Intelligent Transportation Systems Early Deployment Planning Study

June 1996

Sacramento Area Council of Governments

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I. EXECUTIVE SUMMARY

Study Goals

Intelligent Transportation Systems (ITS) refer to innovative approaches to solving transportation problems and providing services to travelers. ITS solutions are typically based on a user's view of the transportation system, and rely on partnerships among transportation system operators and service providers in both the public and private sector for implementation of projects. The Early Deployment Planning Study (EDPS) is intended to identify Intelligent Transportation Systems (ITS) strategies which address transportation problems occurring in the Sacramento region, and recommend a blueprint for implementing these strategies.

The EDPS started with a workshop of study participants, which identified a listing of transportation problems facing the region. Six goals for ITS implementation which addressed these problems were developed, using input from the workshop group, and the SACOG Regional Planning Partnership:

- ***Reduce Roadway Traffic Congestion***
- ***Reduce Pollution from On Road Sources***
- ***Improve Traveler Safety***
- ***Improve Transit Service Utilization***
- ***Facilitate Commercial Vehicle Travel***
- ***Minimize the Impacts Of Through and Inter-Regional Travel***

Inventory Existing and Programmed ITS Projects

One of the guidelines used throughout the EDPS was to build on existing systems, and to take advantage of current ITS initiatives in the Sacramento region. This guideline was especially important in defining new ITS project concepts which will be needed to provide the selected ITS user services.

In total, over $15 million in existing or programmed ITS projects were identified, covering a wide range of ITS user services. These existing and programmed projects provide building blocks for future implementation of ITS in the region.

Traffic Operations Systems (TOSs) on the Freeway System.TOS's include a wide range of monitoring and management tools, such as traffic monitoring stations, ramp meters, close circuit television cameras, changeable message signs, and highway advisory radios. These facilities are monitored and controlled from a Transportation Management Center (TMC), jointly staffed and operated by Caltrans District 3 and the California Highway Patrol Valley Division. These systems fall into the incident management, traffic control, and en-route traveler information user services.

Traffic Operations Centers (TOC's) for Sacramento City and County. Both the City of Sacramento, and the County of Sacramento, have made significant investments in TOC's, which are functionally similar to

the Caltrans/CHP TMC described above. The major difference is that the TOC's are primarily intended to centralize management and coordination of surface street traffic signal systems in each jurisdiction, while the TMC is primarily focused on incident management and response. These facilities fall into the traffic control user service area.

Public Transit Management Systems. The major example of this is Paratransit, Inc.'s "PASS" system. This system is used to streamline routing and dispatch of Paratransit passenger vehicles, and has greatly improved the flexibility and reliability of this service. This system falls into the public transit management user service area.

Freeway Service Patrol (FSP). The Sacramento Transportation Authority operates the FSP in Sacramento County. This service falls into the incident management user service area.

SAFE Call Boxes. The Capitol Valley Regional Safe Authority operates the call box program in Sutter, Yuba, Sacramento, Yolo and San Joaquin Counties. The call boxes provide a limited degree of incident management user service, as well as traveler safety and security.

Demonstrations and Field Operation Tests (FOT's). In addition to these ITS projects, three significant ITS demonstration projects are currently going on in the Sacramento region. As demonstrations, all are projects which are funded for limited operational periods. However, opportunities for full implementation of the successful portions of each demonstration are being explored by the project sponsors and lead agencies.

- ***California Smart Traveler*** - This program includes two elements applicable to the Sacramento region: the "l-800-COMMUTE" service, and the Smart Traveler Internet Site. Both provide the public with direct access to roadway condition information, transit schedules, and services such as ride matching. The project is currently sponsored by Caltrans, and other project sponsors and funding is being sought.

- ***TransCal*** - This project focuses on integration of travel information and services for the San Francisco Bay Area-Sacramento-Sierra Foothills-Tahoe-Reno travel corridor, and provision of this information and services directly to travelers through a variety of media: local radio and TV broadcasts; electronic kiosks; a dial-up telephone advisory; in-vehicle displays; and hand-held digital displays. TransCal also includes an ambitious transit information and incentive project for the Reno-Tahoe area. The TransCal partnership is primarily interested in developing test versions of these services, and will be working with local agencies and organizations to develop approaches for sustained operation of the successful elements of the demonstration.

- ***Sutter County ITS Program*** - This is a demonstration of four ITS project elements: "smart" call boxes, which also serve as fog-detectors and traffic monitors; emergency vehicle traffic signal preemption systems; forward-looking infra-red (FLIR) collision avoidance systems for emergency vehicles operating in foggy conditions; and public transit management systems.

Information on existing and programmed projects was collected by SACOG, and verified by project sponsors. Listings were circulated for review in special ITS workshops, and at meetings of the Partnership. In some cases, cost information was not available.

Selection of Candidate ITS User Services

For planning purposes, "ITS" was defined as a set of 29 "user services". The ITS users services are defined not according to particular technologies or products, but rather, in terms of services which directly or indirectly benefit travelers in the Sacramento region. Starting from the goals identified above, the listing of 29 user services was examined in a workshop of study participants and at the Partnership, and reduced to a subset of 14 user services which have unique applicability in the Sacramento region. This subset included five users services which were determined to be of general applicability in the region, due to the number and cross-section of travelers benefitted, the number of transportation problems addressed, and other criteria.

- ***Traffic Control*** (e.g. traffic signal coordination, ramp metering, and coordination of traffic controls across jurisdictional boundaries)
- ***Incident Management (e.g.*** monitoring and surveillance systems, and coordination of agencies responding to incidents)
- ***En-Route Driver Information*** (e.g. changeable message signs and highway advisory radio)
- ***Emissions Testing and Mitigation*** (e.g. monitoring of air quality "hot spots")
- ***Public Transportation Management*** (e.g. GPS-based dispatching and monitoring of transit vehicles)

An additional eight user services were determined to be applicable in the region, but limited in terms of the potential beneficiaries or the number of transportation problems addressed.

All of the study findings and recommendations outlined above were summarized in the "Interim Report: Goals, Objectives and User Services Selection" (5/9/95), which was reviewed by the Partnership and accepted by the SACOG Board of Directors in May 1995. This report summarized the major policy directions for ITS implementation in the Sacramento region, which were the subject of the following phases of the EDPS.

Delivery of Selected User Services

The tasks outlined-above were completed by SACOG staff, working in concert with EDPS participant agencies and organizations. Identifying options for delivery of the selected user services was primarily the responsibility of the technical consultant for the EDPS, JHK Associates. JHK Associates participated in the workshops referenced above, and did additional Interviews and focus groups of study participants in developing an approach for delivering the selected user services. The user services delivery system included recommendations for a set of eleven collaborative, interagency projects, in concert with existing and programmed projects, and with other ITS projects proposed by single agencies. Listed below are some of the major interagency projects, which were recommended to be considered for early deployment (i.e. in 5 years or less).

Urban Area Traffic Control Network. This project involves roadway and transit systems in the urbanized area of Sacramento, and would provide a computer and communications network for exchange of traffic operations and incident data. This would provide tools for system operators such as Caltrans, City and County government agencies, to better manage and coordinate traffic signals and incident management across jurisdictional boundaries. This project concept is dependent on the development of various traffic

and incident management projects currently planned or programmed by participating agencies, such as the Sacramento Downtown Mastercontroller Project and the Sacramento County Traffic Operations Center. A funding proposal for a portion of this project concept was advanced by Caltrans District 3, California Highway Patrol, County of Sacramento, City of Sacramento, Regional Transit, and several private traveler services companies, for the Federal Highway Administration "ITS Model Deployment Initiative (MDI) Program".

Transit Services Network. This project would provide a computer and communications network for exchange of schedule, ride request' and other information among transit operators in the region. This would be a system operator's network, which supplement existing customer services provided by the operating agencies. It would also provide a basis for developing interactive transit trip planning services for individual travelers. This project is dependent on various public transit management projects planned and programmed by the participating agencies. A transit trip planning system for Sacramento Regional Transit District was also a part of the Sacramento MDI Proposal.

Traveler Information Database. This project would establish an integrated database of real-time information on all modes of travel, which could be disseminated to travelers through a variety of means, including the local broadcast media' the Internet, dial-up telephone advisories, information kiosks, and other more advanced devices. Many examples of this type of database exist around the country. The closest thing which Sacramento has is the Smart Traveler program, which provides a limited amount of real-time travel data through the Internet and through the "1-800-COMMUTE" service. While the establishment of the database is proposed to be a public agency initiative, the dissemination of the information to the public is expected to be a private sector role. El Dorado and Placer Counties are developing plans for a traveler information system to deal with tourist and local travel needs during the Gold Rush Sesquicentennial and other attractions in the area. A traveler information database for the Sacramento urbanized area' plus public access to the database via the local broadcast media' the Internet, and other means was also a part of the Sacramento MDI Proposal.

In concert with these projects, JHK Associates recommended a number of interagency coordination projects: developing standardized information and data exchange protocols, regional incident management procedures, and demand management and operations. These coordination efforts would be undertaken in concert with the above-mentioned project efforts.

In total, the recommended interagency projects, combined with projects proposed by single agencies, total $55 million dollars for projects with known costs. However, because many of the proposed projects are conceptually defined at this point' and because the technologies and products which would be used are changing rapidly, this total cost estimate should be considered as very preliminary. (For comparison, agencies in the Atlanta region have spent approximately $190 million to develop a fully integrated advanced traffic management system, public transit management system, and traveler information system in preparation for the Olympics in Summer 1996.)

This proposal for ITS user services delivery was detailed by JHK Associates in the "Project Summaries and Technology Assessment" binder (10/11/95) and in the "Summary Analysis Report" (10/11/95). These documents were circulated to all EDPS participants, and presented for review and comment at an ITS workshop, and to the Partnership.

Expected Traveler Benefits

Estimates of benefits of ITS projects are based on research by JHK Associates on ITS projects implemented in other parts of the country. Because the ITS projects recommended in this study are conceptual, the benefits are expressed as ranges, with the low end of the range corresponding to low-level project implementation with a minimum level of interagency coordination, and the high end of the range corresponding to high-level project implementation, with the maximum level of interagency coordination. Also, for some project types, initial implementation efforts have already been made, and implementation of future elements may provide lower incremental benefits. Again, these estimates are based on actual, measured results achieved in other parts of the country, and not on simulations.

Freeway and Incident Management Systems. These systems include the various TOS projects sponsored by Caltrans District 3, the proposed Caltrans/CHP Regional TMC, and elements of the proposed Urban Area Traffic Control Network. In other areas, the range of measured benefits have been:

- Travel time decreases of 20 to 48 percent;
- Travel speed increases of 16 to 62 percent;
- Freeway capacity increases of 17 to 25 percent; and
- Significant decreases in average response time to incidents.

Traffic Signal Systems. These systems include surface street traffic signal coordination projects, and advanced traffic management projects such as the City of Sacramento Downtown Master Controller Project and the County of Sacramento TOC Project. The range of measures benefits have been:

- Travel time decreases of 8 to 15 percent;
- Travel speed increases of 14 to 22 percent;
- Decreases in the number of vehicle stops of up to 35 percent; and
- Decreases. in average driver delay of 17 to 37 percent.

Additional benefits of video surveillance included in the City of Sacramento and County of Sacramento TOC projects arereduced maintenance and field operations costs.

Transit Management Systems. These systems include automated vehicle location (AVL) systems, advanced communications and dispatch systems, and transit vehicle signal preemption. The range of measures benefits for these projects have been:

- Decreases in transit travel time of 5 to 8 percent;
- Increases in on-time performance of 12 to 23 percent; and
- Decreases in response time to incidents such as transit vehicle breakdowns and security calls.

Benefits for other ITS projects, such-as traveler information systems, **have** not been well documented. However, some local data on user acceptance and impact of travel behavior will be generated as part of the TransCal project and the Smart Traveler program.

Funding and Implementation Plan

For the purposes of funding, ITS projects break down into three general categories: multi-agency collaborative projects, single agency projects, and showcase or demonstration projects. Six sources of funding are available for these project types: local agency/operator budgets; regionally-allocated transportation funding programs; state transportation funding programs; direct Federal ITS funding programs; private sector participation; and dedicated public funding programs. Other than special Federal ITS funding programs, no discretionary funding source is dedicated for ITS projects. ITS projects will have to compete with other types of projects for limited public funding.

For single-agency projects, the primary funding source should be local agency and operator budgets, with regionally allocated funding or state sources as a secondary funding source for projects with a broad area of benefit.

For multi-agency, collaborative projects, regionally-allocated and state funding sources should be considered as primary sources, with supplemental and matching funds from local agency and operator budgets, and private sector participation.

For showcase or demonstration projects, Federal funding sources should be considered primary, with supplemental funding from state, regionally-allocated, and private sector sources.

Three project concepts are proposed for implementation in the Sacramento region in the short range (i.e. next five years).

- Urban Area Traffic Control Network.
- Transit Services Network
- Traveler Information Database

An ITS Coordination Group, including any local agency operator interested in working toward implementation of these project concepts, should be established. The Coordination Group would be tasked with information sharing, project coordination, and development of funding for multi-agency ITS projects. In the coming year, specific action items for the group will be:

- Follow up on the Sacramento Model Deployment Initiative proposal,
- Investigation and development of private sector partnerships.
- Coordination with ongoing ITS demonstration projects in the region, and with other ITS planning and project development efforts in the region and in adjacent regions.

The funding and implementation strategy is detailed in the "Task 9 Technical Memorandum: Funding and Implementation Strategy", and was presented for review and comment to EDPS participants at a special workshop, and later to the Partnership.

II. INTRODUCTION

The Sacramento ITS Early Deployment Planning Study (EDPS) is co-sponsored by SACOG, Caltrans District 3, and the California Highway Patrol Valley Division, with SACOG serving as the lead agency. A three-member Coordination Team, with representatives of the study sponsors, is directing the study. Each of the Congestion Management Agencies in the study area' which include El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba counties are serving as ex-officio members of the Coordination Team, which provided management oversight for the project.

JHK Associates served as the technical consultant for the project. JHK Associates has experience in planning, design, and operation of ITS systems nationwide, and also served a key advisory role to Federal Highway Administration (FHWA) in development of the ITS Early Deployment Planning Program. JHK assisted in evaluation of the benefits of ITS, development of a concept for delivering key ITS user services, and identifying project concepts necessary for implementing these use services in the Sacramento region.

The EDPS was funded through an FHWA Early Deployment Planning grant' with matching funds provided by SACOG and Caltrans District 3.

Study Participants

When the EDPS scope of work was defined, it was decided that the project would be supported by existing SACOG Advisory Committees, with no special technical advisory committee established. Input for the EDPS came from several sources:

ITS Workshops. The main input came from a series of five workshops, which ranged from two hours to one-and-one-half days in length, the workshops were attended by representatives of 18 local agencies. On the average, eight to ten agencies were represented at each workshop. Topics which were covered included: identifying transportation problems; rating the applicability of ITS user services for each transportation problem; preliminary review of the "system architecture" for delivery of ITS user services; and review of the conceptual ITS projects recommended by the JHK Associates; and . The workshops were supplemented by a series of focus group meetings and interviews conducted by JHK Associates.

SACOG Advisory Committees. Additional input came from the SACOG Advisory Committees. The major source of input was from the Regional Planning Partnership. Eight items related to this project were presented for discussion at the Partnership, and all the technical memorandums and interim reports were presented for review and comment. Presentations were also made to the Freight Advisory Committee, the Transit Coordinating and Productivity Committee, and the Bicycle and Pedestrian Task Force.

Finally, presentations on the project were made to the Yolo County Transportation Authority, the Bi-County Transportation Authority, and to the technical advisory committees of the Sacramento Transportation Authority and the Placer County Transportation Authority.

A log of all meetings, workshops, and SACOG advisory committees at which discussions on the EDPS, and a listing of study participants by agency, is provided in Appendix A.

National ITS Program Overview

The Ititermodal Surface Transportation Efficiency Act (ISTEA) was enacted in 1991, and established the "Intelligent Vehicle-Highway Systems" program (now referred to as the Intelligent Transportation Systems or "ITS" program). ISTEA also set forth ITS goals, specified planning, implementation, and reporting requirements, and authorized funding through fiscal year 1997.

In the past, response to increased traffic demands resulted in the construction of new transportation facilities. ISTEA changes this by encouraging improved efficiency in managing existing facilities. The emphasis has been shifted from facility construction to the provision of user services, where users include travelers, transportation providers, and all others impacted by the transportation system.

The ITS Program, as an explicit component of ISTEA, provides flexibility to state and local governments to fund projects that have the greatest potential to benefit users and the transportation system. By providing a framework for planning, the ITS program promotes coordination between government agencies and the private sector in the development and deployment of user services. The ITS Program has also outlined a deployment vision aimed at smoothing intermodal linkages and creating a coordinated national transportation system.

The Federal Highway Administration (FHWA) has funded projects in 75 of the nation's largest metropolitan areas, to investigate ITS applications at the local level. The Sacramento area was selected as one of the regions to be included in the national Early Deployment Program. Through the completion of the EDPS, the Sacramento region will be in a better position to compete for and receive implementation funding, which may be forthcoming from FHWA and other sources. Since economic and political support for the construction of new facilities is increasingly limited, the vitality of the region's transportation network is dependent upon maximizing the benefits of the existing infrastructure. ITS offers some unique approaches to doing this.

In addition to funding the Early Deployment Planning Program, FHWA and the Federal Transit Administration (FTA) have provided funding for various ITS demonstration projects, field operation tests (FOT's) and "model deployment" projects. Two examples of these projects funded through this program in the Sacramento region will be discussed later.

More recently, the U.S. Department of Transportation announced "Operation Timesaver", which is a major program oriented to implementing key ITS elements across the nation by 2001. As part of this effort, . FHWA and FTA sponsored the "ITS Model Deployment Initiative Program" (MDI). The MDI Program was allocated $20 million dollars for 1996, and will provide matching funds for implementation of fully-integrated, intermodal ITS programs in two or three metropolitan areas. Several agencies in the Sacramento area recently submitted a proposal for this Program.

ITS User Services

For planning purposes, "ITS" was defined as a set of 29 "user services". The ITS users services are defined not according to particular technologies or products, but rather, in terms of services which directly or indirectly benefit travelers in the Sacramento region. This explicit reference to services which provide tangible benefits to travelers reflects the user perspective which is part of ITS planning. Technologies and products are changing and evolving very quickly, and any reference to a specific technology today may be obsolete in a year or two. The needs of traveler for information, services, and benefits of more efficiently managed transportation systems are less likely to change in the short range, and are a better reference point for ITS planning. Additionally, the user service concept, since it is not dependent on technical expertise, allowed for non-technically trained individuals to participate in the study, especially in the early phases (definition of goal, objectives and selection of user services).

The 29 ITS user services are grouped into seven "bundles", and are listed below. A more detailed description of the user services is provided in Appendix B.

Travel and Transportation Management.

- ***En-Route Driver Information*** - Provides accurate, real-time travel advisories to drivers at the roadside (e.g. through changeable message signs) and inside the vehicle (through the radio or 'special in-vehicle graphic displays) for convenience and safety.
- ***Route Guidance*** - Provides travelers with simple instructions on how to reach their destinations, after the traveler has started the trip.
- ***Traveler Services Information*** - Provides a business directory, or "yellow pages" of service information, specially tailored to the needs of specific traveler groups (e.g. to tourists, commuters, etc.).
- ***Traffic Control*** - Manages the movement of traffic on streets and highways (e.g. coordinated traffic signals, ramp meters, etc.)
- ***Incident Management*** - Helps public and private organizations quickly identify incidents and respond and effectively to return roadway facilities to normal flow (e.g. video surveillance, coordinated dispatch, etc.).
- ***Emissions Testing and Mitigation*** - Provides information for monitoring air quality and developing air quality improvement strategies at "hot spots" of vehicle emissions (e.g. the Bureau of Auto Repair tailpipe monitoring program).

Travel Demand Management

- ***Pre-Trip Travel Information*** - Provides information for selecting the best departure time, transportation modes and routes, before a traveler begins a trip (e.g. radio traffic reports, "on-line" traveler information systems).
- ***Ride Matching and Reservation*** - Makes ride sharing more convenient by providing tools for finding rideshare partners (e.g. Sacramento Rideshare's automated ridematching system on "1-800-COMMUTE").
- ***Demand Management and Operations*** - Supports policies and regulations designed to mitigate the

environmental and social impacts of traffic congestion (e.g. HOV lanes, HOV bypass lanes at ramp meters).

Electronic Payment

- ***Electronic Payment Services*** - Allows travelers to pay for transportation services electronically (e.g. automated debit account payment for privatized roadway facilities, like State Route 91 in Southern California).

Public Transit Operations

- ***Public Transportation Management*** - Automates operations, planning, and management functions of public transit systems (e.g. Paratransit, Inc.'s ride request and dispatch system).
- ***En-Route Transit Information*** - Provides information to travelers using public transportation (e.g. real-time information kiosks and changeable message signs at transit stations, like those being built in Atlanta for the Summer Olympics).
- ***Personalized Public Transit*** - Provide flexibly routed transit vehicles for more convenient service to customers.
- ***Public Travel Security*** - Creates a secure environment for public transportation patrons and operators (e.g. video monitors on transit vehicles or stations).

Commercial Vehicle Operations

- ***Commercial Vehicle Electronic Clearance*** - Facilitates domestic and international border clearance, minimizing stops (e.g. HELP, Inc.'s weigh-in-motion systems at weigh stations in Western states).
- ***Automated Roadside Safety Inspection*** - Facilitates roadside inspections.
- ***On-Board Safety Monitoring*** - Senses the Safety status of a commercial vehicle, cargo, and driver.
- ***Commercial Vehicle Administrative Processes*** - Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.
- ***Hazardous Material Incident Response*** - Provides immediate description of hazardous materials to emergency responders.
- ***Commercial Fleet Management*** - Provides communications between drivers, dispatchers, and intermodal transportation providers.

Advanced Vehicle Control and Safety Systems

- ***Longitudinal Collision Avoidance*** **:** Helps prevent head-on and rear-end collisions between vehicles, or between vehicles and other objects or pedestrians.
- ***Lateral Collision Avoidance*** - Helps prevent collisions when vehicles leave their lane of travel.
- ***Intersection Collision Avoidance*** - Helps prevent collisions at intersections.
- ***Vision Enhancement for Crash Avoidance*** - Improves the driver's ability to see the roadway and objects that are on or along the roadway.

- ***Safety Readiness*** - Provides warnings about the condition of the driver, the vehicle, and the roadway.
- ***Pre-Crash Restraint Deployment*** - Anticipates an imminent collision and activates passenger safety systems before the collision occurs.
- ***Automated Highway Systems*** - Provides a fully automated, "hands-off," operating environment.

Emergency Management

- ***Emergency Notification and Personal Security*** - Provides immediate notification of an incident and an immediate request for assistance.
- ***Emergency Vehicle Management*** - Reduces the time it takes emergency vehicles to respond to an incident.

III. STUDY GOALS AND OBJECTIVES

The recommendations of the EDPS were targeted to address a specific set of transportation problems. This section describes those problems which were identified most frequently by the agencies responsible for planning and operating the region's transportation infrastructure. The problem set has been limited to those problems which local agencies believe can be addressed in whole or in part by ITS programs.

Problem Definition

A workshop for EDPS participants was held at the beginning of the study, in order to develop a "long list" of transportation problems to be addressed in later phases of the study (see Appendix C for results of the workshop). This long list was consolidated by SACOG staff and JHK Associates to a set of six major problem areas, and detailed in the "Task 1 Technical Memorandum: Problem Definition" /1/. A summary table from this memorandum is shown in Table 1. The technical memorandum was presented at a later workshop, and to the Regional Planning Partnership. The six problem areas are discussed below.

Congestion. "Recurrent congestion" is generally caused when higher traffic volumes exceed roadway capacity along certain segments, and typically occurs during commute periods and on weekends during ski season. "Incident congestion" is caused by an accident, vehicle breakdown, or other event which causes a disruption in normal traffic flow. **A** recent study of incident congestion in the Sacramento region suggests that incident-related freeway congestion represents as much as 77 percent of total freeway delay /2/. Between 1986 and 1993, vehicle hours of delay more than tripled. Caltrans now estimates that over one-half million vehicle hours are lost each year due to congestion on the freeway system alone. SACOG forecasts that the average amount of congestion and delay experienced by drivers and passengers in the region will triple between 1995 and 2015 /3/.

Congestion affects a broad population of travelers. Although the extent of congestion is greatest during commute hours, truckers, shoppers, transit passengers on buses, and recreational travelers, are affected. Because of its inherent unpredictability, incident-related congestion affects an even broader cross-section of travelers than recurrent congestion.

Air Pollution. The Sacramento region is classified as a non-attainment area for Federal and State ozone standards. In 1994, measured levels of ozone exceeded the Federal standard 9 days and the State standard 47 days. Unlike congestion, which directly affects only travelers on the region's transportation system, air pollution affects virtually all residents in the region.

The three major causes of vehicle emissions identified for this study include: the number of vehicle trips, the characteristics of the vehicles, and the length and speed characteristics of their trips.

The number of engine starts correlates directly with the number of vehicle trips.' Approximately one-third of all emissions result from starting and stopping the engine, and have nothing to do with of the length of the trip, or any other trip characteristic. Therefore, strategies which reduce the number of vehicle trips will be effective in reducing the total emissions in the region.

TABLE 1

Summary of Transportation Problems

PROBLEM	SPECIFIC PROBLEM CATEGORIES	CAUSES	SEVERITY	LOCATIONS	WHO IS AFFECTED?	TREND	KEY INDICATORS
Congestion	Recurrent congestion; incident related congestion.	High peak hour demand; lack of flexibility and alternative routes/ modes; incidents.	Thousands of hours lost per day; direct financial impacts on freight, transit operators	Heavily traveled freeways/ highways; major street intersections.	All travelers; commuters and peak hour travelers hit hardest.	Historically, congestion growth has outpaced population growth; this trend expected to continue.	Person hours of delay; point-to-point travel times; average speeds; LOS at intersections.
Air Pollution	Vehicle emissions; regulatory issues.	Emissions from vehicle travel, exacerbated by congestion	Extent of health impacts unknown; severe impacts on transportation project development	Regional.	Regional—affects all travelers and residents.	Recent improvements in air quality; vehicle emissions expected to decline in short term; potential increases in long term.	Tons of emissions; "hot spot" concentrations
Safety	Traffic accidents; personal security on transit.	Increasing amount of travel; weather activity level around transit stops, in vehicles.	Thousands of injuries and fatalities per year on roadways; unknown number of incidents on transit.	Regional.	All travelers.	Historically, number of fatalities and injuries declining; no forecast.	Number accidents; number of fatalities; accident rates
Transit Productivity	Declining transit mode share; schedule, fare, and route coordination.	Complex travel needs; reduced service levels; perceived security problems.	Varies by operator.	All operators and service areas.	Transit riders directly affected; all travelers indirectly affected.	Commute share decreased 50% from 1980 to 1990; forecasts for slightly higher shares based on major transit capital improvements.	Total passenger volumes; passengers per revenue mile or hour; overall modal split.
Freight Transportation	Problems impacting operators; freight impacts on residential areas.	Effects of congestion; impact of regulation; resident./ comm. vehicle conflicts	Operators facing increasing costs	Focused on major roadways and areas around distribution centers, and truck trip generators.	Freight operators; consumers (through. higher prices).	Historically, truck travel increasing faster than population. conflicts.	Truck volumes; truck miles; size/location of distribution centers, major generators.
Inter-regional and Through Travel	Recreational; other.	Peak in recreational travel coincide with area peaks.	Severe in ski season.	Major freeways and highways; Yuba City- Marysville	All travelers; users of freeways hit hardest.	Growing with population.	Number of recreational and other travelers.

SOURCE JHK Associates, 1995

Automobiles are the largest single source of on-road emissions, with 20 percent of total ROG and 22 percent of total NOx emissions /4/. There are special concerns about the extent of "dirty vehicles" within each class, which emit at rates much higher than average. Statewide programs such as the Department of Motor Vehicles emissions testing program do not fully address this concern since many vehicles are not registered or are exempt from emissions testing.

The characteristics of the vehicle trips themselves are also factors in determining emissions. The minimum rate of NOx emission occur at- moderate speeds, between 30 and 40 miles per hour (MPH), and increases dramatically at speeds above and below this range. For ROG, the minimum emission rate occurs at speeds of about 50 MPH, and increases dramatically at speeds over 55 MPH and below 15 MPH.

Safety. Concerns about traveler safety include traffic safety and transit security. Traffic safety includes concerns about the risk of injury or death due to accidents on the regions roadway system. Problems related to vehicle burglaries and vandalism at park-and-ride stations, and incidents involving passengers in transit vehicles and at stops, were frequently mentioned as reasons transit ridership is avoided.

The Sacramento region experienced over 26,000 reported traffic accidents, 231 of which resulted in fatalities, in 1993. Those most directly affected were travelers involved in accidents, and their families, however, all travelers were indirectly affected through costs of automobile and health insurance.

In the Sacramento region, fatality and injury rates per vehicle mile have steadily decreased since 1986. Many factors have contributed to this decrease, including improved vehicle safety systems, seat belt and helmet laws, stricter laws and enforcement regarding drunk driving, and other factors.

Transit Productivity. Three problems were cited by many sources related to transit productivity. First, transit mode share has slipped in the last ten years in the face of tremendous increases in overall travel in the region. Between 1980 and 1990, the transit share of work trips declined by 50 percent, from about three percent to two percent of commuters. Second, the need for better route, fare and schedule coordination across operators was identified as a specific functional problem in the region. The third major problem cited was the lack of a seamless, user-friendly system for providing transit information to potential passengers.

Transit operators also expressed concern regarding additional service requirements and lack of funding for legislative and regulatory mandates such as the Americans with Disabilities Act (ADA) and the Clean Air Act 1990 amendments (CAA). Another problem identified was decreasing operating revenues in the face of increasing service costs. Most transit operators specifically identified paratransit and demand-responsive transit services such as dial-a-ride as particularly difficult services to provide in a cost-effective manner.

Because current transit passengers have managed to overcome these problems, future improvements must specifically target travelers for whom transit may be a viable alternative to driving.

Freight Transportation. Problems related to freight transportation include regulation of truck activity, increasingly strict emissions requirements for truck engines, and inconsistencies in designation and

enforcement of truck routes. Administrative requirements associated with truck weighing, safety inspections, registrations, and licensing were cited as factors affecting the efficiency of trucking in the region. One example of the level of regulatory activity which affects truckers in the region is the number of vehicles stopped and weighed at the Antelope scales on I-80: 450,000 vehicles are processed annually at this facility. This does not include seasonal activity and spot-checks at other temporary and random scales and/or inspection sites.

Another problem area includes problems that the public perceives to be caused by freight movements in the region. Significant among these problems are the congestion impacts of trucks during peak hours, the air quality impacts of truck operations, and the impacts of truck traffic on surface streets. Traffic and noise impacts of truck distribution facilities and other generators of truck traffic in residential areas have also been cited. As with total vehicle miles traveled, growth in truck travel has outpaced population growth in the last decade. Between 1983 and 1992, truck travel increased by 67 percent, while population increased 36 percent.

For rail movements, safety problems associated with a significant number of at-grade crossings were cited as serious concerns. Increased Pacific Rim trading activity has led to concerns about the impact of this activity on intermodal freight terminals. Like all California ports, the Port of Sacramento has seen steady growth in containerized shipments which are processed through adjacent truck and rail terminals.

Interregional and Through Travel. The most frequent problem related to interregional and through travel is the impact of recreational travel bound fdr the Sierra-Tahoe region. This problem is most often expressed in terms of the recurrent congestion impacts of this traffic in the urbanized areas, and incident and weather related congestion in the mountain areas. Difficulties in getting current information about upstream weather and roadway conditions (e.g. chain requirements) to travelers in advance of a point of no return were also mentioned. I-80 and US-50 are the routes most severely impacted. These impacts occur on Friday nights in the eastbound directions, with less severe impacts on Sunday nights in the westbound directions.

To a certain extent, interregional travel is likely to increase with population within the region. However, through traffic depends as much on the supply of recreational facilities in the Sierra-Tahoe region, demand for goods in the Central and Western states, and population growth and demand for recreation in other regions, such as the Bay Area.

Goals and Objectives

Six goals were developed in direct response to the problems defined above. Each of these goals is capable of being addressed in varying degrees by implementation of one or more of the ITS user services. In the following pages, several objectives are also identified which would contribute toward meeting each of the goals.

Goal # 1: Reduce Congestion. Congestion occurs when demand exceeds capacity. Therefore, the objectives which will support this goal are aimed at reducing demand and/or improving the "effective" capacity of facilities through traffic management strategies. The following specific objectives support this goal:

a) ***Reduce peak vehicle demand in congested corridors*** - Studies have shown that auto occupancies in the peak periods currently range from 1.17 to 1.26. The abundance of single occupant travel clearly contributes to congestion in capacity limited corridors. SOV demand can be reduced by mode shift or shifts to HOV travel.

b) ***Provide real-time information on travel routes, modes and travel times*** - Travelers may be able to alter the origination time of trips or postpone discretionary trips if they know such trips would be made under congested conditions. If travelers can be alerted to alternate routes and modes, demand may be reduced in critical sections of the network.

c) ***Reduce number and duration of incidents*** - Studies indicate that the congestion resulting from incidents can last three to five times as long as the incident itself. Therefore, if the incidents can be cleared in less time, the resulting congestion will be reduced dramatically.

d) ***Implement traffic management strategies to reduce delay on major facilities*** - Congestion'occurs where demand exceeds capacity. In many cases, the effective capacity of a given segment is not constrained by physical dimensions, but rather the traffic controls at the location. Delay and congestion may be reduced by reducing the number of stops and starts that occur in the system.

Goal #2: Reduce Pollution. A considerable portion of the air quality problem is related to vehicle emissions. Objectives which will support this goal will reduce the number of vehicles and target exceptionally "dirty" vehicles for clean up. The following objectives support the goals of reducing pollution.

a) ***Reduce number*** *of* ***"dirty" vehicles*** - A disproportionate share of the vehicle emissions in the area is caused by a specific set of "dirty" vehicles. Therefore, a disproportionate amount of benefit may be realized by removing such vehicles from the system or identifying and targeting such vehicles for clean up.

b) ***Make transportation operations responsive to prevailing air quality*** - A number of traffic control strategies may be used to facilitate traffic movements in certain areas, or discourage travel in other areas. If such strategies were selected based on prevailing air quality, air pollution could be minimized in certain hot spots or subareas on a given day.

c) ***Implement traffic management strategies to minimize emissions*** - A large portion of vehicular emissions occurs during the start up and acceleration of vehicles. By providing a consistent travel speed and minimizing vehicle stops, such emissions would be reduced.

d) ***Reduce total vehicle trips*** - Vehicle starts are a significant contributor to the prevailing air pollution. By promoting modal shifts away from single occupant autos, and reducing the amount of discretionary travel, such emissions could be reduced.

