT OPERATORS
  - MISSOURI HIGHWAY PATROL AND ILLINOIS STATE POLICE
- PUBLIC INFORMATION MEETINGS HELD FEBRUARY 9, 1994
- PUBLIC PRESENTATION OF RESULTS APRIL 13, 1994

BI-STATE ST. LOUIS AREA
IVHS PLANNING STUDY

PUBLIC CONCERNS:

- CONGESTION
- IMPROVE PUBLIC TRANSIT
- GOOD LINKAGE BETWEEN AUTOMOBILES AND TRANSIT
- MANAGEMENT OF HIGH TECH SOLUTIONS BY GOVERNMENT

BI-STATE ST. LOUIS AREA
IVHS PLANNING STUDY

FOCUS GROUP CONCERNS:

- NEED FOR INFORMATION SO THAT PEOPLE CAN MAKE THEIR OWN DECISIONS
- ACCOMMODATE DELIVERIES
  - PICK-UP
  - DROP OFF
- LOSS OF TIME AT WEIGH STATIONS
- TRAFFIC CONTROL DURING CONSTRUCTION AND MAINTENANCE WORK

SUMMARY FOR 02/09/94 MEETING, 2:00 P.M.

BI-STATE ST. LOUIS AREA
IVHS PLANNING STUDY

EARLY IMPLEMENTATION PLAN QUESTIONNAIRE

	RANK	IVHS USER SERVICES
3	2/2/5	MOTORIST AID CALL BOXES
	0/0/1	WEIGH-IN-MOTION
5	O/6/2	HIGHWAY ADVISORY RADIO (HAR)
	0/0/2	CABLE TV TRANSPORTATION CHANNEL
2	5/4/6	MOTORIST ASSIST PATROLS/ EMERGENCY PATROL VEHICLES
6	0/5/2	HIGHWAY ADVISORY TELEPHONE
4	1/4/3	INTERSTATE ROUTE DIVERSION SIGNS
1	18/3/2	REGIONAL TRAFFIC INFORMATION CENTER
8	1/2/1	RIDE SHARING/TELECOMMUTING/FLEX--TIME
	0/10/0	PUBLIC-PRIVATE PARTNERSHIPS
	0/1/1	INFORMATION KIOSKS
7	1/1/3	CONSTRUCTION/MAINTENANCE WORK DATABASE
	_____	OTHER (write in) ______________________
	_____	OTHER (write in) ______________________

1st /2nd/ 3rd ranking

BI-STATE ST. LOUIS IVHS

PUBLIC INFORMATION MEETING

Feb 9, 1994 2:00

Name	Representing	Telephone
LES EASH	SELF	849-8736
Mike Pritchett	Ill. D.O.T.	(618) 346-3273
Mike Staggs	FHWA	(314) 636-7104
Tom KAISER	DRIVER	9666270
Larry Welty	MHTD	340-4100
Jim Murray	MHTD	340-4202
JIM WHITE	COUNTY POLICE	889-2111
Tom Brooks	FHWA	314-636-7104
GARY ELLERSTAD	ST. CHARLES COUNTY	(314) 441-7186
Linda Wilson	MHTD	340-4117
JOE LaBome	Private citizen	618-624-6786
Omar Feeler	Sverdrup Civil	770-4519
Mary Cay O'Malley	Sverdrup Civil	770-4089
Keith Hinkebein	Sverdrup Civil	770-4917
Louis Spranaitis	5621 So. Bdwy	353-5878
Don Gayou	self	994-9059
DEWEY BROWN	City of Florissant	839-7643
CHARLES W KEIM	PUBLIC	487-4791
Don Spencer	St. Louis County	854-6502
DONNA DAY	EAST-WEST GATEWAY	421-4220
BRAD HUBBARD	HCI	427-2727
MIKE GEISER	Chesterfield	537-4738
Mike Peck	Chesterfield	537-4740
Ken Cox	MHTD	340-4317

Mike James	MHTD	340-4321
Beth Dare	MHTD	340-4315
Rich Schmidt	MHTD	340-4318
Neil Venneman	ST. LOUIS STREET DEPT	647-3111

E D W A R D S A N D K E L C E Y , I N C .

One Corporate Center, 7401 Metro Boulevard
Minneapolis, Minnesota 55439

Telephone: (612) 835-6411
Fax: (612) 8357376

Engineers
Planners
Consultants

BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

PUBLIC INFORMATION MEETING SUMMARY
7:30 p.m., February 9, 1994

This public information meeting was held on Wednesday, February 9, 1994 at the Engineer's Club of St. Louis, 4359 Lindell Blvd., St. Louis. A total of eight people were in the audience, though only five signed in (see attached sign-in sheet), and picked up the handout materials (attached to the 2:00 p.m. meeting summary).

PART A - PROJECT OVERVIEW

MHTD Project Manager Dale Ricks began the meeting at 7:35 p.m. by welcoming everyone. He explained the goals and schedule for the project, the Bi-State St. Louis Area Intelligent Vehicle Highway Systems (IVHS) Planning Study. He explained that the project final report may be delayed from April, 1994 to May due to a potential public-private partnership in the communications area that is being explored.

Ricks explained that a consultant team headed by Edwards and Kelcey, Inc. (EK) had been selected to undertake the study and would be conducting today's meetings. He noted that after a short presentation, most of the meeting would be devoted to comments and questions from the audience. Ricks then introduced Jim Giblin, EK Project Manager who chaired the meeting, and Gary Rylander, EK Deputy Project Manager. Giblin explained that a short presentation about the project would be made first, followed by comments/questions from the audience and an opportunity for everyone to state their opinions on priorities.

Giblin gave a brief explanation of "traffic engineering" and "IVHS", and noted that urban areas can no longer build enough roadways to eliminate congestion. A freeway management plan is being developed in order to better manage traffic. He explained how IVHS technologies collect traffic data and that information is used to determine how well traffic is moving and to locate incidents. The traffic data is also made available to the public to help them plan their trips, through the media, cable TV, traffic information kiosks in office buildings and shopping centers, etc. He discussed how incidents and accidents have a major impact on traffic safety and flow, and for this reason having an incident management plan is important.

Because of the small number of attendees and the fact that most were familiar with the project, Giblin altered the format from the afternoon meeting. At this point, he used overhead transparencies of handout material to review the project schedule, public concerns, focus group concerns and explain the Early Implementation Plan (EIP) questionnaire (as he had done at the 2:00 p.m. meeting earlier that day). He asked everyone to take a few minutes to fill out the EIP questionnaire by ranking the top three IVHS user service categories, from their perspective. The questionnaires were collected and tabulated, with the following results:

1. Motorist Aid Call Boxes
2. Motorist Assist Patrol/Emergency Patrol Vehicle service
3. Interstate System Route Diversion Signs/Cable TV Channel (tie)

A complete summary of the rankings, showing the number of votes for first, second and third priority, is attached. He explained that when tonight's results were combined with those from the afternoon meeting, the following overall priority rankings resulted:

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

PART B - COMMENTS AND QUESTIONS FROM THE AUDIENCE

At this point, Giblin opened the floor to comments and questions from the audience. For ease of reference, each has been numbered and presented in sequential order. As these are summary notes and not a verbatim transcript, remarks have been paraphrased. Responses are by Giblin unless noted otherwise.

1. What about air quality 7 RESPONSE: Estimates of emissions will be made, though not in a detailed analysis because that would be very complex and beyond the scope of the study. Ricks commented that it is difficult to get "before" data for the nature and duration of incidents, while "after" data will be easy to obtain.

2. It will be tough to get local fire departments to give up responding to calls on the Interstate system because they get funding for doing so. RESPONSE: Ricks noted that fire departments are not a problem; rather, it is the local police agencies.

3. Are rail systems part of this study? RESPONSE: No, the Interstate freeway system is the focus of the study. FOLLOW-UP: What about where they cross the rivers? A discussion followed about transit usage and how ridership can be improved. The ridership characteristics on the Washington, DC Metro subways and AMTRAK were discussed, along with inexpensive cars and cheap, plentiful gasoline in the St. Louis area. Giblin noted that travel patterns between rail systems and automobile drivers are very different; convenience, reliability and personal security are major issues when people are deciding whether to drive or take transit.

4. How will this be funded? RESPONSE: Funding for implementation will need to be approved by the East-West Gateway Coordinating Council, the region's metropolitan planning organization. There are a number of possible funding sources; federal "Congestion Mitigation and Air Quality" (CMAQ) funds may be available.

5. I did not receive a notice of this meeting, but heard about it from others. RESPONSE: Many notification letters were sent out. I don't know why you did not receive one since you attended the October public information meeting: you should have.

6. The Creve Coeur TMA has CMAQ-generated traffic data which we will provide to you. RESPONSE: Thank you. Please send it Bill Bunte at Crawford, Bunte, Brammeier.

There being no further comments or questions from the audience, Ricks thanked everyone for attending and indicated that a summary of this meeting will be prepared so that it could be taken into account in the study.

The meeting concluded at 9:05 p.m.

Prepared by,

Gary F. Rylander
Edwards and Kelcey, Inc.

Attachments

SUMMARY FOR 02/09/94 MEETING, 7:30 P.M.

BI-STATE ST. LOUIS AREA

IVHS PLANNING STUDY

EARLY IMPLEMENTATION PLAN QUESTIONNAIRE

	RANK	IVHS USER SERVICES
1	2/1/0	MOTORIST AID CALL BOXES
		WEIGH-IN-MOTION
	1/0/0	HIGHWAY ADVISORY RADIO (HAR)
3	1/1/1	CABLE TV TRANSPORTATION CHANNEL
2	1/2/0	MOTORlST ASSlST PATROLS/ EMERGENCY PATROL VEHICLES
		HIGHWAY ADVISORY TELEPHONE
3T	12/0/3	INTERSTATE ROUTE DIVERSION SIGNS
	1/1/0	REGIONAL TRAFFIC INFORMATION CENTER
	0/0/1	RIDE SHARING/TELECOMMUTING/FLEX-TIME
	1/0/2	PUBLIC-PRIVATE PARTNERSHIPS
	0/1/0	INFORMATION KIOSKS
	0/l/l	CONSTRUCTION/MAINTENANCEWORK DATABASE
		OTHER(write in)____________
		OTHER(write in)____________

1st /2nd / 3rd ranking - blank means no votes

BI-STATE ST. LOUIS IVHS
PUBLIC INFORMATION MEETING
Feb. 9, 1994 7:30 pm

Name	Representing	Telephone
Robert Prager, P.E.	Intuition and Logic	968-3863
PATI TROUT	Creve Coeur TMA	993-6323
LAURIE PETERFREUND	ST. LOUIS COUNTY ECONOMIC COUNCIL	889-7663
Bill Grogan	East-West Gateway	421-4220
Brent M Vaughn	Student, SIU-E	822-0223 223 McCullough Ave Kirkwood MO 63122-5813

C. IVHS FIELD EQUIPMENT COMMUNICATIONS REQUIREMENTS AND INTERFACES

St. Louis IVHS Field Equipment Communication Requirements and Interfaces for all Fiber Network

Hub to Field Equipment Connectivity:

Single mode fiber optic cable can be used as the physical medium for hub connectivity to all of the field equipment including the Closed Circuit Television Systems, Vehicle Detection Systems, Variable Message Signs, Ramp Metering Stations, Traffic Signal systems, Weigh-in motion stations, and weather/fog detection devices. Since large distances are present between field equipment and hub sites (>5 miles), single mode rather than multimode fiber optic cable is the recommended physical medium. This is because sinnals transmitted over single mode fiber exhibit less attenuation (loss) over large distances in comparison to multimode fibers.

When compared to the alternative communication methods that use twisted wire pair (TWP) cable, or coaxial cable, fiber optic cable has numerous advantages. Some of these advantages include smaller size and weight, immunity to lightning damage, electrical isolation with no chance of ground loops or potential shifts, absence of spark or shock hazard, and immunity to electromagnetic interference (EMI) and radio frequency interference (RFI). Where possible, and practical, fiber optic connections from the hubs to the low data rate equipment should be configured as multidrop circuits. These connections should be in a “tree” configuration, using the same pairs in the main fiber optic cable to serve more than one field device on the same circuit. Each field equipment unit should communicate with the hub in full duplex mode (bi-directional). Four single mode fibers should be used to connect field equipment sites to the multidrop circuit, with each multidrop circuit representing one communications channel. Two of these fibers should be used for full-duplex communications, and the other two should be provided for redundancy. Single mode optical fiber should also be used as the physical medium for transmitting camera video signals to each hub in a point to point communications configuration. Four fibers should be used to connect each camera to the SONET hub. Two of these fibers will be used for video and data communications between the CCTV sites and the hubs, and the other two fibers should be provided for redundancy.

Vehicle Detection System (VDS):

Description: Microwave radar detectors will be used to provide information such as vehicle presence, speed, count, and vehicle classification in order to maintain a safe and sufficient flow of traffic.

Data Transmission Requirements: All radar detectors make use of a low power microwave radar transceiver. The radar transceivers are tuned and fixed for X-Band frequency operation. These transceivers operate on the principal of Doppler radar theory. Detectors can transmit data via an RS-232 or RS-422 serial port at a speed of 2400 or 4800 bps. A data multiplexer (data field terminal) can be connected to a maximum of 8 vehicle detectors to provide power and collect data via this RS-232 or RS-422 connection. Data will be transmitted to the multiplexers at a rate of 2400 or 4800 bps. A fiber optic transceiver with an RS-232 interface should be connected to the individual detectors or multiplexer to transmit and receive 1200 or 4800 bps serial data to and from a Synchronous Optical Network (SONET) hub via fiber optic cable. All of the vehicle detection data will be collected by a Time Division Multiplexer (TDM) or channel bank via a fiber optic transceiver at the SONET hub. Typically, 20 VDS stations per channel are connected to a multidrop circuit.

Communication Interface: The communication interface between a vehicle detector/multiplexer and fiber optic transceiver should be an RS-232 cable. If a multiplexer is used, the communications interface between the detectors and multiplexer will be an RS-232 cable for distances less than 100 feet and an RS-422 cable for distances greater than 100 feet. The multiplexer and/or detector fiber optic transceiver interface to the SONET hubs via single mode fiber optic cable in a multidrop configuration.

Closed Circuit Television (CCTV)

Description: Closed Circuit Television (CCTV) field units will be located along the roads for visual detection of traffic patterns. Each CCTV unit will consist of a color Charge Coupled Display (CCD) camera; pan, tilt, and zoom lens (PTZ) driver; a control receiver; and CODEC (coder decoder) equipment.

Data Transmission Requirements: Full motion video data from the CCTV field units should be transferred to the traffic operations center via the SONET backbone network. The CCD camera's analog video signal must be compressed and digitized by CODEC equipment to make it compatible with the digital SONET network. This CODEC equipment can be located in an environmentally controlled cabinet at the CCTV field site. Most CODEC equipment will digitize full motion 10 MHz analog video signals at DS-3 rates (45 Mbps). The DS-3 CODEC also transmits and receivers camera control data to the control receiver via an RS-232 or RS-422 serial port . This data signal is multiplexed with digitized video images and can have transmission rates up to 9600 bps. A DS-3 fiber optic transceiver can transmit these digitized video signals and data signals to the SONET hub over single mode fiber. A DS-3 fiber optic transceiver should be located at the SONET hub to receive this multiplexed signal. The communications architecture between the SONET hub and each CCTV field site should conform to a star topology configuration. The digitized DS-3 video signal and data signal should then be received by a SONET Add Drop Multiplexer (ADM) . The ADM can convert multiple DS-3 electrical signals into OC-12 or OC-48 optical signals for transmission into the SONET backbone network. The OC-12 optical signal has a channel capacity of 622 Mbps, while OC-48 has a channel capacity of 2.5 Gbps.

Communication Interface:
The communications interface between the CCD camera and control receiver/CODEC equipment should be coaxial cables with BNC type connectors at both ends. This same type of cable can be used to connect the CODEC equipment to the DS-3 fiber optic transceiver. An RS-232 or RS-422 cable should be the interface between the CODEC and camera control receiver for the transmission of camera control messages. Single mode fiber should be the interface between the fiber optic transceivers at the CCTV field site and SONET hub.

Highway Advisory Radio (HAR)

Description: A HAR will provide advance driver information. The system will incorporate a 10 watt class D transmitter located throughout the freeway network at HAR stations. The HAR will also have computer control and digital downloading capabilities.

Data Transmission Requirements: A Class D transmitter can transmit audio signals to automobiles via a vertical whip antenna at a bandwidth of 530 kHz. It is recommended that HAR messages be digitally downloaded to the HAR stations from a remote location. Since the HAR stations are computer controlled, digitized audio data can be downloaded to the stations via fiber optic transceivers. This data can be received at the HAR stations using fiber optic transceivers, that receive asynchronous serial data at transmission speeds of 2400 to 9600 bps. These digitized audio messages can be transmitted from a central location to the HAR stations over single mode fiber optic cable via a SONET hub. This fiber optic cable should be linked to a TDM at the SONET hub. Current HAR technology requires that each HAR be connected to the hubs in a point to point configuration, with each HAR representing one communications channel.

Communication Interface: The fiber optic transceivers can receive the digitized audio messages via single mode fiber optic cables that are linked to the SONET hub. RS-232 cable should be the interface between the fiber optic transceiver and the HAR computer control equipment. Coaxial cable should be the interface between the class D transmitter and the vertical whip antenna.

Variable Message Signs (VMS)

Description

The VMS will display real time motorist traffic information about traffic congestion, lane closures, and freeway incidents.

Data Transmission Requirements: The VMS controllers can transmit and receive asynchronous serial data to and from a SONET hub via a fiber optic transceiver at transmission rates of 1200-9600 bps in a multidrop configuration. All of the VMS data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Typically, 20 VMS stations per channel are connected to a multidrop circuit.

Communication Medium: It is recommended that the VMS controllers be connected to SONET hubs via multidrop single mode fiber optic cable.

Ramp Metering Stations (RMS)

Description: The use of RMS helps to regulate traffic flow onto the mainline freeway during peak travel times.

Data Transmission Requirements The RMS controllers can transmit and receive asynchronous serial data to and from a SONET hub via a fiber optic transceiver at transmission rates of 1200-9600 bps in a multidrop configuration. All of the RMS data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Typically, 20 RMS stations per channel are connected to a multidrop circuit.

Communication Medium: It is recommended that the RMS controllers be connected to the SONET hub via multidrop cable.

Traffic Signal Systems

Description: Signal controllers will located at intersections throughout the bi-state St. Louis region.

Data Transmission Requirements: The traffic signal controllers can transmit and receive asynchronous serial data to and from a SONET hub via a fiber optic transceiver at transmission rates of 1200-9600 bps in a multidrop configuration. All of the signal controller data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Typically, 6 signal controller per channel are connected to a multidrop circuit.

Communication Medium: It is recommended that the traffic signal system controllers be connected to the SONET hub via single mode fiber optic cable.

Weather and Fog Detection Devices

Description: Weather and fog detection devices will be located along the mainline freeway at the SONET hub locations for weather data collection.

Data Transmission Requirements: Weather and fog detection controllers can transmit and receive data from the SONET hub equipment via fiber optic transceivers. All of the weather and fog detection data can be collected by a Time Division Multiplexer (TDM) at the SONET hub. Since the weather and fog detection devices are located at each hub, each detection device represents one communication channel and are connected to the hubs in a point to point configuration.

Communication Medium: It is recommended that the weather and fog detection controllers be connected to the SONET hub equipment via point to point single mode fiber optic cable.

SONET Hub Equipment

Each SONET hub should have communications equipment that interfaces with the field equipment. Fiber optic transceivers should be located at each SONET hub to transmit and receive asynchronous serial data from the vehicle detection systems, highway advisory radios, variable message signs, ramp metering stations, and traffic signal systems. Data from the fiber optic transceivers should be transmitted to a Time Division Multiplexer (TDM) via an RS-232 cable. A TDM at the hub allocates time slots to each of these input communication channels. The TDM converts the input analog signals into digital formats using Pulse Code Modulation (PCM) techniques, resulting in signals that have much lower Bit Error Rates (BER) and less sensitivity to noise than comparable analog signals. A typical TDM has 24 analog channel inputs, each with a data transmission rate of 64 kbps. Therefore, the TDM output channel capacity becomes 1.544 Mbps, which conforms to a DS-1 signal level. The SONET ADM will receive this multiplexed digital electrical signal via an electrical patch cord or coaxial cable, and will convert the signal into an OC-12 or OC-48 optical signal for transmission into the SONET backbone. Each of the SONET hubs should be linked together with single mode fiber cables as explained in Technical Memorandum 9.

The SONET ADM will also receive digitized video signals from a DS-3 fiber optic transceiver via a 75 ohm coaxial cable with a BNC connector at both ends. The ADM will convert the input DS-3 signals into OC-12 or OC-48 optical signals for transmission into the SONET backbone.

ADMs use either Time Slot interchange (TSI) or Time Slot Allocation (TSA) multiplexing schemes. TSI is a switching process that moves a time slot from one data stream to a time slot in another data stream. TSA assigns time slots to each ADM node on a dedicated basis and maps service demands (e.g., DS1s and/or DS3s) into these dedicated time slots in the high-speed, multiplexed signal. TSI is the recommended ADM multiplexing scheme for this communications architecture. An ADM with TSI capability is more flexible than TSA for high-speed lines in terms of service and facility grooming. TSI is also inherently supported by larger crossconnect systems, which terminate signals at the DS3 level and cross-connect signals at the DS1 level.

An ADM and digital cross-connect system (DCS) should be placed at the traffic operations center. The ADM can convert a received OC-12 or OC-48 optical signal into a STS-12 or STS-48 electrical signal. The STS-12 or STS-48 signal is then demultiplexed into 12 or 48 STS-1 signals, and converted into DS-3/DS-1 signals. These signals should then be transferred to a digital cross-connect system (DCS). A DCS is a computerized facility that allows DS3 (representing video and camera control data) and DSI (representing VDS, HAR, VMS, RMS, traffic signal system, weather/fog detector data) channels to be remapped electronically. For instance, this system will allow the digital reassignment and redistribution of VDS communications channels into DSO formats. The DCS will provide the traffic operations center access of data on a per-channel basis. DCSs also allow signals to be routed without having to be demultiplexed. Typical applications include: remote diagnostics; maintenance and provisioning; routing and restoration; and network reconfiguration and bandwidth allocation. All of the communications interfaces are depicted in Figure 1.

Fiber Optic Cable Quantization

Tables 1-4 depict the fiber optic communication requirements for the four phases of the St. Louis project: short term, mid-range, long range, and ultimate in Missouri and Illinois. These tables represent approximate fiber counts, and were compiled for cost estimation purposes only. They do not reflect the actual number of fiber that will be installed in the communications system. These counts are based on multipoint communications between the VDS, VMS, Signal Controllers, and RMS and each SONET hub. Point to point to communications is assumed to occur between SONET hubs and each of the following sites: CCTV, HAR, and weather detectors. In addition, the tables show the required point to point fiber optic cables between each of the SONET hubs. In these calculations, four single mode loose buffered fibers are used as the physical medium for one communications channel (two of these fibers are redundant), and for communications between SONET hubs.

The fiber count calculations are made on a hub by hub basis. In other words, approximations are made on the number of required fiber that connect each field equipment site to each hub. This count is related to the number of communication channels between each hub and the field equipment sites. In a multidrop configuration, the fiber optic cable extends the entire distance between a hub and the farthest multidropped field equipment site. However, in a point to point link, fiber counts are based on placement of fiber at incremental levels along the mainline conduit. In these approximations, a uniform increment of 12 fibers per mile is chosen between each hub and field equipment site for point to point communications. Fiber optic cables usually contain fiber counts that are multiples of 12. Such a technique reduces the cost associated with placement of cable with large numbers of fibers over the long distances. In addition, it is assumed that fiber optic cable is spliced every 4 miles, and pull boxes are located every 500 feet. Tables 1-4 summarize the fiber optic cable counts for the different phases of the project.

Once the fiber optic cable is quantified, a cost estimate can be established for fiber optic cable, conduit, splice enclosures, pull boxes, and manholes for the different phases of the project. This is done in Table 5.