Improve Travel Safety. Travel safety will be improved through improvements in vehicle technologies and driver awareness to potentially hazardous situations. The following objectives support the goal of improving travel safety.

a) ***Warn travelers of adverse weather and roadway conditions*** - The Sacramento region experiences

a variety of weather conditions which can significantly impair driver visibility, cause slippery road conditions, or even road closures. Advance warning of fog, snow, and ice conditions would enable drivers to exercise caution.when needed and to be alert to potential hazards.

b) ***Promote advances in transportation safety technologies***- When accidents occur, the severity of injury and property damage is related to a number of factors. Advances in safety technologies within the vehicle and in the roadway and rail networks can significantly reduce the severity of accidents. In-vehicle restraint systems, warning systems, and braking systems have made significant improvements over the past several years. These systems as well as improvements in traffic control devices have the potential to further improve travel safety.

c) ***Increase security of public transportation systems*** - Improvements in safety can occur in all travel modes. Public transportation providers are increasingly concerned about passenger safety at stations, parking lots, and on the vehicles themselves. There are a number of opportunities within the ITS program to enhance safety in these areas.

d) ***Enhance emergency response capabilities*** - In many accidents, the severity of injury is related to the time between the accident occurrence and the time that medical attention is provided. Studies have shown that the fatality rate can be decreased when medical response times are reduced. Response times can be reduced through improved notification and dispatch systems.

e) ***Facilitate consistent travel speeds on freeway and local streets to reduce accidents*** - Many vehicle accidents result from congested travel conditions in which drivers are repeatedly accelerating and stopping. Improving the consistency of travel speeds would reduce the frequency of this type of accident.

f) ***Manage primary incidents to reduce the number of secondary incidents.*** When an incident creates stop and go traffic and standing queues, a large number of secondary accidents often result. ITS systems which alert motorists to downstream incidents can heighten awareness and decrease the number of secondary accidents.

Goal #4: Improve Transit Service Utilization. There is a considerable investment in public transportation infrastructure which is not being utilized to its fullest extent. Objectives supporting this goal will attempt to increase the public's return on this investment through increasing its role as a viable transportation service in the region. The following objectives support the goal of improving transit service utilization.

a) ***Improve continuity of transit services*** - There are currently 12 transit service providers in the Sacramento region. The operations of each service are not coordinated with respect to scheduling, routing, or fare structure. As a result, travelers are implicitly discouraged from traveling via transit across jurisdictional boundaries. Coordination of schedules and routes among service providers will enhance transits position as a regional travel option.

b) ***Provide timely distribution of transit information*** - Many potential transit riders cite a lack of information as an impediment for their use of the system. There are many avenues to improve the content, timeliness, and availability of transit service information. As the general public has better access to such information, potential benefits of transit service will be easier to market.

c) ***Improve accessibility to transit*** - Transit service utilization is fundamentally tied to the accessibility of such service from trip origins. ITS programs which provide flexibility in routing will improve accessibility and in turn, utilization.

d) ***Increase frequency and quality of transit service*** - The competitiveness of transit service as a legitimate travel option depends upon its ability to offer flexible frequent service. ITS programs which improve on-time performance and quality of service and provide opportunities for more frequent service will increase utilization.

e) ***Improve coordination between transit operators*** - Movement toward seamless operations and administration of transit services has the potential to reduce confusion among travelers and in turn, make transit easier to use.

f) ***Improve competitiveness of transit*** - Improvements in transit service utilization will require such services to be more competitive with the automobile. Specifically, such services must be competitive in travel times and in flexibility for routing and scheduling.

g) ***Provide management tools to better utilize operations resources*** - Transit utilization will fundamentally be improved if the services are provided in the most efficient way possible. ITS systems which allow providers to track vehicle locations, driver work schedules, and vehicle maintenance records all contribute to better operating performance.

Goal #5: Facilitate Commercial Vehicle Movements in the Region. The Sacramento area is strategically located with respect to goods movement in Northern California and the Western U.S. The economic vitality of the region is dependent upon efficient movement of commercial freight through the area. The following objectives support the goal of facilitating commercial vehicle movement in the region.

a) ***Reduce truck volumes on non-designated truck routes*** - A number of local agencies have experienced increased volumes of trucks which are believed to be related to a lack of information on designated truck routes. Improved identification of truck routes could concentrate such movements toward facilities and adjacent land uses more conducive to such travel.

b) ***Decrease regulatory delays for commercial vehicle operators*** - Commercial vehicle movements can be facilitated by reducing delays due to regulation (weighing, inspection, etc.) as well as congestion.

c) ***Provide real-time information on alternative conditions*** - When congestion is caused by high demand, or reduced capacity associated with incidents, the magnitude of the delays can be reduced if travelers upstream are notified of the conditions ahead. Commercial vehicles have a vested economic interest in travel times. Information concerning alternate routes to avoid congestion will facilitate their operation in the region.

d) ***Streamline administration of commercial vehicle operations*** - Commercial vehicle operators are not only regulated on the roadway, but in their administrative procedures as well. ITS programs which ease the administration associated with such regulation will improve the ability of commercial vehicles to operate in the region.

Goal #6: Minimize the Impact of Through and Inter-Regional Travel The Sacramento area is both a beneficiary and victim of impacts related to through travel. Objectives within the ITS program will attempt to maximize the benefits that come from these travelers, while minimizing their negative contributions to congestion in the region. The following objectives support the goal of minimizing the impacts of through and inter-regional travel.

a) ***Provide general travel information on available routes and modes*** - The impacts of through travel can be fundamentally reduced by altering the travel modes used by such travelers, and by discouraging such travel during peak periods. Greater distribution of information on travel options through Sacramento has the opportunity to alter the behavior of trips originating in the Bay Area or in the Sierras.

b) ***Provide real-time information on alternative modes and travel times*** - Congestion on I-80 and US 50 may be eased by providing information to through travelers who may be unfamiliar with the local network and alternative routes.

c) ***Warn travelers of adverse weather and roadway conditions*** - The Sacramento area experiences a variety of weather conditions which can impair driver visibility. Warning devices which can alert drivers to fog or slippery roadways can reduce weather related accidents that contribute to congestion.

d) ***Improve distribution of real-time route closure and vehicle restriction information*** - Congestion is often exacerbated by the presence of snow or fog which can cause road closures and strand motorists traveling through the region. Distribution of information on adverse travel conditions enables through travelers to adjust trip times through the region, or make better informed locations on where to stop while waiting for weather to pass.

IV. SELECTION OF USER SERVICES

Using the results of the problem definition process, and the goals and objectives summarized above, these user services can be screened to determine which ones are potentially the most effective in the Sacramento area.

This report section describes the user service selection process for the Sacramento region, and identifies the areas of benefit that may be realized from the user services with the greatest applicability for the region. The selection process categorizes each of the user services based on their utility for general application, orientation toward specific groups of travelers, and private sector orientation. The user services selection process was detailed in the "Task 2 Technical Memorandum: Prioritize ITS User Services" /5/, which was based on input from an ITS workshop, and presented for review and comment to the Regional Planning Partnership. The user services selection, along with the problems, goals and objectives reported in Section III of this Report, were summarized and presented to the SACOG Board for review in an Interim Report for the EDPS /6/.

The remainder of the EDPS was focused on the 14 user services with the EDPS participants determined to have general applicability in the Sacramento region, or were applicable to a specific traveler group. The remaining 15 user services were determined to have very limited applicability in the Sacramento region, or were not likely to be implementation responsibilities for the EDPS participants.

Selection Criteria

The selection of user services took into account several primary criteria.

Users Affected. User services which directly address problems of a general nature (i.e., problems which affect most residents or travelers) were more likely to be selected for further study.

Problem Coverage. This criteria refers to the range of problems identified in the previous section which a particular user service could address, either directly or indirectly. User services which addressed a broad range of problems were selected for further study.

Functional Commonality. Some user services require functions that provide a basis for the deployment of other user services. User services which were necessary in terms of providing functions for other user services were selected for further study. .

Three secondary criteria were also considered.

Likely Deployment Responsibility. For some user services, the major deployment agents are likely to be national or international (i.e., many of the advanced vehicle control and safety systems), and not within the

purview of any public or private regional entity. User services likely to be deployed at a scale above this region were given lower priority. Many of the vehicle systems user services fell into this category.

Current Deployment Status. Several user services have already been partially deployed in the region. This fact was considered where the existing deployed service provided a building block for enhancements or a functional commonality with other user services. These user services were given higher priority. However, unless a particular user service met the criteria related to users affected, problem coverage, or provided a basis for deployment of other services, the current deployment status was not considered to be relevant.

Likely Deployment Timeframe. Some user services include applications whose benefits have been proven in this region or in other areas. Others are based on applications whose benefits are unproven, or are still in the development stage. User services for which applications and benefits have been proven either in the region or elsewhere were given higher priority.

User Services with General Applicability in the Region

The following ITS user services were determined to be generally applicable in the region, because of the number of users affected, the potential geographic coverage, and the commonality each had with other ITS user service. For example, many of them are necessary building blocks for generating travel information for other purposes.' Also, for each of these user services, considerable progress has already been made in terms of planning, programming and implementing systems.

Traffic Control. This user service possesses functional commonality with many other user services. Given the amount of travel which is done on roadways, either in automobiles, commercial vehicles or transit vehicles, the number of users affected is large. Additionally, various agencies have already begun deployment of basic elements of this user service in the form of coordinated traffic signal systems, transit vehicle signal pre-emption, ramp meters, HOV bypass lanes, traffic monitoring stations, and surveillance equipment. These systems provide a solid base for early implementation efforts.

Incident Management. By quickly returning a roadway to normal function after accidents or other more minor incidents, and by reducing the potential for secondary accidents, incident management affects a broad range of travelers on the region's roadways. These travelers include commuters, transit passengers, freight transporters, recreational travelers, and others. Incident management also addresses a range of problems, such as congestion, safety, and inter-regional and through traffic. Various agencies in the region have already deployed key incident management elements, such as Freeway Service Patrol, Traffic Management Teams, and others, which provide a basis for future deployment and improvements.

En-Route Driver Information. The ability to communicate key information to travelers during their trip was cited by many sources as a useful service to travelers. In addition to the potential for affecting route choice, en-route driver information can also improve operations in incident areas by giving drivers advance notice of the need to merge away from a blocked lane. This service effects a broad range of travelers on the region's roadways, and certain basic elements have already been deployed.

Emissions Testing and Mitigation As a transportation problem, air pollution is unique in that it directly affects the health of all residents of the region, and not just travelers. Clearly, many ITS services address

concerns about air pollution in various ways. However, without better tools to evaluate their effects on air quality, the impact of these strategies on air quality may not be known. This is true not only of ITS applications, but other transportation strategies as well.

Public Transportation Management. Systems supporting this user service generate the real-time transit system information which is the basis of other user services such as en-route transit information and pre-trip travel information. This user service also addresses a range of problems such as: the need for better schedule, route and fare coordination; increasing operating costs; and recurrent congestion problems and vehicle emissions problems.

User Services with Applicability to Specific Traveler Groups

The following user services were determined to be applicable in the region, but are more focused on specific traveler groups and area residents.

Route Guidance. This user service has the potential to address problems related to congestion, especially for travelers who are unfamiliar with the region and can be guided to routes that avoid congestion. However, until more travelers have in-vehicle systems, or personal digital assistants (PDAs), the benefit from this user service is likely to be limited.

Pre-Trip Travel Information. This user service has the potential to modify route and time of departure of travelers, based on congestion, incident, and weather conditions. Travelers who could derive the greatest benefits from this service are those making discretionary trips, which can be scheduled or routed more flexibly than commuter trips.

Ride Matching and Reservation This user service is targeted at commuters, and has been extensively deployed in the region by Rideshare, various TMAs and employers. By reducing the number of vehicle trips, this user service can contribute to reduction of congestion and emissions. Rideshare is currently deploying a computer-based ridematching system which will have the potential for real-time ridematching.

Demand Management and Operations. Some aspects of this user service overlap with ride matching and reservation, and with traffic control. Unique elements of this service are related to reducing travel demand through compressed work weeks, telecommuting, and other strategies. These unique elements should be the focus of applications of this user service. However, many of these applications involve complex management and labor issues which fall outside the scope of this study.

Personalized Public Transit. This user service has the potential of providing better service to lower density areas, at a lower cost than traditional fixed route service. Additionally, this service has applications for providing paratransit and ADA-compliant services, which are a great concern to transit operators and mobility-impaired persons. For this reason, this service merits further consideration.

Public Travel Security. This user service addresses concerns related to personal safety of transit riders and employees. Deployment of this user service may make transit more attractive to some potential riders. Priority should be given to development of transit management tools, and traffic control strategies to improve transit service.

Commercial Fleet Management. This user service provides direct benefit to freight operators, by allowing for more efficient routing and dispatch of trucks. This service also benefits travelers in general, by minimizing the impact of trucks in congested segments of the roadway system. Generation of the real-time information on roadway system performance, which would provide crucial information needed for implementation of this service.

Hazardous Material Incident Response and Emergency Vehicle Management. These user services provide important special-purpose incident management applications, which improve response to major incidents. These are important user service, which are both provided using a variety of ITS and non-ITS applications by various agencies which provide emergency response.

User Services with Limited Applicability for Public Sector Deployment

The following ITS user services were determined to be of limited applicability in the region, based on the likelihood of early implementation, or involvement in implementation by the study participants.

Traveler Information Service. This was given a low priority for this region because the service was expected to provide benefits for a relatively small number of travelers.

En-Route Transit Information. This service should be considered after transit operators have developed the capability of generating real-time information on transit operations.

Electronic Payment Services. The lack of toll facilities and of proposals for congestion pricing limits the utility of this user service to transit fare collection. If toll facilities or congestion pricing are considered in the future, this user service would merit higher priority.

Commercial Vehicle Electronic Clearance. Automated Roadside Safety Inspection. and Commercial Vehicle Administrative Processes. These user services directly address only problems related to the impact of regulation on freight operators. Additionally, opportunities for deployment of these services in the region are limited, and not directly in control of agencies within the region.

On-Board Safety Monitoring. Deployment of this user service is likely to be initiated by vehicle manufacturers, and/or freight operators on their own initiative.

Emergency Notification and Personal Security. This user service is extensively deployed through cellular phones and call boxes. Other applications, such as mayday systems in vehicles, are potentially beneficial, but are likely to be deployed by vehicle manufacturers or owners on their own initiative.

Advanced Vehicle Control and Safety Systems User Services. These user services largely focus on in-vehicle systems which will be deployed by vehicle manufacturers. One exception to this may be intersection collision avoidance, whieh may be deployed locally. Until specific applications of this user service are available, traffic control, incident management, and emergency response user services should be given higher priority.

V. ASSESSMENT OF BENEFITS OF ITS USER SERVICES

The purpose of this section is to determine potential areas of benefit that could be realized from implementation of the selected ITS user services, discussed in the previous section, in the Sacramento region. .

At this point in the ITS program development process it is only possible (and necessary) to identify the topical areas of benefit. The specific level of benefit that may be achieved in the Sacramento area will be sensitive to a number of project specific factors. Some of the project specific factors that will influence the level of benefit include the demographics of travelers, the configuration of the transportation network, the severity of the problem being addressed, the number of stakeholders directly influenced by the project, and the level of implementation of the user services.

In assessing the potential areas of benefit that may result from ITS deployment, it is necessary to make assumptions on the areas of application and the stakeholders who may benefit from each user service. The implementation scenarios given in the following pages are made for the purposes of the benefits assessment only. The scenarios should not be construed as a precursor for the project development priorities or descriptions that may be produced in subsequent tasks.

In reviewing this section, it should be noted that many of these benefits are already being realized by Sacramento area ITS stakeholders. These benefits are occurring where the strategies have been partially implemented through the projects identified at the end of this section. Because many of the services are already being provided to some extent, the magnitude of "additional" benefit will not be as high as the figures identified in this section. The specific figures quoted in this section are applicable for initial implementation of the services.

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Traffic Control

Objective. The traffic control user service manages the movement of traffic on streets and highways.

Area of Application. This user service will be provided in areas with a network or corridor of traffic signals and on the urban freeway system.

Stakeholders Who Benefit. Traffic control will help to ensure the safe and efficient movement of all users of the surface transportation system, including private automobiles, commercial and transit vehicles, as well as non-vehicular travelers such as bicyclists and pedestrians.

Potential Benefit. In its early stages, the primary benefits of the traffic control user service will take the form of reduced stops and delays. The traffic signal coordination element of traffic control has proven to benefit motorists significantly. A recent study of the City of San Jose's traffic signal coordination program reported that motorist travel times were reduced by 16%, delays declined by 38%, and vehicle stops dipped

39% /7/. Other studies of traffic signal coordination have produced similar results /8,9/. These programs have shown benefit/cost ratios of up to 62% /10/. The freeway traffic management element (primarily demand management through ramp entry control) of traffic control also results in significant user benefits. A review of freeway traffic management systems throughout the country revealed that ramp entry control has the potential to increase mainline speeds by 8 to 20% while reducing overall system delay by 16% /1 1,12/ Freeway accident rates have decreased by 40 to 50% as a result of ramp metering.

In addition to these initial quantifiable benefits, the underlying surveillance, data processing, and communications technologies that are a part of the traffic control user service will contribute to other ITS services such as in-vehicle navigation systems, trip planning and routing systems, and public transportation, emergency vehicle and commercial fleet management systems. The ultimate benefits expected to be derived from these user services include increased productivity, savings in travel time, delays, and driver frustration. Traffic control will also help to mitigate the environmental and energy impacts of surface transportation by reducing harmful vehicle emissions and fuel wasted by congestion and navigational inefficiencies. Because the general public will be the beneficiary of these energy and environmental improvements, the total benefits are expected to be significant.

Incident Management

Objective. The incident management user service enhances existing capabilities for detecting incidents and taking the appropriate actions to restore the roadway to a normal function as quickly as possible.

Area of Application. This service will be provided throughout the state highway system and on major arterial roadways.

Stakeholders Who Benefit. The traveling public benefits from reduced incident related delay. Accident victims benefit from reduced response times to incidents. Emergency response fleets, enforcement agencies, the private towing and recovery industry, and those that operate and maintain the transportation system also benefit by being able to conduct their operations more effectively.

Potential Benefit: Studies conducted on Los Angeles highways by the California Department of Transportation during off-peak periods have shown that for each additional minute required to clear a lane-blocking incident, an additional four or five minutes of congestion result. The resulting congestion is often much greater during peak periods /13/. Thus, it stands to reason that prompt incident removal can have a significant impact on reducing non-recurrent congestion. The Orange County IVHS Study reports that incident management can reduce non-recurrent congestion on the freeway system by 37% /14/. The implementation of an incident management system in metropolitan Toronto has reduced average incident duration from 86 minutes to 30 minutes, a decrease of 65% /15/. This has resulted in a reduction in non-recurrent vehicular delay of 77%.

The Minnesota Highway Helper Program has reduced the duration of a stall (the most frequent type of incident, representing 84% of service calls) by eight minutes /16/. Using representative numbers, annual benefit through reduced delay totals $1.4 million for a program that costs $0.6 million to operate.

The Maryland CHART program started as an "Eyes and Ears" program and now is in the process of expanding to more automated surveillance with lane sensors and video cameras. This program is expected

to return about a ten-to-one benefit-to-cost according to draft analyses /17/.

Public Transportation Management

Objective. The public transportation management user service applies advanced vehicle electronic systems to various public transportation modes and uses the data generated by these modes to improve service to the public.

Area of Application. This service would be provided to all public transportation systems in the Sacramento region.

Stakeholders Who Benefit. Direct users of this service are the public transportation operators, however all transit riders benefit from the service.

Potential Benefit. Public transportation management will benefit both the transportation provider and the passenger. The benefits of public transportation management will accrue to the customer in the form of improved service reliability, schedule information accuracy, on-time performance and reduced cost (cost in these terms is inferred from reduced wait times, and is not meant to imply lower fares).. An evaluation of the public transportation management system (consisting of an automatic vehicle monitoring and communications system) in Dublin, Ireland indicated that passengers experienced a 24% reduction in excess wait times and that the frequency distributions of buses more closely matched the schedules /18/. A productivity improvement reported in Portland was the use of a bus priority system integrated with the traffic signal system on major arteries /19/. By allowing buses to either extend green time or shorten red time by only a few seconds, the bus travel time was reduced by between five to eight percent. This will result in faster service for the customer and would allow the use of fewer vehicles to serve that route.

The first phase of the PASS system, new dispatching software implemented by Paratransit in early 1995, has allowed rider boardings to be scheduled within a 30 minute period instead of the previous 90 minute period. The second phase, on board terminals on busses, will be followed by a third phase, installing a GPS locating system on buses.

Transportation service providers will also benefit from better operational control over their vehicles and through lower costs derived from better utilization of and greater productivity from employees. Results from a study of the public transportation management system (also consisting of an automatic vehicle monitoring and communications system) in Cincinnati indicated that weekday bus miles of travel were reduced 7.2% and platform hours reduced by 8.2% /20/. Furthermore, many of the labor intensive repetitive tasks now manually performed can be automated. The employee can be greatly assisted with these technologies, thus creating less stress and increasing job satisfaction.

Emissions Testing and Mitigation

Objective.The emissions testing and mitigation user service is used to provide area-wide pollution information for use in monitoring air quality conditions and framing air quality improvement strategies.

Area of Application. It is anticipated that this service would be provided at locations of vehicular air

pollution, including the freeway system and intersections.

Stakeholders Who Benefit. Direct users of this service are not just air quality and traffic management personnel, but all residents of the Sacramento region benefit.

Potential Benefit. Environmental benefits are expected to be modest in size, unless congestion pricing becomes reality. Typical travel demand management benefits are on the order of two to four percent reductions in overall vehicle miles traveled (VMT), as well as hydrocarbon (HC) andcarbon monoxide (CO) mobile source emissions /21/. Reducing oxides of nitrogen (NOx) by even this amount is more uncommon in the benefits analysis. Similar magnitude results accrue from flow improvements via TMC's on freeways. Benefits of this magnitude are unfortunately similar in magnitude to a single year's growth in VMT. Signal coordination and optimization claim emission benefits in the range of 10%, in addition to travel time improvements. This size of benefit contrasts with vehicle improvements leading to a reduction in vehicle sources of 39% for HC and 40% for CO while VMT increased 41% in the decade from 1982 to 1991. In a report produced for the Illinois DOT, planners basically pass traffic flow improvements off as a short term benefit rather than a longer term building block for emissions reductions, saying that flow improvements simply allow more dispersed land use patterns /22/. Small benefits are also expected from electronic toll collection and commercial vehicle operations (CVO) border crossing/weigh station bypass.

En-Route Driver Information

Objective. The en-route driver information user service provides travel-related information to drivers after their trips have begun.

Area of Application. It is anticipated that this information will be provided to travelers on all state highways (both urban and rural) as well as major urban arterials.

Stakeholders Who Benefit. Users of this service include the drivers of private, commercial, and transit vehicles.

Potential Benefit. Direct benefits associated with en-route advisory information were quantified in the Orange County IVHS Study /14/. The study indicated that en-route driver information (changeable message signs, highway advisory radio, and In-vehicle display devices) has the potential to reduce by 23% delay associated with non-recurrent congestion on the freeway. Recurrent freeway delay was reduced four percent. Congestion on surface streets was reduced by 11% as a result of en-route driver information.

In addition to these direct reductions in delay, other benefits of driver advisory information will occur. For example, measurable reductions in traffic congestion presents obvious advantages for the traveler, but the indirect consequences are also significant. These include reduction of "secondary" or congestion-related accidents, improved transit service, and reduced fuel consumption and emissions from idling engines. Productivity gains result not only from workers who waste less time commuting, but also from lower operating costs to fleet operators and greater returns on capital investment in public transportation.

Public perception of information accuracy is also of importance. The INFORM project found that 29% of survey respondents rate the information as very useful and 75% as moderately useful or better, 63% rated the information as usually or always accurate, and 45% said that they sometimes changed their routes

based on the information /23/.

Increased collection and creative use of information will assist drivers in making informed decisions to use transit and other ride-sharing arrangements. Less vehicle-miles of travel will result, with associated environmental and energy conservation benefits. Personal mobility will be enhanced by making transit services better understood and more accessible, especially to the transportation-disadvantaged, including the elderly and disabled, and residents or visitors in geographically remote communities.

Public Travel Security

Objective. The public travel security user service supports innovative applications of technology to improve the security of public transportation systems.

Area of Application. This service will be provided by all transit agencies in the Sacramento region.

Stakeholders Who Benefit. Users of this service include transit customers and employees, transit operators, law enforcement agencies, and the general public.

Potential Benefit. Concerns related to safety and security are often cited by potential transit passengers as disincentives to using public transit. These concerns include both personal safety (e.g. safety of passengers from crime or harassment on board a transit vehicle or at a stop) as well as the security of property (e.g. an automobile parked at a LRT station parking lot). Unfortunately, statistics on the actual occurrence of incidents of this type are not consistently tracked and tabulated, so the actual magnitude of risk for passengers is not known. Two things are known, largely from anecdotal evidence: (a) that many potential transit passengers do perceive a risk to traveling by public transit, which is greater than the risk of traveling by private automobile; and (b) that some incidents, both on transit vehicles and at stops and parking lots, do occur which fuel this perception. Any measured increase the actual security, or the perceived security of transit passengers, would encourage higher transit ridership. This would help transit operators by increasing ridership and revenues, and would benefit the region generally by decreasing the number of vehicle trips.

Personalized Public Transit

Objective. The personalized public transit user service involves the use of flexibly routed vehicles offering more convenient service to customers.

Area of Application. This service will be provided in low population density areas where conventional fixed route transit is prohibitively expensive and cost inefficient.

Stakeholders Who Benefit. Users of this service include travelers in lesser populated localities and neighborhoods wishing to use public transit. Transit providers also benefit by improved efficiency in . allocating operating resources.

Potential Benefit. From the users' perspective, time savings when making trip requests, reducing waiting time for the bus to arrive, and increased confidence that the requested service will be delivered. The

availability of this service in suburban areas might allow a family to have only one car, a significant economic benefit. From the transportation operator perspective, better vehicle utilization, increased ridership and revenues, increased system capacity with no additional vehicles, increased average vehicle occupancy, increased average speed due to reduced dwell times, and increased productivity of.employees. From the community perspective, there may be benefits from fewer adverse environmental impacts.

Ride Matching and Reservation

Objective. The ride matching and reservation user service develops and encourages ridesharing by providing real-time ridematching information along with reservations and vehicle assignments.

Area of Application The only limits placed on this users service are based on the number of travelers with access to the information.

Stakeholders Who Benefit. Users of this service include daily commuters as well as occasional travelers or visitors to the area who are not familiar with local travel options.

Potential Benefit. Benefits for the ride matching and reservation user service include increased public access to shared ride modes, decreased congestion, reduced harmful environmental effects, more flexible, user-friendly ridesharing service (often at less cost to the user than driving alone). Sacramento Rideshare's Oracle database implementation in mid-I994 has improved ridematching services considerably. The database now accommodates students with varying day-to-day schedules. Users can also request their schedule to be "inactive", then later updated, eliminating the need to purge and re-enter certain static user information. The system is user-friendly and flexible, allowing users to update their own records in some cases.

Demand Management and Operations

Objective. The demand management and operations user service generates and communicates operational, management, and control strategies that will support and facilitate the implementation of programs, policies, and regulations designed to reduce the number of single occupant vehicles (SOV), affect mode shifts from SOV's to HOV's, and provide mobility options for those who wish to travel more efficiently, at a different time, or to a different location.

Area of Application. This service will be provided for all travelers in the Sacramento region.

Stakeholders Who Benefit. Users of this service are Travel Demand Management (TDM) programs, however all travelers benefit from their implementation.

Potential Benefit. Travel demand management has the potential to produce significant benefits in the following areas: reduction of vehicle trips by 20 to 40 percent at employment locations; reduction of congestion by 5 to 10 percent along congested corridors; reduction of peak hour vehicle use of approximately 5 percent on area-wide basis, can be achieved through an aggressive TDM program supported by ITS /24/. TDM also can reduce the need for additional parking facilities, increase transit ridership, and improve employee morale and productivity.

Route Guidance

Objective. The route guidance user service provides travelers with instructions on turns and other maneuvers to reach their destinations.

Area of Application. This service would be available to all travelers that choose to purchase an in-vehicle device, or other personal portable or hand-held devices.

Stakeholders Who Benefit. Users of this service include drivers of private automobiles, High Occupancy Vehicles (HOV) and van pools, commercial operators, and public transit drivers, especially for non-route specific services such as paratransit and demand responsive transit.

Potential Benefit. The greatest benefit associated with route guidance is the reduction of navigational waste for both personal and business travel. Navigational waste includes excess vehicle miles of travel, time selecting a route, and time subsequently following the route. Systems with access to real-time traffic information can provide motorists with the least-congested route, further reducing travel time. Numerous studies have been conducted to evaluate the benefits of in-vehicle route guidance devices /25,26,27,28,29,30/. While results of these studies vary somewhat, with travel time reductions in the range of three to eleven percent, all indicate the potential for increased travel efftciency. Field studies performed during the TravTek project in Orlando Florida showed that vehicles with an active TravTek device experienced a decrease in travel time of 19% if the route is followed properly, a 20% decrease in travel time if turns are missed (i.e., when turns are missed by both TravTek and the unequipped control vehicle) /31/. TravTek was also demonstrated to provide time savings in regaining the desired route, and decreased the probability of missing a given turn from 5.4% to 3.6%.

In addition to reducing overall travel time, personal stress can be reduced by not having to search for landmarks or signs for routing directions.

Pre-Trip Travel Information

Objective. The pre-trip travel information user service provides travelers with information prior to their departure and before a mode choice decision is made.

Area Of Applications. The only limits placed on this user service are based on the number of travelers with access to the information.

Stakeholders Who Benefit. Users of the service include all travelers, including commercial vehicle operators, as well as providers who will develop and market pre-trip information services.

Potential Benefit. Potential benefits of pre-trip travel information have not been quantified. However, it is anticipated that pre-trip travel information services will result in more efficient use of congested corridors by encouraging mode changes and changes in departure times and routes. Pre-trip travel information will also enhance the efftciency and safety of recreational travel.

Surveys performed in Seattle and Boston indicate that providing travelers with pre-trip information results

in an even split between travelers who change route of travel and travelers who change time of travel. An additional five to ten percent change in travel mode was forecast based on the information /32/.

Commercial Vehicle Fleet Management

Objective. The commercial vehicle fleet management user service provides real-time communications for vehicle location, dispatching, and tracking to reduce delays resulting from congestion and incidents.

Area of Application. This service will be provided by private fleet operators choosing to invest in the required equipment.

Stakeholders Who Benefit. Users of this service include commercial vehicle drivers, dispatchers, and intermodal transportation providers.

Potential Benefit. The primary benefits of this service involve increases in economic productivity. Fleet Management techniques have the potential to enhance just-in-time deliveries, thus reducing costs to fleet operators and transportation-dependent industries. Substantial secondary benefits could be realized through commercial carrier routing to avoid congestion which may help reduce delay-related emissions and fuel waste. Commercial carrier mobility could be enhanced as travel times become more predictable. In addition, transport capacity could effectively increase as intermodal transport becomes a more effective tool for moving commercial goods.

Productivity improvements reported by motor carriers (in a 1992 study) using advanced vehicle monitoring and communications technology provide an indication of the magnitude of benefits. For intercity irregular-route trucking, Telesat Canada estimates use of its system increased loaded mileage 9% to 16% and reduced operating costs from 12 to 20 cents per truck mile /33/. Schneider Co. of Green Bay, Wisconsin reported a 20% increase in loaded miles and the elimination of check calls saves approximately two hours per day resulting in a driver salary increase of $.50 per week, but that the primary benefit is improved customer service. Trans-Western Ltd. of Lemer, Colorado credited their system for improved driver relations, noting that drivers are able to drive 50 to 100 additional miles per day, and driver turn-over has decreased from 100% to 30%. Frederick Transport of Dundas, Ontario, estimates an increase of 20% in loaded miles, a reduction of $30 from $150 per month in telephone charges, 0.7% greater load factor and 9% increase in total miles. North American Van Lines of Fort Wayne, IN reports 16.9% additional shipments, 5.7% fewer deadhead miles, 3.8% fewer cancellations and 24.5% expedited pickups and deliveries. Best Line of Minneapolis, Minnesota estimates a $10,000 a month savings since 300 drivers previously lost about 15 minutes each day waiting to talk with dispatchers. Mets of Indianapolis, Indiana performed tests that showed vehicle utilization increased by 13%. In addition, United Van Lines of Fenton, Missouri claims that the ability to track and recover stolen vehicles is expected to reduce theft insurance premiums.

Hazardous Materials Incident Response

Objective. The hazardous material incident response user service applies advanced technologies to enhance the safety of incident response procedures.

Area Of Application. This service will be provided on all transportation facilities in the Sacramento region.

Stakeholders Who Benefit. Users of this service include not only emergency response personnel, but also the general public.

Potential Benefit. To the consumer, the benefits of this service include improved traffic safety, reduced delays, and decreased risk. The improved information would potentially reduce adverse impacts of incidents such as: injuries, property damage, evacuations, traffic delays, and non-optimal emergency response resources

Emergency Vehicle Management

Objective. The emergency vehicle management user service reduces incident response times by providing emergency response agencies with emergency vehicle fleet management, route guidance, and signal priority.

Area of Application. All emergency response agencies in the Sacramento region will have access to this user service.

Stakeholders Who Benefit. This user service has three primary users: law enforcement services, emergency medical services, and fue services. Accident victims and those in need of aid will benefit from improved emergency response times. Research has demonstrated that prompt, appropriate medical care is an important factor in reducing the severity of injuries received in a crash, and indeed the survival rate of those requiring resuscitation.

Potential Benefit. Emergency vehicle fleet management will assist service providers in managing their fleets and assigning appropriate vehicles to emergency calls. Route guidance systems, already in use by EMS providers in some regions, assist response teams in locating crash sites, and transporting victims to a medical facility. EMS providers will also be able to take advantage of improvements in route guidance. Signal priority at intersections for EMS vehicles would provide additional protection for EMS vehicles crossing intersections by providing warning to drivers on opposing routes.

VI. INVENTORY OF EXISTING AND PROGRAMMED ITS PROJECTS

The section provides a description of the ITS systems which are existing or already programmed (i.e. funded and scheduled for construction) in the region. These systems represent the steps taken to date in meeting the user service needs of the area. To best illustrate how these past efforts fit into the overall ITS program needs, each existing or planned system is discussed relative to the user service it provides. The mapping of existing and planned elements to the overall program needs is the first step in defining a delivery scheme for the user services.

The delivery system development that will be described in the following section of this report will concentrate on integrating the existing and programmed elements, broadening them to address the full needs of the user services they are only partially fulfilling, and adding the provisions for those user services which have not yet been addressed in the region.

Travel and Transportation Management

Transportation Management Center (TMC). Caltrans District 3 and the California Highway Patrol (CHP) operate a TMC, located in the CHP Sacramento Communications Center. The TMC monitors CHP officer communications, television media, call box calls, cellular 911 calls, Freeway Service Patrols and video cameras (Figure 1). The TMC is supported by a Computer Assisted Dispatch (CAD) system. The TMC also has a small media center, where CI-IP staff prepares traffic reports for local broadcast media. The Caltrans TMC Master Plan has designated Sacramento as one of three planned Regional Transportation Management Centers (RTMC) in California. Caltrans submitted an application for TSM funding for the Sacramento RTMC, and was allocated $7.98 million by the CTC.