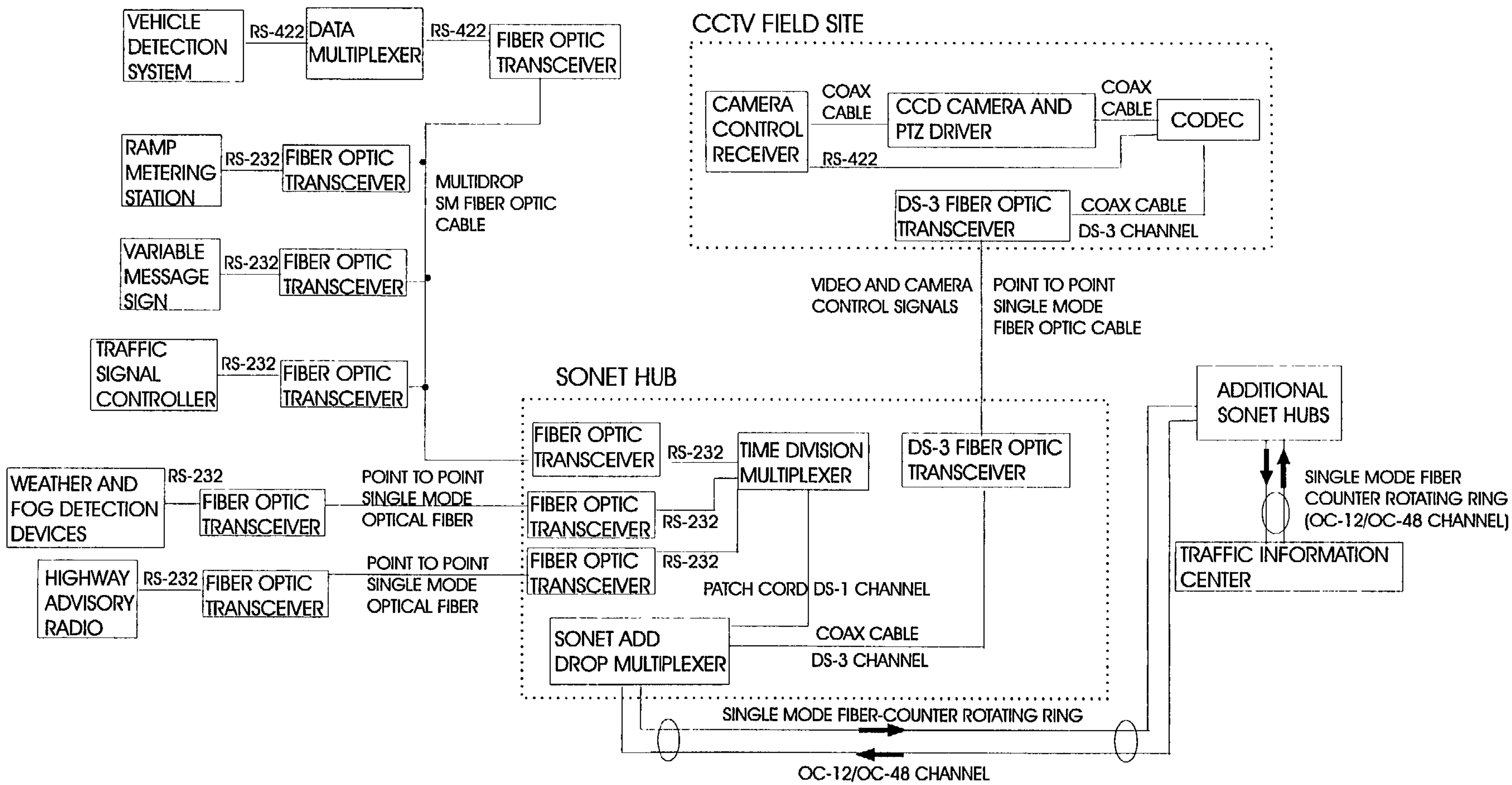

Figure 1- Recommended Field Equipment Communication Interfaces

Table 1												
Short Term Phase (6 Monthes-2 years)												
	Number			**Total**	**# of Channels**			**Total**	**# of Fiber (SM)**			**Total**
									(4 Fibers per Channel)			
Hub #	2	3	12		2	3	12		2	3	12	
	MO TIC	70&370	IL TIC		MO TIC	70&370	IL TIC		MO TIC	70&370	IL TIC	
CCTV* (1 per Channel)												
MO	9	12	2	23	9	12		21	36	48		84
IL			6	6			6	6			24	24
Both States				29				27				108
VDS (20 per channel)												
MO	20	50		70	1	3		4	4	12		16
IL			21									8
Both States				91			2	6			8	24
VMS (20 per channel)												
MO	5	4		9	1	1		2	4	4		8
II			[illegible]	[illegible]			[illegible]	[illegible]			[illegible]	[illegible]
Both States				0				3				12
HAR' (1 per channel)												
MO	0	1		1	0	1		1	0	4		4
IL			0	0			0	0			0	0
Both States				0				1				4
Slgnal Controllers (6 per Channel)												
MO	9	23		32	2	4		6	8	16		24
IL			0	0			0	0			0	0
Both States				0				6				24
Weather Detectors* (1 per Channel)												
MO	1	1		2	1	1		2	4	4		8
IL			1	1			1	1			4	4
Both States				3				3				1;
RMS (20 per Channel)												
MO	4	0		4	1	0		1	4	0		4
IL			0	0			0	0				0
Both States				4				1				4
SONET* backbone												
MO									4	4		8
IL											4	4
Both States												0
Grand Total (Eqt. @ Fiber)												
MO	48	91	2	141	15	22	0	37	64	92	0	156
IL	0	0	29	29	0	0	10	10	0	0	44	44
Both States	48	91	31	170	15	22	10	47	64	92	44	200
Multidrop Fiber Total												
MO									20	32	0	52
IL									0	0	12	12
Both States									20	32	12	64
Point to Point Fiber Total												
MO									44	60	0	104
IL									0	0	32	32
Both States									44	60	32	136
Total Mileage of 4" Conduit												
MO	18	35		53								
IL			12	12								
Both States	18	35	12	65								
Multidrop Cables-Number of fiber in each cable												
(covers entire segment)												
MO	24	36		n/a								
IL			12	n/a								
Point to Point Cable Segments-12 fibers per cable												
(add 12 fiber cable every mile)												
MO	18	35		n/a								
IL			12	n/a								
Number of Pull Boxes (every 500')												
MO	190	370		560								
IL			127	127								
Both States	190	370	127	687								
Number of Manholes (every 4 miles)												
MO	5	9		14								
IL			3	3								
Both States	5	9	3	17								
Splice Enclosures (every 4 miles)												
MO	5	9		14								
IL			3	3								
Both States	5	9	3	17								
* Point to Point Communications												

Table 2

Midterm Phase

	Number					Total	# of Channels					Total	# of Fiber (SM)					Total
Hub #	5	6	7	8	10		5	6	7	8	10		5	6	7	8	10	
	270&170	270&70	70&40/64	270 &55	55&64/50		270&170	270&70	70&40/64	70 &5	55&64/50		270&170	270&70	70&40/64	70 &5	55&64/50	
CCTV* (1 per Channel)																		
MO	7	7	5	11		30	7	7	5	11		30	28	28	20	44		120
IL					6	6					6	6					24	24
Both States						36												144
VDS (20 per channel)																		
MO	26	7	7	53		93	2	1	1	3		7	8	4	4	12		28
IL					16	16					1	1					4	4
Both States						109												32
VMS (20 per channel)																		
MO	1	0	0	4		5	1	0	0	1		2	4	0	0	4		8
IL					1	1					1	1					4	4
Both States						6												12
HAR* (1 per channel)																		
MO	0	1	0	0		1	0	1	0	0		1	0	4	0	0		4
IL					0	0					0	0					0	0
Both States						1						0						4
Signal Controllers (6 per Channel)																		
MO	15	12	0	18		45	4	2	0	3		9	16	8	0	12		36
IL					25	25					5	5					20	20
Both States						70												56
Weather Detectors* (1 per Channel)																		
MO	1	1	1	1		4	1	1	1	1		4	4	4	4	4		16
IL					1	1					1	1					4	4
Both States						5												20
RMS (20 per Channel)																		
MO	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0
IL					0	0					0	0					0	0
Both States						0												0
SONET* backbone																		
MO													4	4	4	4		16
IL																	4	4
Both States																		20
Grand Total (Eqt @ Fiber)																		
MO	50	28	13	87	0	178	15	12	7	19	0	53	64	52	32	80	0	690
IL	0	0	0	0	49	49	0	0	0	0	14	14	0	0	0	0	60	186
Both States	50	28	13	87	49	227	15	12	7	19	14	67	64	52	32	80	60	876
Multidrop Fiber Total																		
MO													28	12	4	28	0	72
IL													0	0	0	0	28	28
Both States																		100
Point to Point Fiber Total																		
MO													36	40	28	52	0	156
IL													0	0	0	0	32	32
Both States																		188
Total Mileage of 4" Conduit																		
MO	13	7	7	29		56												
IL					9	9												
Both States						65												
Point to Point Cable Segments-12 fibers per cable																		
(add 12 fiber cable every mile)																		
MO	13	7	7	29		n/a												
IL					9	n/a												
Point to Point Cables-12 fibers per cable																		
(add one additional cable every 4 miles)																		
MO	13	7	7	29		n/a												
IL					9	n/a												
Number of Pull Boxes (every 500')																		
MO	138	74	74	306		592												
IL					95	95												
Both States						687												
Number of Manholes (every 4 miles)																		
MO	4	2	2	8		16												
IL					3	3												
Both States						19												
Splice Enclosures (every 4 miles)																		
MO	4	2	2	8		16												
IL					3	3												
Both States						19												

* Point to Point Communications

Table 3

Long Term Phase

	Number			Total	# of Channels			Total	# of Fiber (SM)			Total
Hub #	1	4	9		1	4	9		1	4	9	
	70&40	270&44	170&40/64		70&40	270&44	170&40/64		70&40	270&44	170&40/64	
CCIV*(1 per channel)												
MO	5	4	5	14	5	4	5	14	20	161	20	56
VDS(20 perchannel)												
MO	45	30	11	86	3	2	1	6	12	8	4	24
VMS (20 per channel)												
MO	1	0	1	2	1		1	2	4	0	4	8
HAR* (1 per channel)												
MO	1	1	0	2	1	1	0	2	4	4	0	8
Signal Controllers (6 per Channel)												
MO	0	27	6	33	0	2	1	3	0	8	4	12
Weather Detectors* (1 per Channel)												
MO	1	1	1	3	1	1	1	3	4	4	4	12
RMS (20 per Channel)												
MO	0	0	0	0	0	0	0	0	0	0	0	0
SONET*backbone												
MO									4	4	4	12
Grand Total (Eqt. @ Fiber)												
MO	53	63	24	140	11	10	9	30	48	44	40	132
Multidrop Fiber Total												
MO									16	16	12	44
Point to Point Fiber Total												
MO									32	28	28	88
Total Mileage of 4" Conduit												
MO	27	13	7 5	47.5								
Multidrop Cables-Number of fiber in each cable (covers entire segment)												
MO	24	24	12	n/a								
Point to Point Cables-12 fibers per cable (add one additional cable every 4 miles)												
MO	27	13	7.5	n/a								
Number of Pull Boxes (every 500')												
MO	285	137	79	501								
Number of Manholes (every 4 miles)												
MO	7	4	2	13								
Splice Enclosures (every 4 miles)												
MO	7	4	2	13								
* Point to Point Communications												

Table 4			
Ultimate Phase			
	Number	#of Channels	# of Fiber (SM)
Hub #	12	12	12
	265&64/5	265&64/50	255&64/50
CCTV* (1 per Channel)			
MO	1	1	4
IL	16	16	64
Both States	17	17	68
VDS (20 perchannel)			
MO	74	4	16
IL	26	2	8
Both States	100	6	24
VMS (20 per channel)			
MO	0	0	0
IL	4	1	4
Both Stat			
HAR* (1 perchannel			
MO	0	0	0
IL	4	4	16
Both States	4	4	16
Signal Controllers (6 per Channel)			
MO	27	2	8
IL	32	3	12
Both States	59	5	20
Weather Detectors* (1 per Channel)			
MO	0	0	0
IL	1	1	4
Both States	1	1	4
RMS (20 per Channel)			
MO	0	0	0
IL	0	0	0
SONET backbone			
MO			4
IL			4
Both States			8
Grand Total (Eqt. @ Fiber)			
MO	102	7	32
IL	03	27	112
Both States	18.5	34	144
Multidrop Fiber Total			
MO			24
IL			24
Both States			48
Point to Point Fiber Total			
MO			8
IL			88
Both States			96
Total Mileage of 4 Conduit			
MO	3		
IL	57		
Both States	60		
Multidrop Cables-Number of fiber in each cable			
(covers entiire segment			
MO	24		
IL	54		
Point to Point Cable Segments-12 fibers per cable			
(add 12 fiber cable every mile)			
MO	3		
IL	57		
Number of Pull Boxes (every 500')			
MO	32		
IL	602		
Both States	634		
Number of Manholes (every 4 miles)			
MO	1		
IL	15		
Both States	16		
Splice Enclosures (every 4 miles)			
MO	1		
IL	15		
Both States	16		
• Point to Point Communications			