The Caltrans/CHP TMC currently delivers the following ITS users services for segments of the State Highway system:

- ***Incident Management*** through the surveillance, monitoring and dispatch functions which the TMC fills.
- ***En-Route Traveler Information*** through the messages communicated to drivers via the changeable message signs and highway advisory radio stations.
- ***Pre-Trip Traveler Information*** through the media interface and traffic reports produces on site.
- ***Traffic*** Control through the monitoring of traffic volumes and densities, and control of the ramp meters.

Traffic Operations Centers (TOC' s) TOC's are similar in some respects the Caltrans/CHP TMC, in that they are centralized facilities for the management of primarily roadway transportation systems. TOC's differ in that they focus on local surface streets, as opposed to the State Highway system for the TMC, and

on management of trafftc signal systems, rather than incident management and traveler information for the TMC. Two significant TOC projects are being implemented in the Sacramento region: the City of Sacramento Downtown Mastercontroller Project, and the County of Sacramento Traffic Operations Center Project. Both projects have common elements. They are intended to provide centralized monitoring and management of extensive systems of trafftc signals (approximately 240 in the City CBD area, and 180 in the County area) as shown in Figure 1. Both are intended to accommodate additional signals and signal systems. Both systems include video monitoring of key intersections and route. segments. The County TOC is expected to include other elements, such as changeable message signs.

The TOC's provide the following ITS user services:

- ***Traffic Control*** through the system monitoring and traffic signal coordination functions they provide.
- ***Incident Management*** through video monitoring of traffic signal breakdowns, accidents, etc. which allow for better, quicker dispatch of field operations staff or emergency services, as necessary.

Changeable Message Signs (CMS). Changeable message signs are currently located on eastbound US-50 at El Dorado Hills and Placerville, on eastbound I-80 at Newcastle and Auburn, and on eastbound I-80 at Dixon (Figure 2). One additional CMS has been funded for westbound US-50 at 48th Street. Two CMS's are also installed on Routes 50 and 89 in the Lake Tahoe area. The County of Sacramento is considering installation of one or more CMS's for the first phase of its TOC project. The locations of these CMS's is not determined.

Changeable message signs provide ***En-Route Traveler Information.***

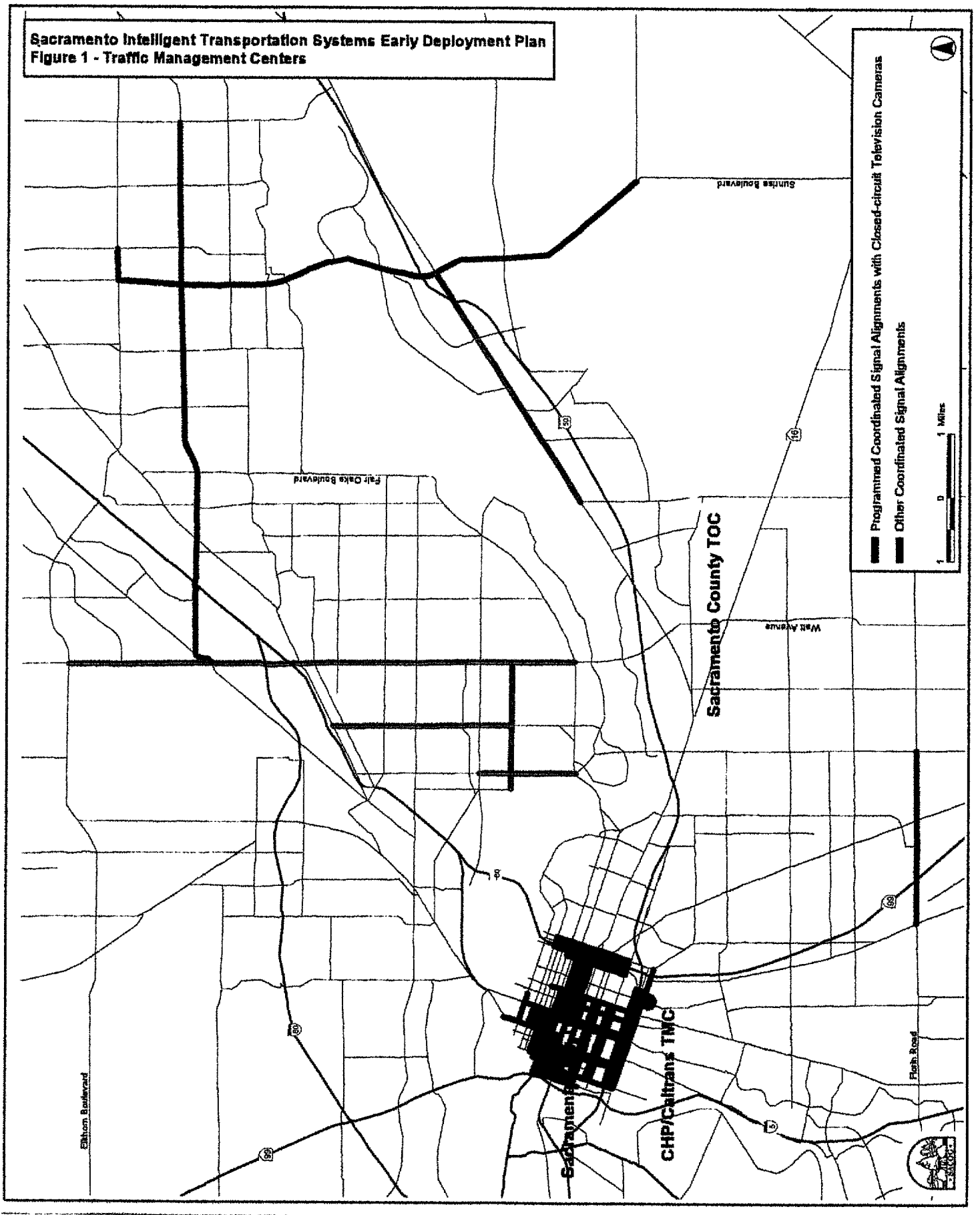
Ramp Meters. A total of 36 meters are currently located at ramps on I-5, US-50, Business 80 and Route 99. An additional 33 ramp meters are scheduled for installation prior to 1998 for these routes (Figure 3).

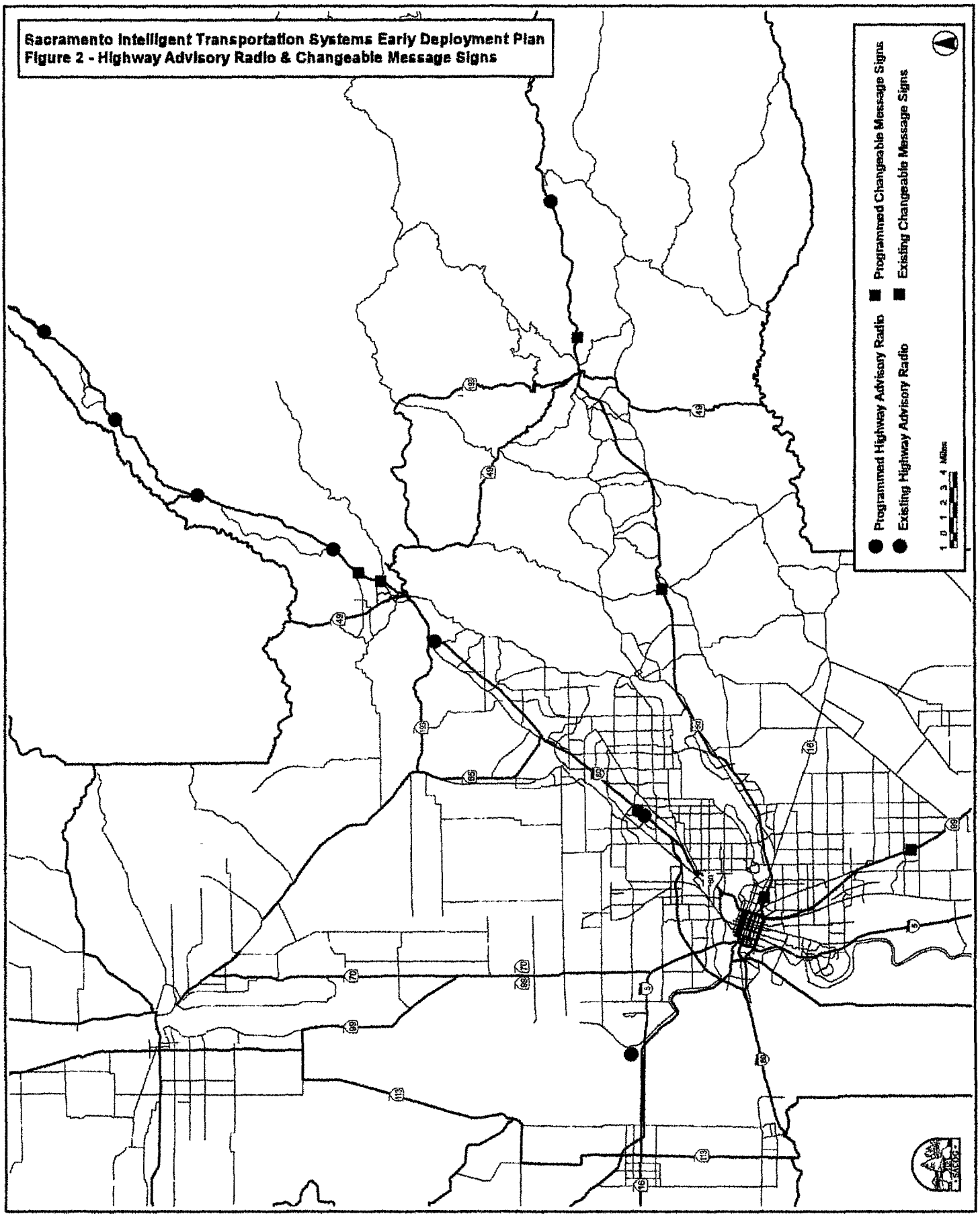
Ramp meters provide ***Traffic Control,*** and where HOV bypass lanes exist, ***Demand Management and Operations,*** user services.

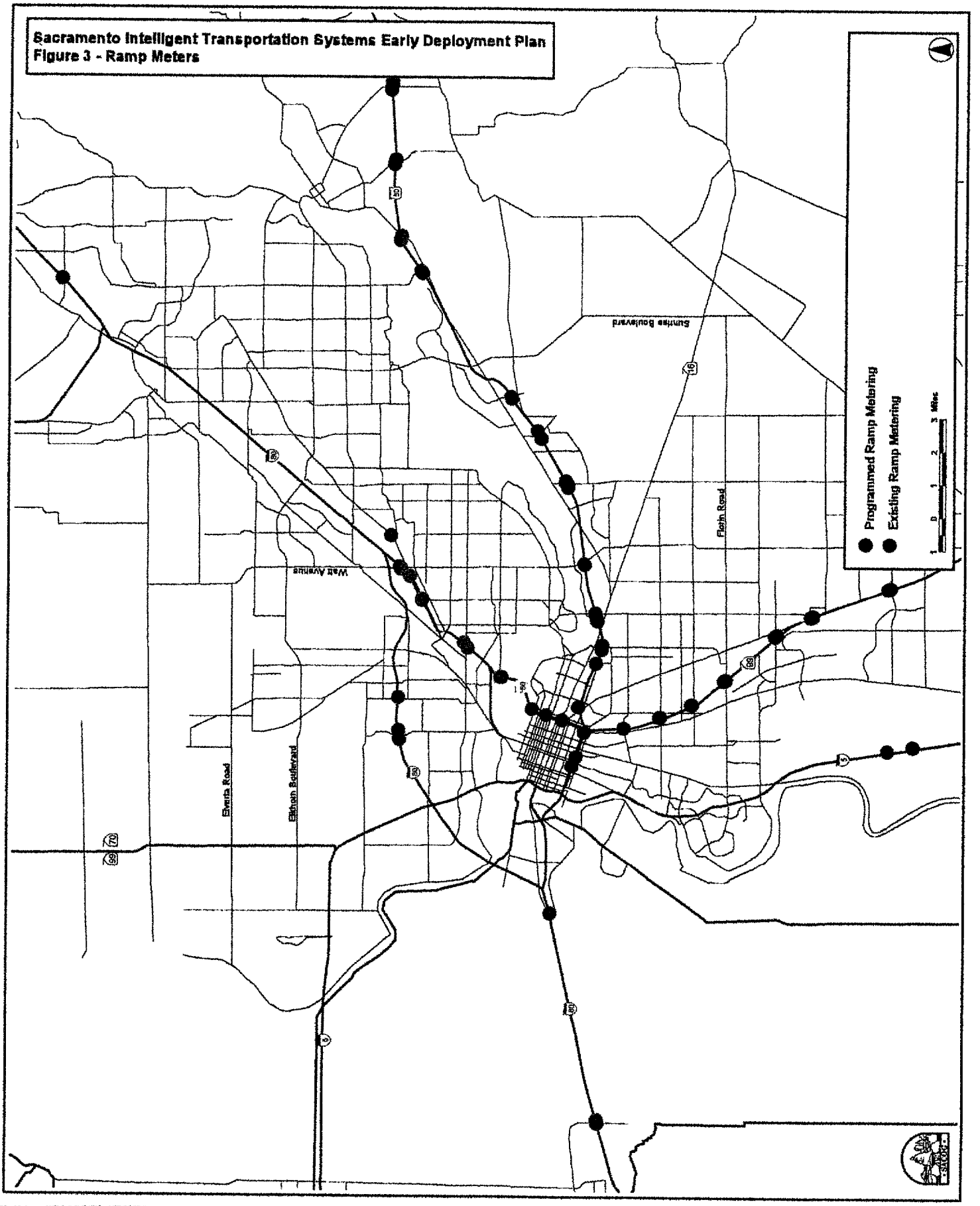
Traffic Monitoring Stations (TMS). TMS's are inductive loops in the roadway, for doing traffic counts, traffic density measurements, and speed measurements. Currently, TMS's are located only on the State Highway system (Figure 4). Most TMS's are connected to the Caltrans/CHP TMC via dial-up telephone lines. All actuated trafftc signals on local roadways include loop detectors as well, but these are not generally used now for remote trafftc monitoring. The City of Sacramento and County of Sacramento TOC projects will allow for utilization of these loop detectors for trafftc monitoring. Traffic monitoring stations are also located at all ramp meter locations and on I-5 at Elk Grove Boulevard.

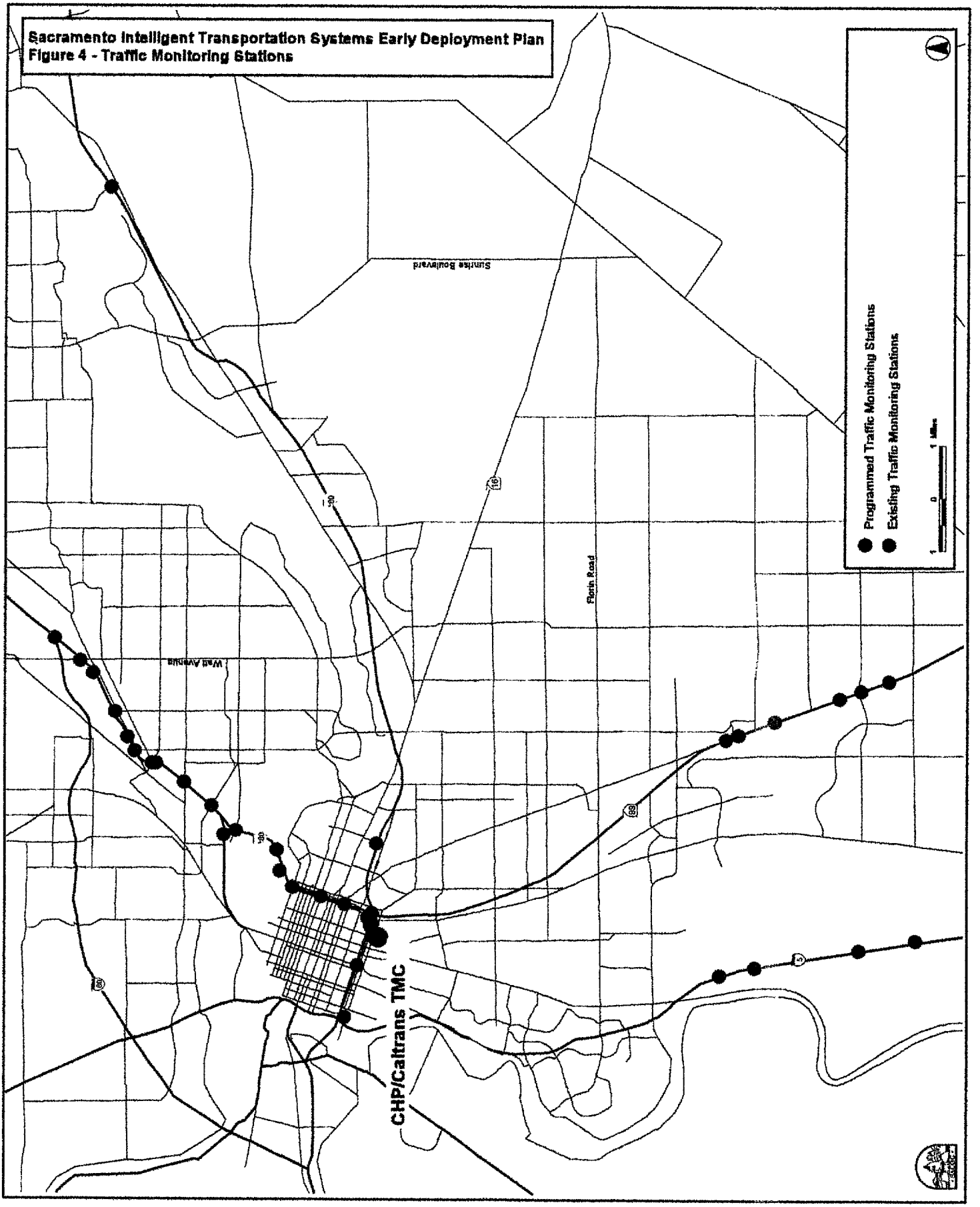
TMS's contribute to ***Traffic Control*** user services.

Closed-Circuit Television Cameras (CCTV' s) Caltrans currently has several CCTV's operating on Route 50 along the W/X corridor, and on Business 80, with several others programmed for installation by 1998. The City of Sacramento will have approximately 8 or 10 CCTV's in operation in the Sacramento Downtown area (Figure 5). The County of Sacramento will install an unspecified number of CCTV's, probably'along Madison and Sunrise Avenue (Figure 1).


Sacramento Intelligent Transportation Systems Early Deployment Plan
Figure 1 - Traffic Management Centers
Programmed Coordinated Signal Alignments with Closed-circuit Television Cameras
Other Coordinated Signal Alignments
1 Miles
Sacramento County TOC
CHP/Caltrans TMC
Sunrise Boulevard
Fair Oaks Boulevard
Watt Avenue
Elkhorn Boulevard
Florin Road


Sacramento Intelligent Transportation Systems Early Deployment Plan
Figure 2 - Highway Advisory Radio & Changeable Message Signs
Programmed Highway Advisory Radio
Existing Highway Advisory Radio
Programmed Changeable Message Signs
Existing Changeable Message Signs
Miles


Sacramento Intelligent Transportation Systems Early Deployment Plan
Figure 3 - Ramp Meters
Programmed Ramp Metering
Existing Ramp Metering
Sunrise Boulevard
Florin Road
West Avenue
Elverta Road
Elkhorn Boulevard


Sacramento Intelligent Transportation Systems Early Deployment Plan
Figure 4 - Traffic Monitoring Stations
Programmed Traffic Monitoring Stations
Existing Traffic Monitoring Stations
Sunrise Boulevard
Florin Road
West Avenue
CHP/Caltrans TMC

Highway Advisory Radio (HAR) Highway advisory radios exist at four locations along US-50 between Placerville and Lake Tahoe, one location on I-80 at Dixon, and at six locations on I-80 between Newcastle and Lake Tahoe. One additional HAR is programmed for installation on I-80 at Greenback Lane near the truck scales (Figure 2). An additional HAR operates near Sacramento Metro Airport, broadcasting airport information. Caltrans and the airport are exploring alternatives for broadcast of travel information at this site. Broadcast messages for the Caltrans HAR's will be controlled from the Caltrans/CHP TMC.

HAR's provide ***En-Route Traveler Information*** user services on limited segments of the State Highway system.

Freeway Service Patrol (FSP). A total of ten tow trucks currently serve the urban portions of Business 80, US-50, and SR-99 (Figure 6). The FSP program may be expanded to include portions of i-5, and I-80 from the Yolo Causeway County.

The FSP provides ***Incident Management*** user services.

Traffic Signal Coordination. The City of Sacramento and County of Sacramento traffic signal coordination systems are discussed above, in the context of their TOC projects. The City of Roseville, County of Placer, City of Davis, and City of Woodland operate or have programmed closed loop systems on major arterials.

Traffic signal coordination provides ***Traffic Control*** user services for affected roadways.

Air Quality Monitoring and Emissions Testing. The Sacramento Air Quality Management District operates 10 air monitoring stations in Sacramento County. Data is downloaded on a daily basis, via phone lines, to a computer at the SMAQMD offices. The Bureau of Automotive Repair conducted a pilot project in 1994 to detect and quantify emissions from passing vehicles. Gross emitters were identified and contacted.

Traveler Information Systems. The major fully operational traveler information system in the Sacramento region is the SmartTraveler Internet Site and the "1-800-COMMUTE" service.

The SmartTraveler Internet Site provides a single collecting point for various single-mode or single operator sources of traveler information: the Caltrans California Highway Information Network (CHIN); Sacramento Regional Transit route information; Amtrak information; and telephone numbers for various other van, shuttle, and taxi services. The Internet Site also provides an on-line version of the Sacramento Rideshare automated ridematching services.

The "1-800-COMMUTE" service is a telephone advisory system analogous to the SmartTraveler Internet Site. Instead of links to other on-line services, though, "1-800-COMMUTE" uses hook-flash transfers to other telephone advisory services in the Sacramento region.

These projects provide ***Pre-Trip Travel Information*** user services.

In addition to these projects, which are fully operational now, TransCal is a three-year federally sponsored Field Operational Test (FOT) that will deploy a comprehensive Interregional Traveler Information System (IRTIS) that integrates road, traffic, transit, weather, and value-added services information from sources

covering the region between San Francisco and the Tahoe-Reno-Sparks area along the I-80 and US-50 corridors.

Travel Demand Management

This bundle of user services alters vehicle demand through incentives and information distribution.

Sacramento Rideshare Ridematching Services. Sacramento Rideshare provides ride matching services for persons desiring to carpool or vanpool. Sacramento Rideshare also provides information to commuters on transit services in their area, bike routes and potential bicycling partners, location of park and ride lots, and telecommuting information. Sacramento Rideshare also assists employers in developing TDM plans. Services are also provided to disabled and bilingual commuters.

Sacramento Rideshare has also deployed a and automated, voice mail system for doing ridematching using "1-800-COMMUTE" described above. The system allows any caller to enter or modify a ridematch request, and request a listing of potential ridematching partners based on the user's preferences and requirements. An "on-line" version of this service is available through the SmartTraveler Internet Site.

These projects fall into the ***Ride Matching and Reservation*** user service category.

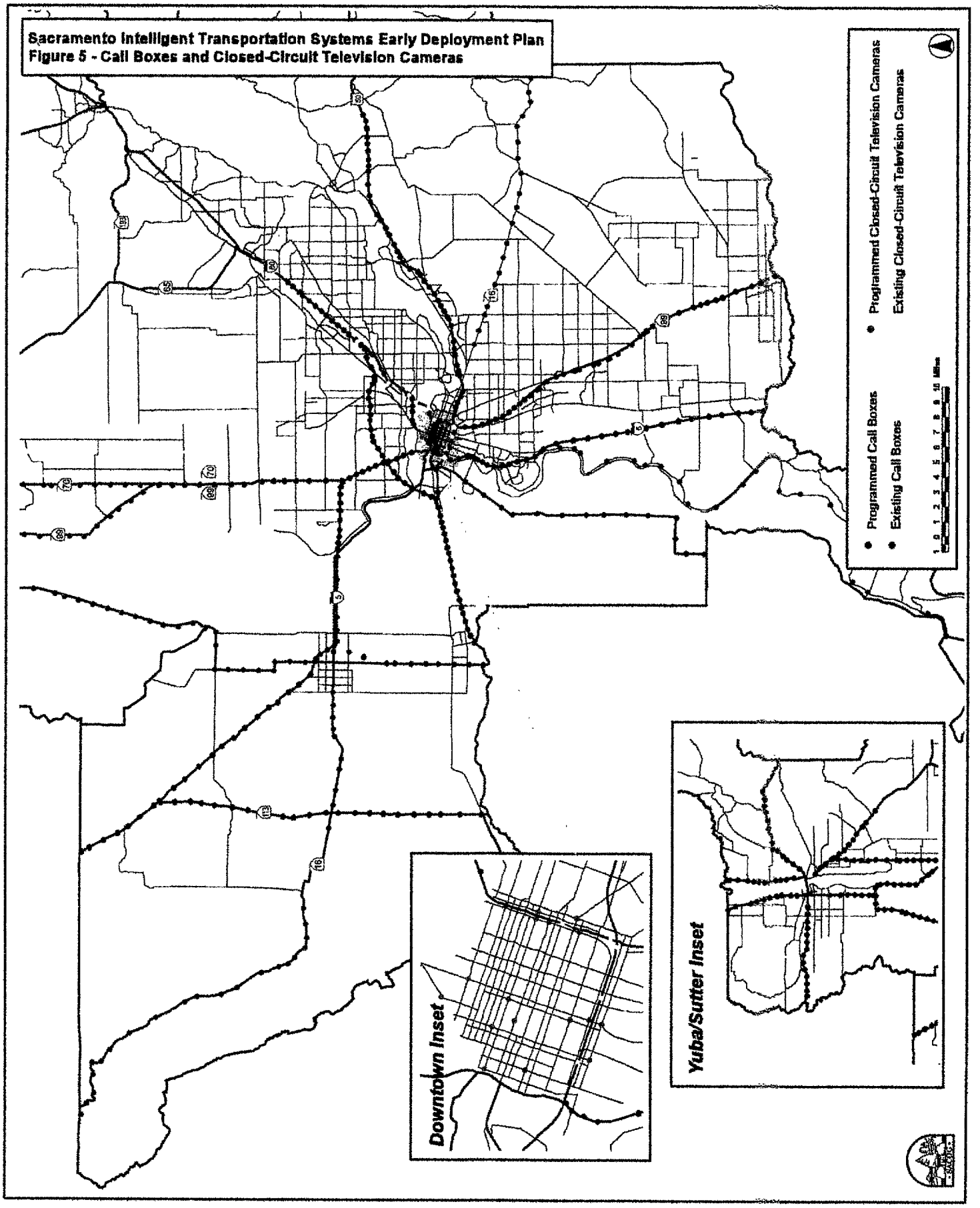
HOV Lanes. In the Sacramento region one high occupancy vehicle (HOV) lane is in operation to give preference to transit and high-occupancy vehicles and promote carpooling. This lane is on Route 99 between Mack Road and Martin Luther King Jr. Boulevard. The HOV lane is in operation at all times of the day. Enforcement is the responsibility of the CHP. This HOV lane is funded for extension south to Elk Grove Boulevard in 1997 and north to L and Q Streets in 1999. There are also numerous HOV bypass lanes at ramp meter locations throughout the region.

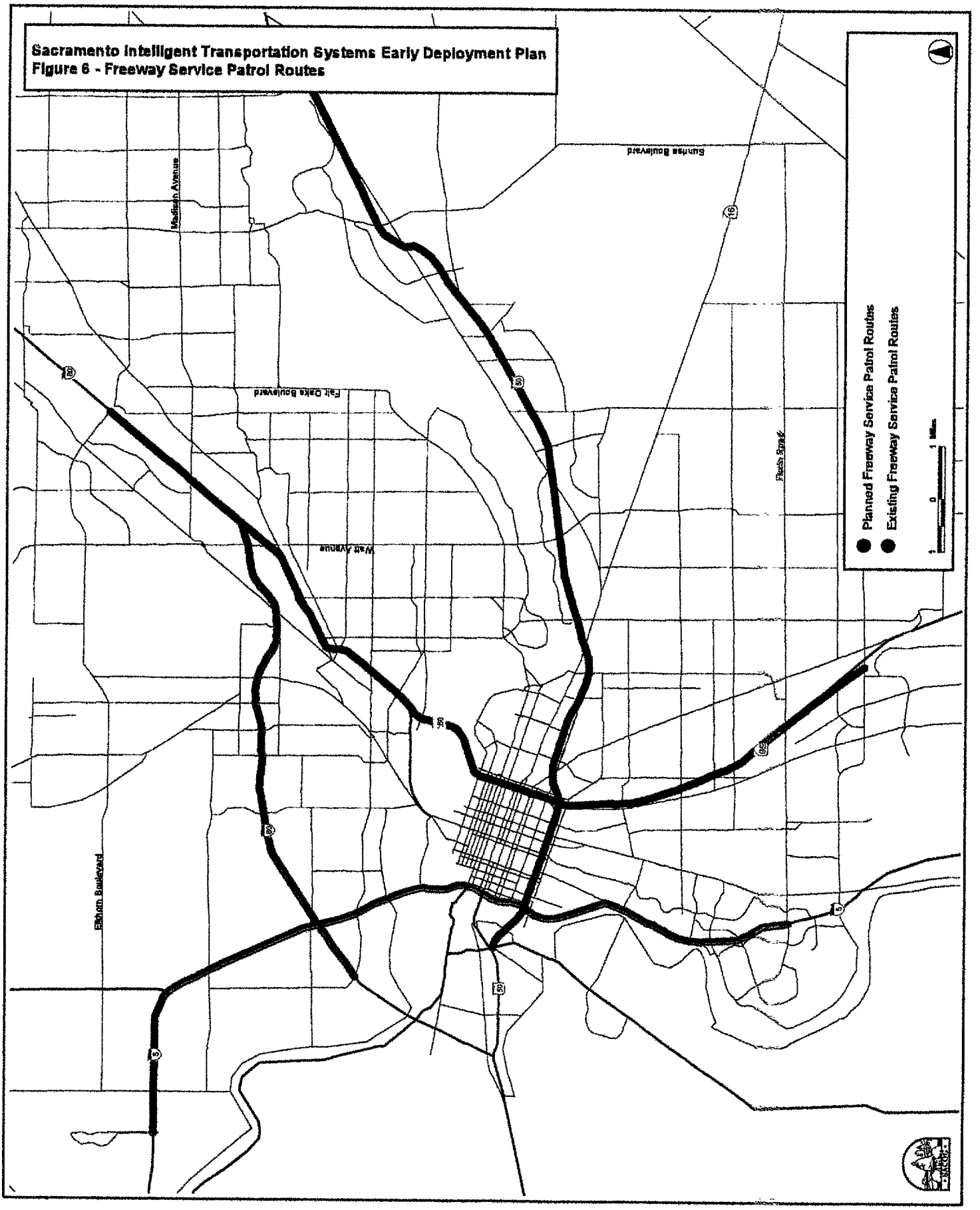
Public Transportation Operations

Paratransit, Inc. in Sacramento currently utilizes an integrated, GIS-based software package for routing, scheduling, and dispatch of paratransit vehicles. The system also integrates detailed information on eligible passengers, service requirements, service areas, and other key data. Paratransit, Inc. intends to utilize report generation capabilities of the system in the near future. The Yolo County Transportation Authority (YCTA) plans to install "smart card" fareboxes on their fixed-route buses. This system would allow travelers to pay for transit trips with a debit card. YCTA has also applied for, and received, funds to upgrade their radio communication system. There is interest in including some type of vehicle location/position capabilities in this new system.

Yuba-Sutter Transit plans to install an in-vehicle data collection system. This system will allow Yuba-Sutter Transit to integrate real-time dispatching, automated vehicle location, and automated trip data collection.

LRT vehicles currently preempt traffic signals at intersections. Other transit vehicle signal preemption alternatives are being explored by RT, the City of Sacramento, and County of Sacramento.


Sacramento Intelligent Transportation Systems Early Deployment Plan
Figure 5 - Call Boxes and Closed-Circuit Television Cameras
Programmed Closed-Circuit Television Cameras
Existing Closed-Circuit Television Cameras
Programmed Call Boxes
Existing Call Boxes
Downtown Inset
Yuba/Sutter Inset


Sacramento Intelligent Transportation Systems Early Deployment Plan
Figure 6 - Freeway Service Patrol Routes
Sunrise Boulevard
Madison Avenue
Fair Oaks Boulevard
Watt Avenue
Florin Road
Elkhorn Boulevard
Planned Freeway Service Patrol Routes
Existing Freeway Service Patrol Routes
0
1 Miles

Commercial Vehicle Operations

Fleet Dispatch. Many private trucking drivers have constant radio communication with dispatchers and can report, or be notified of, congestion or adverse conditions.

Mayday. Many private companies also operate in-vehicle radios that are equipped with "mayday" type devices to use in case of hijacking or other problems requiring driver aid.

Commercial Vehicle Electronic Clearance. The HELP, Inc. (Heavy Vehicle Electronic License Plate) system will equip participating vehicles with an automatic vehicle identification (AVI) transponder. At designated "pre-pass" sites the truck will be weighed and classified. If the information matches the information in the database, the driver will be notified to continue without stopping at the approaching inspection station. Pre-pass sites along Interstate 5 in California are currently operating at Dunsmuir Grade, Cottonwood, Santa Nella, Grapevine, Castaic, and San Onofre. Additional sites are to be deployed along Interstate 80, including Cordelia in 1997, and Antelope and Donner Pass in 1998/1999.

Weigh-In-Motion. Weigh-In-Motion sites are currently located in the east and west bound lanes of I-80 at Antelope, in the southbound lanes of I-5 at Del Paso, on Route 49 near Auburn, and in the westbound lanes of US 50 in West Sacramento.

Emergency Management

Motorist Aid Call Boxes. Approximately 700 solar-powered, cellular call boxes are located at one-half-to-one-mile intervals on all state routes and interstates in Sacramento, Yolo, and Yuba counties (Figure 6). Call boxes are linked directly to a California Highway Patrol dispatcher who will send necessary aid. It is anticipated that call boxes will be installed on highways in Sutter County during Summer 1996. The communications capability within these call boxes will support traffic census stations, fog detectors, and CMS's.

Emergency Vehicle Traffic Signal Preemption. Many jurisdictions have installed emergency vehicle traffic signal preemption equipment. In most cases, emitters have been installed in fire department vehicles.

Advanced Vehicle Control and Safety Systems

These systems are being developed by the private sector and offered directly to consumers. Examples include anti-lock braking systems and air bag restraint systems. Additionally, the Greyhound company has implemented a longitudinal collision avoidance system on many of their buses.

Sutter County plans to equip county fire trucks with infrared locators that can be used in collision avoidance and in locating crash victims during inclement weather.

VII. OPTIONS FOR DELIVER OF ITS USERS SERVICES

This section of the report describes the development of a delivery system or "system architecture" for the user services that can meet the requirements for the user services. Existing and programmed projects in the region have been used as one reference point in development of a recommended user services delivery system. However, the user service delivery system must not be based on specific projects or technologies, since these change and evolve quickly. The major reference points in development of the recommended user services delivery system are the stated desires of the EDPS participants, and the functional requirements for delivering users services as defined in national ITS standards reports /34,35/.

The reader is referred to "Project Summaries and Technology Assessment" for complete documentation of the technology assessment /36/. This document details technologies available at the time of writing. Again, these technologies change very rapidly.

The Concept of a User Service Delivery System or "System Architecture"

The user service delivery system or "system architecture" should not be confused with a technical design or specification. "User service delivery system" or "system architecture" can be defined by analogy to a common household item which exhibits good, flexible system architecture: home stereo equipment. Home stereos are made up of several basic components, with standard functions and relationships to other components (amplifiers, tuners, CD players, cassette decks, record players, speakers, etc). As anyone who has visited a stereo dealer well knows, the range of quality, features, and price is mind-boggling, offering the consumer an almost infinite number of choices for systems within a given price range. However, a consumer can purchase components from different manufacturers with relatively little fear that the components will not function together, as long as the system purchased includes the basic functional components. Additionally, even consumers with limited knowledge of electronics can successfully set up a functional system with little or no difficulty. The agreements regarding basic system components, the relationships between the components, and the standards which govern the interconnection of components constitutes the "system architecture" for home stereo equipment.

Within the ITS, there are multiple layers of system architectures. In this context, architecture refers to the organization or structure of **a** series of components or elements. The organization of ITS elements can be examined at several levels, including:

- ***Individual system elements*** (e.g. a loop detector in a roadway, a traffic signal controller, or a GPS receiver in a vehicle)
- ***Subsystems*** (assemblages of system elements to perform basic ITS functions such as 2-way communications)
- ***Systems*** (assemblages of subsystems, e.g. a system of coordinated traffic signals, or a video surveillance system on a transit vehicle)
- ***Regional*** (Linkages between systems to expand areas of benefit to all travelers)
- ***National*** (Standards for system components and common elements of regional architectures)

The regional level is the focus of this project.

The development of a user services delivery system for the Sacramento area followed a structured process starting with problem definition, proceeding through a definition of requirements, and identifying the required ITS functions to be provided within individual systems and regional elements of the system. Once the ITS functions and inter-system data flows were defined, the characteristics of alternative delivery systems were described. As presented, the alternatives were intended to stimulate local discussion concerning which configuration was best suited to the requirements of each user service. The outcome of this section was a "Candidate User Service Delivery System" which can be described in both technical and institutional terms.

On the national level, the U.S. Department of Transportation has initiated the development of a National ITS system architecture that will describe how ITS components interact and work together. During the first phase, completed in early 1995, four teams led by Hughes Aircraft, Westinghouse Electric, Rockwell International, and Local Federal Systems, examined four alternative approaches to a national architecture. Two teams, led by Rockwell International and Loral Federal Systems, emerged from this process to cooperatively develop a consensus National ITS Architecture that will be completed 1996.

Need for a Coordinated User Services Delivery System

The method by which each user service can be delivered is described by a high level flow chart describing what the system does, and what functions are required to do it. (The actual flow charts are included in Appendix D.) The selection of the delivery system is driven by user service requirements and how they are allocated to subsystems. If the delivery system is not properly organized, agencies will be unable to share data, or cooperate in carrying out a process which requires field devices to interact across jurisdictional rights of way.

The delivery system also implies agency responsibilities for the development and provision of each user service function. Without such a structured approach, individual agencies are destined to redundantly develop systems which provide overlapping functions.

It should be noted that the user services delivery system is a tool which facilitates implementation. It is a means to an end, but not the end itself. There will be considerable flexibility afforded to local agencies within this architecture. One way in which this flexibility will be "built in" is by employing a modular approach.

A modular design allows system elements to evolve with advances in technology, and allows the program to be developed in stages. In so doing, the individual components of the program can be built to plateaus defined by the current level of proven technology. Staged implementation allows individual agencies and the region as a whole to match incremental implementation needs or upgrades with funding opportunities as they present themselves. It is unlikely that a single funding source will fund the implementation of the entire program, **or** even one agency's involvement in the program. Therefore, it is important for the program to be developed in such a way that it can be implemented in logical pieces that are technologically sound. The modular delivery scheme is what allows this to happen.

The development of an organized delivery system can be relatively complex in that it deals with very high level administrative and ownership issues and very detailed technical issues. As a result, there is great potential to become caught up in various analyses and debates along the way and lose sight of the needs or objective of the function under discussion. In order to structure this process, a framework was established which would enable each element of the program to be traced to a goal, objective or guiding principle. Figure 7 indicates that the user services and guiding principles are the key inputs to the process. The guiding principles are the ground rules that were applied when making trade-off decisions during this process. The user services themselves have been defined in earlier sections of this document.

With the user services and guiding principles as background, a conceptual organization or structure is established. The concept identifies the elements (agencies, travelers, vehicles, etc.) that must be addressed, and indicates what type of information or data needs to flow between each element. This task is initially carried out without regard to the physical locations of such elements, or the frequency in which such information must be passed. The structure is easily presented in graphical form, and provides a basis for discussion among potential system operators.

Once a general structure has been established, the functions, or requirements for the user services can be explored in technical detail. The appropriate functions are mapped to the agencies responsible for delivery of a given service. With the functions defined for a given agency, technology assessments can be conducted for specific applications. A generalized view of the technology assessment process is presented at the end of this chapter.

Guiding Principles

The development of a user service delivery system can be a very complex process. The process is complex because it deals with a wide variety of broad institutional issues and detailed technical issues that inherently involve many people. Definition of a structure which will be the framework for short-term and long-term deployment requires individual agencies, departments within single agencies, and the region as a whole to make certain commitments which have potential implications for their organizational structure and operating procedures. In many cases, these commitments will require changes, which do not come about easily.

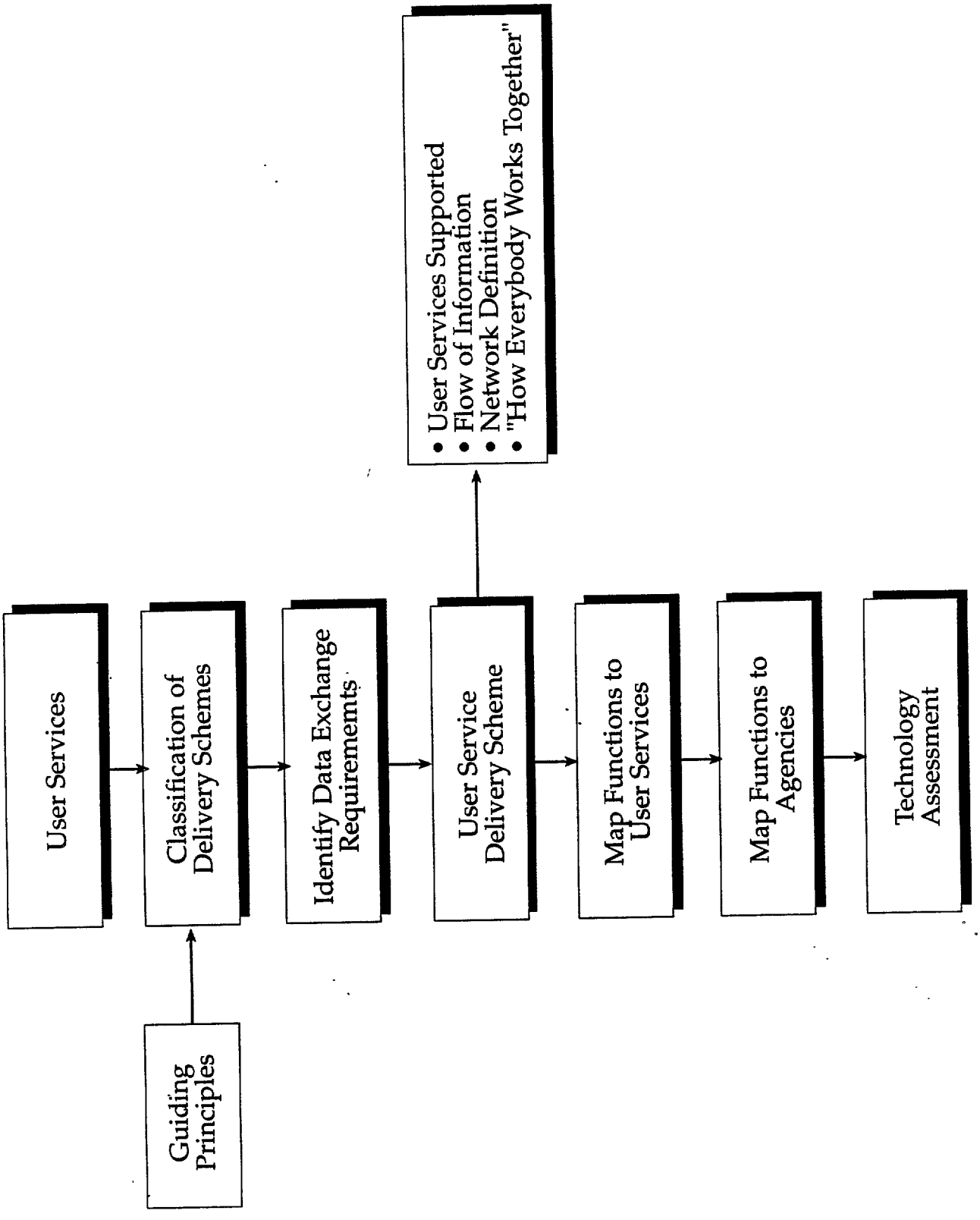
The guiding principles listed below were developed to guide the architectural development by establishing ground rules for the process. Generally, the principles are intended to ease concerns about the autonomy of local agencies, potential requirements that would limit operational flexibility, and the nature of commitments being made in this process. These principles are objective statements describing characteristics that will be exhibited in the Sacramento area's ITS structure:

- ***Expandability*** - The user services delivery system must be open, modular, adaptable, and expandable. As other agencies, system operators, and private sector companies develop ITS functional capabilities, and choose to participate in ITS implementation, the basic framework for user services delivery should be flexible enough to accommodate them.

- ***Interagency Coordination*** - Coordination starts with communications, and the ability to share a common set of information regarding system performance With this information as a basis, and with tools necessary for implementation of coordinated operational strategies, agencies and system

FIGURE 7

Development of the User Service Delivery Program



SOURCE: JHK Associates, 1995

operators can provide better system performance and user services to the traveling public. The user services delivery system must include adequate data exchange to support interagency coordination efforts.

- *Common Interfaces* - Data exchange is achieved via common standards and interfaces. Common standards allow interoperable systems to be developed by independent parties.

- *Build on Existing and Near-Term Technologies* - To the extent that the ultimate goal of the EDPS is a framework for "early deployment", short range project concepts included in the user services delivery system should be based on currently available technologies.

- *Build on Existing Initiatives* - The user services delivery system must take advantage of existing infrastructure, and build on these initiative where possible.

User Service Delivery Options

There are two basic ways to deliver any individual user service, or all services in the ITS program: Delivery of each user service can be approached by individual agencies acting alone, (autonomous delivery), or groups of two or more agencies in collaboration (collaborative delivery). Seldom is one method used for all user services. Some are best delivered autonomously, others in collaboration.

In considering the alternative configurations presented here, it should be understood that the Sacramento area's ITS program will include some services which will be delivered by individual agencies acting autonomously, and some services which will be delivered by multiple agencies acting collaboratively.

Characteristics of Collaborative Delivery Services which are delivered on a collaborative, wide-area basis have several distinguishing characteristics. The more significant characteristics can be summarized as follows:

- *Oversight of implementation and operational procedures provided by single body with multi-jurisdictional representation* - Through the collaborative efforts of multiple agencies from the region, a single body takes responsibility for the delivery of the service throughout the entire region.

  Note: the "single body" is normally a multi-agency partnership, governed by an agreement which outlines areas of collaboration. In no case in this report should collaboration be taken to imply loss of a specific agency's control over the operations of systems in its jurisdiction.

- *Uniform approach to system development in all jurisdictions and sub-regions* - With this approach, the technologies and strategies for delivering a given user service are consistent among all participating agencies and system operators. Operational procedures and specific hardware need not be identical, but rather, may be based on compatible hardware and software systems. The goal is to provide user services in ways that appear "seamless" (i.e. without major noticeable changes at jurisdiction or service area boundaries) to travelers.

- *Single source responsible for data collection, analysis, and control functions* - A single task-force representing the agencies of the region, and governed by a common agreement among participating agencies and system operators, carries out all technical tasks, including data collection, analysis, control, and distribution.

- *Economy of design and scale* - Because a single, multi-agency entity is responsible, and the technologies and systems are compatible among participating agencies and system operators, this configuration naturally benefits from economies of design and scale. Such benefits are realized in capital costs, as well as in maintenance and operations.

Characteristics of Autonomous Delivery Systems. In a purely autonomous approach, each individual agency would be responsible for delivering all user services within their respective jurisdictions. The characteristics of this configuration can be summarized as follows:

- *Individual agencies operate autonomously establishing agency-specific implementation priorities and operationalprocedures* - Because individual agencies maintain complete responsibility for all design, program development, and operational decisions, they maintain complete autonomy. As such, they are unaffected by, and have no influence over decisions made by agencies in adjacent jurisdictions, and can tailor the system to meet unique needs within their service areas.

- *Individual systems provide data gathering, analysis and control functions within jurisdiction boundaries* - Each agency operates its own system which gathers the data, and performs the analyses needed to support the mission of the given agency. Exchange of data with other agencies or system operators is done on an "as needed" basis, within the constraints of the data collection, formatting, and distribution systems available.

- *Each agency develops individual agreements/linkages to other agencies when they need/want to interact* - In instances where agencies identify the need to coordinate operations or share information with another agency, the two agencies form a relationship for that purpose. A separate relationship, be it a formal Memorandum of Understanding or a simple informal request for information, occurs with each other agency on an individual basis. There is no necessary requirement for consistency of these agreements among different agencies.

"Combined" Delivery Systems. In some ways, the "autonomous" and "collaborative" system definitions can be looked at as ends of a continuum. In practice, no delivery system is fully autonomous nor collaborative for all user services. Some user services are delivered more autonomously, and others more collaboratively. Additionally, the level of collaboration for a given user service can be tailored to the needs of the participating agencies and system operators. For example, all data gathering and information sharing functions could be collaboratively provided, with actual management control provided on an autonomous basis.
The characteristics of "combined" configurations can be summarized as follows:

- *Individual agencies provide data gathering, analysis and control functions* - Systems designed, constructed and operated by individual agencies are responsible for collecting data and information from within their own jurisdictions. Oftentimes, the individual agency will then also be responsible for analysis of that data and oversight of those systems which provide traffic control

in their jurisdiction.

- *Agencies are linked to central distribution mechanism for automated data exchange - The* data and information gathered within the individual agency systems is distributed to a central database, where it is available for access by other agencies, the general public, or value added private sector entities.

- *Centralized management of services/functions that make sense.* It was noted earlier that the overall ITS delivery system for the Sacramento area will include autonomous and collaborative delivery systems. The challenge in developing the overall relationships is to identify those Services which best serve area stakeholders, and are most efficient, when they are delivered and managed collaboratively.

Shown on Figure 8 is a concept delivery system for the Sacramento region, which is a "combined" delivery system. The diagram includes five high level "networks", indicated by the boxes. The networks are of two basic types: "operator" and "user" networks.

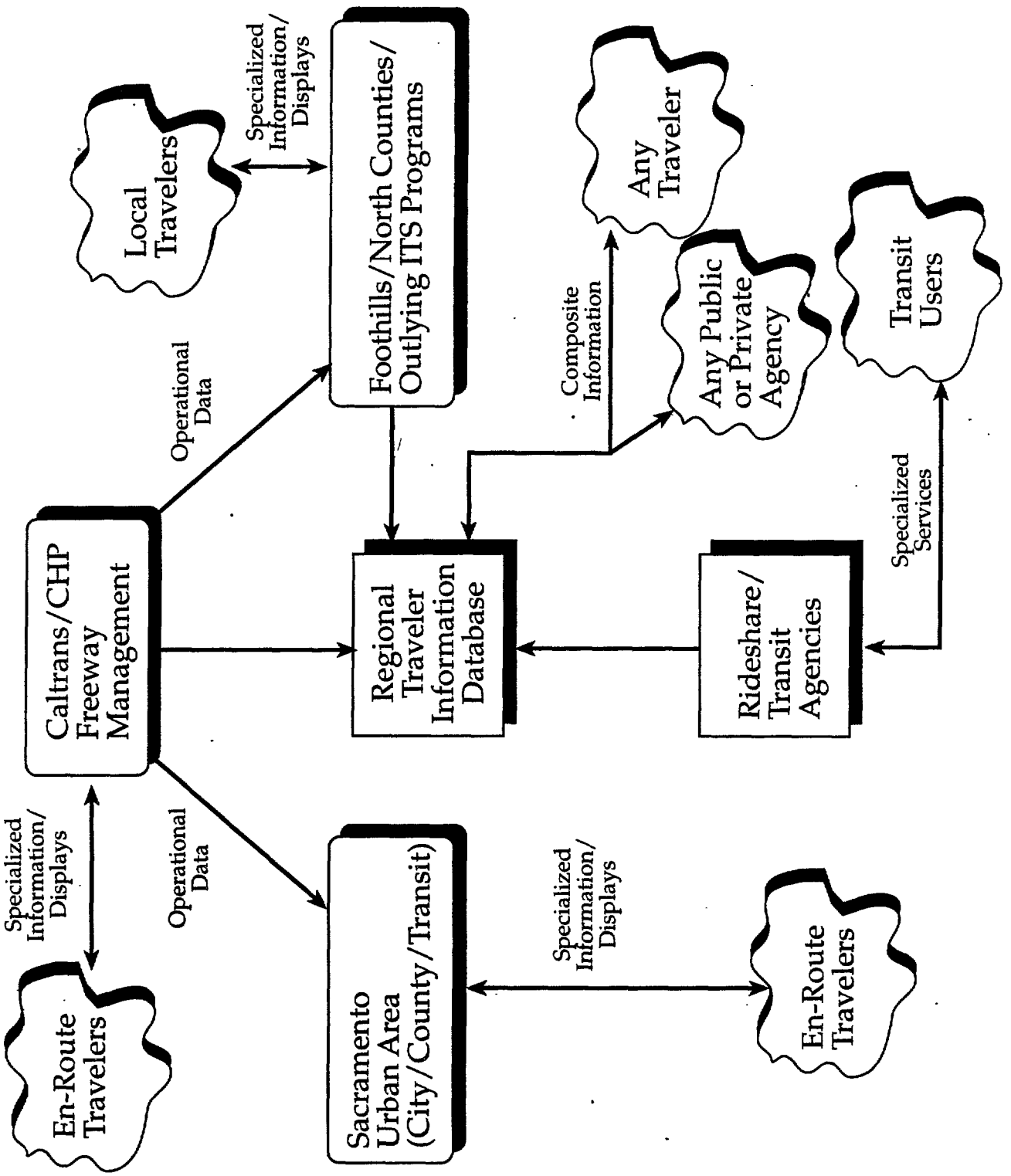
(Note: the term "network" is used, because these basic system components are likely to be built on communications and computer networks among the participating agencies and system operators. However, it is not meant to suggest that each "network" shown in the diagram translates to one discrete project. Rather, a collection of projects which are functionally related and build toward the system shown must be undertaken by the participants in each network.)

- *Operator Networks* are designed to provide system operators with management and control tools, to allow them to monitor and improve the performance of the systems they control. An important part of this is the ability to share information about system boundaries (e.g. a "gap" between two coordinated traffic signal systems, or a transit stop where transfer between two transit systems is possible). In addition to providing tools for the operators, operator networks create new sources of real time information which may be of great interest to travelers, and to private sector companies which provide information and services to travelers. The key operator networks shown in the flow chart are an Urban Area Network, a Regional Network, a Sierra Foothills network, and a Transit Agencies Network. At this stage these networks are very generalized and "high level". More detail will be provided later in the report.

- *User Networks* are intended to provide information and services to travelers, either directly or via "value added resellers" (VAR's). VAR's are generally private companies which provide traveler information and services to the general public. Some examples of VAR's: traffic reporting companies, which provide traffic reports to local broadcast media; auto clubs, which provide travel information, insurance, etc. to members; and "on-line" vendors, which provide travel. information to the public, along with commercial travel information (such as tourist destinations and attractions). The range and type of VAR's specializing in traveler information, services, and products is expanding rapidly. The key "user network" shown is a Regional Traveler Information Database. One function of this network is to provide some basic roadway and transit information directly to the public, similar to the SmartTraveler Internet Site and similar systems now being developed in many regions around the country. Another function will be to provide formatted travel data to VAR's, for secondary distribution to travelers.

FIGURE 8

Concept Delivery System



SOURCE JHK Associates, 1995

Individual agencies maintain autonomy for control functions with their jurisdictions, but data and information of interest to others is exported to some form of collaborative distribution mechanism. These data may include real-time parameters, or historical information that is logged within the individual agencies and passed to the collaborative system on a regular interval. It is important to note that even with a centralized information source shown in the diagram, agencies participating in each network still maintain capabilities of providing information directly to users (e.g. Caltrans messages broadcast to drivers via changeable message signs and highway advisory radio stations, Sacramento Regional Transit Customer Services delivered via their own telephone advisory system, etc.).

The remainder of this report section will provide additional detail to the very generic, high-level flow chart shown in Figure 8.

Interagency Data Flows

The conceptual view of collaborative and autonomous delivery systems can be considered in the Sacramento area's context by examining Figure 8. Information on traffic volumes, levels of congestion, and travel options are provided on a regional basis through a central location (the Traveler Information Database). Traffic control functions and operation of transit systems are retained at the local level with multiple agencies providing these services.

The next step in the development of the system is to consider the needs of individual agencies. Individual agencies have needs related to delivering their local services and will also be required to provide information to agencies or systems responsible for collaborative delivery of services.

Interviews and meetings were held with local agencies to identify types and sources of information that would be helpful to them in carrying out their missions. At the same time, consideration was given to the needs of a regional traveler information database.

The matrices shown in Tables 2 to 4 identity the information/data needs of the various agencies, and the desired sources of that information. The large number of agencies involved prevented the use of a single matrix to describe the information/data needs and sources for all the agencies. In order to facilitate the definition of the agency-to-agency relationships, the region was divided into three subgroups: Foothills and North Counties (Table 2); Sacramento Urban Area (Table 3);and Transit Providers (Table 4).

The division into three sub-groups is not meant to imply that there would be separate systems or that these subgroups would be independent. This organization also does not mean that agencies shown in one matrix will be unable to exchange data or information with an agency listed in a different subarea. To embellish this point, several agencies/entities are shown in each of the subareas. These agencies/entities include Caltrans, CHP, local police and fue services, and the Traveler Information Database. The Traveler Information Database was included in the matrices to facilitate identification of information these agencies could provide to the database.

The agencies grouped in the Foothills and North Counties area include Placer County agencies, El Dorado County agencies, Folsom, Sutter County, Yuba County, Marysville, and Yuba City. For the purposes of this matrix, transit providers are grouped into a single category. This simplifying consolidation was made since no single transit agency had unique information requirements for itself, nor was any transit service

TABLE 2

Required Agency Data Exchange: Foothills & North Counties Area

FROM \ TO	Caltrans	CHP	Local Police/Fire	Transit Operators	Commercial Operators	Traveler Information Database	Folsom	Placer County Agencies	El Dorado County Agencies	Sutter County	Yuba County	Yuba City	Marysville
Caltrans		Incident Locations				Volumes							
CHP			Incident Locations										
Local Police/Fire													
Transit Operators													
Commercial Operators						Travel Times							
Traveler Information Database	Incident Locations	Incident Locations		Schedules, Routes			Volumes	Volumes, speed	Volumes	Volumes	Volumes	Volumes	Volumes
Folsom	Volumes					Volumes							
Placer County Agencies	Signal Data Video					Volumes							
El Dorado County Agencies						Volumes							
Sutter County						Volumes							
Yuba County						Volumes							
Yuba City						Volumes							
Marysville						Volumes							

SOURCE: JHK Associates, 1995

TABLE 3

Required Agency Data Exchange: Urban Area

FROM \ TO	Caltrans	CHP	Local Police/Fire	Transit Operators	Commercial Operators	Traveler Information Database	Rideshare	Sacramento County	Yolo County	City of Sacramento	Davis	Woodland	West Sacramento	SMAQMD
Caltrans		Incident Locations				Volumes, Speed Road Closures		Video, Ramp Queue Data, Link Conditions		Video, Ramp Queue Data, Link Conditions		Volumes, Incident Locations	Ramp Queue Data	
CHP						Incident Locations								
Local Police/Fire		Incident Locations												
Transit Operators		Incident Locations				Schedules, Routes		Pre-emption Information		Pre-emption Info/LRV Location				
Commercial Operators														
Traveler Information Database	Volumes				Travel Times, Road Conditions			Volumes	Volumes	Volumes	Volumes	Volumes	Volumes	
Rideshare														
Sacramento County	Video, Signal Coordination Data	Incident Locations				Volumes, speed				Signal Coordination Data				
Yolo County		Incident Locations												
City of Sacramento	Video, Signal Coordination Data	Incident Locations				Volumes, speed		Signal Coordination Data						
Davis		Incident Locations				Volumes								
Woodland		Incident Locations				Volumes								
West Sacramento		Incident Locations												
SMAQMD	CMS Messages													

SOURCE: JHK Associates, 1995

TABLE 4

Required Agency Data Exchange: Transit Providers

TO \ FROM	Regional Transit	CSU Hornet Express	Davis Community Transit	Folsom Stage Line	Galt Tracs	Paratransit	Yolo County Transit Authority	Yuba-Sutter Transit Authority	Lincoln Transit	MV Transportation	UniTrans	El Dorado County Transit Providers	West Sacramento	Other Placer County Providers	Nevada County STAGE
Nevada County STAGE														Routes, Schedules	
Other Placer County Providers	Routes, Schedules											Routes, Schedules			Routes, Schedules
West Sacramento															
El Dorado County Transit Providers														Routes, Schedules	
UniTrans							Routes, Schedules								
MV Transportation															
Lincoln Transit															
Yuba-Sutter Transit Authority															
Yolo County Transit Authority											Routes, Schedules		Signal Preemption		
Paratransit	Routes, Schedules			Routes, Schedules								Routes, Schedules			
Galt Tracs															
Folsom Stage Line															
Davis Community Transit															
CSU Hornet Express															
Regional Transit						Routes, Schedules								Routes, Schedules	

SOURCE: JHK Associates, 1995

provider in this sub-region identified by another agency as being a unique source of information.

The primary types of information being exchanged include traffic volumes, speeds, and incident locations, as well as road closure information. The traffic volumes will be organized within the traveler information database, where it can be drawn upon to assist in decision support for area planning and congestion management agencies. Speed data can be used by the traveler information database to calculate travel times that will be used in user services such as Pre-Trip Travel Information and Route Guidance.

The agencies grouped into the Urban Area category include Regional Transit, Sacramento Rideshare, Sacramento County, Yolo County, the City of Sacramento, Davis, Woodland, the City of West Sacramento, and SMAQMD.

The information exchanged among urban area agencies will go beyond historical volumes and real-time speed data. Additional requirements include access to freeway and surface street video, and real-time queuing information at freeway ramps.

The transit providers indicated in the matrix were invited to a meeting to discuss data exchange needs specific to their missions. This meeting revealed that the primary area of interest lies in schedule coordination.

The Yolo County Transit Authority is also interested in exchanging signal pre-emption data with signal controllers in West Sacramento to give signal priority to approaching buses.

Candidate User Services Delivery System

Based on the information yielded through the agency data requirements, it was possible to refine the flow chart shown in Figure 8, to show all of the required data flows and more detail on the key networks included. The results of this refinement is the "Candidate User Services Delivery System", shown in Figure 9. A series of arrows are shown between various agencies and groups of agencies. These arrows represent data or information that must be exchanged in order for:

- collaborative services to be provided
- local agencies to improve the quality of their services at jurisdiction boundaries
- the traveling public and private sector to have a single point of access for information they need or want.

The information flows can be refined as indicated in this graphic to illustrate the nature of the communication between networks and agencies. Data in the various databases will be continuously available to users. However, the update frequency for the stored data will vary with each type of data. Data that rarely changes (updated no more often than once a month) is considered "static", more frequently updated data is defined as "periodic", and data that is constantly being updated (updated at least once per minute) is called "real-tune."

Examples of "static" data include the configuration of the freeway and light rail systems. "Periodic" data includes updates to transit schedules and locations of construction zones. "Real-time" requirements include coordinated traffic signal operation, where cycle timing parameters are exchanged.

The frequency of data updates does not imply that "real-time" data is fresher, or somehow better, than less frequently updated data. Instead, the distinction is made to correspond with the user's update requirements. The update interval is critical to the database designer because it drives the type of technology that will be selected to process the data.

Individual components of the "Candidate User Service Delivery System" are shown in greater detail in Figures 10 to 14, and discussed below. (Note: The parenthetical acronyms in the upper portion of each box are network designations that are referenced on later diagrams).

Urban Network (Figure 10). The urban area would be served through a computer and communications network that facilitates efficient, coordinated operations among all the participating agencies and system operators. Signal timing parameters would be exchanged between the City and County to reduce delay at their mutual boundaries. Real-time video and ramp meter queue data would be exchanged between Caltrans and the City and County to reduce delay at surface street/freeway connections. Regional Transit's light rail system could provide signal pre-emption data to the City and County through this network. The signal pre-emption data may be used by the City and County to modify signal timing in response to train movements in order to reduce delay caused by trains as they travel through the signal network. The network would also provide link condition and incident location information to the Traveler Information Database to encourage travelers to avoid congestion and plan fewer vehicle trips.

Regional Network (Figure 11). This network is assumed to be centered in the Caltrans/CHP TMC. The TMC can exchange data with the other sub-regional networks to reduce delay and improve air quality. This network would provide the most important communications links to furnish current and reliable information on State Highway system route conditions and incidents to the en-route driver and the Traveler Information Database. Various air quality agencies could monitor emissions levels at certain "hot spots" and background ambient air quality levels in the region. The monitoring system would be linked with traffic control system operators via this network to convey notifications that air quality thresholds have been exceeded. The Regional Network may also provide communications infrastructure to serve commercial vehicle fleet operations, if desired.

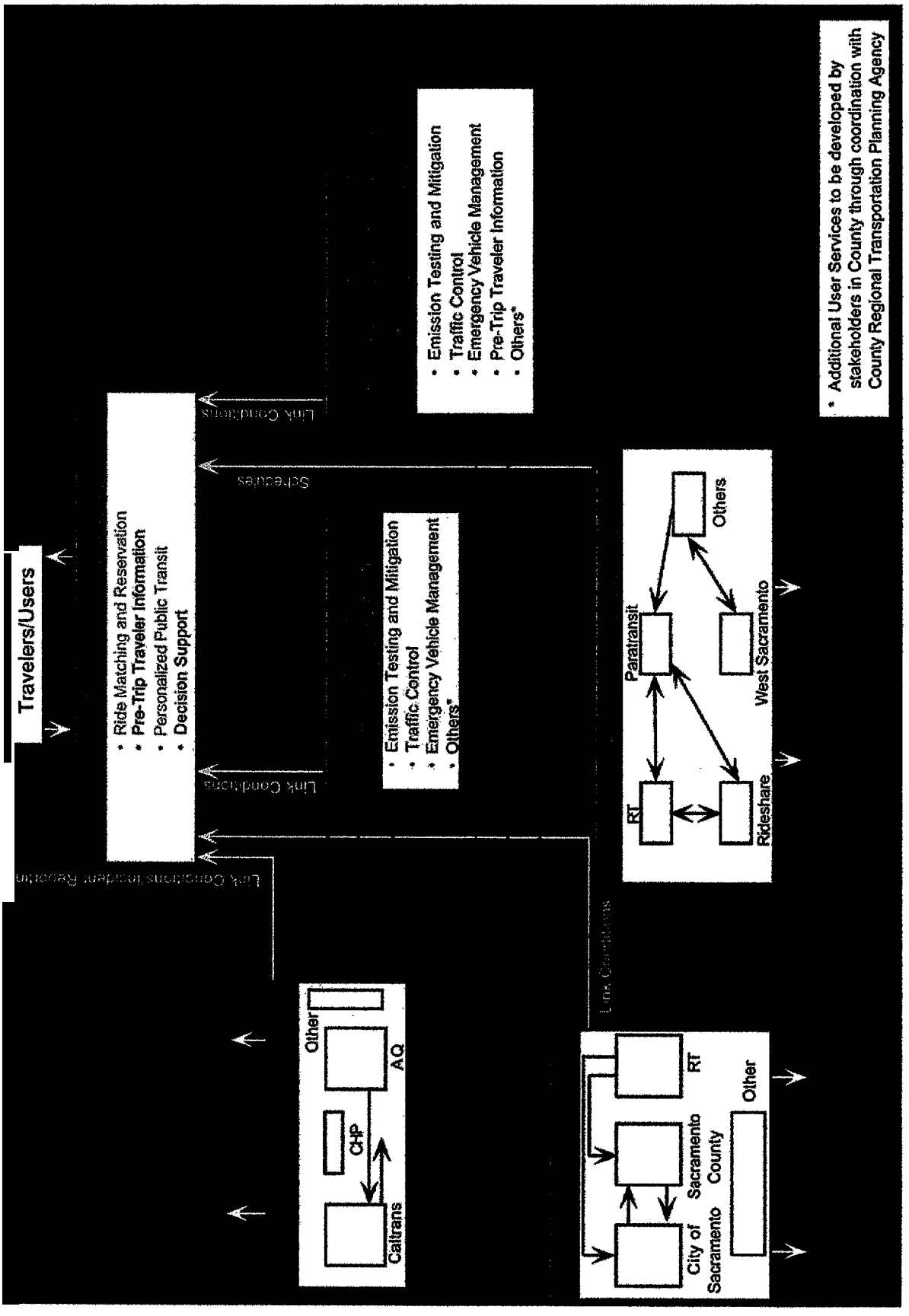
Ramp metering systems, en-route traveler information systems, and the Traveler Information Database can also utilize the communications links of this network to orchestrate a regional demand management and operations strategy to reduce or spread demand at critical locations in the roadway network.

El Dorado County Transportation Commission and Placer County Transportation Planning Agency ITS Programs (Figure 12). The planning process for this study has been open to any agency interested in participating. Several agencies in El Dorado and Placer Counties have elected to participate in the various workshops, meetings, and document review as part of this study, and the "Candidate User Service Delivery System" reflects the input of these agencies. However, in both El Dorado and Placer Counties, the Regional Transportation Planning Agencies (RTPAs) have initiated separate ITS oriented planning initiatives. One key initiative that these agencies are jointly pursuing is a traveler information system, which is intended to be fully operational by the time of the Gold Rush Sesquicentennial Celebration events.