Table 4			
Ultimate Phase			
	Number	# of Channels	# of Fiber (SM)
Hub #	12	12	12
	255&64/50	255&64/50	255&64/50
CCTV* (1 per Channel)			
MO	1	1	4
IL	16	16	64
Both States	17	17	68
VDS (20 per channel)			
MO	74	4	16
IL	26	2	8
Both States	100	6	24
VMS (20 per channel)			
MO	0	0	0
IL	4	1	4
Both States	4	1	4
HAR* (1 per channel)			
MO	0	0	0
IL	4	4	16
Both States	4	4	15
Signal Controllers (6 per Channel)			
MO	27	2	8
IL	32	3	12
Both States	59	5	20
Weather Detectors* (1 per Channel)			
MO	0	0	0
IL	1	1	4
Both States	1	1	4
RMS (20 per Channel)			
MO	0	0	0
IL	0	0	0
Both States	0	0	0
SONET* backbone			
MO			4
IL			4
Both States			8
Grand Total (Eqt. @ Fiber)			
MO	102	7	32
IL	83	27	112
Both States	185	34	144
Multidrop Fiber Total			
MO			24
IL			24
Both States			48
Point to Point Fiber Total			
MO			8
IL			88
Both States			96
Total Mileage of 4" Conduit			
MO	3		
IL	57		
Both States	60		
Multidrop Cables-Number of fiber in each cable			
(covers entire segment)			
MO	24		
IL	24		
Point to Point Cable Segments-12 fibers per cable			
(add 12 fiber cable every mile)			
MO	3		
IL	67		
Number of Pull Boxes (every 500)			
MO	32		
IL	602		
Both States	634		
Number of Manholes (every 4 miles)			
MO	1		
IL	15		
Both States	16		
Splice Enclosures (every 4 miles)			
	1		
IL	15		
Both States	16		
* Point to Point Communications			

Table 5

St. Louis Mainline Communications Cost Estimate

Item	Description	Unit	Unit Cost	# of Units MO	# of Units IL	Total Cost MO	Total Cost IL	Both States	Vendor
Short Term Phase									
Conduit	4" Conduit-4 Innerduct System	Mile	$17,000	53	12	$901,000	$204,000	$1,105,000	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
12 Fiber Cable		Mile	$4,200		12		$50,400	$50,400	SIECOR
24 Fiber Cable		Mile	$6,600	18		$118,800	$0	$118,800	SIECOR
36 Fiber Cable		Mile	$9,400	35		$329,000	$0	$329,000	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered								
(One additional 12 Fiber cable placed every mile)		Mile	$4,200	53	12	$222,600	$50,400	$273,000	SIECOR
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	14	3	$42,000	$9,000	$51,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	14	3	$11,900	$2,550	$14,450	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	560	127	$560,000	$127,000	$687,000	Utility Structur
Subtotal						$2,185,300	$443,350	$2,628,650	
Midterm Phase									
Conduit	4" Conduit-4 Innerduct System	Mile	$17,000	56	9	$952,000	$153,000	$1,105,000	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
12 Fiber Cable		Mile	$4,200	7		$29,400	$0	$29,400	SIECOR
24 Fiber Cable		Mile	$6,600	7		$46,200	$0	$46,200	SIECOR
36 Fiber Cable		Mile	$9,400	42	9	$394,800	$84,600	$479,400	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered								
(One additional 12 Fiber cable placed every mile)		Mile	$4,200	56	9	$235,200	$37,800	$273,000	SIECOR
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	16	3	$48,000	$9,000	$57,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	16	3	$13,600	$2,550	$16,150	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	592	95	$592,000	$95,000	$687,000	Utility Structur
Subtotal						$2,311,200	$381,950	$2,693,150	
Long Term Phase									
Conduit	4" Conduit-4 Innerduct System	Mile	$17,000	47.5	0	$807,500	$0	$807,500	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
12 Fiber Cable		Mile	$4,200	7.5	0	$31,500	$0	$31,500	SIECOR
24 Fiber Cable		Mile	$6,600	24	0	$158,400	$0	$158,400	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered	Mile	$4,200	47.5	0	$199,500	$0	$199,500	SIECOR
(One additional 12 Fiber cable placed every mile)									
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	13	0	$39,000	$0	$39,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	13	0	$11,050	$0	$11,050	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	501	0	$501,000	$0	$501,000	Utility Structur
Subtotal						$1,747,950	$0	$1,747,950	
Ultimate Phase									
Conduit	4" Conduit-4 Innerduct System	Each	$17,000	3	57	$51,000	$969,000	$1,020,000	CARLON
Multidrop Fiber Optic Cable	Single Mode Loose Buffered								
24 Fiber Cable		Mile	$6,600	3	57	$19,800	$376,200	$396,000	SIECOR
Point to Point Fiber Optic Cable	Single Mode Loose Buffered	Mile	$4,200	3	57	$12,600	$239,400	$252,000	SIECOR
(One additional 12 Fiber cable placed every mile)									
Manholes (Placed every 4 miles)	Placed at each Splice Point	Each	$3,000	1	15	$3,000	$45,000	$48,000	Utility Structur
Splice Enclosures	Fiber Optic Enclosure	Each	$850	1	15	$850	$12,750	$13,600	SIECOR
Pull Boxes	Placed every 500 feet	Each	$1,000	32	602	$32,000	$602,000	$634,000	Utility Structur
Subtotal						$119,250	$2,244,350	$2,363,600	
Grand Total						$6,363,700	$3,069,650	$9.433.350	

D. IVHS SYSTEM INSTALLATION OPTIONS

BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

IVHS SYSTEM INSTALLATION OPTIONS

April, 1994

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. However, no set of contract documents will ever be perfect. Some facilities, such as underground utilities, may not be shown on the plans or marked out in the field (a consequence of erroneous or inadequate records), and their existence remains an unknown until the contractor literally runs into them. A time lag usually exists between the design phase and the actual start of construction during which conditions as reflected in the plans, or the technological state-of-the-art, may have changed. Finally, regardless of how definitive and certain the contract documents are, there will always be some conflicting interpretations as to their exact meaning.

Good contract management and thorough construction inspection are essential to a system's success. The biggest errors, longest delays, and the largest cost overruns have occurred during system installation. Unless this phase is properly managed, it can break a project, and turn the system into an operational failure and maintenance nightmare.

Intelligent Vehicle Highway System (IVHS) installation depends on effective construction contract administration and supervision, close cooperation among all involved parties, 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.

This chapter describes recommended procedures and practices for successful traffic control and surveillance system installation. Areas covered include:

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

PRECONSTRUCTION ACTIVITIES

Contract Supervision and Administration

Responsibilities and procedures for supervising the contractor and administering the construction contract can vary widely, depending on the contracting agency and the size of the project. Where federal and/or state aid funding is involved, additional requirements must be followed.

Most important, the respective roles and chain of command for decision making in the field and requirements for approvals by others must be clearly understood by all supervising engineers and inspectors and the contractor's representatives. Misunderstanding of such roles and requirements frequently leads to unnecessary errors, costs, and delays during construction and can lead to lawsuits.

As with any process, the construction management framework consists of both formal and informal elements. The formal requirements and channels-of-communication should be addressed and clearly defined in the specifications. It is emphasized that the formal elements apply equally to both parties of the construction contract--the contractor and the contracting agency. A frequent complaint by contractors is the delays incurred while the agency reviews submittal and processes change orders. Unreasonable delays will endanger good working relationships. If the review cycle is greater than the specified time, the contractor will likely be entitled to an extension of contract time, and possibly additional compensation. The agency and other involved parties must therefore respond promptly to all written correspondence from the contractor. Not only is this contractually required, but timely responses keep the ball in the contractor's court, thereby helping to ensure that the project moves along productively.

Obviously, it is in everyone's best interest if the formal channels-of-communication can be streamlined as much as possible. One possibility is to have the "official" submittal sent to the contracting agency with copies also delivered to all reviewing agencies. In this manner, the time spent solely for the transportation of the documents can be minimized. Those in the chain-of-command with review or approval authority should be kept in the loop as the project progresses. They will thus be more likely to review and sign-off in an expeditious manner.

The ultimate success of the system implementation phase depends on the informal elements of the process--specifically the experience, knowledge, cooperation, fairness, and commitment on the part of all participants. In fact, there is perhaps no other aspect of the system process where the relations between the individuals are so important. For example, there have been instances where the contract documents were less than ideal (e.g., split responsibilities, ambiguity, incomplete testing provisions, etc.), but because the individuals maintained good relations the traffic control system was successful. At the same time, there are other examples where the specifications and plans were quite good in terms of their accuracy and certainty, yet one or more individuals involved in the process automatically adopted an antagonistic and confrontational posture, with the result that major problems occurred.

Such exceptions are not meant to diminish the need for well-written specifications and accurate plans. Rather, they illustrate the critical importance of good human relations during system implementation. There will always be some interpretation of even the best contract documents--the contractor generally viewing them as the maximum requirements while the owner considers them to be the minimum requirements. The best way to resolve any differences in the interpretation is through cooperation and compromise.

Successful construction management consists of being fair, but firm. The “hard nosed” approach in which the project engineer and inspectors exhibit an unyielding insistence on the “letter of the specifications,” allowing no deviations no matter how justified, will seldom produce a successful system. At the other end of the spectrum, token ineffective management and inspection will also likely yield unsatisfactory results. Laxity and permissiveness in contract supervision will lead the contractor to believe that shortcuts or substandard workmanship will be tolerated, resulting in an unsuccessful system.

A major factor which is frequently overlooked or ignored in construction management is the need to establish a common goal. The most successful projects are those in which the agency gets the best job at the lowest cost, and the contractor realizes a profit.

Project Engineer

The key player during the construction management effort is the Project Engineer. The engineer has a many-sided responsibility. As the authorized representative of the owner, he/she is concerned with all of the owner’s interests in the system construction and equipment procurement contracts. In this role, the engineer, with the help of a staff of inspectors, reviews contractor submittal, approves construction methods, watches the work to assure that the workmanship is satisfactory and that no defective materials are used, makes monthly measurements of the work completed and reports to the owner the amount of payment due the contractor, conducts component system acceptance tests, and generally enforces all requirements and provisions of the plans and specifications. The engineer should spend most of his/her time on-site and maintain close contact with the contractor’s superintendent. However, the engineer should avoid exercising direct and complete control over the contractor’s operations. Otherwise the contractor’s independent-contractor relationship with the owner may become a master-servant relationship, which could relieve the contractor of some of his/her obligations and impose unanticipated liabilities on the owner.

One of the most valuable resources available to the project engineer is access to the design engineer. There is no quicker way to resolve questions concerning any aspect of the project than to ask the person who was responsible for the design. This situation is optimum when the design engineer is part of the installation process. This is possible under several different forms of contracting, but is most prevalent in the Systems Manager form of contracting. Another resource that is invaluable to the project manager is a skilled, educated, and motivated team of inspectors.

Another important function of the engineer is that of arbitrator of the contract documents. The engineer must interpret the requirements of the plans and specifications, and serve as an arbitrator of disputes between the contractor and the owner. As such, it is imperative that the project engineer be impartial, honest, and fair in such matters--even if it means deciding against the agency for whom he/she is an agent or even an employee.

Expertise and attitude are critical qualities in a successful project engineer. The engineer must obviously have an intimate knowledge of the contract documents, and his/her expertise should encompass both systems knowledge and construction experience. The systems knowledge is necessary for overseeing the technical requirements of the contract documents, while the construction experience is necessary for administering the general provisions. There are numerous examples of implementation problems and delays occurring simply because the engineer, as well as the inspectors, were totally unfamiliar with the electronic components and software complexities associated with traffic control systems. These construction managers, who were otherwise very competent, had no recourse but to base their decisions on the "letter of the specifications" when system knowledge and engineering judgement were needed. Similarly, problems have arisen when construction management responsibilities were assigned to system engineers who did not possess the necessary contract administration experience.

This combination of systems knowledge and construction management experience is seldom found in a single person. Thus, a team approach is usually necessary to assure that the project is successfully managed. For example, in one system, a contract administrator from the Construction Section of a State DOT was appointed the Project Engineer; and he alone could approve change orders and changes in work. The other members of the project team consisted of staff from the Traffic Control Systems Unit of the Department; they were given free rein for approval of matters within their particular areas of technical expertise and advised the engineer on other matters. Other system projects have used a similar arrangement for project management, except that, consultants were utilized to provide the necessary system's expertise and advice during construction.

Successful application of the team approach requires close liaison and good human relations between all members of the construction management team. The responsibilities and authority (e.g., approve catalog cuts, issue change orders, deviate from plans and specifications due to field conditions, final approvals, etc.) of each participant must be clearly spelled out, and the channels-of-communication identified. Furthermore, the contractor should also be made aware of the various authorizations and responsibilities to avoid any confusion during construction.

When consultants are being used for technical advice, they should play an ongoing role. If consultants are not brought in until a crisis has arisen, they will not have the project background needed to make an optimal contribution. It has also proven useful if the consultants are permitted to talk directly with the contractor. Finally, all team members must always be kept informed of the project status and any developing issues, and be involved in the decision making as appropriate.

Another important consideration is the attitude of the Project Engineer. The Project Engineer should be someone who is willing to take responsibility for making things happen, and will take great pride in a successful outcome. While this person must be assertive and firm, he/she must also fair. Successful construction management requires give and take and unbiased thinking. The right attitude is always one of "win-win" between the agency and the contractor.

Generally, a project engineer is assigned by the contracting agency to be responsible for direct supervision of the project work. The project engineer usually has contracting authority on all matters pertaining to contract execution, and is subject only to administrative direction from agency superiors. Various agencies use other titles for this position such as "resident engineer" or "supervising engineer." On large projects separate project and resident engineers may be assigned, the latter having responsibility for direct, day-to-day on-site supervision. Assistants and inspectors are usually assigned for direct supervision and inspection of the various phases of the work.

System Integrator

Any traffic control system can be thought of as having four distinct components, a computer system, a communications network, local control and detection hardware, and applications software. A cursory examination of the background of each of these four components reveals four distinctly different lineages. The computer system will trace its heritage back to the mainframe computer industry. The lineage of the communications network is founded in the telecommunications industry.

The local controller and detector hardware brings yet another culture to the forefront. Whether the control equipment follows the Type 170 or the NEMA standards, the supplier is basically a custom electronic manufacturer who has targeted his resources to a very specialized market, supplying traffic control equipment. The fourth component is the applications software. The suppliers in this last category, are the most highly specialized and have evolved from either the traffic consulting community, or the defense contracting industry.

The role of the System Integrator is to employ the contributions of each of these four diverse trades to achieve an efficient operating traffic control system that meets the user's requirements. To gain a perspective on how a System Integrator performs his function, it is useful to consider the organizations that are typically involved in the installation of a traffic control system: the User Agency, the System Designer, the Contracting Agency, the Prime Contractor, the System Suppliers, and the Subcontractors.

The User Agency is the owner of the system. In the United States, this is typically a City, State, or Toll Authority. This agency typically knows well the operational requirements or the system, but frequently does not have anyone on staff who understands the intricacies of the technology of the system. In spite of this, it is imperative that the operating agency has at least one person who is dedicated to the project and who will function as an advocate of the project within the organization.

The System Designer will range in skills from one with strong knowledge of the computer and communications technology; to a designer who understands little of the operational needs of the agency but has considerable strengths in the system technologies. Ideally, the designer should have strengths in both areas and would bring a combination of understanding both the functional requirements and the technical solutions to the project. The System Designer is typically a consulting firm although some agencies undertake the design function in-house. The products generated by the designer are plans, specifications, and cost estimates that are required to advertise and award the contract. During the construction phase, the design firm is generally involved as a reviewer of the work and available to interpret plans and specifications.

The Contracting Agency frequently is the state agency that is responsible for highways. The responsibilities of this agency begin with overseeing the selection of the system designer and continue through the administration of the construction contract. A primary responsibility of the contracting agency is to make sure that all contracting requirements are met and that each participating organization meets its contractual requirements. This is the agency that supplies the project inspectors who are accountable for authorizing payments to the contractor. A primary focus of the contracting agency is to make sure that all rules and regulations concerning the administration of the contract are followed. Few contracting agencies have the luxury of being able to employ engineers who are specialized in the complex technologies of today's traffic control and surveillance systems. In fact, it is not uncommon for the contracting agency to rely heavily on the system designer for technical expertise.

The Prime Contractor is the agency that has the responsibility of producing the operating system. This is the organization that has the responsibility of system integration. For most traffic control and surveillance system contracts, the most costly elements of work are associated with the field construction. The cost of installing conduit, footings, installing local control hardware, and pulling wire cables are cal of field construction. Since these elements represent most (i.e., 90% +) of the work, it is common to see electrical contractors who are efficient in performing these tasks as the prime contractor. The prime contractor, therefore has a role in the project to construct the specified filed components. The prime contractor, however, has a second role--that of integrating all of the elements in the operating system.

System integration has many dimensions; equipment selection and acquisition, hardware interfacing, and monitoring software development are several of the more important dimensions. Most specifications allow the prime contractor latitude in selecting hardware items. This responsibility, therefore, implies a need to select hardware that meets specifications, and hardware that will be delivered in a timely manner when it is needed. A primary criterion when procuring hardware, is not only the quality of the hardware itself, but also the quality of the installation support which is frequently provided by another organization, the distributor. A closely related issue is the need to make sure that the hardware from one manufacturer will interface and operate correctly with the hardware from a second manufacturer. Interfacing issues are particularly critical with communications and computer hardware.

The history of traffic control and surveillance systems has demonstrated time and again that the most trouble-prone element of the system is the software. It is important to recognize that real-time, control software is among the most difficult and complex assignments in the field of Traffic Engineering. Virtually all electrical contractors subcontract this work element to firms that specialize in traffic control software.

The role of the System Integrator is two-fold: 1) to monitor the progress of the software supplier to be sure that a software package is ready to be installed when the field construction is complete, and; 2) to test, retest, and test the software again before installing it on the streets.

In summary, the System Integrator, has a role like the conductor of a symphony orchestra with the plans and specifications providing an analogy to the musical score. Through the skillful efforts of the system integrator, various suppliers and subcontractors will make this contribution at the right time in the project.

Inspectors are employed to ensure that construction is performed in accordance with the plans, specifications, and related contract provisions. Inspectors are generally on-site throughout the construction operations and act as the project engineer's representative on routine field decisions and interpretations. However, all directions to the contractor on major actions such as field plan revisions and change orders, defective work, unacceptable materials, or work suspensions are normally handled through the project engineer. Inspectors should also keep the project engineer informed of work progress and of any disputes or misunderstandings with the contractor regarding work performance, materials acceptance, or interpretation of the plans and specifications. Similarly, even though the project engineer does have a qualified inspector(s) to directly observe and inspect the work, on occasion the project engineer should personally visit the job sites and review the inspection operations and reports.

On large, multifaceted projects, a team of inspectors may be necessary. In such cases a chief or head inspector is usually designated.

Where installation is a relatively minor portion of a larger highway or street construction project, separate electrical and/or "traffic signal" inspectors may be assigned to inspect the traffic system installations. Specialty division of inspection work has become increasingly common, particularly for traffic system work, due to the increasing sophistication and complexity of electronic equipment. Most roadway construction inspectors have little familiarity with traffic control and surveillance equipment.

By contrast, on small jobs such as single signal installation with little or no roadway work, the project engineer may also serve as inspector. Alternatively, a signal or electrical inspector may be assigned full field supervision and inspection responsibilities. In either case, the field engineer or inspector would likely be responsible to the public works director or engineer of the contractor agency. Electrical inspectors so assigned must also understand installation and inspection requirements for the non-electrical signal installation components. The inspection checklist provided later in this section is intended to assist in an inspector(s) in conducting a thorough inspection of all traffic signal installation components.

One of the problem areas of traffic control system projects is project inspection. Inspectors assigned to such projects often lack the electronic systems experience and qualifications. Past experience indicates that a multitude of things can go wrong on a relatively straightforward signal installation job when inexperienced inspectors are used. The potential for mistakes on a complex traffic control system project is significantly greater. Regardless of whether such errors are the result of an honest mistake, carelessness, incompetence, or even premeditated; if errors are not discovered until final inspection or later during maintenance, costly rework or repair may be required, resulting in a less-than-successful system.

Successful inspection consists of providing an adequate number of inspectors to observe all of the contractor's activities. Furthermore, some or all of these inspectors must be qualified in the electrical and systems area. Given the great advances that have occurred in electronic and systems technology, coupled with an emphasis on roadway and bridge projects, some agencies do not possess this systems inspection capability. There are ways for overcoming this problem:

- Establish a small group of inspectors who are trained and assigned to handle systems work. This is feasible only for those agencies which plan to fund and manage several system projects over a number of years. Another consideration is the ability to assign members of the system inspection group to other duties within the agency when there is limited or no system construction underway.

- The best technical inspectors are often those individuals who will be operating and maintaining the system once it is completed. Using such a group to supplement the construction inspection force has proven very successful. A potential drawback of this approach is that during a major system expansion these personnel will be unable to perform their normal duties while administering and inspecting the expansion contract. The owner may be planning to staff up the system maintenance unit to operate the new system and to use this expanded staff for inspection. It will be necessary in such cases to plan ahead and initiate the position descriptions, classification, and recruitment process sufficiently in advance to train the new people and have them available at the time they are needed.

- Contract inspection services have also been very successful. One form of contract inspection is to hire a systems consultant to supplement the agency's inspection force and provide systems expertise during construction. The responsibilities of the system consultant can be extended to include all contract administration--construction inspection as well as the role of "project engineer".

- A team approach may be desirable. Inspection includes record keeping, testing and observation of the work. Maintenance technicians will have much of the experience required for good electrical inspection but will probably not be familiar with record keeping and other procedural aspects of the job. Thus a mix of experienced project inspectors and maintenance technicians may be the best approach to traffic control inspection.

When contract inspection and/or engineering services are used, the system consultant becomes an agent of the owner. It is good practice to state the terms and conditions of the relationship in a written agreement. The agreement should address, as a minimum, the following:

- Who is the official contracting agency, the engineer, etc.
- Final approval regarding contractor submissions, extra work, test results, etc.
- Authority to deviate from the plans and specifications, to change quantities, to issue written change orders, resolve disputes, etc.
- Any restrictions/requirements as to inter-organization communications (consultant-contractor).

The contractor should also be made aware of the terms of the agreement to avoid any confusion during construction. Regardless of the manner in which construction inspection is provided, it is imperative that the inspection force have the appropriate knowledge and expertise, that they be on hand before the start of construction, and that a sufficient number of inspectors are available so all work is thoroughly inspected and the contractor's progress is not delayed.

Regardless of the particular assignments and procedures applicable to a given project, the project engineer should take all necessary steps to ensure that all supervisors, inspectors, and contractor's representatives understand in advance their respective responsibilities and procedures to be followed when questions arise. One good method is for the project engineer to hold an informal preconstruction meeting with all project assistants and inspectors to explain and answer questions regarding work expectation. Recommended items to be covered include:

1. Delegation of work and chain of command.
2. Responsibilities of the assistants and their role in the overall engineering supervision and inspection.
3. Employee work hours, overtime arrangements, holidays, and performance standards.
4. Employee legal relations and responsibilities to the public, the contractor, and visiting officials.
5. Applicable regulations regarding misstatements, false reporting, or similar fraudulent representations.

6. Frequency of tests and inspections, and procedures to follow when unacceptable work or improper methods or equipment are encountered on the job.
7. Quality and quantity control and documentation procedures.

On large or lengthy projects, supplementary meetings at appropriate intervals throughout the construction process may be helpful as a reminder or refresher and to acquaint any new personnel with the required policies and procedures.