The expectation is that the input from agencies in both counties through this study would provide some building blocks for their independent ITS planning efforts. Their ITS planning initiatives would need to

FIGURE 9

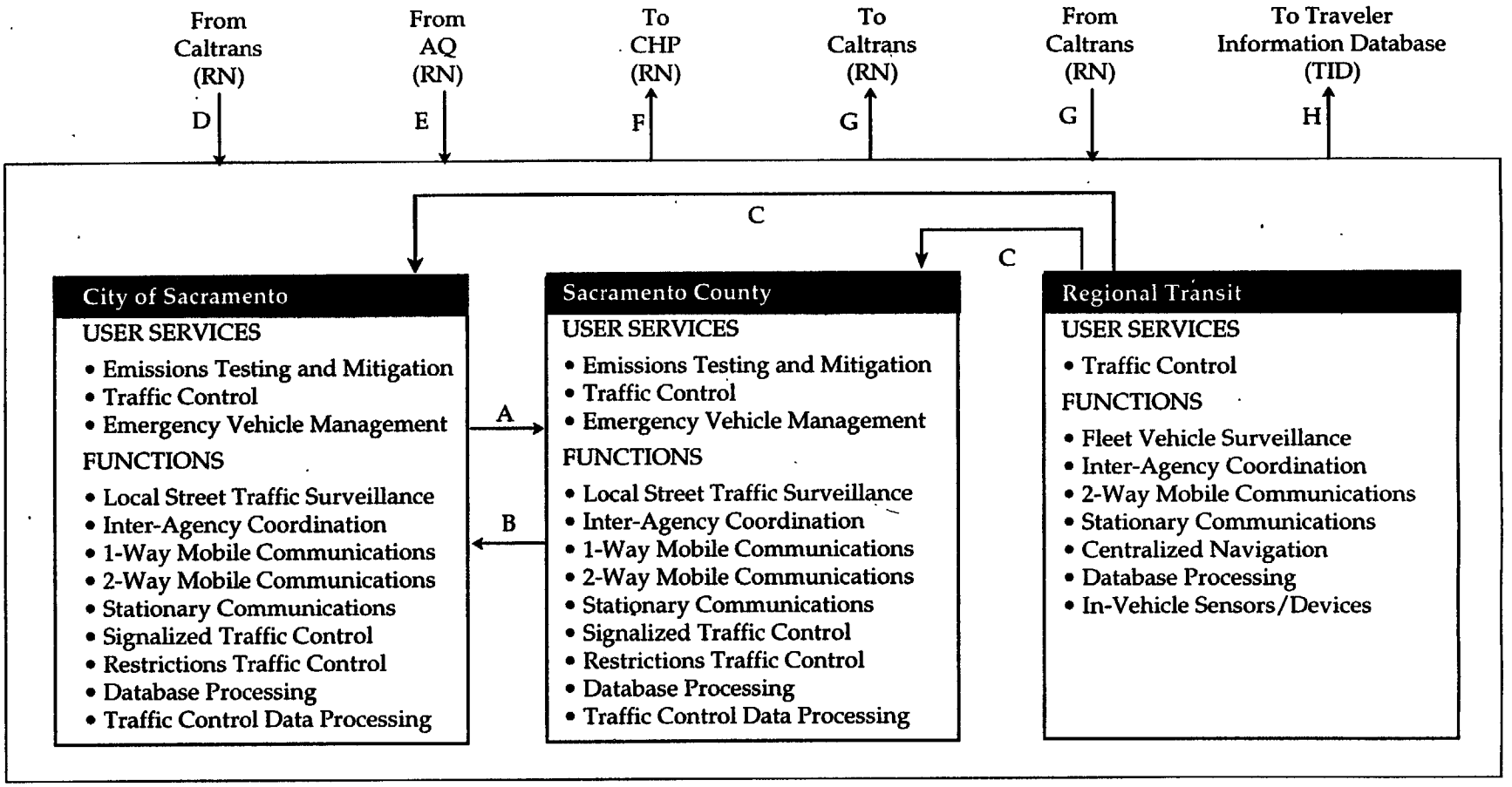
Candidate Delivery System



SOURCE: JHK Associates, 1995

FIGURE 10

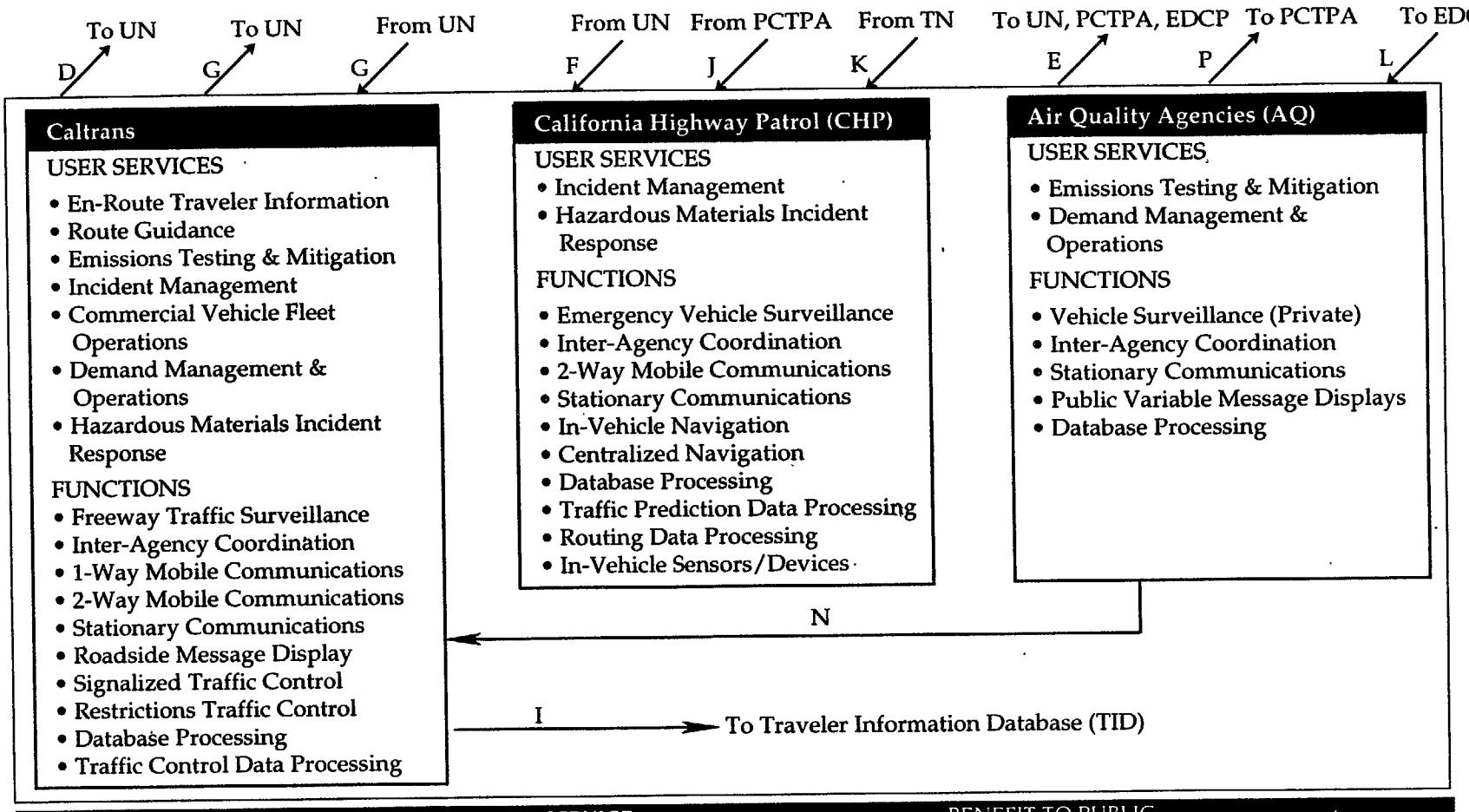
Service Delivery in the Urban Area



DATA FLOW	USER SERVICE	BENEFIT TO PUBLIC
A-Signal Timing Parameters	Traffic Control	Reduced Delay at City/County Boundaries
B-Signal Timing Parameters	Traffic Control	Reduced Delay at City/County Boundaries
C-Signal Timing Parameters, LRV Locations	Traffic Control	Reduced Delay at Light Rail Crossings
D-Video, Ramp Queue Data, Link Conditions	Traffic Control	Reduced Delay at Surface Street/Freeway Connections
E-Air Quality Strategy	Emissions Testing and Mitigation	Better Air Quality
F-Incident Locations	Incident Management, Hazardous Materials Incident Response	Reduced Delay by Incidents, Reduced Delay
G-Video	Incident Management	Reduced Delay at Surface Street/Freeway Connections
H-Link Conditions	Pre Trip Travel Information	Reduced Congestion and Delay, Fewer Vehicle Trips

SOURCE: JHK Associates, 1995

FIGURE 11
Delivery of Regional Services

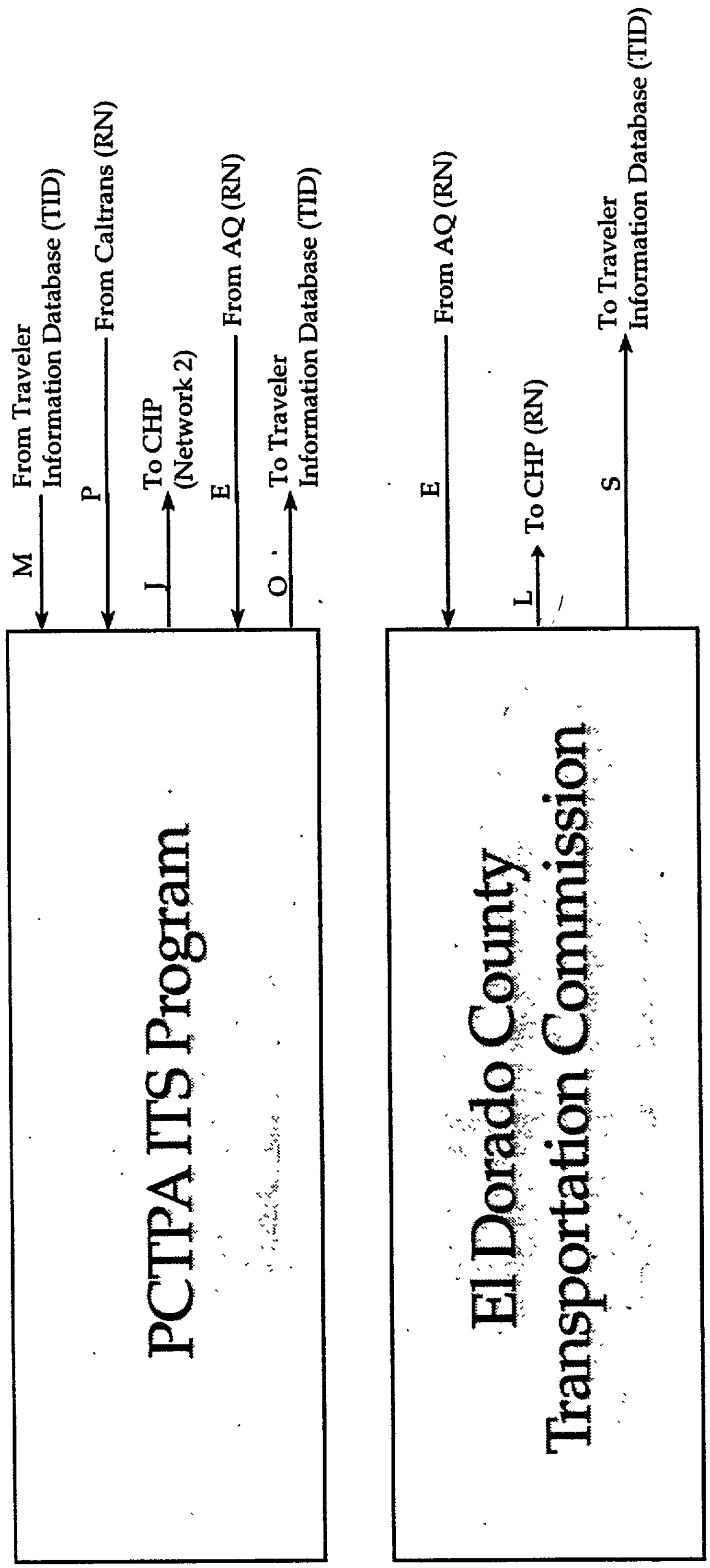


DATA FLOW	USER SERVICE	BENEFIT TO PUBLIC
D-Video and Ramp Queue Data	Traffic Control, Incident Management	Reduced Delay at Surface Street/Freeway Connections, Reduced Delay by Incidents
E-Air Quality Strategy	Emission Testing and Mitigation	Better Air Quality
F-Incident Locations	Incident Management, Hazardous Material Incident Response	Reduced Delay by Incidents, Improved Response to HazMat Incidents
G-Video/Signal Coordination Data	Traffic Control	Reduced Delay at Surface Street/Freeway Connections
I-Link Conditions and Incident Reports	Pre-Trip Travel Information	Reduced Congestion and Delay
J-Incident Locations	Incident Management	Reduced Delay from Incidents
K-Incident Locations	Incident Management	Reduced Delay from Incidents
L-Incident Locations	Incident Management	Reduced Delay from Incidents
N-Air Quality Driven Control Strategy	Emission Testing and Mitigation	Better Air Quality Through Reduced Emissions
P-Video	Traffic Control	Reduced Delay at Surface Street/Freeway Connections

SOURCE JHK Associates, 1995

FIGURE 12

Service Delivery in the Foothills Area



DATA FLOW	USER SERVICE	BENEFIT TO PUBLIC
J-Incident Locations	Incident Management	Reduced Delay by Incidents
E-Air Quality Strategy	Emission Testing and Mitigation	Better Air Quality
M-Ride Requests	Ride Matching and Reservation	Single Point of Contact for Transit Patrons
O-Link Conditions	Pre-Trip Travel Information	Reduced Congestion and Delay
P-Video	Traffic Control	Reduced Delay at Surface Street/Freeway Connections
L-Incident Locations	Traffic Control	Reduced Delay by Incidents
S-Link Conditions	Traffic Control	Reduced Congestion and Delay

SOURCE: JHK Associates, 1995

be coordinated if exchange of data is desired with the other systems which deliver regional, transit, and public information services to the surrounding region.

Study participants from both counties expressed interest in providing tourist information, link conditions, and incident locations to travelers in the region.

Placer County participants indicated an interest in exchanging signal timing parameters between Caltrans, Placer County, and the Cities of Roseville and Rocklin to reduce delay at signalized intersections in the region.

Transit Network (Figure 13). The transit providers network would provide communications infrastructure to receive ride requests and information queries from the Traveler Information Database, and, in turn, send ride confirmations and coordinated schedule information back to the traveler. Ride requests for carpools, Vanpools, taxicabs, and other demand responsive transit providers would be processed through this network. The network would also enable individual providers to electronically access schedule and route information of other trip providers in the region. The network would provide a communications link between Yolo County Transit Authority and the City of West Sacramento to provide transit preferential signal pre-emption. Transit vehicle incident information would be provided to CHP via this network. Also, Sacramento Regional Transit indicated a desire to support transit trip planning services for their Customer Services Center, and possibly for an on-line transit services web-site.

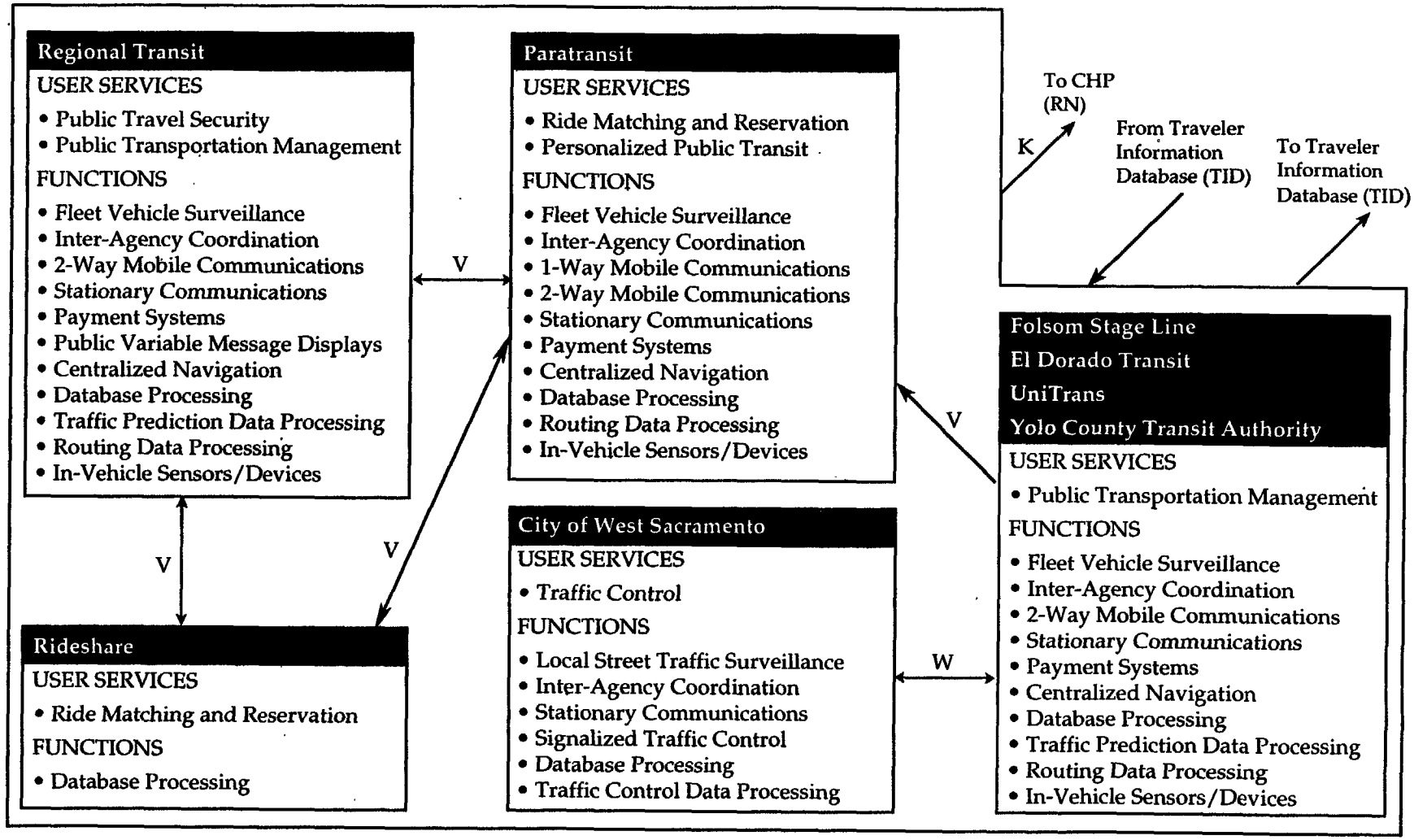
Traveler Information Database (Figure 14). The Traveler Information Database would be the single point of access for some travelers, transportation agency staff, and commercial fleet operators as they seek information on travel data or conditions. The "user" who is interested in pre-trip traveler information would be able to access link conditions and incident reports from the Region-Wide, Urban Area, and Foothills Networks through one interface. The "user" who is considering a trip by transit would be able to send ride requests to the Transit Network and receive schedule information in return.

The Traveler Information Database would be developed incrementally. During the various stages of its development, existing sources of traveler information would invariably continue to function. For example, the transit providers would continue to operate their telephone based information service redundantly until there is a clear indication that transit patrons can be served as well or better by the Traveler Information Database. While the database could ultimately be the most complete and reliable source of travel information from various sources, the gradual implementation of the database would require a transitional period when existing agency interfaces would remain until they are no longer needed.

The SmartTraveler Internet Site and 1-800-COMMUTE projects represents an initial step towards the development of the Traveler Information Database shown. The main feature of the project is a real-time ridematching service for commuters. The system also provides a telephone transfer referral to the Caltrans Highway Information Network (CHIN), rail service providers, and local transit providers. Static telecommute information is also provided to those who live or work in Placer or Nevada Counties.

FIGURE 13

Delivery of Transit Services

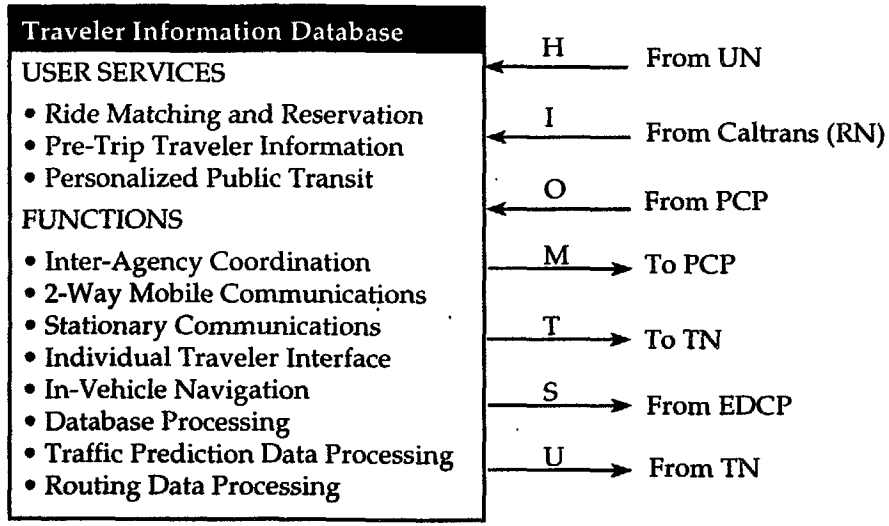


DATA FLOW	USER SERVICE	BENEFIT TO PUBLIC
K-Incident Locations	Incident Management	Reduced Delay by Incidents
T-Ride Request	Ride Matching & Reservation	Provides Single Point of Contact for Transit Patrons
U-Schedules	Personalized Public Transit	Provides Single Point of Contact for Transit Patrons
V-Schedule Coordination	Ride Matching & Reservation	Provides "Seamless" Transit System
W-Signal Preemption	Public Transportation Management	Reduced Transit Travel Times In Yolo County

SOURCE: JHK Associates, 1995

FIGURE 14

Providing Information to the Public



DATA FLOW	USER SERVICE	BENEFIT TO PUBLIC
H-Link Conditions	Pre-Trip Traveler Information	Reduced Congestion and Delay
I-Link Conditions and Incident Reports	Pre-Trip Traveler Information	Reduced Congestion and Delay
M-Ride Request	Ride Matching and Reservation, Personalized Public Transit	Provides Single Point of Contact for Transit Patrons
O-Link Conditions	Pre-Trip Traveler Information	Reduced Congestion and Delay
S-Link Conditions	Pre-Trip Traveler Information	Reduced Congestion and Delay
T-Ride Request	Ride Matching and Reservation, Personalized Public Transit	Provides Single Point of Contact for Transit Patrons
U-Schedules	Ride Matching and Reservation, Personalized Public Transit	Provides Single Point of Contact for Transit Patrons

SOURCE: JHK Associates, 1995

The delivery system just illustrated described technical relationships between agencies. Those relationships are needed to permit multiple agencies to cooperatively improve the quality of service provided to inter-jurisdictional travelers, and to improve the quality of service being delivered by individual agencies.

Autonomous and Collaborative Delivery. The matrix shown in Table 5 illustrates how the specific user services are delivered within individual agencies. The letter "A" indicates that the agency listed provides the service autonomously within their jurisdictional boundaries. The letter "C" indicates that the service is delivered to the region through *collaboration* between multiple agencies. Services delivered through collaboration require a listed agency to cooperate (administratively and/or technically) with other agencies, to ensure that the service provided meets the needs of the travelers they intend to serve. This "client satisfaction" is only achieved by providing a consistently high quality of service throughout the region.

User Service Requirements

The next step in developing the ITS program is to define the specific requirements or features that will be provided by each service. These requirements or functions will lead to identification of the technologies that will be used in carrying out the services. Functional requirements for user services are reported in detail in U.S. Department of Transportation (US DOT) publications /34,35/.

Functional Areas. The requirements for each user service are met in technical terms by a number of "functions". The US DOT National Program -Plan identifies 17 "functional areas" which can be considered as sub-components of the overall ITS system. "Functional areas" are basically groupings of technologies, which are intended to accomplish particular required functions in support of user services. In this way, the technical requirements for each user services can be determined, without specifying a specific technology or product. This allows for flexibility to adjust to new technologies and products as they evolve, without losing site of the essential function which is required to deliver a user service. See Appendix D for an excerpt from the US DOT National Program Plan.

These functions must be reflected within the Sacramento area's ITS projects in order for the ITS system to be effective in addressing the problems identified previously.

Following is a brief description of each functional area, with examples of the types of technologies that would fall under the given area.

- *Traffic Surveillance* - Technologies that collect information about the status of the traffic stream. Possible technologies include loop detectors, infrared sensors, radar and microwave sensors, machine vision, aerial surveillance, closed circuit television, acoustic, in-pavement magnetic, and vehicle probes.

- *Vehicle Surveillance* - Technologies that collect a variety of information about specific vehicles. These technologies include weigh-in-motion devices, vehicle identification, vehicle classification, and vehicle location.

- *Inter-Agency Coordination* - Technologies that connect travel-related facilities to other agencies such as police, emergency services providers, weather forecasters and observers, and among

Traffic Management Centers (TMC), transit operators, etc.

- *1- Way Mobile Communications* - Any communication technology that transmits information to potentially mobile reception sites but cannot receive information back from those sites. Possible technologies providing this function include Highway Advisory Radio, FM subcarrier, spread spectrum, microwave, infrared, commercial broadcasts, and infrared or microwave beacons.

- *2-Way Mobile Communications* - Any communication technology that transmits information to potentially mobile reception sites and allows receipt of information from those same sites. Possible technologies include cellular telephones, 2-way radio, spread spectrum, microwave, infrared, and 2-way satellite.

- *Stationary Communications* - Any communication technology that connects stationary sites. Technologies include fiber optics, microwave, radio, land lines.

- *Individual Traveler Interface* - Devices that provide information flow to a specific traveler. Technologies meeting this function include touch screens, keypads, graphics displays and computer voices at kiosks; keypads, computer voice, and head-up displays in vehicles; personal communications devices carried with the traveler; and audiotex from any phone.

- *Payment Systems* - Technologies that enable electronic fund transfer between the traveler and the service provider. The technology areas include Automated Vehicle Identification (AVI), smart cards, and electronic funds management systems.

- *Variable Message Displays* - Technologies that allow centrally controlled messages to be displayed or announced audibly to multiple users at a common location such as a roadside display or display board in a transit terminal. These technologies would typically be applied to provide information on highway conditions, traffic restrictions, and transit status.

- *Signalized Traffic Control* - Technologies, that allow for real-time control of traffic flow. Possible technologies include optimized traffic signals, ramp metering, reversible lane designation, and ramp/lane closures.

- *Restrictions Traffic Control* - Operational techniques that restrict the use of roadways according to regional goals. Techniques include HOV restrictions, parking restrictions, and road use (congestion) pricing.

- *Navigation* - Technologies that determine vehicle position in real time. Technologies that provide this function include GPS, LORAN, dead reckoning, localized beacons, map database matching, and cellular triangulation.

- *Database Processing* - Technologies that manipulate and configure or format transportation-related data for sharing on various platforms. General purpose data base software currently exists and is currently being adapted to transportation needs such as data fusion, maps, and travel services.

- *Traffic Prediction Data Processing* - Data prodessing relating to prediction of future traffic

TABLE 5

Mapping of User Services to Agencies/Entities

AGENCY \ USER SERVICE	Traffic Control	Incident Management	En-Route Driver Information	Emissions Testing and Mitigation	Public Transportation Management	Route Guidance	Pre-Trip Travel Information	Ride Matching and Reservations	Demand Management and Operations	Personalized Public Transit	Public Travel Security	Commercial Vehicle Fleet Management	Hazardous Materials Incident Response	Emergency Vehicle Management
Caltrans	A	C	C	C		C	C	A	C			C	C	
Sacramento County	A			C			C		C					
Yuba County	A													
Sutter County	A													
Placer County	A			C			C		C					
El Dorado County	A												C	
Yolo County	A													
CHP		C	C			C	C					C	C	A
City of Sacramento	A			C			C		C					
Davis	A													
Woodland	A													
West Sacramento	A													
Roseville	A			C			C		C					
Rocklin	A			C			C		C					
Folsom	A													
Marysville	A													
Yuba City	A													
Rideshare								C						
Local Police/Fire														A
Commercial Operators						C						C	C	
Regional Transit		C			A	C	C	A		A	A		C	
Other Transit Operators		C			A	C	C	A		A	A		C	
SMAQMD				C					C					
STA		C											C	
Capitol Valley SAFE		C												

A and C denote an agency's participation in an autonomously or collaboratively delivered service, respectively

SOURCE: JHK Associates, 1995

situations. Algorithms with potential applications include real-time traffic prediction, and traffic assignment.

- *Traffic Control Data Processing* - Data processing related to the real-time control of traffic. Algorithms with potential applications include optimal control and incident detection, and the interaction of route selection and traffic control.

- *Routing Data Processing* - Data processing related to routing of vehicles including the generation of step-by-step driving instructions to a specified destination. Algorithms under development include the scheduling of drivers, vehicles, and cargo; route selection; commercial vehicle scheduling, and route guidance.

- *In- Vehicle Sensors/Devices* - Technologies providing a range of sensing functions to be located within vehicles. Functions addressed by these technologies include monitoring of vehicle performance and driver performance; determination of vehicle position relative to the roadway, other vehicles, and obstacles; improvement of vision in adverse conditions; and on-board security monitoring.

Also included in Appendix D are a series of flow charts illustrating what functional areas are required for each user service.

Mapping of Functional Areas to User Services

The matrix shown in Table 6 identifies the relationship between user services and the functional areas. This matrix reveals the "depth" to which the user services must be delivered in order to meet the needs of the Sacramento area. Previous work on this project inventoried existing and planned ITS projects and categorized them according to which user service or user service bundle they belong. At that point, it was only possible to determine that the user service was being provided in some measure, but it was unclear from a technical perspective, as to how completely the user service requirements were being satisfied. With the functional areas identified here, the full technical requirements of those user services are now clear.

Circles in the matrix indicate the functional areas are needed to provide a selected user service. The filled circles indicate where functions are being provided to some degree, either by existing or by programmed projects. Two important observations should be made.

- Most of the deployment efforts to date have been directed toward field based infrastructure indicated by the circles near the top of the chart. Little has been done to automate the inputs, outputs, or processing functions as indicated by the circles at the bottom of the chart. This lower portion of the chart is the focus of the user service delivery system.

- A filled circle does not indicate that the function has been fully deployed by all agencies. Rather, filled circles only indicate that one or more agencies have deployed the function.

The last step in the. development of the delivery scheme identifies which capabilities that each agency or entity must have in order to support the regional user services. To aid in this process the 17 Functional

TABLE 6

Functional Capabilities Required to Deliver User Services

FUNCTION / USER SERVICE	Traffic Control	Incident Management	En-Route Driver Information	Emissions Testing and Mitigation	Public Transportation Management	Route Guidance	Pre-Trip Travel Information	Ride Matching and Reservations	Demand Management and Operations	Personalized Public Transit	Public Travel Security	Commercial Vehicle Fleet Management	Hazardous Materials Incident Response	Emergency Vehicle Management
Freeway Traffic Surveillance	◒	◒	○		○		○		○			◒	◒	○
Local Street Traffic Surveillance	◒		○		○		○		○					○
Fleet Vehicle Surveillance					○	○				◒	○	○		
Emergency Vehicle Surveillance						○							○	◒
Vehicle Surveillance (Non-Commercial Vehicles)				○		○								
Inter-Agency Coordination	○	◒	◒	○	○	○	◒	◒	○	○	○		◒	○
1-Way Mobile Communications		◒	◒	○		○			○		○		◒	
2-Way Mobile Communications		◒	○		◒	○		○		◒	○	◒	◒	◒
Stationary Communications	◒	◒	◒	○	○		◒		◒		○	○	◒	◒
Individual Traveler Interface		○	○		○	○	◒	○	○	○			○	
Payment Systems					○			○		○				
Roadside Message Display		◒	◒										◒	
Public Variable Message Displays							○		○					
Signalized Traffic Control	◒	○							○				○	◒
Restrictions Traffic Control				○			○		○					
In-Vehicle Navigation		○			○	○							○	
Centralized Navigation					○		○	○		◒		○		○
Database Processing	◒	○	○	○	○	○	○	◒	○	○	○	○	○	○
Traffic Prediction Data Processing					○	○	○					○		
Traffic Control Data Processing	◒	○				○							○	○
Routing Data Processing		○			○	○	○	○		○		○	○	○
In-Vehicle Sensors/Devices														

SOURCE: JHK Associates, 1995

Areas were refined in some categories to produce a list of 22 functions. The functions were then mapped to individual agencies through the matrix shown on Table 7. This matrix indicates those functions which must be provided by each agency in order for them to participate in the candidate user service delivery system.

The association of these functions to each agency/entity begins to provide an understanding of the extent of each agency's participation in the overall ITS program. Those agencies who have functions to perform must next examine the technologies available to serve those functions. The mapping contained in the above matrix represents the functionality required for deployment of a given user service. These users services are defined by functionality rather than technology to allow selection of the appropriate technology that satisfies functional requirements at the time of detailed design. As a result, each of these functional areas can currently be provided in numerous ways by a wide range of available or evolving technologies.

A separate document technical assessment has been produced for this project to define the current state-of-the-art/practice of ITS technologies in North America, Europe, and Japan /36/. This document is arranged around the functional areas shown in the above matrix., Applications, issues, and systems are discussed for each functional area. However, it is not possible to draw definitive conclusions on the technologies most appropriate for the Sacramento region.

The technology appropriate for a given function may differ from agency to agency and application to application. Technology assessments must be on-going to consider changes in technology and areas of application.

As subsequent projects develop detailed user service delivery systems and move closer toward deployment of an ITS system, it will be appropriate to select specific technologies. However, based on experience from other ITS systems currently being deployed, in some cases it is possible at this time to suggest certain technologies as likely candidates for use in the Sacramento region.

Technologies identified below satisfy their respective functional requirements but they should be viewed only as potential candidates for providing the selected user services. As each of the projects identified in Chapter 5 moves through detailed design stages toward deployment, a more definitive technology selection can be made.

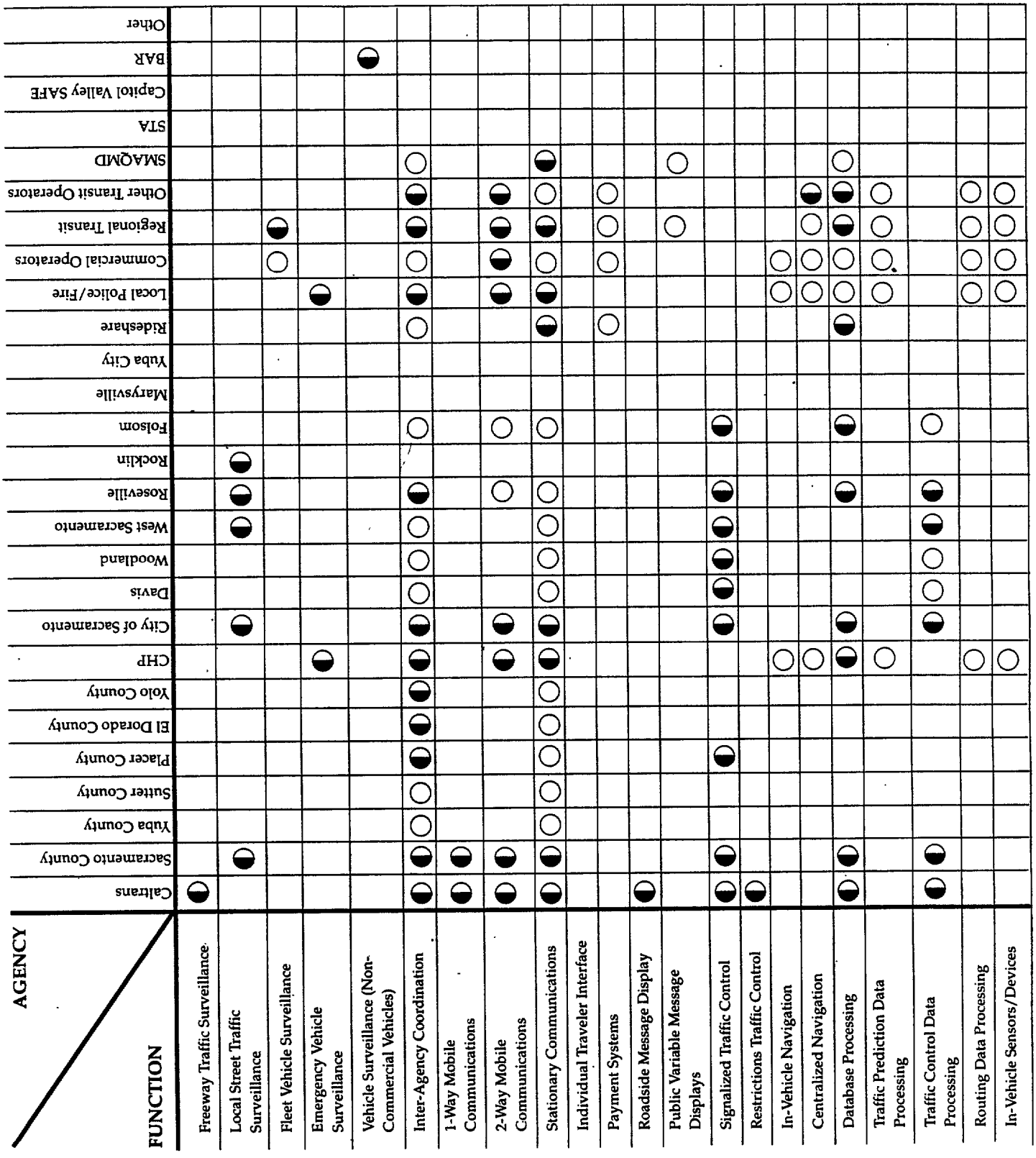
Traffic Surveillance - The inductive loop detector has been the dominant form of in-pavement surveillance used in the Sacramento region. Inductive loop detectors function by changing inductance when a vehicle stops or passes over the loop. This presence indication is processed to provide measurements of volume and occupancy. Speed and classification information may also be provided by connecting the loops in pairs.

Overhead mounted detectors installed to the side of the roadway permit maintenance activities to be performed with minimal disruption to the traffic flow. Microwave radar detectors are the favored method of providing overhead mounted detection. These detectors direct low power energy toward the roadway. As vehicles pass through the beam, a portion of the energy is reflected back toward the detector where presence and speed can be measured.

Weather and environmental sensors will also be necessary for ITS deployment in the Sacramento

TABLE 7

Functional Capabilities Required of Agencies to Support User Services



SOURCE: JHK Associates, 1995

region. These technologies are still in an early state of development. Recommendation of weather and environment sensor technologies is not possible until specific ITS applications are identified during detailed design.

Closed-circuit television (CCTV) has been used extensively in traffic management systems for roadway surveillance and incident verification. Specific applications of CCTV to be used in the Sacramento region (i.e., monitoring or verification) will determine the appropriate technologies for a given project.

Video image processing uses a computer with signal processing algorithms to interpret the roadway images and extract the information needed for traffic surveillance and control. Innovations in this area are causing the state-of-the art to change very rapidly. If video image processing is to be used in the Sacramento region, the specific technology chosen should be selected during the detailed design phase.

- *Vehicle Surveillance* - Automated vehicle classification systems count the number of vehicle axles and record the information continually at a location. Based on cost and installation requirements, Piezo sensors are likely to be used in the Sacramento region. Piezo sensors are mounted flush with the surrounding pavement, and produce an electronic signal on deformation by passing vehicle tires.

  Automatic Vehicle Identification (AVI) provides electronic reading and recording of a vehicle's identity as it passes specific points without requiring any action by the driver or an observer. Microwave/RF/UHF technology has a high resistance to environmental elements and is highly reliable and flexible. For these reasons, this technology is likely to be used in meeting the Sacramento region's AVI needs.

  Weigh-In-Motion (WIM) systems collect and record individual axle weights and gross vehicle weights for vehicles passing over equipment embedded in the pavement. WIM technology is used mainly for truck weight enforcement and data collection, and is often used in conjunction with vehicle classification and AVI systems.

- *Vehicle Location* - Automatic vehicle location (AVL) systems provide real-time information regarding vehicle position and progress. A number of technologies exist for providing this information, but the most likely technology for application in the Sacramento region is Global Positioning.

- *Interagency Coordination* - The inter-agency coordination function is not a "true" technology. This function depends on consensus-building processes, agreements, memorandums of understanding, etc. between agencies involved in ITS deployment and will be achieved during detailed design phases.

- *Mobile Communications* - Mobile communications technologies for public ITS elements will be selected during the detailed architecture design. Technologies for applications involving private vehicles will likely be selected based on marketing decisions by private companies.

- *Stationary Communications* - Stationary communications technologies, much like that of mobile

communications, will be selected during actual ITS design. To date, stationary communications have relied predominantly on leased telephone lines and a limited amount of agency-owned cable. The various technologies are highly dependent on the user service delivery system. Until a detailed delivery system has been'developed, it will not be possible to determine which technology will be employed.

- *Individual Traveler Interface* - The traveler interface at trip origin is expected to use a number of different technologies to provide potential travelers with information. Television, personal computer, radio, traveler advisory telephone, and kiosk are all expected to be viable technologies for traveler interface in the Sacramento region.

  Because in-vehicle and on-person traveler interface systems are expected to be developed in the private sector, it is not appropriate to speculate on technology selection. The important factor is that these technologies remain compatible with the traveler information database.

- *Payment Systems* - Public transit electronic fare collection systems allows passengers fast and convenient access to the transit system. In a region-wide application, passengers could use a single card for their intermodal traveling needs without the need to keep track of transfer slips or to maintain exact change. It is likely that a system for the Sacramento region would come from one of the following vendors: AT&T IVHS Communications Systems, Cubic Precision Systems, Datafare, and GFI Genfare.

  A potential road pricing scheme for the Sacramento region is smog fees; These fees would charge individual motorists for the harm caused by the emissions their vehicles dump into the environment. Emissions would be estimated as the product of miles driven by the vehicle, and the vehicle's per-mile pollution emission rates.

- *Variable Message Displays* - Variable message signs (VMS) provide motorists with real-time information pertinent to freeway travel. Selection of a VMS technology is likely to be influenced by the current Caltrans VMS practice. Currently Caltrans uses a Model 500 bulb matrix sign. It is expected that Caltrans will continue to use this sign on freeways for ITS applications.

- *Signalized Traffic Control* - Traffic signal systems further developed under the Sacramento area ITS will be coordinated and will provide some degree of traffic responsive operation. Coordination will reduce travel time and required stops, while traffic responsive operation will allow for signal plans to adapt to changing local traffic conditions.

- *Restrictions Traffic Control* - Ramp metering systems will operate on a region-wide basis. Region-wide metering allows meters to respond to congestion by modifying metering rates throughout a corridor rather than only at on-ramps directly affected by the congestion.

  Demand balancing is often needed to direct traffic away from areas of congestion to reduce traffic demand approaching the location. Regional demand balancing typically shifts traffic from one freeway to another freeway, or from one mode to another. Traveler information and ramp metering will be used to implement demand balancing.

- *Navigation* - Because navigation systems are expected to be developed in the private sector, it is

not appropriate to speculate on technology selection. What is important is that these systems are autonomous and remain compatible with the traveler information database.

Data Processing - Numerous technological decisions will be made with respect to data processing. However, these are highly dependent on the outcome of the detailed user service delivery system design phase. The Transcal field operational test (FOT) project is slated to demonstrate "TRANSVIEW" software for its traveler information system.

In-Vehicle Sensor/Devices - It is likely that in-vehicle sensors and devices will be employed in the Sacramento ITS. These may include hazard warning systems, bad weather driving assistance systems, and collision warning systems. It is not possible at this time to speculate on specific technologies for these systems. However, it is important that whatever technologies are eventually chosen be compatible with the user service delivery system.

VIII. RECOMMENDED ITS PROJECT CONCEPTS

The development of ITS projects in the Sacramento region currently takes place in an environment which relies on individual agencies to conceive projects, select technologies, and prioritize deployment within their respective jurisdictional boundaries. This environment maximizes agency autonomy and allows those individuals most knowledgeable of local problems to develop and implement solutions. However, there are many problems in the region which transcend jurisdiction boundaries, and whose solutions are beyond the means or charter of an individual agency. In these instances, a higher level of multi-agency coordination is needed to develop and carry out strategies for the mutual benefit of the respective agencies' constituents. This coordination is needed on many levels ranging from the very technical to the policy or procedural levels.

The ITS program developed under the Early Deployment Planning Study has been structured to 1) maintain the current autonomy of individual agencies for ITS development within their boundaries, 2) to identify those program elements which benefit most from multi-agency coordination and regional perspective, and 3) identify those projects which may "fall between the cracks" if system development continues on its current course within the various entities of the region.

The projects in the latter two categories can be considered as the "glue" which ties the program together and ensures that agencies can share information and resources, and that the individual systems within agencies are used to their fullest potential for the benefit of all travelers in the region. No single agency can serve as the leader for these types of projects, since no single agency has the authority over the entire transportation network of state highways, local streets and transit systems. This functional segregation of agency responsibilities over the various components and/or areas of the transportation system means that no single agency fully represents the inter-jurisdictional or regional traveler as their constituent. Also, there currently is not a consistent technical framework for exchanging information between agencies.

To ensure that these program elements are addressed in an organized, comprehensive manner, a series of project descriptions has been developed which describe the work required, the agencies that must work together in their implementation, and the initial implementation cost. A rudimentary implementation sequence was also developed for these projects in order to identify project dependencies and likely deployment timeframes.

The intent of these descriptions is to provide sufficient detail such that potential sponsors and funding sources can be identified. It should be noted that the initial costs identified for the projects do not include on-going operations and maintenance costs of hardware and software, or the agency staff time that may be necessary to oversee the acquisition of system elements from commercial vendors.

As noted earlier, it is not the intent of this ITS program to identify needs or dictate priorities within the individual jurisdictions. Local agencies will maintain their full authority to conceive and implement ITS projects to serve their respective residents, and are encouraged to do so. However, where possible, such

projects should be designed to be technically compatible with the region's technical standards for data exchange, as developed in the following projects.

The reader is referred to a separate document titled, "Project Summaries and Technology Assessment", for more detailed information on the ITS project summaries /36/. Project costs will be presented in the next section of the report.

- *Project Number 1: Traveler Information Database* - This project would develop a database and host software to gather and distribute information gathered through the regional user service delivery system. Database development would address input, storage, and output (retrieval) processes. Information placed in the database would be received from various agencies and entities in accordance with data exchange policies and protocols established by other projects. This data would then be stored and updated as needed to serve travelers, system operators, and transportation planners. Traveler information would include incident locations, route link conditions, carpool information, transit schedules and routes, and other specialized information.

- *Project Number 2: Regional En-Route Traveler Information and Route Guidance Services* - This project would develop a system for providing current and reliable information on route conditions to the en-route traveler. The system would process and prioritize data from Caltrans, CHP, local enforcement agencies, and the traveler information database. Advisory messages would be disseminated through technologies such as changeable message signs, highway advisory radios (HAR), and the commercial media.

- *Project Number 3: Regional Demand Management and Operations Services* - This project would develop policy and strategies to use the ITS infrastructure to manage demand in the urban area. Project sponsors would: develop demand management policy for air pollution non-attainment days, special event congestion, and targeted recurrent congestion; determine information exchanges required to facilitate policy; develop specific demand management strategies based on information to be exchanged.

- *Project Number 4: Regional Incident Management/Hazardous Materials Incident Response Services* - This project would develop a regional incident management program which minimizes the time necessary to detect, respond to, and clear incidents occurring in the transportation network. Interagency agreements would be required to establish communications flows and operational strategies to respond to incidents of **various** types and geographic locations. The system configuration would address the need to minimize response time while deploying the appropriate level and type of response.

- *Project Number 5: Regional Emissions Testing and Mitigation Services* - This project would develop a system to: a) link existing area-wide air quality monitoring and public outreach efforts such as the "Spare-the-Air" campaign to the Traveler Information Database (Project 1); and b) install additional air quality monitoring station at "hot spots" of congestion, to provide a source of air quality data which can be linked to transportation operating strategies.

- *Project Number 6: Sacramento Urban Area Traffic Control Network* - The agencies listed would develop a data exchange network to facilitate operation of the urban transportation system near jurisdiction boundaries. Signal timing parameters would be exchanged between the City and

County. Real-time video and ramp meter queue data would be exchanged between Caltrans and the City and County. Regional Transit's light rail system would provide signal pre-emption data to the City and County through this network. This network would also provide link condition and incident location information to the Traveler Information Database.

- *Project Number 7: Placer County Traffic Control Network* - This project would develop a data exchange network to facilitate coordinated operation of traffic signals in the jurisdiction of the participating agencies. The network would exchange incident locations, volume and speed data, and, to the extent available, signal timing and video data. This network would provide the participating agencies better information to operate traffic signals in their jurisdiction, and to respond to operating conditions outside their jurisdiction. The network would also provide link and incident location information to the Traveler Information Database described in Project 1.

- *Project Number 8: Sierra Counties Traveler Information System* - El Dorado County Transportation Commission and Placer County Transportation Planning Agency, along with other agencies, have entered into an agreement to develop an traveler information system to serve the needs of travelers and tourists in the region. Specific strategies for informing tourists of local attractions, events (e.g. the Gold Discovery Sesquicentennial), and travel restrictions (e.g. local road closures due to snow) would be developed through inter-agency consensus. Tourist information, link conditions, and incident locations would be provided to the traveler information database through this network.

- *Project Number 9: Transit Services Network* - This project would develop a network to receive ride requests and information queries from the Traveler Information Database and, in turn, send ride confirmations and coordinated schedule information back to the traveler. The network would also enable individual providers to electronically access schedule and route information of other trip providers in the region.

- *Project Number 10: Stundurdized Network Information Exchange Protocols* - Specific communications protocols would be established to govern the exchange of data between sub area networks. The protocols and interfaces would be defined under the guidance of a technical committee representing the affected jurisdictions. The protocols would conform with national standards *here practical and would not be bound by proprietary requirements that may be associated with an individual network. The products of this work would be a technical specification detailing communication protocols and interfaces at each network connection within the regional architecture. The project would also produce a procedural document describing an approach for ensuring the security of the data, and identifying technical contacts and areas of responsibility for each agency. Procedures would also address maintenance responsibilities for inter-network links.

- *Project Number II: Regional Decision Support and Data Collection System* - This project would develop a system to gather data which describe link conditions on key segments of the transportation network. Volume and other historical information from these key segments would then be used to support on-going planning functions and congestion monitoring required by Federal and State programs. These key segments are prioritized into groups of 20, based on the severity of congestion. This system would also provide link condition information to the Traveler Information Database (Project 1).

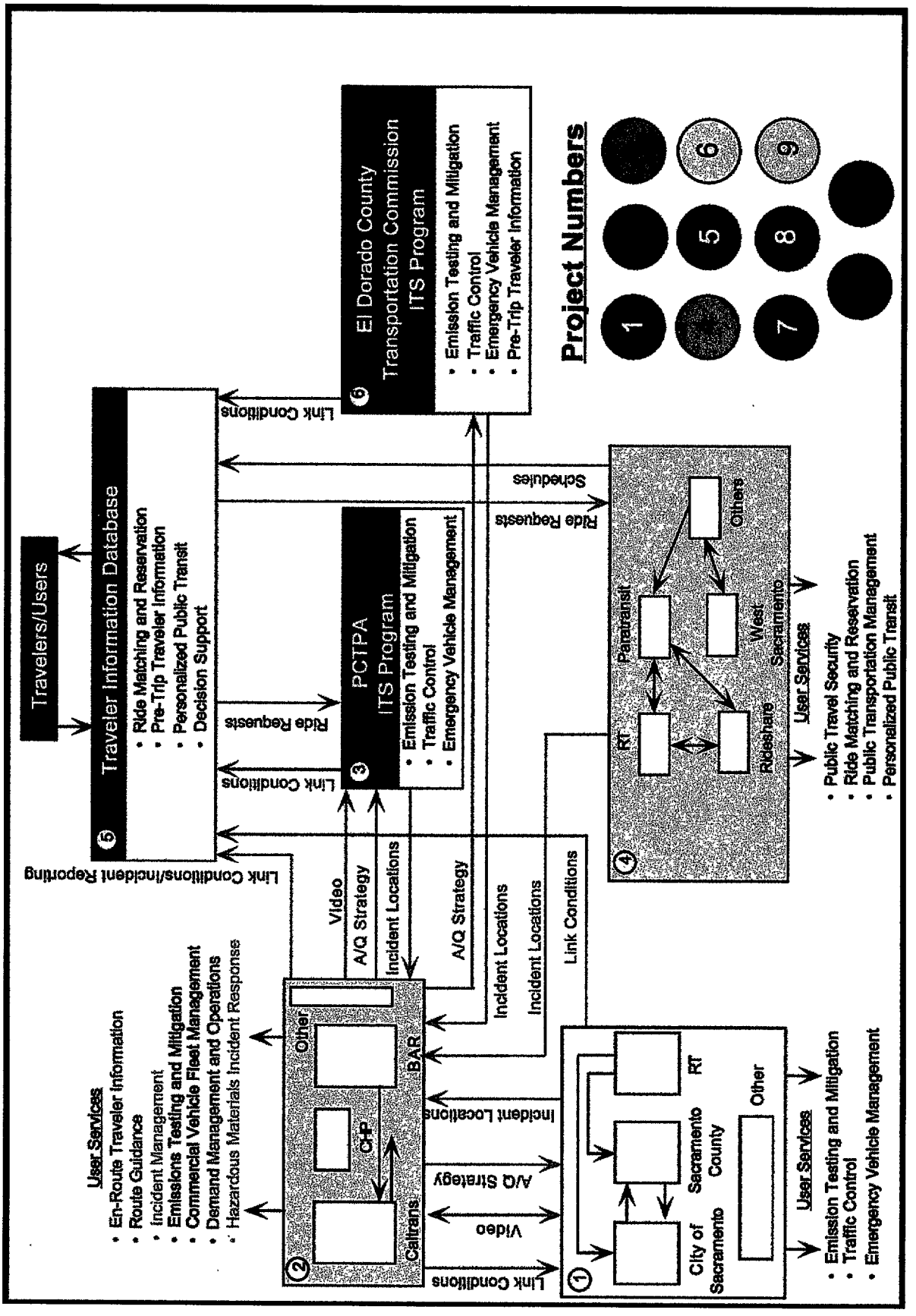
Figure 15 illustrates the relationship of the individual projects to the overall "Candidate User Service Delivery System." The project numbers listed in the lower right are color coded to various portions of the graphic.

The graphic reinforces the fact that the individual projects defined in this document address the regionally delivered services and provisions for inter-agency data transfer.

The graphic indicates implementation timeframes for the ITS regional program elements. The timeline shown in Figure 16 the initial phase of an ongoing project that would continue to expand on this original effort. As such, each project contains the initial portions of hardware and software needed to initially serve travelers in the region to some minimum level. Beyond these initial projects, subsequent expansion would continue into the indefinite future. The pace of further expansion would be driven by the level of success achieved by the initial projects. The ending dates, then, do not signify an ultimate completion of ITS projects, but merely completion dates for a base level of service provided to travelers in the region.

FIGURE 15

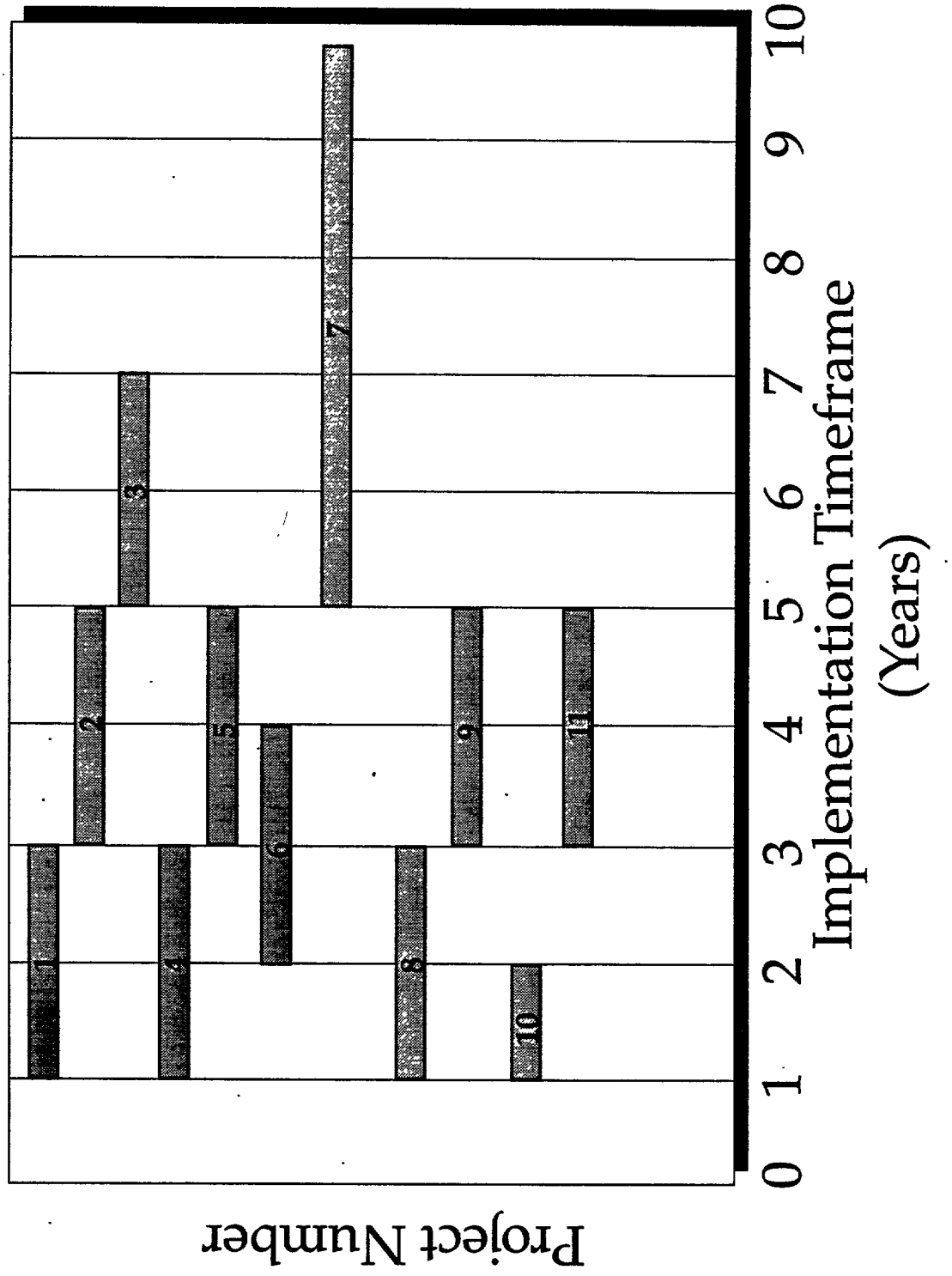
Relationship of Projects to Delivery System



SOURCE: JHK Associates, 1995

FIGURE 16

Relationships of Project Initiation Dates



SOURCE: JHK Associates, 1995

IX. FUNDING AND IMPLEMENTATION STRATEGY

Project Types

Projects required to implement the EDPS as described in Section VIII of this report fall into three general categories, based on the organization(s) which will ultimately be responsible for implementation, listed below.

Single Agency/Organization Projects. These are projects which are initiated and sponsored by a single agency, and provide benefit to travelers in the sponsoring jurisdiction. In many cases, single agency projects are required in order to participate in later, multi-agency ITS project efforts. One example of this is Advanced Traffic Management Systems: In order to provide and regional coordination, individual local agencies must have implemented traffic signal coordination, and ideally centralized all distributed signal systems at a Traffic Operations Center (TOC). Another example: in order to provide accurate, up-to-date transit information and services on a traveler information database, individual transit operators must have implemented some information and management systems. These necessary local "functional capabilities" are identified in Section 4 of the "Summary Analysis Report". Most of the projects or improvements which fall into this category would ultimately be the responsibility of the sponsoring agency to conceive, fund, design, build and operate. Some design guidelines would come out of national, state, or regional standards and protocols, where applicable. However, implementation would not depend on partnerships with other. agencies, and the implementing agency and travelers in the agencies jurisdictions would benefit from these improvements, with or without participation in a larger, multi-agency ITS system.

Based on known ITS projects which fall into this category, the total non-recurring cost is $37.9 million (Table 8). However, only a portion of the total projects in this category are known, total cost of these projects could be significantly higher. The annual operating costs of projects in this category are impossible to estimate, because many of the projects would be included in agency operating budgets. In some cases, there would be no incremental agency operating cost, because the new projects would be operated and maintained by existing agency staff. For other projects, there is a potential for operating cost savings due to increased efficiency.

Multi-Agency/Operator. Collaborative Projects. These twelve projects are described in Section 5 of the "Summary Analysis Report". These projects require coordination and participation of several agencies and organizations for implementation. In general, these projects are not ground-breaking projects either technologically or institutionally. Projects of similar types have successfully been implemented in other parts of the country. However, implementation in this region would require a high level of interagency coordination.

Based on known ITS projects in this category, the total non-recurring cost is $16.6 million (Table 9). However, three of the projects in this category are planning/design projects, which may have follow-up capital projects associated with them later. The cost of installation of communications equipment to several of the information network projects is not included in the cost estimates. The cost of ITS programs in Placer County and El Dorado County are not known at this time. For these reasons, the total implementation cost will be higher.

Table 8
PROPOSED SINGLE AGENCY ITS PROJECTS

#	Project	Non-Recurring / Capital Cost $	Potential Funding Sources	Lead Agency	Project Status
	TRAFFIC MANAGEMENT PROJECTS				
A	Route 51/80/160; TOS and ramp meters	$4,115,000	STP, TSM	Caltrans	Seeking funding
B	Interstate 5; TOS and ramp meters	$5,377,000	STP, TSM	Caltrans	Seeking funding
C	Route 50; TOS and ramp meters	$3,652,000	STP, TSM	Caltrans	Seeking funding
D	Traffic Operations Center - Phase II	$12,700,000	STP, CMAQ, TSM	Sacramento County	Seeking funding
E	Traffic Operations Center - Phase III	$6,000,000	STP, CMAQ, TSM	Sacramento County	Seeking funding
F	West Street Signal Interconnect	$81,000	STP, CMAQ, TSM	City of Woodland	Awarded $71K CMAQ funding
G	Additional Traffic Management Projects	Not Known	TBA	TBA	
	Subtotal for Known Traffic Management Projects	**$31,925,000**			

Source: SACOG, 1996.

Table 8 (cont'd)
PROPOSED SINGLE AGENCY ITS PROJECTS

#	Project	Non-Recurring / Capital Cost $	Potential Funding Sources	Lead Agency	Project Status
	PUBLIC TRANSIT MANAGEMENT PROJECTS				
H	Modifications to RASS System	$268,000	STP, TSM	Paratransit, Inc.	Seeking funding
I	Information System Expansion	$150,000	FY 96 Measure A, FTA Section 9	Sacramento RT	In FY96 Capital program
J	Transit Trip Planning System	$300,000	Fed or State ITS Prog.	Sacramento RT	Seeking funding
	Internet Access to Transit Trip Planning	$200,000	Fed. of State ITS Prog.	Sacramento RT	Seeking funding
K	Additional Public Transit Management Projects	Not Known	TBA	TBA	
	Subtotal for Known Public Transit Management Projects	**$918,000**			
	DEMAND MANAGEMENT AND OPERATIONS PROJECTS				
L	Additional Demand Management Projects	Not Known	TBA	TBA	
	Subtotal for Known Demand Management Projects	**$0**			
	INCIDENT MANAGEMENT PROJECTS				
L	Yolo County Freeway Service Patrol	$60,000	Caltrans, STA Match	Yolo County Transit Authority	MOU with STA approved
M	Sacramento County Freeway Service Patrol	$3,503,971	CMAQ, STP	Sacramento Transportation Authority	Awarded $1.8M in STP funding
N	Additional Incident Management Projects	Not Known	TBA	TBA	
	Subtotal for Known Incident Management Projects	**$3,563,971**			

Source: SACOG, 1996.

Table 8 (cont'd)

PROPOSED SINGLE AGENCY ITS PROJECTS

Page 3 of 3

#	Project	Non-Recurring / Capital Cost $	Potential Funding Sources	Lead Agency	Project Status
	PUBLIC TRANSIT SECURITY PROJECTS				
O	LRT Security System	$1,150,000	FY 96 Measure A, State Transit Capital Improvement, FTA Section 3	Sacramento RT	In FY96 Capital program
P	Transit Bus Security System	$400,000	FY 96 Measure A, FTA Section 9	Sacramento RT	In FY96 Capital program
Q	Additional Transit Security Projects	Not Known			
	Subtotal for Known Public Transit Security Projects	**$1,550,000**			
	Total for Known Projects of All Types	**$37,956,971**			

Source: SACOG, 1996.

Potential Showcase Projects. These are projects which could be considered to be "ground-breaking" in some sense, either in terms of the technology being used or applied, or in terms of the institutional relationships on which the projects are based. Some of the projects listed in Table 9 may fall into this category, if they were ambitiously applied, or integrated with some of the existing "field operation tests" (FOT's) and demonstrations in the region.

- *TransCal* - TransCal is a FHWA-sponsored FOT of three advanced travel services: 1) an Inter-Regional Traveler Information System (IRTIS); 2) an "mayday" Emergency Notification System (ENS); and 3) a Transit Frequent Passenger Program (TFPP). The TransCal project administered by the Caltrans Office of New Technology, at the direction of a multi-agency, public/private management board. Unique features of TransCal are its inter-regional, two-state scope (including public and private partners from the Bay Area, Sacramento, Sierra/Foothill counties, and the Tahoe/Rena Basin), and the involvement of the private sector as active partners, bringing their own resources to the project. The IRTIS design is being completed, and an RFP has been released for operation of the IRTIS system during the test period. The test period was budgeted for 5 months, starting this summer. It is expected that the successful bidder for operation of IRTIS will significantly extend this operational period. The TFPP portion of the project is still being defined, and the ENS portion will be the subject of later stages of the project.

- ***1-800-COMMUTE*** - The "1-800-COMMUTE" project is a Caltrans-sponsored traveler information system, which allows callers to access a variety of travel information and services from a single phone number. "l-800-COMMUTE" includes a menu of options for: 1) local transit information; 2) Amtrak information; 3) rideshare services; 4) state highway road conditions; and 5) telecommute information. The local transit, Amtrak, state highway, and telecommute information options are "pointers" to other, existing services which are also accessible through separate, direct dial numbers. For these services, "l-800-COMMUTE" provides the user with toll-free, single number access. The rideshare services item is unique, in that it allows the user to interactively enter ridematching information and request a ridematch list by phone, a service which is only available through "l-800-COMMUTE". (Ridematching services are also available by dialing Sacramento Rideshare directly, through participating employers, and through various rideshare and transportation management agencies in the region). The "1-800-COMMUTE" project is funded for one-year of operations by Caltrans New Technology and Research Program. The future operating cost of the program (the majority of which is the cost of the "1-800" phone calls, transfers of calls from "1-800-COMMUTE" to other phone numbers, marketing, and operation and maintenance of the voice processing system) are expected to be assumed by Caltrans or the participating agencies and organizations.

- *California Smart Traveler Internet Site* - The Smart Traveler Internet Site is a statewide source for traveler information and services. The Sacramento portion of the site includes: periodically updated transit information for Sacramento Regional Transit and CSU Shuttles; directories of telephone numbers for other transit, shuttle, and alternative mode operators; links to the California Highway Information Number (CHIN), Amtrak, airport information, and other web sites with traveler information and services; The Smart Traveler Internet Site is partially supported by private funding. For other regions, such as Los Angeles, Orange County, and San Diego, real time traffic and.other travel information are available.

- *Sutter County ITS Program* - The Sutter County ITS Program is a federally funded FOT of ITS technologies in Sutter County, and is a cooperative effort between the County, Caltrans, Yuba-Sutter

Table 9
PROPOSED MULTI-AGENCY ITS PROJECTS

#	Project	Non Recurring / Capital Cost $	Potential Funding Sources	Lead Agency	Other Involved Agencies	Project Status
1	Traveler Information Data Base/1/	$515,000	CMAQ,STP,TSM,FED. ITS *LOCAL MATCH, PRIVATE*	Caltrans/SACOG	RT, Sac.City, Sac. Co., PCTPA, EDTC	Proposed for early impl. in EDPS
2	En Route Traveler Information and Route Guidance Services	$2,450,000	CMAQ,STP,TSM,FED. ITS *LOCAL MATCH, PRIVATE*	Caltrans	CHP, RT, Sac City, Sac. Co	Proposed for later impl. in EDPS
3	Demand Management and Operations Services/2/	$75,000	CMAQ, FED. GRANTS *LOCAL FUNDS*	SACOG/Rideshare	AQMD's, RT, Caltrans	Proposed for later impl. in EDPS
4	Incident Management and Hazardous Materials Response Services/2/	$150,000	CMAQ,STP,TSM,FED. ITS *LOCAL MATCH*	CHP	Caltrans, Local Law Enforcement/Fire	Proposed for later impl. in EDPS
5	Emissions Testing and Mitigation Services	$1,200,000	CMAQ, FED. GRANT	?	AQMD's, Caltrans, Sac. City, Sac. Co., others	Proposed for later impl. in EDPS
6	Sacramento Urban Area Traffic Control Network/3/	$1,100,000	CMAQ,STP,TSM *LOCAL FUNDS*	Sac.City or Co.	Caltrans, RT	Proposed for early impl. in EDPS
7	Placer County ITS Program	TBA	TBA by PCTPA, Others	PCTPA	TBA by PCTPA	Pursuing Gold Country ATIS currently
8	El Dorado County ITS Program	TBA	TBA by EDTC, Others	EDTC	TBA by EDTC	Pursuing Gold Country ATIS currently
9	Sacramento Transit Services Network	$390,000	CMAQ,FED.TRANSIT GRANTS *AGENCY FUNDS*	RT	Caltrans, Rideshare,YCTA, EDT, FSL, YSTA	Proposed for early impl. in EDPS
10	Network Information Exchange Protocols/2/	$300,000	CMAQ *LOCAL FUNDS*	Caltrans/SACOG	PCTPA, EDTC, RT, Sac. City, Sac Co., others	Concurrent w/ Proj. 1, 6, 9, 11 and 12.
11	Regional Decision Support System	$2,450,000	CMAQ	Caltrans	Sac. City, Sac. Co., others	Concurrent w/ Proj. 1, 6, 9, 11, and 12
12	Caltrans/CHP Regional Transportation Management Center	$7,980,000	TSM *AGENCY FUNDS*	Caltrans	CHP, Sac City, Sac Co., SACOG	Awarded TSM funding
Total		$16,610,000	PRIMARY SOURCE *SECONDARY SOURCE*			

Source: SACOG, May 1996

Notes:

/1/ Capital cost is for central database hardware and software only, does not include any connection costs from local agencies, nor local agency costs of collecting information.