Construction Sequence

A typical construction sequence for an IVHS installation may involve one or more contracts. In either case the sequence is similar and includes:

- installation of communication infrastructure
- installation of foundations
- construction of control center
- installation of electric service
- installation of field assets (i.e., CCTV, signs, detectors, HAR and weather stations)
- activation of complete communications system
- activation of field assets
- system integration

Traffic Control Plan

Safe and efficient routing of traffic through and/or around the work zone during construction is an important component of system installation. Basic plans and/or specifications informing the contractor of minimum traffic control requirements are normally included in the contract documents by the contracting agency. Detailed traffic control plans are generally prepared by the contracting agency only for complex projects involving staged construction, detours and/or bypass roads.

Prior to construction, the contractor should submit a detailed traffic control plan to the project engineer for review and approval. All warning devices, traffic control hardware, and related provisions of the control plan must conform to the federal Manual of Uniform Traffic Control Devices (Ref. 1). Similar state or local agencies' manuals that incorporate the federal standards may also apply. In addition to the plan details for regulating traffic, the control plan should specify the names and duties of agency and contractor representatives responsible for implementing the plan and provisions for informing law enforcement and emergency service agencies of all lane closures, detours, or other changes in traffic control that will occur during the construction process.

Preconstruction Conference

A preconstruction conference with the contractor and other interested parties is normally conducted on all construction projects, including traffic signal installation. Many agencies have formal, written policies for the conduct and content of the preconstruction meeting. Whether formally or informally conducted, however, the primary goal of such a conference is to establish a sound working relationship and a clear understanding of the work to be accomplished, procedures to be followed, and respective obligations and expectations among all parties affected.

Prior to the conference, the project engineer and any key inspectors or supervisory assistants should thoroughly review the plans and specifications and visit the project site, making special note of any potential conflicts or items that might require clarification or field modification. A project supervisory staff that displays a thorough knowledge and understanding of the plans will help gain the confidence and cooperation of the contractor and the other parties involved.

Every construction contract is a joint venture of the contracting agency and the contractor.

The project engineer should clearly establish this "common objective" at the opening of the preconstruction conference. Other items covered under a typical agenda include:

1. Project Engineer/Inspector/Contractor relationships and responsibilities.
2. Labor and Equal Employment Opportunity requirements.
3. Project Scheduling.
4. Coordination with utilities.
5. Traffic control plan.
6. Required permits and other legal responsibilities.
7. Construction safety regulations, including required inspections and documentation.
8. Special construction features, site access, field office, and laboratory requirements.
9. Subcontractors' responsibilities including requirement that all direction be handled through the prime contractor.
10. Contractor's material list, including suppliers and anticipated delivery dates.
11. Emergency provisions, including names and phone numbers of all who might need to be called in the event of an emergency.

Meeting attendance, agenda, and any major comments or concerns expressed with regard to any of the agenda items should be properly documented. Most agencies have standard forms and/or formats for documenting the preconstruction conference.

Due to the specialized nature of electronic systems, an additional special preconstruction meeting may be advisable immediately prior to starting electrical work on complex projects or where a separate electrical subcontractor is involved. the project engineer, electrical inspector, contractor's supervisor, and electrical contractor's representatives should thoroughly review the plans, specifications and details and discuss any installation problems and concerns that are anticipated based on prior experience.

Notification to Proceed

Construction work cannot proceed until a written "work order" or "notice to proceed" is provided to the contractor. Normally this notice is provided by the project engineer.

Prior to issuing the work order, the project engineer usually must be notified by his or her agency that the necessary funds have been authorized. On federal and/or state aid projects, additional approvals must be obtained by the engineer, usually in writing, before the notice can be given for the contractor to proceed.

Shop Drawing Reviews

Following notification to proceed, but prior to actual construction, the contractor must normally submit working or "shop" drawings detailing the fabrication and erection of all nonstandard equipment required on the project.

For all industry-standardized items, the contractor should submit the manufacturer's or supplier's catalog cuts, certification of compliance, and/or similar documentation that the item as furnished to the contractor will comply with the pertinent plans and specifications. Certified test reports and/or samples for testing may also be requested by the contracting agency.

The project engineer and inspector(s) should review the shop drawings and product certifications thoroughly for compliance with the plans and specifications and acceptability for use on the project. Each shop drawing must be stamped and the applicable following designation checked:

- Acceptable (approved)
- Unacceptable (disapproved)
- Approved as noted (deficiencies identified)

Sampling and Testing of Materials

Material sampling and testing, depending on the nature of the material being tested, may be conducted either on- or off-site. Materials produced or prefabricated at remote locations are often inspected at the manufacturing site by representatives of the contracting agency. Inspection during manufacture is ordinarily made on the basis of random sampling and testing. All furnished materials shall be new.

Field testing is normally conducted by the inspector and assistants on the basis of pre--specified minimum sampling rates. Acceptability is determined by the test results and/or the inspector's visual observations as to the compliance with specifications and shop drawings.

On-site materials should be checked for such items as:

1. Size, diameter, length, color, thickness, and similar physical properties.
2. Manufacturer' s name, production location, production date, any required certification (e.g., Underwriters Laboratory listing).
3. Serial and model number of all electrical components.

Materials that are found to be defective, damaged, or otherwise unacceptable should be rejected and removed from the site. Appropriate documentation should be prepared as discussed in the "Construction Records" section that follows.

Electric Service Confirmation

Provisions for electric service to the signal installation as defined in the plans and specifications should be confirmed with the utility responsible for such service. Final electric service connectors to energize the signal installation are normally not installed by the electric utility until the signal installation is nearly complete. In practice, failure to confirm the details of such connections immediately prior to actual signal installation often has resulted in costly construction revisions and delays.

Important items include:

1. Source of power (location.
2. Size of service (e.g., 100 amp, single phase).
3. Feed:
    - underground (manhole)
    - above ground (pole)
4. Whether a meter will be required.
5. Location of meter, if required.
    - poles
    - meter cabinet
    - controller cabinet
6. Special requirements of utility company:
    - wire type, size, gauge (AWG)
    - number of conductors
    - conduit type (rigid metal or PVC)

Communications Carrier

Many IVHS type projects make use of leased communications services. The communications carrier may be the local telephone company, and the technology may be as simple as twisted-wire pairs of copper wire. With the more complex systems, however, the technology is likely to be based on coaxial or fiber-optic cable, or even data radio (i.e. spread spectrum/micro lane).

Prior to installing any equipment which uses the facilities of a communications network, it is highly desirable to meet with representatives of that utility to determine the details and logistics of how the system is to be interfaced to the network. Of particular concern, is the licensing agreements, rate tariffs, payment of the monthly bill and switchover procedures. Who should performs the final hookup, what trade unions are allowed to perform what work, and who are the responsible supervisors for each agency are typical issues that must be resolved.

CONSTRUCT/ON RECORDS

Adequate documentation during construction is essential to the successful administration of all construction projects. Records required for system installation projects are similar to those for any roadway construction project. Each contracting agency normally has its own specific recordkeeping procedures, responsibilities, and record formats, including, where applicable, provisions for complying with federal and/or state aid requirements.

Generally, these records consist of:

1. Daily project diaries
2. Weekly status reports
3. Monthly estimates
4. Inspection and test reports
5. Plan revisions and change orders

Typical recordkeeping requirements for each of these categories are summarized below. All supervisory engineers and inspectors should be thoroughly familiar with the specific recordkeeping requirements of the contracting and funding agencies.

Daily Diaries

Daily diaries are commonly kept by each supervising engineer and inspector. On large projects, separate inspection diaries may be kept for each major construction item. On small projects, all entries may be recorded in a single “project diary” kept by the project engineer or authorized representative.

The diaries provide a written, day-to-day record of all important events, activities, decisions, and discussions. These include such items as weather conditions, location and quantities of materials installed, inspections and tests performed (including summary results), unusual conditions or problems encountered, major decisions and actions taken, and official conversations, telephone calls, or discussions related to the project. Any accident should be described in detail.

All entries should be neat, concise, and complete. When entries are made by more than one person, each entry should be signed individually. These diaries are an essential part of the project records should the project be subjected to audit, investigation, or litigation. They are also useful for determining construction progress and for judging claims for extra work.

To facilitate monitoring of installation progress, the project manager can use the design plan sheet as a supplement to the diary. Completed installation of each major item is recorded on the plan sheet, and the actual to-date quantity of each item is listed in the summary of quantities. This provides the project engineer a simple, quick, and effective means for estimating overall work progress.

Weekly Status Reports

Most contracting agencies require submission of weekly reports by the project engineer or authorized representative. These reports generally summarize the weekly accomplishments, overall construction progress, weather conditions, working day changes and delays, work suspensions/resumptions, contractors and subcontractors performing work, and any major problem encountered.

Monthly Estimates

Partial payments to the contractor for completed work are ordinarily based on monthly estimates prepared by the project engineer. Most contracting agencies have standard procedures and forms for recording materials, labor, and equipment used on the job and measured or estimated quantities of installed pay items required to determine the amount of partial payment due the contractor.

Some agencies require a daily or weekly tabulation of contract quantities placed for each pay item. This tabulation, and the contractor's breakdown of item cost, can be useful to the project engineer in preparing the monthly estimate. Lists of materials on hand but not yet placed may also be required.

On large projects, monthly estimates for such items as traffic signal installation may be difficult to determine, particularly where traffic signals are paid for on a lump sum or per signal basis. If a progress payment agreement for such items is not provided directly by agency policy, the project engineer should be sure to negotiate a partial payment plan with *the* contractor during the preconstruction conference.

Inspection and Test Reports

Each contracting agency normally has many different forms for reporting the results of inspections and tests on equipment, materials, and workmanship. Included are such records as plant inspection, materials, test reports, materials inspection reports, job control tests, storage of materials certificates, defective materials reports, equipment tests, and equipment weight certifications. All inspectors and project supervisory personnel should be thoroughly familiar with the forms and any manuals or other instructions for performing the tests and inspections. The project engineer and/or inspectors should review the project records frequently to ensure that all required reports are complete, accurate, and promptly submitted. Wherever practicable, the forms should be completed in the field by inspection personnel to minimize time expenditures and avoid subsequent transaction errors.

PIan Revisions and Change Orders

The construction plans and specifications are intended to provide for a completed installation. However, prevailing conditions at the time and location of installation may require changes in the contract documents. Such changes must be approved before the contractor can proceed with the work affected.

A paradox of the low-bid process is that the contractor who wins the project also has the greatest risk of losing money. Contractors base their bids on their interpretation of the conditions identified on the plans and the requirements in the specifications. Should these conditions and specified requirements change or prove erroneous, or should the contractor's interpretation be different than the engineers, then the project may start to cost the contractor more than originally anticipated as reflected in the bid. Given the low bidder's minimal tolerance for being subjected to additional costs, the contractor can easily end up in an unprofitable situation. Since profit is a precondition to a contractor's continued existence, the construction manager can expect to see change order requests and claims for additional compensation.

Most requests for extra compensation result from the contractor's contention that he/she was required to provide extra work and materials by reason of errors in the contract documents, changes, additions, delays and the like during the course of construction. It is the engineer's responsibility to determine if claims are legitimate and, if so, to determine an equitable value of the additional compensation. In general, a contractor is entitled to additional compensation under the conditions described below:

- <u>Actual Quantities Exceed Initial Estimate</u> -- Since it is the very nature of most unit-price contracts for the owner to agree to pay the contractor for each unit of work accomplished and/or material installed, this is usually not a problem. It is noted, however, that severe budgeting problems can occur if it becomes necessary to significantly increase certain quantities during system construction.

- Reduction in Quantities/Elimination of Work -- The contractor is usually not entitled to loss-of-profits resulting from the actual quantities being less than originally estimated, or elimination of entire items of work. This assumes, of course, that the specifications give the engineer the right to reduce quantities and to omit portions of the work. There are exceptions to this general rule. The elimination of work cannot alter the main purpose of the contract (i.e., to install a traffic control system). Furthermore, the contractor may be entitled to an adjustment in the unit price of an item if the reduction in quantities increases his/her unit cost of procuring or installing the item.

- Failure of Plans and Specifications -- As previously noted, the owner impliedly warrants the sufficiency of the plans and specifications supplied to the contractor. A corollary of this rule is that the contractor is entitled to additional compensation for any extra work resulting from defective plans and specifications. Defective in this sense means that the contract documents are technically incapable of producing the desired result, or they make misrepresentations of essential facts and conditions. A frequent example of this are underground utilities which have been hit and damaged by the contractor, but which were not shown on the plans nor marked in the field. Generally, the contractor cannot be held responsible to pay for the repairs. Another example is the use of existing conduit for communications cable. If the contractor is unable to install the cable in the conduit as specified due to blockages, collapses, severe bends, bends between handholes, existing cables that are tangled, or insufficient space, he/she is entitled to additional compensation for the time and materials initially spent attempting to install the cable, for locating and identifying the conduit problems, and for any resulting delays.

- Work Beyond the Contract Scope -- In general, a contractor who performs additional work not shown on the plans nor defined in the specifications is entitled to additional compensation if the work was requested by the agency. Following on with the conduit example, the contractor would also receive additional compensation for any repairs or other adjustments made to the existing conduit, if directed by the Project Engineer, and if such work was not included in the contract documents. Extra work of this nature is often relatively minor, involving incidental items which were inadvertently left out of the contract documents--for example, resetting a brick walk, or replacing an entire sidewalk slab (as required by local codes) when the specifications only require replacement of the trench width. However, there have been instances where the specifications were vague or incomplete concerning a major system item, resulting in substantial extra costs.

- Delays Caused by Owner -- A contractor is entitled to additional contract time for any delay caused by the owner, the owner's agent, or another contractor engaged by the owner on the same project. If the delay results in increased costs to the contractor, the contractor may also be entitled to additional compensation.

  The contract documents also apply to the agency, and the agency must be prepared to satisfy these requirements so as to not interfere with the contractor's work. Examples of delays which have been attributable to the owner or the owner's agents include failure to review contractor submittal within the specified time, failure to provide all government-furnished equipment and installations in accordance with the contractor's schedule, failure to complete make-ready work for utility poles on time, failure to complete testing for acceptance, and incomplete or substandard work provided by other contractors hired by the owner in conjunction with system implementation. The latter situation might include a leased-line communication network that is not functioning properly when contractor is ready to commence system integration, system detectors installed by another contractor which are inoperable, and a computer room contract that is still in progress when the central hardware is ready for shipment and installation.

- Change in Manner of Performance -- When the contract documents do not specifically describe the method of performance, the customary economical method is proper. If the contractor is directed by the engineer to perform in a more expensive manner than is customary, (i.e., night work limited work hours on an Interstate Road 9:00 Am to 3:00 PM contraflow lanes, etc.) the contractor is entitled to additional compensation. As such, when advanced techniques are contemplated, they should be specifically provided for in the contract documents.

Change Orders provide the formal means by which the contract documents may be modified with minimal impact on the system process. Some change orders should be expected during the construction process--after all, the estimated quantities can only be a close approximation; no design is ever all-inclusive and unknown conditions and additional work are bound to be encountered; and the participants in the system process, being human, are prone to change their minds sometime during the process. At the same time, “significant” change orders can be avoided by thorough planning, accurate and comprehensive design, and firm construction management.

Change order report forms generally must be completed by the project engineer or authorized representative. Change orders can cover such items as increased or decreased quantities, design alterations, materials substitutions or alterations, revisions to contract payment or completion time provisions, and other modifications to the specifications or special provisions. To avoid confusion, each change order should cover only one subject. Most change orders must also be signed by the contractor and approved by other responsible officials of the contracting agency. When FHWA funds are involved, change orders for increases or decreases of 20 percent or more on major contract items require approval by the FHWA area engineer. Similar approval by state officials may also be necessary for change orders on local state aid projects. Supplemental agreements generally require additional approvals. It is extremely important that the project engineer and his representatives be aware of all such requirements to avoid construction delays and potential future liability problems.

All design changes during construction should also be neatly and accurately recorded on applicable design plan sheets, which will become the record “as-built” plans. Included are such typical field modifications as signal pole or controller relocations, detector or conduit placement, and wiring or electrical modifications ordered as a consequence of field conditions and inspection.

E. EMISSIONS IMPACT ESTIMATES FOR POTENTIAL IVHS PROJECTS

APPENDIX E

BI-STATE ST. LOUIS AREA IVHS PLANNING STUDY

Emissions Impact Estimates for Potential IVHS Projects

I. Introduction

The following report provides emission estimates for current and future traffic volumes along the interstate highway system in the bi-state St. Louis area and includes an analysis of the potential impact that MHS measures could have on these pollutant emissions. Estimates are provided for various segments of the Interstate system which are presently experiencing significant travel delays. These segments are listed below and illustrated in Exhibit 1.

- Interstate 44 (EB); From Bowles Ave. to Route 61/67 (A.M. Peak)
- Interstate 55 (NB); From Meramec Bottom to Railroad Overpass (A.M. Peak)
- Interstate 55/70 (WB) From North B&O to West end of Poplar Street Bridge (AM Peak)
- Interstate 64 (EB); From Interstate 170 to Bellevue (A.M. Peak)
- Interstate 64 (WB); From Oakland to Interstate 170 (A.M. Peak)
- Interstate 64 (EB); From interstate 170 to State Line (P.M. Peak)
- Interstate 64 a From State Line to Interstate 170 (P.M. Peak)
- Interstate 70 (EB); From Cave Springs to Earth City (A.M. Peak)
- I-70 Exit ramp (EB/SB) From I-70 to I-270 (AM Peak)
- Interstate 70 (EB); From East Grand to Broadway (P.M. Peak)
- Interstate 70 (WB); From Union to Jennings Sta. (P.M. Peak)
- Interstate 70 (WB); From Earth City to Fairgrounds (P.M. Peak)
- Interstate 270 (EB/NB); From Interstate 64/40 to Route AB (A.M. Peak)
- Interstate 270 (EB); From Hanley/Graham to Route N (P.M. Peak)
- I-270 Exit ramp (NB/WB) From I-270 to I-70 (PM Peak)

II. Methodology

Traffic count information for the above segments, as well as others, was collected from the Missouri Highway & Transportation Department (MHTD) and the Illinois Department of Transportation (IDOT). These particular segments were chosen because their existing travel speeds are less than 45 mph during peak period(s). This travel speed data was also obtained from recent MHTD and IDOT studies of the freeway system.

Emission calculations were based upon the two-hour peak volume, the relative travel speed, the length of the segment and the appropriate emission factors for HC, CO and NO. The formula that was used was obtained from the Federal Highway Administration's, "A Method for Estimating Fuel Consumption and Vehicle Emissions on Urban Arterials and Networks". The emission factors were provided by the East-West Gateway Coordinating Council as generated from the MOBILES computer program. These emission factors correlate to the measured travel speed of a corridor.

Using this information, two different scenarios were examined. First, the current emissions were calculated and compared to estimates based on increased speed increments of 5 and 10 miles/hour. For the purposes of these calculations, the two-hour peak volumes were assumed to remain constant with the increase in speeds.

Secondly, Annual Growth Rates were provided by MHTD for the interstate system based upon 1992-1993 data. The AGR was then used to determine both ADT and peak hour volumes for the year 2013 (20 years), from which emission estimates were calculated. Travel speeds were assumed to remain constant for these calculations, although speeds would generally be lower due to increased volumes.

For both conditions, increased speeds would result in reduced emissions. An increase in travel speeds could be achieved by "flattening out the peaks" during peak traffic hours through traffic management strategies proposed for the IVHS system. These measures would presumably lessen the number and magnitude of traffic surges, thereby preventing congestion that might result from those conditions,

III. Emissions Estimates

Tables 1 and 2 illustrate the emission estimates for the previously mentioned segments. These results show comparisons of current emission estimates to those with increased speed increments and projected 20 year traffic growth estimates.

These calculations indicate that the opportunity exists to reduce both present-day and future auto emissions through improved traffic management The potential present-day benefits which could be derived from a five or ten-mile per hour increase in peak hour travel speeds are illustrated in Table 1. The second table illustrates the extent to which emissions could increase over the next 20 years due to projected traffic growth. The degree to which travel speeds could be increased through IVHS measures to offset these added emissions offers another potential benefit from this program.

It should be noted that the emission estimates contained in this memorandum are not intended to represent accurate pollutant calculations for the St. Louis area or its freeway system. Rather, the potential impacts are intended to illustrate the order of magnitude that may be realized through the implementation of IVHS strategies.

IV. Summary and Conclusions

By summarizing the attached tables, as shown in Table 3, it can be seen that the selected links would generate roughly 470,000 Ibs/year of HC, 3.68 million Ibs/year of CO and 625,000 Ibs/year of NO_x. These totals may be expected to increase by 315,000, 2.42 million and 390,000 Ibs/year, respectively, within the next 20 years without any improvements, although the increase in pollutants would likely be even greater since higher volumes would result in even slower travel speeds. These additional emissions would represent increases of approximately 65%.

As shown, the implementation of IVHS technologies may be expected to increase peak hour travel speeds by as much as five or ten miles per hour. These changes in travel speeds would result in emissions savings of 60 to 100 thousand Ibs/year of HC, 575 to 955 thousand Ibs/year of CO, and an increase of 780 to 10,600 Ibs/year of NO_x. Emissions of HC and CO would both be reduced by 12 to 25%, but NO_x emissions would increase from 0 to 2%.

As previously mentioned, these totals do not represent pollutant calculations for the entire St. Louis area or its freeway system. However, it may be reasoned that HC and CO emissions could be reduced by 12 to 25% along those sections of freeway on which IVHS measures are applied, while NO, emissions would remain relatively unchanged. An equivalent level of improvements might also be assumed for the 20 year forecasts, thereby offsetting, to some degree, those emissions increases that would be caused by higher traffic volumes.

TABLE 1

POTENTIAL PRESENT-DAY EMISSION REDUCTIONS ALONG THE INTERSTATE HIGHWAY SYSTEM WHICH COULD RESULT PROM INCREASED TRAVEL SPEEDS

Corridor/Location: I-44 (EB); Bowles Avenue to Route 61/67 (AM)									
lbs/day lbs/yr.	Existing Speed: 34.2 mph			Projected Speed: 39.2 mph			Projected Speed: 44.2 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	121	866	191	107	769	190	98	706	195
Annually	31,460	225,160	49,660	27,820	199,940	49,400	25,480	183,560	50,700

Corridor/Location: I-55 (NB); Meramec Bottom to Railroad Overpass (AM)									
lbs/day lbs/yr.	Existing Speed: 25.8 mph			Projected Speed: 30.8 mph			Projected Speed: 35.8 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	96	752	124	85	635	125	76	555	126
Annually	24,960	195,520	32,240	22,100	165,100	32,500	19,760	144,300	32,760

Corridor/Location: I-55/70 (WB) North End B&O to West end of Poolar Street Bridee (AM)									
lbs/day lbs/yr.	Existing Speed: 17.5 mph			Projected Speed: 22.5 mph			Projected Speed: 27.5 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	159	1,313	158	130	1,052	153	107	868	152
Annually	38,780	41,340	341,380	141,080	33,800	273,526	27,820	225,680	39,520

Corridor/Location: I-64 (EB): I-170 to Bellevue (AM)									
lbs/day lbs/yr.	Existing Speed: 20 mph			Projected Speed: 25 mph			Projected Speed: 30 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	88	734	96	75	593	95	66	498	95
Annually	22,880	190,840	24,960	19,500	154,180	24,700	17,160	129,480	24,700

TABLE 1 (CONTINUED)

Corridor/Location: I-64 (WB): Oakland to I-170 (AM)									
lbs/day lbs/yr.	Existing Speed: 29.5 mph			Projected Speed: 34.5 mph			Projected Speed: 39.5 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	66	500	94	58	433	95	54	387	96
Annually	17,160	130,000	24,440	15,080	112,580	24,700	14,040	100,620	24,960

Corridor/Location: I-64 (EB): I-170 to State Line (PM)									
lbs/day lbs/yr.	Existing Speed: 23.7 mph			Projected Speed: 28.7 mph			Projected Speed: 33.7 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	299	2,381	364	261	1,982	363	233	1,707	365
Annually	77,740	619,060	94,640	67,860	515,320	94,380	60,580	443,820	94,900