/2/ This is a planning project Cost is to fund staff time and consultant for project.

/3/ Capital cost does not include local agency data collection and retrieval systems

Transit, five local fue districts, and the Capitol Valley Regional SAFE. The program includes the installation, test period operation, and evaluation of: 1) "smart" call box technology; 2) emergency vehicle signal preemption; 3) forward-looking, infrared collision avoidance systems for emergency vehicles; and 4) advanced public transit management system. The smart call boxes are expected to be installed in late 1996.

Examination of existing and programmed ITS projects shows that in the past, single agency projects have been the most prevalent. Table 10 lists existing and programmed ITS projects in the region.

Funding Types

No locally allocated funding source is explicitly set aside for ITS implementation. Some federal funding for ITS field operation tests (FOT's), demonstration projects, and implementation have been made available on a competitive basis. ITS projects will have to compete with other transportation projects for the limited and diminishing pool of public funds, and demonstrate clear benefits to travelers and residents of the region to' compete with other types of projects for limited funding. However, it is believed by many that certain ITS applications may be candidates for innovative funding, especially from private sector sources. Funding for ITS projects will come from six general sources:

Local Agency/Operator Budgets. For transportation projects; this funding includes gas tax subventions, Local Transportation Funds, transit fares, and other local contributions including development impact fees. SACOG has estimated that over the next five years, these sources will generate a total of about $1.0 billion /38/. However, this figure includes Measure A funds (which are fully allocated to projects), and other sources which are committed to system maintenance and operation.

All public agencies program funds from their own revenue sources for new projects, operational improvements, maintenance, and other investments in infrastructure. These revenues are also used to match funding from other sources where required. Many agencies have made ITS investments in their infrastructure using these funds, especially for traffic signal improvements, emergency vehicle signal preemption, and communications equipment. The EDPS will provide guidance to local agency staff in making investments in transportation infrastructure which supports delivery of selected ITS user services.

Regionally Allocated Transportation Funds. These fund sources include Surface Transportation Program /Congestion Management Air Quality (STP/CMAQ), Transportation Enhancement Activities (TEA), and various transit operating revenues. SACOG estimates that the total amount in this pool over the next five years for this region is about $370 million. However, no "earmark" or "set aside" has been made for ITS projects out of this fund source, and the actual amount of funding available will depend on legislative issues such as the ISTEA reauthorization, Historically, only a small portion of these funds have been used for ITS projects.

ITS projects were proposed for about $16 million of the total pool of $35.5 million for the last round of regional STP and CMAQ funds. Only $3.2 million (just over 9 percent) was allocated to ITS projects. ITS projects recommended for funding included a Traffic Operations Center (TOC) from Sacramento County, and continued operation of the Freeway Service Patrol.

State Transportation Funds. These fund sources include State Transportation Improvement Program (STIP) funding, State/Local Partnership, Transportation System Management (TSM), Transit Capital Improvement

Table 10
EXISTING AND PROGRAMMED ITS PROJECTS

#	Project	Non-Recurring/ Capital Cost $	Funding Source	Funding Program	Lead Agency	Project Status
1	I-80 (I-5 to Route 244) Ramp Meters	$955,000	Interstate Maintenance	State TSM, other	Caltrans	Under Construction
2	Route 99 (Mack Rd. to 12th) NB Ramp Meters	$1,908,000	National Highway System Fund	State TSM, other	Caltrans	Installed and Operating
3	Downtown Sacramento; Traffic Signal Master Controller Project	$2,600,000	ISTEA/STP	Regional STP	City of Sacramento	City ready to advertise bids
4	Route 50 (10th to 17th) Ramp Meters	$409,000	National Highway System Fund	State TSM, other	Caltrans	Under Construction
5	Route 50 (Yolo Co. to Stockton Blvd.) Ramp Meters, TOS Improvements	$766,000	Interstate Maintenance	State TSM, other	Caltrans	Under Construction
6	Route 51 (Rte 50 to A Street) Ramp Meters	$409,000	National Highway System Fund	State TSM, other	Caltrans	Installed and Operating
7	Route 51 (American River to I-80) Ramp Meters	$1,258,500	National Highway System Fund	State TSM, other	Caltrans	Construction underway
8	Route 51 (American River to I-80) TMS and CCTV	$337,000	National Highway System Fund	State TSM, other	Caltrans	Installed and Operating
9	Route 51/99 (Stockton Blvd. to El Camino) CCTV's	$1,728,000	National Highway System Fund	State TSM, other	Caltrans	Programmed for Construction in 1995
10	Route 49 (Lincoln to Dry Creek) Traffic Signal Coordination	$340,000	State Cash	State TSM	PCTPA, Caltrans	
11	Paratransit Inc.; PASS System	$60,000	Paratransit	Paratransit Operating funds	Paratransit, Inc.	Installed and operating
12	STA Freeway Service Patrol (annual)		ISTEA/STP	Regional STP	STA, Caltrans, CHP	Ongoing
13	Capitol Valley SAFE Call Boxes	$2,500,000	$1 annual vehicle reg. fees	SAFE Annual Budget	SAFE	Ongoing
14	Paratransit Inc.; PASS System Upgrade	$500,000	ISTEA/STP	Regional STP	Paratransit, Inc.	Awaiting transfer of Regional STP funds
15	Transportation Management Center	N/A	N/A	Caltrans Annual Operating Budget	Caltrans, CHP	On going
16	Traffic Management Teams	N/A	N/A	Caltrans Annual Operating Budget	Caltrans	On going
17	Sacramento County Traffic Operations Center - Phase I	$1,600,000	ISTEA/STP, local funds	Regional STP, local funds	Sacramento County	Awarded $1.4 million CMAQ funding, advertising for bids
Total for Known Projects		$15,370,500				

Source: SACOG, 1996.

(TCI), and other programs. SACOG has estimated that the regional share of this source over the next five years is about $375 million. A large portion of this funding is allocated on a formula basis, and has been programmed for specific projects. For some large roadway improvement projects, ITS elements can be integrated with the other improvements. Other funds, such as TSM, are awarded on a competitive, statewide basis. TSM funds have been used by Caltrans for some of the existing Traffic Operations Systems (TOS) infrastructure on the freeway system. The Caltrans/CHP Regional Transportation Management Center has been allocated $7.98 million in TSM funding.

Direct Federal ITS Funds. The Federal Highway Administration (FHWA) has administered an ambitious program of funding for ITS research and development, testing, planning and other projects. In the last fiscal year, a total of $114.5 million for ITS activities was included in the overall ISTEA budget. The ITS budget for FY 1996 $223 million, including $41 million in "earmarked" ITS projects. Additionally, $20 million was allocated for the "Model Deployment Initiative" program, to fully fund two or three integrated ITS projects in metropolitan areas around the nation. (Note: Several agencies in Sacramento collaborated on an application for this, program. Future efforts of this type would be coordinated through the proposed ITS coordination group). It is not known what level of funding will be made available for project implementation (as opposed to research and technology demonstrations), but FHWA staff have indicated that they intend to propose some additional funding for project implementation in the coming federal budget negotiation.

Private Sector Participation. Several Federally-funded "field operation tests" (FOT's) have included significant representation and financial participation by private sector companies and organizations. Examples of these FOT's in Central and Northern California are TransCal (mentioned above), TravInfo in the Bay Area, and the Yosemite Area Traveler Information (YATI) project. These FOT's are publicly funded to operate for. a limited demonstration period only. Each FOT partnership includes private sector contributions during the demonstration period. Additionally, each also expects or includes private sector participation in the sustained operation of the systems, after the test periods are over. Different options for private sector participation are build into each FOT.

- *Yosemite Area Travel Information (YATI) Project* - YATI is a Advanced Traveler Information System (ATIS) for Yosemite National Park and the surrounding area. YATI includes several components. One is en-route traveler information, which is built on changeable message signs and highway advisory'radio. Information regarding Yosemite National Park, and the roadways providing access to it, is communicated directly to drivers en-route to the Park. YATI also includes an Internet site, telephone advisory system, and information kiosks. These services provide information on the Park and roadway conditions, but also include point-of-interest (POI) information for the surrounding area in addition to the Park. YATI is sustained by a joint powers agreement, which allows area Chambers of Commerce access to the kiosks and Internet site for the purposes of selling advertising for POI operators around the Park. Part of the YATI operating costs are expected to be paid by these advertising revenues.

- *San Francisco Bay Area TravInfo Project* - TravInfo is an ATIS system for the San Francisco Bay Area. TravInfo includes a central travel information database, which compiles real time traffic data from Caltrans District 4 TOS's, incident reports from participating cities, counties, and transit operators, and Metropolitan Transportation Commission's (MTC's) transit information database (routes, schedules, stop locations, and fares). TravInfo integrates data from these sources at a Traveler Information Center (TIC), which will be operated on a contract basis by a private sector operator. Direct access to TravInfo information is provided through a dial-up advisory system. However,

TravInfo information will also be made available to private traveler information companies, such as traffic reporting companies, via leased telephone lines. The TIC operations for the demonstration period will be financed in large part through a federal ITS grant. MTC, in partnership with a number of public agencies and private companies in the Bay Area, is planning to convert the TIC to a self-sustaining operation, whereby the TIC is operated at no cost to public agencies, by a private sector company which resells TravInfo-generated information.

- *TransCal Field Operations Test* - The IRTIS portion of TransCal is an ATIS for the San Francisco Bay Area-Sacramento-Rena-Tahoe travel corridor (Interstates 80 and 50), which was described above. TransCaI includes private sector partner participation in the IRTIS demonstration period, through contribution of professional and technical labor, contribution of products, and contributions of other services (such as broadcast time by an FM sub-carrier, for example), as do the other FOT's described above. The TransCal partnership has not yet adopted a model for continued private sector participation in the sustained operation of TransCal components after the demonstration period. Because of the significant amount of tourism and recreational travel in the Corridor, the YATI private participation model may be appropriate.

Dedicated Public Funding. An example of this source is the vehicle registration fee which funds the Capital Valley SAFE program. To the extent that ITS projects may advance objectives of the SAFE program, this source may be relevant to the EDPS projects. One example of a project of this type is the Sutter County ITS project, which includes call-box-based traffic monitoring and fog detection. The Capital Valley SAFE Board recently agreed to participate in a proposal for matching funding for a project which would close a major gap in call box coverage in the region, by installing TOS monitoring components.

SACOG has recently undertaken a project to assess the voter willingness to approve new, regional funding sources dedicated to transportation improvements. The preliminary results of the survey work from this project are that: a) additional sales taxes are unlikely to garner voter support, irrespective of the transportation projects funded; and b) additional gas taxes may be feasible, if the taxes are spent on important transportation projects, and if the revenues returned to the source county. Some ITS-oriented project-types finished high on the list of stated preferences for transportation projects among those voters surveyed. Specifically, two ITS items were rated by significant percentages likely voters to be "very important" transportation improvements: synchronized traffic signals and'electronic warning signs for congestion. (Synchronized traffic signals finished at the top of this list, with 67 percent of likely voters rating it "very important"). While this may indicate potential support for a new funding source for ITS projects, development of a new source of funds would take a number of years and may not be relevant for early implementation.

Funding Strategy

Table 11 summarizes a funding strategy for the ITS projects, based on the funding categories outlined above.

Single Agency Projects. For single agency projects, the primary funding source should be agency capital and operating funds. For projects which are technically single agency, but cover a large geographic area, a wide cross-section of travelers, or fund a single agency project which is critical to the success of a larger, regional level project, other regional funding sources may be appropriate. Based on past history of federal funding of ITS, single agency projects are unlikely to compete well. Very limited opportunities exist for public/private

Table 11
PROPOSED FUNDING SOURCE BY ITS PROJECT TYPE

	PROJECT TYPE		
FUNDING SOURCE	Single Agency Initiative	Multi-Agency Collaborative	Showcase
Local Agency	Primary	Potential Matching Funds	n/a
Regional	Secondary	Primary	Potential Matching Funds
State	Secondary	Primary	Secondary
Federal ITS	n/a	Limited Potential	Primary
Private Participation	n/a	Secondary	Secondary
Dedicated	n/a	Limited Potential	n/a

Source: SACOG, 1996.

Notes:
"Local Agency" funds include local agency revenues expended for transportation capital and operating improvements.
"Regional" funds include regionally allocated transportation funds (STP, CMAQ, TEA, etc.).
"State" funds include STIP, SHOPP, State TSM, TCI, and other statewide fund sources.
"Federal ITS" funds include money set aside for ITS projects in ISTEA.
"Dedicated" funds include special revenue sources dedicated to specific transportation projects and/or uses.

"Single Agency Initiative" projects include transportation captial and operating improvements which can be undertaken by a single agency, and operating within their jurisdiction or service area.
"Multi-Agency Collaborative" projects include ITS projects involving participation by and coordination among a number of operator agencies, generally using existing, "off the shelf technologies.
"Showcase" projects include those which apply or demonstrate a ground-breaking new technology or institutional arrangement.

"Primary" means the most likely source of funds.
"Secondary" means supplementary funds.
"Limited Potential" means that funding would be highly dependent on specifics of a proposed project.
"Potential Matching Funds" means that funding source may provide seed or match money.

partnerships for single agency projects. Exceptions may be private sector funding of specific data collection devices, such as video cameras at critical intersections, or installation of transmission lines or other infrastructure in concert with privately financed roadway improvements.

Single agency projects, funded through agency-controlled revenues and supplemented with other, outside sources, have represented the major category of ITS project implemented in the Sacramento region (see Table 10). Information in Table 8 suggests that this category of project is likely to remain the largest public agency investment in terms of numbers and total costs of projects. In fact, participation by any ITS project or system which delivers services on a larger scale to regional and inter-regional travelers will depend on a minimum level of functional capability on the part of each participating agency, as mentioned earlier. However, even though these investments may be made on a single agency basis, significant added value and flexibility can be achieved by ensuring that these single agency projects are compatible with those being made in other adjacent jurisdictions, and that the potential for sharing of information and coordinated management of facilities is realized.

Multi-Agency Projects. For multi-agency projects, local agency funds would be appropriate to match funding provided from other sources. Regional and State transportation funding should be viewed as a primary funding source, since multi-agency projects are likely to provide large-area or region-wide services to travelers. Recent funding history for ITS projects for this funding source demonstrates that greater understanding and comfort level among local jurisdictions for ITS projects must be developed, or funding of multi-agency projects will be hit-or-miss at best. Because of the increased coverage of multi-agency projects, they are more likely' to compete well for Federal ITS funding. Again, because of the potential for wide geographic coverage, the potential for involving private sector partners in development or operation costs of multi-agency projects is greater than for single agency projects. Also, for multi-agency projects, the possibility of development of a dedicated source of funding is somewhat greater, since the "audience" of potential beneficiaries is larger.

One major report has recently been published on the benefits of integrated ITS strategies for solving transportation problems and improving system performance /39/. Listed below are some of the key findings relevant to the Sacramento region.

- *Freeway and Incident Management Systems* - This includes video surveillance, traffic monitoring stations, ramp metering, changeable message signs, highway advisory radio, and other tools for monitoring'and managing traffic on freeways and ramps. Range of measured benefits: travel time decreases of 20 to 48 percent; travel speed increases of 16 to 62 percent; freeway capacity increases of 17 to 25 percent; and significant decreases in average response times to incidents.

- *Traffic Signal Systems* - This includes computerized traffic signal coordination and monitoring on surface streets. Range of measured benefits: travel time decreases of 8 to 15 percent; travel speed increases of 14 to 22 percent; decreases in number of vehicle stops of up to 3 5 percent; and decreases in delay of 17 to 37 percent.

- *Transit Management Systems* - This includes automated vehicle location (AVL) systems, communications systems, and transit vehicle signal preemption. The range of measures benefits: decreases in travel time of 5 to 8 percent; increases in on-time performance by 12 to 23 percent; and reductions in incident response times.

Benefits for other ITS strategies are currently based on simulations or survey extrapolations. Some concrete

benefits of ATIS for the Sacramento region should be demonstrated by the TransCal FOT and the Smart Traveler projects in the region.

Showcase or Demonstration Projects For showcase projects, the primary source of funding should be Federal. Showcase projects by definition go beyond current practice in terms of implementation of ITS technology, or demonstrates a new technology. Because of the benefit provided to other regions around the country in learning from these showcase applications, a large Federal role in funding them, at least for a demonstration period, is appropriate. Local and regional sources should be secondary sources, for matching purposes, for these projects. Because of the stated goals of the Federal ITS program, and because of the broad geographic area which has been covered in previous showcase projects, private sector participation in at least the FOT's has been strong.

Current indications are that technology demonstrations may be given less priority in terms of future Federal funding, in favor or integrated deployment of ITS projects. Potential showcase projects in this region will build upon, extend the operation period, or expand the scope of the existing FOT's. An important component of developing a viable proposal is local agency and private sector involvement and support.

Implementation Strategy

The goals of ITS implementation in the region are: reduce congestion, reduce pollution, improve travel safety, improve transit utilization, facilitate movement of commercial vehicles, and minimize the impacts of through and inter-regional travel.

To meet these goals, a listing of 14 ITS user services were selected for implementation in the region: 1) traffic control; 2) incident management; 3) en-route driver information; 4) emissions testing and mitigation; 5) public transportation management; 6) route guidance; 7) pre-trip travel information; 8) ride matching; 9) demand management; 10) personalized public transit; 11) public transit security; 12) commercial vehicle fleet management; 13) hazardous materials incident response; and 14) emergency vehicle management.

This report identified several project concepts, which would facilitate coordinated delivery of these selected user services to the region's travelers. In this section, recommendations are made for which project concepts should be the focus of short range implementation efforts in this region.

Project Concepts for Short-Range Implementation. Based on existing and programmed ITS project commitments, and on ongoing ITS FOT's and demonstration projects in the region, the following project concepts should be considered for short range implementation (Note: For the purposes of this study, "short range" means within three years; medium range means three to five years; and long range means beyond five years):

- *Sacramento Urban Area Traffic Control Network* - The concept for this project is an information exchange network, which would allow critical traffic operations and incident data among Caltrans District 3, California Highway Patrol, Sacramento City, and Sacramento County. This information could then be used to better coordinate traffic signal operations and responses to incidents. Further, this project would provide a central, real-time traffic and incident information source which could supplement existing and proposed traveler information systems. Because of existing investments made by the participating agencies in advanced traffic management systems, these agencies are in a

position to advance on this project. This project, with the working title "Sacramento Area Transportation Network" (SATRN) was included in a proposal for funding through the federal "ITS Model Deployment Initiative Program" /40/.

A second project concept recommended in the "Summary Analysis Report" is complementary: development of standard data exchange protocols. In fact, this project would be implemented as part of the design process for the "Sacramento Urban Area Traffic Control Network".

- *Traveler Information Database* - The concept for this project is a coordinated set of databases for traveler information for the Sacramento region, which would be accessible to travelers in a variety of ways: Internet web-sites; a dial-up telephone advisory systems; personal digital assistants (PDA's); in-vehicle displays; information kiosks; and local broadcast media. The project concept is to establish the database, with the flexibility of formatting output for a variety of these output devices and modes. If the information database is established and accessible to traveler information and service companies, the provision of some of these output modes may be commercially supported. Existing Internet web-sites and local broadcast media outlets make these output modes the most promising for short range implementation. However, FOT's demonstrating information kiosks, PDA's, in vehicle displays, and telephone advisory systems also provide opportunities for short- to medium- range implementation of these output modes. Efforts are already underway to develop a traveler information system for the Sierra Foothills area, in anticipation of the Sesquicentennial Anniversary of the California Gold Rush.

- *Transit Services Network* - This' project is intended to develop integrated transit information and transit trip planning capabilities for the participating transit agencies. In addition to supporting the existing customer service functions for the participating agencies, this project would allow for additional modes of accessing transit information and trip planning services. For example, these services could be incorporated into the traveler information database mentioned above, and provided via the Internet or other output modes. This project would require development of additional management and information processing capabilities within each participating agency.

  This project concept was listed-in Section VIII of this report for medium range implementation. In the interest of providing multi-modal transportation information and services in the traveler information database, this project concept is recommended for short range implementation.

These projects and preliminary cost estimates are listed in Table 8 and 9. Some of the functional capabilities needed by participating agencies in order to implement these projects are listed in Table 7. More detailed project descriptions are provided in other EDPS report documents /36,37/.

Implementation Guidelines. Based on input from study participants, several overall guidelines on ITS implementation are recommended:

- *Orientation to the Traveler* - Travelers in the region are customers of agencies operating transportation systems. Where benefits can be provided to travelers, coordinated, multi-agency projects should be pursued. All projects should include monitoring and evaluation to demonstrate the benefits provided to travelers.

- *Operational Autonomy* - Maintaining operational autonomy of transportation systems was a priority

for most of the agencies participating in this project. The multi-agency projects listed in Table 2 were developed with this limitation in mind. This means that multi-agency projects are limited largely to information sharing among participating agencies. Delivery of benefits (either through improved system performance, or better information) to travelers will require cooperative agreements among the participating operators.

- *Open for Expansion* - Any multi-agency project should be open to participation of other agencies in the future. Integrated networks and systems should be based on "off-the-shelf' software and hardware whenever possible, and should be scaled to allow for later expansion.

- *Build on Existing Investments* - Future ITS projects should focus on integration of existing systems, and take advantage of infrastructure, training, and other investments made by local agency operators.

ITS Coordination Group. In order to take advantage of opportunities for implementation of ITS projects in the region, an ad hoc forum for coordinating ITS activities should be established. Some roles for the ITS Coordination group are: information sharing, coordination of ITS projects, and funding development for ITS projects. SACOG can provide staffing support for this group.

An example of activities for this group for the 1996/97 fiscal year are:

- *Follow-up on the Sacramento Model Deployment Initiative Proposal* - Participants in the proposal have indicated an interest in developing an agreement for the purposes of future funding proposals. Some agencies which were unable to participate in the MDI proposal due to time constraints may be interested in a future effort. Other funding sources may be appropriate for funding some or all of the project proposal.

- *Private Sector Role in ITS Implementation* - So far, private sector participation in ITS in the region has been limited to FOT's. However, many companies, especially in the traveler information and services industry, are actively developing ITS products and services which may be deployed in the region. Some outreach to these companies could be done, and potential partnerships in ITS project implementation could be explored and discussed.

- *Coordination with Ongoing ITS FOT's and Demonstrations* - The FOT's provide unique opportunities for ITS implementation, because the funded demonstration periods allow for the benefits of ITS to be seen concretely. Additionally, each FOT actually provides system software and hardware, which may provide the basis for implementation of ITS on a wider scale in the region. Minimally, the ITS coordination group could provide input to the FOT's as they progress, and provide information and assistance where appropriate. Potentially, the ITS coordination group could play an active role in discussions and actions needed to sustain successful and beneficial portions of the FOT's beyond their demonstration periods.

- *Coordination with ITS planning and project implementation in Placer and El Dorado Counties* - Placer and El Dorado Counties have their own ITS planning and project implementation efforts under way. To date, coordination between Placer, El Dorado, Sacramento, Yolo, Yuba and Sutter Counties has been informal, through the EDPS workshops and meetings. With the formation of an ITS coordination group, more explicit coordination on project planning, prioritization, funding, and implementation should be established. The current MOU's between SACOG, the Placer County

Transportation Commission (PCTC), and El Dorado County Transportation Commission (EDTC) lay out roles and responsibilities of each agency, and are not expected to need revision to accommodate ITS activities. However, some additional staff-level protocols for ITS projects will need to be agreed upon.

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APPENDIX A: LIST OF EDPS PARTICIPANTS

APPENDIX A

The following lists show the standing SACOG committees that met to discuss issues surrounding the ITS Early Deployment Planning Study over the past year and a half:

ITS EDPS Coordination Team:
February 1, 1996
September 15, 1995
July 26, 1995
July 11, 1995
May 19,1995
May 9, 1995
April 7, 1995
December 12, 1994

SACOG Board of Directors:
May 8,1995
May 18, 1995
March 16, 1995

Regional Planning Partnership:
May 23,1996
March 28, 1996
February 29,1996
June 22, 1995
May 25,1995
March 23, 1995
January 26,1995
December 8, 1994

Transit Coordinating and Productivity Committee:
February 22, 1995
November 21, 1994

Freight Advisory Council:
February 16,1995
December 16, 1994

Bicycle and Pedestrian Advisory Committee:
April 13, 1995

The following list is of local agency staff that participated in the ITS Early Deployment Planning Study Workshops over the past year and a half:

Grieg Asher	Placer County Transportation Planning Agency
Michael Baker	California Air Resources Board
Cameron Beebe	City of West Sacramento Public Works
Tom Brinkman	Placer County Public Works
Peter Christiansen	Sacramento Metropolitan Air Quality Management District
Paul Congi	California Highway Patrol
Bob Cooper	City of Sacramento
Mar-tie Dote	Yolo County Transit Authority
Tim Douglas	Placer County Transportation Planning Agency
Dave Driscoll	Caltrans District 3
Bill Durant	Paratransit Inc.
Mike Evans	Caltrans District 3
Jerry Fitch	Sacramento County Public Works
John Gedney	El Dorado County Department of Transportation
Kevin Green	California Highway Patrol
Kay Hanson	Caltrans New Technologies
Steve Hetland	Sacramento County Public Works
Norman Horn	Sacramento Transportation Authority
David Liu	Sutter County Department of Public Works
Velma Lucero	Sacramento Rideshare
Steve Lykins	California Highway Patrol Valley Division
Larry Pagel	City of Roseville Public Works
Anthony Palmere	Sacramento Regional Transit District
Andy Parvin	El Dorado County Transportation Commission
David Pelz	City of Davis Public Works
Jeffery Pulverman	Caltrans District 3
Brian Simi	Caltrans District 3
Mark Siroky	City of Folsom Public Works
David Yatabe	City of Sacramento Public Work

ITS Early Deployment Planning Study Workshop Dates:

May 9, 1996
February 8,1996
'August 15,1995
February 24, 1995
December 12,1994

APPENDIX B: ITS USER SERVICE DESCRIPTIONS

APPENDIX B

Intelligent Vehicle Highway Systems

A Primer on User Services

November 15, 1994

work, transit schedules, etc. When fully deployed, route guidance systems will provide travelers with directions to their destinations based on real-time information about the transportation system. The route guidance service will consider traffic conditions, status and schedule of transit systems, and road closures in developing the best route. Users of the service include not only drivers, but also non-vehicular travelers, such as pedestrians or bicyclists, who could get specialized route guidance from a hand-held device.

Traveler Services Information

Provides a business directory, or yellow pages of service information.

Traveler setices information provides quick access to travel related services and facilities. Examples of information that might be included are the location, operating hours, and availability of food, parking, auto repair, hospitals, and police facilities. Traveler services information would be accessible in the home, office or other public locations to help plan trips, and might also be available en route. When fully deployed, this service will connect users and providers interactively, to request and provide needed information.

Traffic Control

Manages the movement of traffic on streets and highways.

This service will provide for the integration and adaptive control of the freeway and surface street system to improve the flow of traffic, give preference to transit and other high occupancy vehicles, and minimize congestion while maximizing the movement of people and goods. Through appropriate traffic controls, the service will also promote the safety of non-vehicular travelers, such as pedestrians and bicyclists. This service requires advanced surveillance of traffic flows, sophisticated analysis techniques for determining appropriate traffic signal and ramp metering controls, and communication of these controls to the roadside infrastructure.' The real-time traffic information collected by the Traffic Control service also provides the foundation for many other user services.

Incident Management

Helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic.

This service enhances existing capabilities for detecting incidents and taking the appropriate actions in response to them. The service uses advanced sensors, information management, and communications to improve the incident management and response capabilities of transportation and public safety officials, the towing and recovery industry, and others involved in incident response. The service helps these groups to quickly and accurately identify a variety of incidents, and to implement a response which minimizes the effects of these incidents on the movement of people and goods.

Emissions Testing and Mitigation

Provides information for monitoring air quality and develop ing air quality improvement strategies.

This service uses advanced vehicle emissions testing systems to identify environmental "hot spots" and implement strategies to reroute traffic around sensitive air quality areas, or control access to such areas. Other technole gies provide in-vehicle or roadside identification of vehicles that are emitting levels of pollutants that exceed state, local or regional standards, and provide information to drivers or fleet operators to enable them to take corrective action.

TRAVEL DEMAND MANAGEMENT

Pre-Trip Travel Information

Provides information for selecting the best departure time, transportation modes and routes

Pre-trip travel information allows travelers to access a complete range of intermodal transportation information at home, work, and other major sites where trips originate. For example, timely information on transit route, schedules, trans-

This service provides systems that monitor the environment in transit stations, parking lots, bus stops, and on-board transit vehicles, and generates alarms, either automatically or manually, when necessary. This improves security for both transit riders and operators.

ELECTRONIC PAYMENT

Electronic Payment Services

Allows travelers to pay for transportation services electronically.

This service fosters intermodal travel by providing a common electronic payment medium for all transportation modes and functions, including tolls, transit fares, and parking. The service provides for a common service fee and payment structure using "smart cards" or other technologies. Such systems could be truly multi-use, allowing personal financial transactions on the same medium. The flexibility that electronic payment services offer also facilitates travel demand management, if conditions warrant.

COMMERCIAL VEHICLE OPERATIONS

Commercial Vehicle Electronic Clearance

Facilitates domestic and international border clearance, minimizing stops.

This service will enable transponder-equipped trucks and buses to have their safety status, credentials, and weight checked at mainline speeds. Vehicles that are safe and legal and have' no outstanding out-of-service citations will be allowed to pass the inspection/weigh facility without delay.

Automated Roadside Safety Inspection

Facilitates roadside inspections.

Automated roadside inspections allow real-time access at the roadside to the safety performance record of carriers, vehicles and drivers. Such access helps determine which vehicle or driver should be stopped for an inspection, as well as ensuring timely correction of previously identified problems.

This service also automates as many items as possible of the manual inspection process. Through the use of sensors and diagnostics, it efficiently checks vehicle systems and driver requirements and ultimately driver alertness and fitness for duty.

On-Board Safety Monitoring

Senses the safety status of a commercial vehicle, cargo, and driver.

On-board systems monitor the safety status of a Vehicle, cargo, and driver at -mainline speeds. Vehicle monitoring includes sensing and collecting data on the condition of critical vehicle components such as brakes, tires, and lights, and determining thresholds for warnings and countermeasures. Cargo. monitoring involves sensing unsafe conditions relating to vehicle cargo, such as shifts in cargo while the vehicle is in operation. Driver monitoring is envisioned to include the monitoring of driving time and alertness using non-intrusive technology and the development of warning systems for the driver, the carrier, and the enforcement official.

Commercial Vehicle Administrative Processes

Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.

Electronically purchasing credentials provide the carrier with the capability to electronically purchase annual and temporary credentials via computer link It reduces burdensome paper work and processing time for both the states and the motor carriers.

For automated mileage and fuel reporting and auditing, this service would enable participating interstate carriers to electronically capture mileage, fuel purchased, trip, and vehicle data by state. This information can be used by the carrier in preparing fuel tax and registration reports to the states.

Intersection Collision Avoidance

Helps prevent collisions at intersections.

This service warns drivers of imminent collisions when approaching or crossing an intersection that has traffic control (e.g., stop signs or a traffic signal). This service also alerts the driver when the proper right-of-way at the intersection is unclear or ambiguous.

Vision Enhancement for Crash Avoidance

Improves the driver's ability to see the roadway and objects that are on or along the roadway.

Improved visibility will allow drivers to avoid potential collisions with other vehicles or obstacles in the roadway, as well as help the driver comply with traffic signs and signals. This service requires in-vehicie equipment for sensing potential hazards, processing this information, and displaying it in a way that is useful to a driver.

Safety Readiness

Provides warnings about the condition of the driver, the vehicle, and the roadway.

In-vehicle equipment will unobtrusively monitor a driver's condition and provide a warning if he or she is becoming drowsy or otherwise impaired. This service could also internally monitor critical components of the automobile, and alert the driver to impending malfunctions. Equipment within the vehicle could also detect unsafe road conditions, such as bridge icing or standing water on the roadway, and provide a warning to the driver.

Pre-Crash Restraint Deployment

Anticipates an imminent collision and activates passenger safety systems before the collision occurs.

This service identifies the velocity, mass, and direction of the vehicles or object involved in a potential crash, and the number, location, and major physical characteristics of any occupants. Responses include tightening lap-shoulder belts, arming and deploying air bags at the optimal pressure, and employing roll bars.

Automated Highway Systems

Provides a fully automated, "hands-off," operating environment,

Automated vehicle operations is a long term goal of IVHS which could provide vast improvements in safety by creating a nearly accident free driving environment. Drivers could buy vehicles with the necessary instrumentation. or retrofit an existing vehicle. Vehicles that are incapable of automated operation, during some transition period, would drive in separate lanes.

Make Plans to Attend the Agency Workshop

8:30 AM, Wednesday December 7,1994
Second Floor Conference Room

Sacramento Area Council of Governments
3000 S Street
Sacramehto, CA 95816

APPENDIX C: NOTES FROM FIRST ITS WORKSHOP

APPENDIX C

SACOG ITS

Early Deployment Plan Study

Jurisdiction Workshop

Summary of

Working Group Sessions

on

Problem Definition

Third Floor Group

The third floor discussion group arrived at the following list of high priority regional or multi-agency issues after discussion of many preliminary ideas (no ranking is implied by the order):

- Modifying traffic flows in response to the specific location of air quality non-compliance measurement sites
- Identify and remove vehicular gross emitters
- Lack of quality, real-time, air quality and traffic data
- Congestion at river crossings or other choke points
- Lack of multi-agency traffic control
- Overloading the 911 system with incident reporting
- Bay Area-Tahoe through trip congestion
- Low mode split
- Lack of funding and lack of coordination to maximizing funding for the region

The preliminary ideas about regional or multi-agency problems included the following (listed in order of discussion):

- Air quality
- Air quality violations only occur at one station at a time
- Lack of quality real-time data
- Monitoring bus on-time performance
- Lack of vehicle emissions data for use in predicting ozone violation days
- Transit service needs to be more flexible
- Congestion, especially perceived congestion
- Quality data related to signal malfunction
- Real-time monitoring of traffic flows
- Recurrent congestion, no inter-agency traffic management system
- Non-recurrent congestion is 77% of all congestion, according to SRI report
- Antiquated equipment
- No alternatives to 911 for accident reporting
- Friday afternoon inter-regional traffic, lack of input/advice warning
- Lack of communications infrastructure
- Lack of before and after studies
- Funding competition
- Lack of maintenance funding
- Lack of coordination with RT
- Low use of alternative modes
- Policy setters/elected representatives don't perceive link form land use to transportation
- Lack of pre-trip information to support park-and-ride
- Lack of real-time alternative mode information, including updates on bus arrival times
- Land use is not evolving the way the transportation system anticipated, i.e. suburban activity centers vs. radial transportation infrastructure
- Lack of funds for implementation of policies
- Lack of loop road

- Lack of acceptance of alternative modes (pedestrian and bicycle) by agencies
- Funding reaources (flexibility)
- Lack of incentives for traveler selection of alternative modes

The following items were identified as transportation problems within an agency that might be applicable to other agencies:

- Lack of surveillance for traffic operations
- Lack of centralized capability of gathering and disseminating information

The following issues were identified as potential obstacles to the implementation of ITS in the Sacramento region:

- Turf (concern over who operates the system, whether current roles and responsibilities are diminished, etc.)
- Regional/local consensus on problems that are trying to be solved
- Incentives for private sector involvement in Sacramento ITS
- Defining transportation problems in terms that are meaningful to the public

APPENDIX D: RELATIONSHIP OF ITS FUNCTIONAL AREAS TO USER SERVICES

APPENDIX D

NATIONAL ITS PROGRAM PLAN

VOLUME I

FIRST EDITION
MARCH 1995

Edited by:

Gary W: Euler
Joint Program Office for ITS
United States Department of Transportation

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ITS America

Planning organizations should be aware of the benefits of integrating the user services in a system.