Corridor/Location: I-64 (WB): State Line to I-170 (PM)									
lbs/day lbs/yr.	Existing Speed: 35.4 mph			Projected Speed: 40.4 mph			Projected Speed: 45.4 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	290	2,190	472	264	1,894	480	243	1,752	498
Annually	75,400	569,400	122,720	68,640	492,440	124,800	63,180	455,520	129,480

Corridor/Location: I-70 (EBI: Cave Sorines to Earth City (AM)									
lbs/day lbs/yr.	Existing Speed: 24.1 mph			Projected Speed: 29.1 mph			Projected Speed: 34.1 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	292	2,321	360	256	1,938	360	228	1,673	362
Annually	75,920	603,460	93,600	66,560	503,880	93,600	59,280	434,980	94,120

TABLE 1 (CONTINUED)

Corridor/Location: I-70 Exit Ramp: I-70 to I-270 (EB/SB) (AM)									
lbs/day lbs/yr.	Existing Speed: 17.9 mph			Projected Speed: 22.9 mph			Projected Speed: 27.9 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	41	342	42	34	274	41	30	227	40
Annually	10,660	88,920	10,920	8,840	71,240	10,660	7,800	59,020	10,400

Corridor/Location: I-70 (EB): East Grand to Broadway (PM)									
lbs/day lbs/yr.	Existing Speed: 36.6 mph			Projected Speed: 41.6 mph			Projected Speed: 46.6 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	62	446	103	56	403	105	52	375	109
Annually	16,120	115,960	26,780	14,560	104,780	27,300	13,520	97,500	28,340

Corridor/Location: I-70 (WB): Union to Jennings Sta. (PM)									
lbs/day lbs/yr.	Existing Speed: 34.1 mph			Projected Speed: 39.1 mph			Projected Speed: 44.1 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	52	384	83	48	342	84	44	314	87
Annually	13,520	99,840	21,580	12,480	88,920	21,840	11,440	81,640	22,620

Corridor/Location: I-70 (WB): Earth City to Fairgrounds (overpass) (PM)									
lbs/day lbs/yr.	Existing Speed: 23.4 mph			Projected Speed: 28.4 mph			Projected Speed: 33.4 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	144	1,150	174	125	955	173	112	821	174
Annually	37,440	299,000	45,240	32,500	248,300	44,980	29,120	213,460	45,240

TABLE 1 (CONTINUED)

Corridor/Location: I-270 (EB/NB): I-64/40 to Route AB (AM)									
lbs/day lbs/yr.	Existing Speed: 26.2 mph			Projected Speed: 31.2 mph			Projected Speed: 36.2 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	64	498	84	57	422	84	51	369	85
Annually	16,640	129,480	21,840	14,820	109,720	21,840	13,260	95,940	22,100

Corridor/Location: I-270 (EB): Hanley/Graham to Route N (PM)									
lbs/day lbs/yr.	Existing Speed: 34.5 mph			Projected Speed: 39.5 mph			Projected Speed: 44.5 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	17	117	26	14	104	26	13	96	27
Annually	4,420	30,420	6,760	3,640	27,040	6,760	3,380	24,960	7,020

Corridor/Location: I-270 Exit Ramp: I-270 to I-70 (NB/WB) (PM)									
lbs/day lbs/yr.	Existing Speed: 34.6 mph			Projected Speed: 39.6 mph			Projected Speed: 44.6 mph		
	HC	CO	NO	HC	CO	NO	HC	CO	NO
Daily	20	149	33	18	133	33	17	122	34
Annually	5,200	38,740	8.580	4,680	34,580	8,580	4,420	31,720	8,840

TABLE 2
POTENTIAL FUTURE EMISSION INCREASES ALONG THE INTERSTATE HIGHWAY SYSTEM
WHICH COULD RESULT FROM THE EFFECT
OF PROJECTED 20-YEAR TRAFFIC GROWTH RATES

Corridor/Location: I-44 (EB); Bowles Avenue to Route 61/67 (AM)									
Travel Speed: 34.2 mph				Length of Section: 3.77 miles					
	Current			20 Years			Net Difference		
	ADT = 48,140			ADT = 80,233			ADT = 32,093		
	Peak Volume = 10,428			Peak Volume = 17,380			Peak Volume = 6,952		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	121	866	191	202	1,443	318	82	577	127
Peak Annually	31,460	225,160	49,660	52,520	375,180	82,680	21,060	150,020	33,020

Corridor/Location: I-55 (NB); Meramec Bottom to Railroad Overpass (AM)									
Travel Speed: 25.8 mph				Length of Section: 2.9 miles					
	Current			20 Years			Net Difference		
	ADT = 41,942			ADT = 69,903			ADT = 27,961		
	Peak Volume = 9,075			Peak Volume = 15,125			Peak Volume = 6,050		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	96	752	124	161	1,253	207	65	501	83
Peak Annually	24,960	195,520	32,240	41,860	325,780	53,820	16,900	130,260	21,580

Corridor/Location: I-55/70 (WB); North B&O to West end Poplar Street Bridge (AM)									
Travel Speed: 17.5 mph				Length of Section: 3.48 miles					
	Current			20 Years			Net Difference		
	ADT = 56,000			ADT = 93,333			ADT = 37,333		
	Peak Volume = 9,279			Peak Volume = 15,465			Peak Volume = 6,186		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	159	1,313	158	265	2,189	263	106	876	105
Peak Annually	41,340	341,380	41,080	68,900	569,140	68,380	27,560	227,760	27,300

TABLE 2 (CONTINUED)

Corridor/Location: I-64 I-170 to Bellevue (AM)									
Length of Section: 1.71 mileS				Travel Speed: 20 mph					
	Current			20 Years			Net Difference		
	ADT = 65,706			ADT = 109,510			ADT = 43,804		
	Peak Volume = 11,779			Peak Volume = 19,632			Peak Volume = 7,853		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	88	734	96	147	1,224	160	59	490	64
Peak Annually	22,880	190,840	24,960	38,220	1,318,240	41,600	15,340	127,400	16,640

Corridor/Location: I-64 (WB); Oakland to I-170 (AM)									
Travel Speed: 29.5 mph				Length of Section: 2.37 miles					
	Current			20 Years			Net Difference		
	ADT = 66,625			ADT = 111,042			ADT = 44,417		
	Peak Volume = 8,397			Peak Volume = 13,995			Peak Volume = 5,598		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	66	500	94	110	833	156	44	333	62
Peak Annually	17,160	130,000	24,440	28,600	216,580	40,560	11,440	86,580	16,120

Corridor/Location: I-64 (EB); I-170 to State Line (PM)									
Travel Speed 23.7 mph				Length of Section: 9.05 miles					
	Current			20 Years			Net Difference		
	ADT = 65,875			ADT = 109,792			ADT = 43,917		
	Peak Volume = 8,489			Peak Volume = 14,148			Peak Volume = 5,659		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	299	2,381	364	498	3,696	606	307	1,315	242
Peak Annually	77,740	619,060	94,640	129,480	1,031,940	157,560	51,740	412,880	62,920

TABLE 2 (CONTINUED)

Corridor/Location: I-64 (WB); State Line to I-170 IWBI: State Line to I-170 (PM)									
Travel Speed: 35.4 mph				Length of Section: 9.07 miles Length of Section: 9.07 miles					
	Current			20 Years			Net Difference		
	ADT = 66,898			ADT = 111,497			ADT = 44,599		
	Peak Volume = 10,930			Peak Volume = 18,217			Peak Volume = 7,287		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	290	2,109	472	483	3,516	786	193	1,407	314
Peak Annually	75.400	569.400	122.720	125.580	914.160	204.360	50.180	344,760	81,640

Corridor/Location: I-70 (EB); Cave Springs to Earth City (AM)									
Travel Speed: 24.1 mph				Length of Section: 5.14 miles					
	Current			20 Years			Net Difference		
	ADT = 89,064			ADT = 148,440			ADT = 59,376		
	Peak Volume = 14,804			Peak Volume = 24,673			Peak Volume = 9,869		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	292	2,321	360	487	3,868	601	195	1547	241
Peak Annually	75,920	603,460	93,600	126,620	1,005,680	156,260	50,700	402,220	62,660

Corridor/Location I-70 Exit Ramp; I-70 to I-270 (EB/SB) (AM)									
Travel Speed: 17.9 mph				Length of Section: 1.46 miles					
	Current			20 Years			Net Difference		
	ADT =			ADT =			ADT =		
	Peak Volume = 5,863			Peak Volume = 9,772			Peak Volume = 3,909		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	41	342	42	69	570	69	28	228	27
Peak Annually	10,660	88,920	10,920	17,940	148,200	17,940	7,280	59,230	7,020

TABLE 2 (CONTINUED)

Corridor/Location: I-70 (EB); East Grand to Broadway (PM)									
Travel Speed: 36.6 mph				Length of Section: 2.47 miles					
	Current			20 Years			Net Difference		
	ADT = 65,987			ADT = 109,978			ADT = 43,991		
	Peak Volume = 8,727			Peak Volume = 14,535			Peak Volume = 5,808		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	62	446	103	103	743	172	41	297	69
Peak Annually	16,120	115,960	26,780	26,780	193,180	44,720	10,660	77,220	17,940

Corridor/Location: I-70 (WB); Union to Jennings Sta. (PM)									
Travel Speed: 34.1 mph				Length of Section: 1.51 miles					
	Current			20 Years			Net Difference		
	ADT = 66,633			ADT = 111,055			ADT = 44,422		
	Peak Volume = 11,564			Peak Volume = 19,273			Peak Volume = 7,709		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	52	384	83	87	640	138	35	256	55
Peak Annually	13,520	99,840	21,580	22,620	166,400	35,880	9,100	66,560	14,300

Corridor/Location: I-70 (WB); Earth City to Fairgrounds (PM)									
Travel Speed: 23.4 mph				Length of Section: 2.5 miles					
	Current			20 Years			Net Difference		
	ADT = 87,868			ADT = 146,447			ADT = 58,579		
	Peak Volume = 14,658			Peak Volume = 24,430			Peak Volume = 9,772		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	144	1,150	174	240	1,916	289	96	766	115
Peak Annually	37,440	299,000	45,240	62,400	498,160	75,140	24,960	199,160	29,900

TABLE 2 (CONTINUED)

Corridor/Location: I-270 (EB/NB): I-64/40 to Route AB (AM)									
Travel Speed: 262 mph				Length of Section:1.17 miles					
	Current			20 Years			Net Differencee		
	ADT = 92,237			ADT = 153,726			ADT = 61,491		
	Peak Volume = 15,128			Peak Volume = 25,213			Peak Volume = 10,085		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	64	498	84	107	830	139	43	332	55
Peak Annually	16,640	129,480	21,840	27,820	215,800	36,140	11,180	186,320	14,300

Corridor/Location: I-270(EB); Hanley/Gaham to Route N (PM)									
Travel Speed: 34.5 mph				Length of Section: .97 miles					
	Current			20 Years			Net Difference		
	ADT = 27,221			ADT = 45,368			ADT= 18,147		
	Peak Volume = 5,533			Peak Volume = 9,222			Peak Volume = 3,669		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	17	117	26	28	195	43	11	78	17
				7,280	50,700	11,180	2,860	20,280	4,420

Corridor/Location: I-270 Exit Ramp; I-270 to I-70 (NB/WB) (PM)									
Travel Speed: 34.6 mph				Length of Section: 1.74 miles					
	Current			20 Years			Net Difference		
	ADT =			ADT =			ADT =		
	Peak Volume = 3,936			Peak Volume = 6,560			Peak Volume =2,624		
(lbs/day) (lbs/yr)	HC	CO	NO	HC	CO	NO	HC	CO	NO
Peak Daily	20	149	33	34	248	54	14	99	21
Peak Annually	5,200	38,740	8,580	8,840	64,480	14,040	3,640	25,740	5,460

TABLE 3

SUMMARY OF POLLUTANT EMISSIONS CALCULATIONS FOR
SELECTED FREEWAY SEGMENTS

Total Emissions (lb/yr)			Projected Change in Emissions from Existing Traffic Due to Increased Travel Speeds	
	With Existing Traffic	Estimated 20-year Increase (with projected traffic growth)	With a 5 mph Increase	With a 10 mph Increase
HC	470,860	314,600	-57,980 (-12%)	100,620 (-21%)
CO	3,677,180	2,416,440	-575,640 (-16%)	-954,980 (-26%)
NOx	625,040	391,040	+780 (0%)	+10,660 (+2%)