3.1 Functional Relationships Among User Services

Each of the 29 user services discussed in Chapter III was analyzed to identify candidate enabling technologies. This analysis is based on a wide range of technologies capable of supporting robust, fully functioned user service implementations. This does not imply that a user service deployment must necessarily include all of the enabling technologies or the functions they provide.

In order to keep the number of technologies at a manageable level, they were grouped into functional areas. In general, each functional area is comprised of one or more separate technologies which can be used interchangeably in a system deployment that provides a user service. For example, two-way mobile communications could be provided by either digital cellular telephones or two-way satellite communications. The functional areas are defined in Table 5-l.

Table 5-1 Function Definitions

Function	Definition
Traffic Surveillance	Surveillance technologies that collect information about the status of the traffic stream. Possible technologies include loop detectors, infrared sensors, radar and microwave sensors, machine vision, aerial surveillance, closed circuit television, acoustic, in-pavement magnetic, and vehicle probes.
Vehicle Surveillance	Surveillance technologies that collect a variety of information about specific vehicles. These technologies include weigh-in-motion devices, vehicle identification, vehicle classification, and vehicle location.
Inter-Agency Coordination	Technologies that connect travel-related facilities to other agencies such as police, emergency services providers, weather forecasters and observers, and among Traffic Management Centers (TMC), transit operators, etc.
1-Way Mobile Communications	Any communication technology that transmits information to potentially mobile reception sites but cannot receive information back from those sites. Possible technologies providing this function include Highway Advisory Radio, PM subcarrier, spread spectrum, microwave, infrared, commercial broadcasts, and infrared or microwave beacons.

Table 5-1 Function Definitions

Function	Definition
2-Way Mobile Communications	Any communication technology that transmits information to potentially mobile reception sites and allows receipt of information from those same sites. Possible technologies include cellular telephones, 2-way radio, spread spectrum, microwave, infrared, and 2-way satellite.
Stationary Communications	Any communication technology that connects stationary sites. Technologies include fiber optics, microwave, radio, land lines.
Individual Traveler Interface	Devices that 'provide information flow to a specific traveler. Technologies meeting this function include touch screens, keypads, graphics displays and computer voices at kiosks; keypads, computer voice, and on-board display systems in vehicles; personal communications devices carried with the traveler; audiotex from any phone; and TV in the office or home.
Payment Systems	Technologies that enable electronic fund transfer between the traveler and the service provider. The technology areas include Automated Vehicle Identification (AVI), smart cards, and electronic funds management systems. This function overlaps with the Electronic Payment user service.
Variable Message Displays	Technologies that allow centrally controlled messages to be displayed or announced audibly to multiple users at a common location such as a roadside display or display board in a transit terminal. These technologies would typically be applied to provide information on highway conditions, traffic restrictions, and transit status.
Signalized Traffic Control	Technologies that allow for real-time control of traffic flow. Possible technologies include optimized traffic signals, tamp metering, reversible lane designation, and ramp/lane closures.
Restrictions Traffic Control	Operational techniques that restrict the use of roadways according to regional goals. Techniques include HOV restrictions, parking restrictions, and mad use (congestion) pricing.
Navigation	Technologies that determine vehicle position in real time. Technologies that provide this function include GPS, LORAN, dead reckoning, localized beacons, map database matching, and cellular/radio triangulation.
Database Processing	Technologies that manipulate and configure or format transportation-related data for sharing on various p1atforms. General purpose data base software currently exists and is currently being adapted to transportation needs such as data fusion, maps, and travel services.

Table 5-l Function Definitions

Function	Definition
Traffic Prediction Data Processing	Data processing relating to prediction of future traffic situations. Algorithms under development include areas such as real-time traffic prediction, and traffic assignment.
Traffic Control Data Processing	Data processing related to the real-time control of traffic. Algorithms under development include optimal control and incident detection, and the interaction of mute selection and traffic control.
Routing Data Processing	Data processing related to routing of vehicles including the generation of step-by-step driving instructions to a specified destination. Algorithms under development include the scheduling of drivers, vehicles, and cargo; route selection; commercial vehicle scheduling, route guidance and multimodal dispatching.
In-Vehicle Sensors/Devices	Technologies providing a range of sensing functions to be located within vehicles. Functions addressed by these technologies include monitoring of vehicle performance and driver performance; determination of vehicle position relative to the roadway, other vehicles, and obstacles; improvement of vision in adverse conditions; and on-board security monitoring.

The user service bundles, introduced in Chapter III, are the starting point for determining the interrelationship of one user service to another. The bundles provide logical groupings and combinations of the user services. By analyzing a user service's relationship to other user services, a system may be conceived over a period of years in a comprehensive and deliberate manner. This approach makes it possible to optimize the use of funds and resources resulting in a more achievable and affordable system deployment.

The results of the analysis of functional commonalities are depicted in Figure 5-2. In the figure, the user service bundle is identified in the upper left hand corner of the chart. The left side of the chart lists the associated functions. The right of the figure lists the user services in the bundle. If a function supports full implementation of a user service, the intersection of the user service row and function column is marked. Note that in some applications it is not necessary to implement all supporting functions to successfully deploy a system providing a user service.

1. Travel and Transportation Management

Applicable Bundle Functions															Provides Deployment Basis For
Data Base Processing	Stationary Communications	Traffic Surveillance	2-Way Mobile Communications	Individual Traveler Interface	Variable Message Displays	Navigation	1-Way Mobile Communications	Traffic Prediction Data Processing	Inter-Agency Coordination	Routing Data Processing	Signalized Traffic Control	Traffic Control Data Processing	Vehicle Surveillance	In-Vehicle Sensors/Devices	
●	●	●	●	●	●	●	●	●	●	●					En-Route Driver Information
●	●	●	●	●		●	●	●		●					Route Guidance
●			●	●		●									Traveler Services Information
●	●	●			●			●	●		●	●			Traffic Control
●	●	●	●		●	●	●	●	●		●	●			Incident Management
●	●			●	●		●		●		●		●	●	Emissions Testing and Mitigation

2. Travel Demand Management

Applicable Bundle Functions															Provides Deployment Basis For
Data Base Processing	Stationary Communications	Individual Traveler Interface	Variable Message Displays	Navigation	1-Way Mobile Communications	2-Way Mobile Communications	Inter-Agency Coordination	Routing Data Processing	Vehicle Surveillance	Payment Systems	Restrictions Traffic Control	Traffic Surveillance	Traffic Prediction Data Processing	Signalized Traffic Control	
●	●	●	●	●	●				●	●	●	●		●	Travel Demand Management
●	●	●	●	●		●	●	●			●	●	●		Pre-Trip Travel Information
●	●	●	●	●	●	●	●	●	●	●					Ride Matching & Reservation

Figure 5-2 Functional Relationships Among User Services

3. Public Transportation Operations

Applicable Bundle Functions														Provides Deployment Basis For
Vehicle Surveillance	2-Way Mobile Communications	Stationary Communications	Individual Traveler Interface	Inter-Agency Coordination	Variable Message Displays	Data Base Processing	Traffic Surveillance	1-Way Mobile Communications	Navigation	Traffic Prediction Data Processing	Payment Systems	Routing Data Processing	In-Vehicle Sensors/Devices	Signalized Traffic Control	
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	Public Transportation Management
●	●	●	●	●	●	●	●	●	●	●					En-Route Transit Information
●	●	●	●	●	●	●			●	●	●	●			Personalized Transit Information
●	●	●	●	●		●	●	●	●				●		Public Travel Security

4. Electronic Payment

Applicable Bundle Functions									Provides Deployment Basis For
Vehicle Surveillance	1-Way Mobile Communications	2-Way Mobile Communications	Stationary Communications	Individual Traveler Interface	Payment Systems	Variable Message Displays	Data Base Processing	Inter-Agency Coordination	
●	●	●	●	●	●	●	●	●	Electronic Payment Services

Figure 5-2 Functional Relationships Among User Services (Continued)

5. Commercial Vehicle Operations

Applicable Bundle Functions											Provides Deployment Basis For
2-Way Mobile Communications	Data Base Processing	Vehicle Surveillance	1-Way Mobile Communications	Stationary Communications	Individual Traveler Interface	In-Vehicle Sensors/Devices	Variable Message Displays	Navigation	Payment Systems	Routing Data Processing	
●	●	●	●	●	●		●				Commercial Vehicle Electronic Clearance
●	●			●		●					Automated Roadside Safety Inspection
●					●	●					On-board Safety Monitoring
●	●	●	●	●	●		●		●		Commercial Vehicle Administrative Processes
●	●	●	●			●		●			Hazardous Material Incident Response
●	●	●	●	●	●			●		●	Freight Mobility

6. Emergency Management

Applicable Bundle Functions														Provides Deployment Basis For
Vehicle Surveillance	1-Way Mobile Communications	2-Way Mobile Communications	Navigation	Data Base Processing	Routing Data Processing	Individual Traveler Interface	In-Vehicle Sensors/Devices	Traffic Surveillance	Inter-Agency Coordination	Stationary Communications	Variable Message Displays	Signalized Traffic Control	Traffic Prediction Data Processing	
●	●	●	●	●	●	●	●							Emergency Notification & Personal Security
●	●	●	●	●	●			●	●	●	●	●	●	Emergency Vehicle Management

Figure 5-2 Functional Relationships Among User Services (Continued)

7. Advanced Vehicle Control and Safety Systems

Applicable Bundle Functions													Provides Deployment Basis For
Individual Traveler Interface	In-Vehicle Sensors/Devices	1-Way Mobile Communications	Traffic Surveillance	2-Way Mobile Communications	Variable Message Displays	Signalized Traffic Control	Stationary Communications	Vehicle Surveillance	Navigation	Data Base Processing	Traffic Prediction Data Processing	Restrictions Traffic Control	
●	●	●	●	●									Longitudinal Collision Avoidance
●	●	●	●										Lateral Collision Avoidance
●	●	●	●	●	●	●		●	●	●	●		Intersection Collision Avoidance
●	●												Vision Enhancement for Crash Avoidance
●	●	●			●		●						Safety Readiness
●	●												Pre-Crash Restraint Deployment
●	●	●	●	●		●	●					●	Automated Highway Systems

Figure 5-2 Functional Relationships Among User Services (Continued)

In the process of planning system deployments to support user services, deploying organizations will consider a broad spectrum of factors. First and foremost, service providers must consider the requirements and problems unique to their communities. While there is no attempt here to develop a model which factors in all possible considerations representative of urban, suburban, or rural communities, there are some investment related factors which lend themselves to analysis. One of the prime considerations is the return on investments associated with installing systems. Therefore, once a region has made a decision to deploy systems contributing to a user service in response to a specific need, community leaders and/or private sector providers will immediately want to know the implications of such an investment, not only in the near term, but for the duration of their planning horizon. Figure 5-2 depicts a model derived from an analysis of bundles of user services. Each user service has the complete set of functionalities visualized for a mature service as derived from the appropriate User Services Development chapter in Volume II.

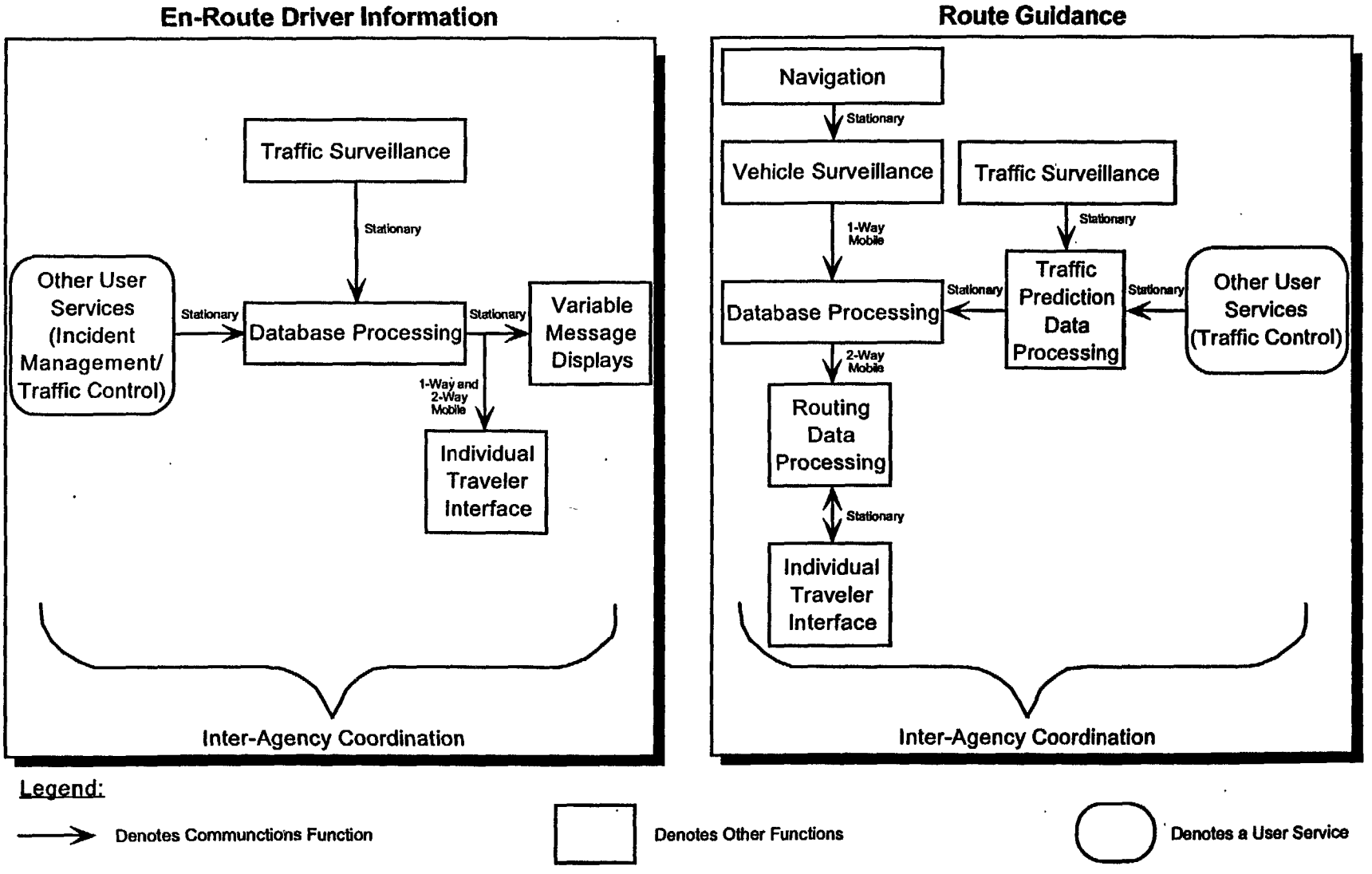
Functional Areas

- Traffic Surveillance
- Vehicle Surveillance
- Inter-Agency Coordination
- 1-Way Mobile Communications
- 2-Way Mobile Communications
- Stationary Communications
- Individual Traveler Interface
- Payment Systems

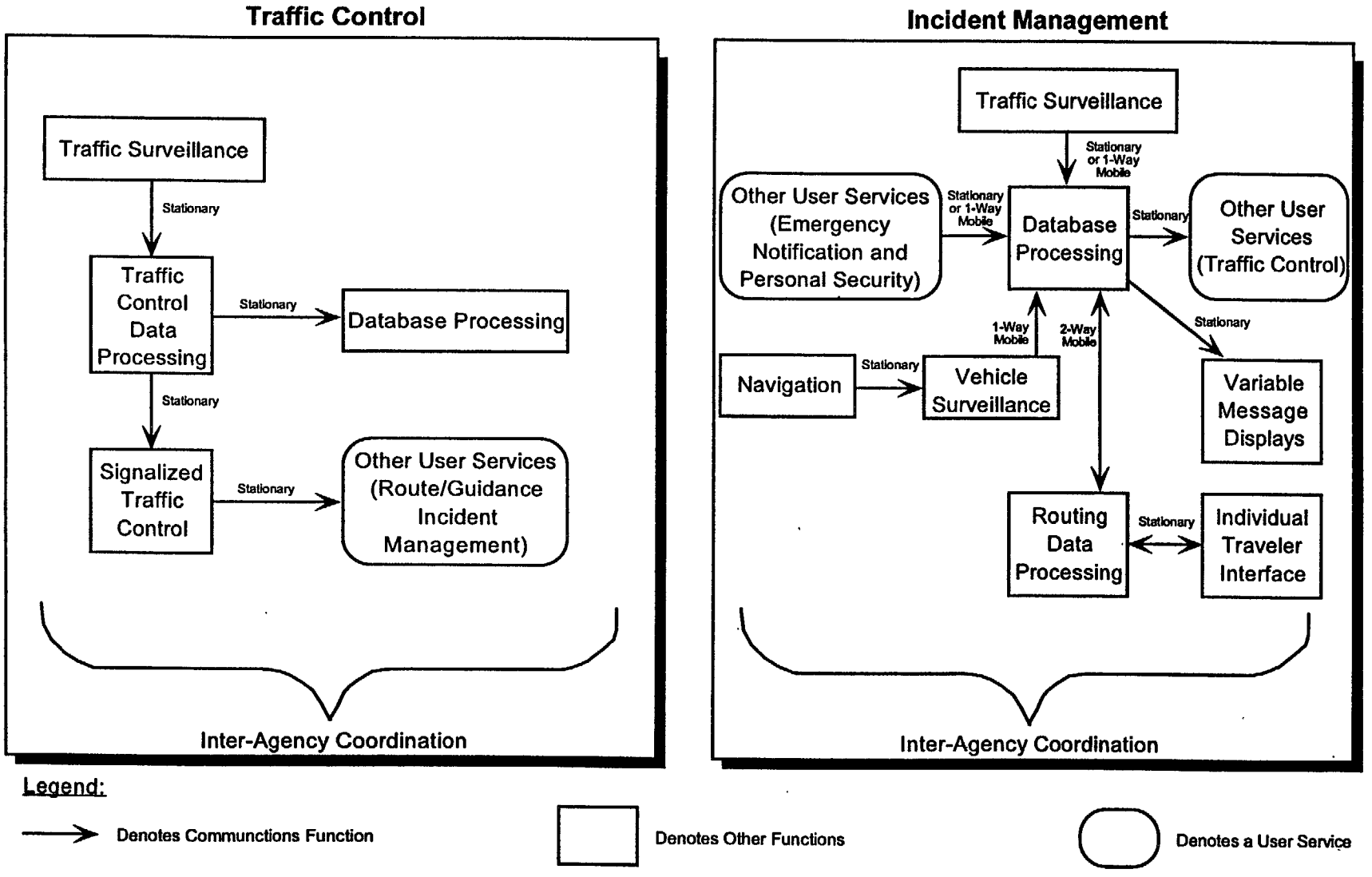
Functional Areas

- Variable Message Displays
- Signalized Traffic Control
- Restrictions Traffic Control
- Navigation
- Database Processing
- Traffic Prediction Data Processing
- Traffic Control Data Processing
- Routing Data Processing
- In-Vehicle Sensors/Devices

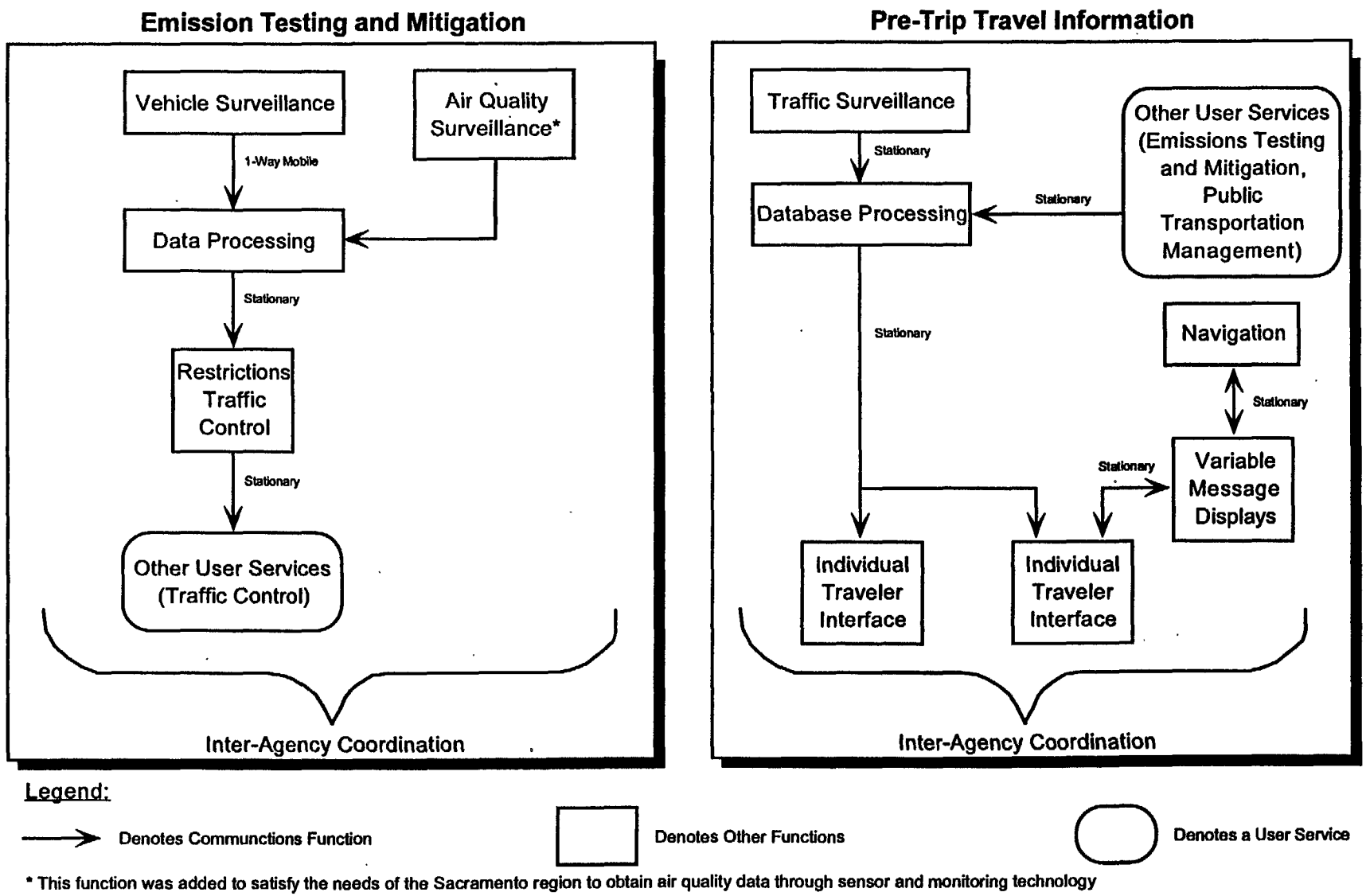
User Service Requirements



User Service Requirements

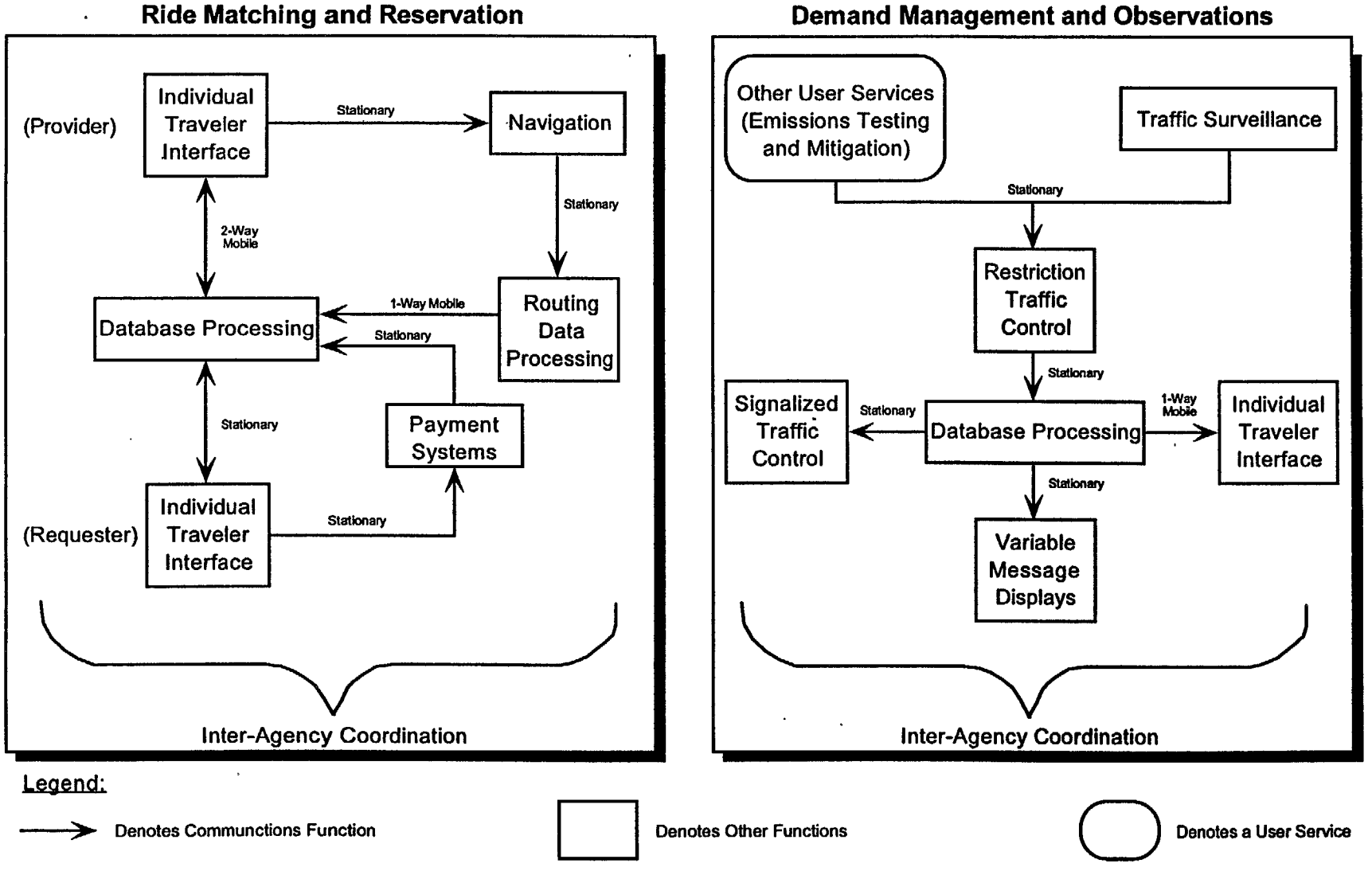


User Service Requirements

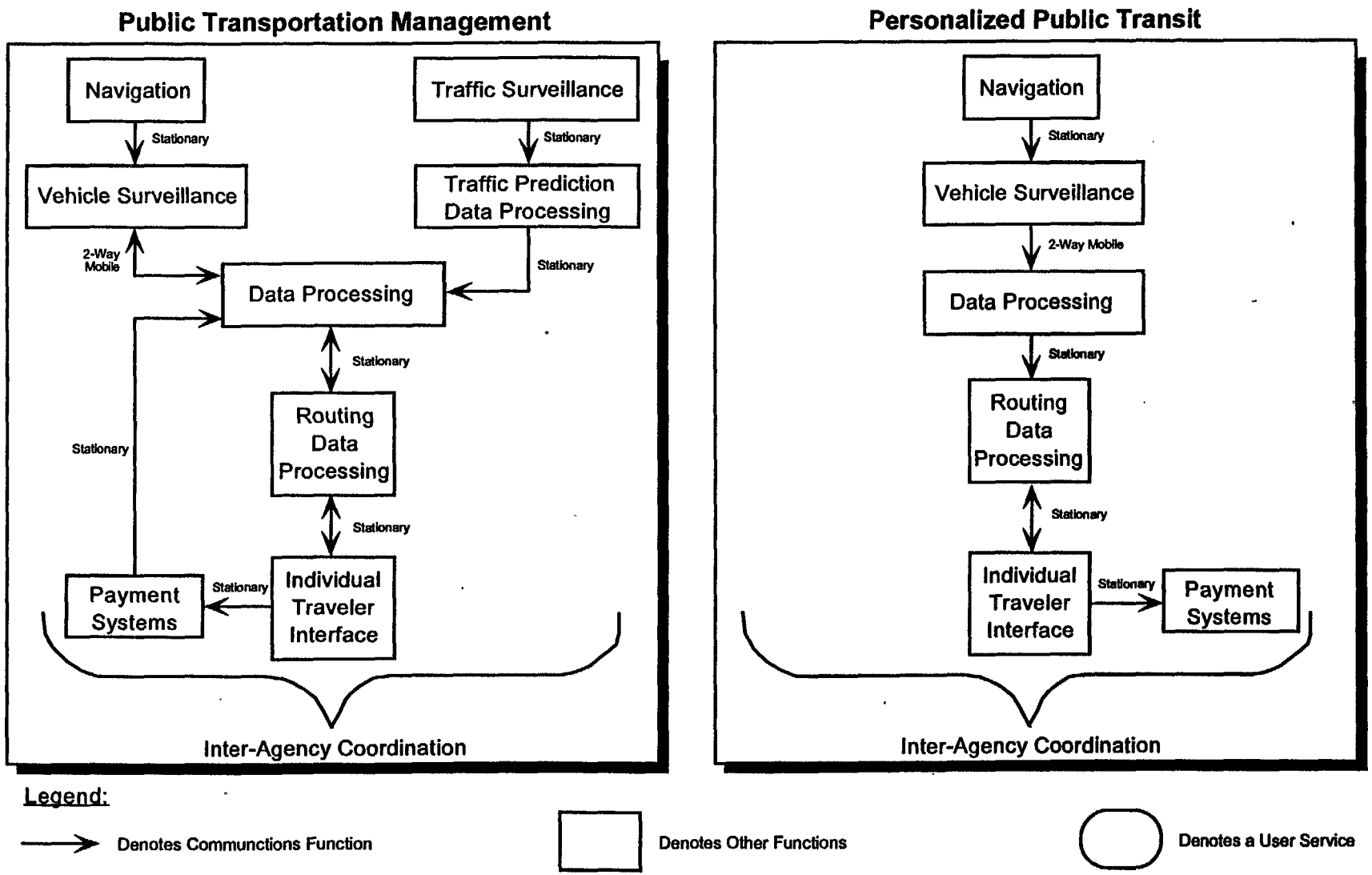


* This function was added to satisfy the needs of the Sacramento region to obtain air quality data through sensor and monitoring technology

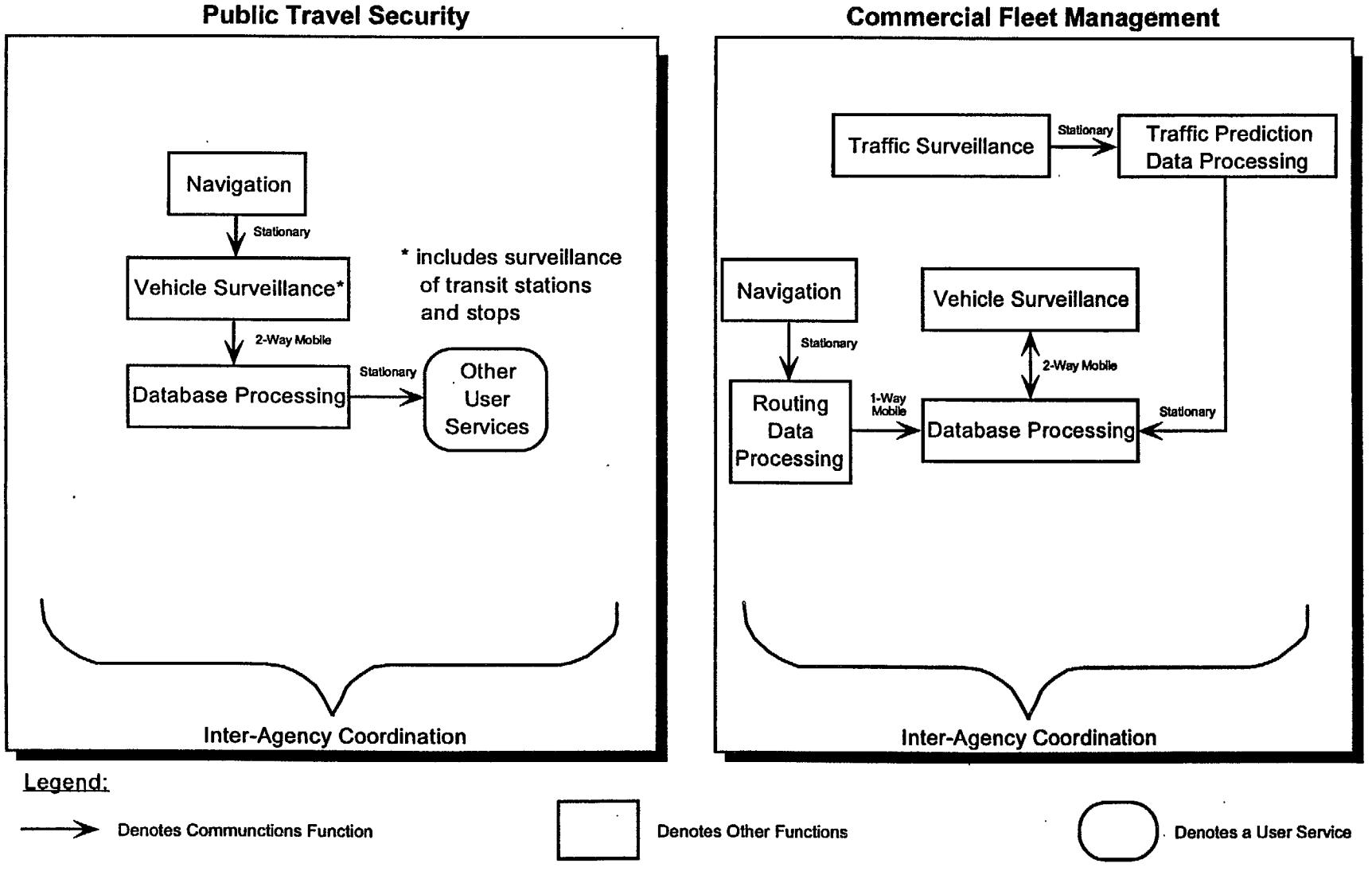
User Service Requirements



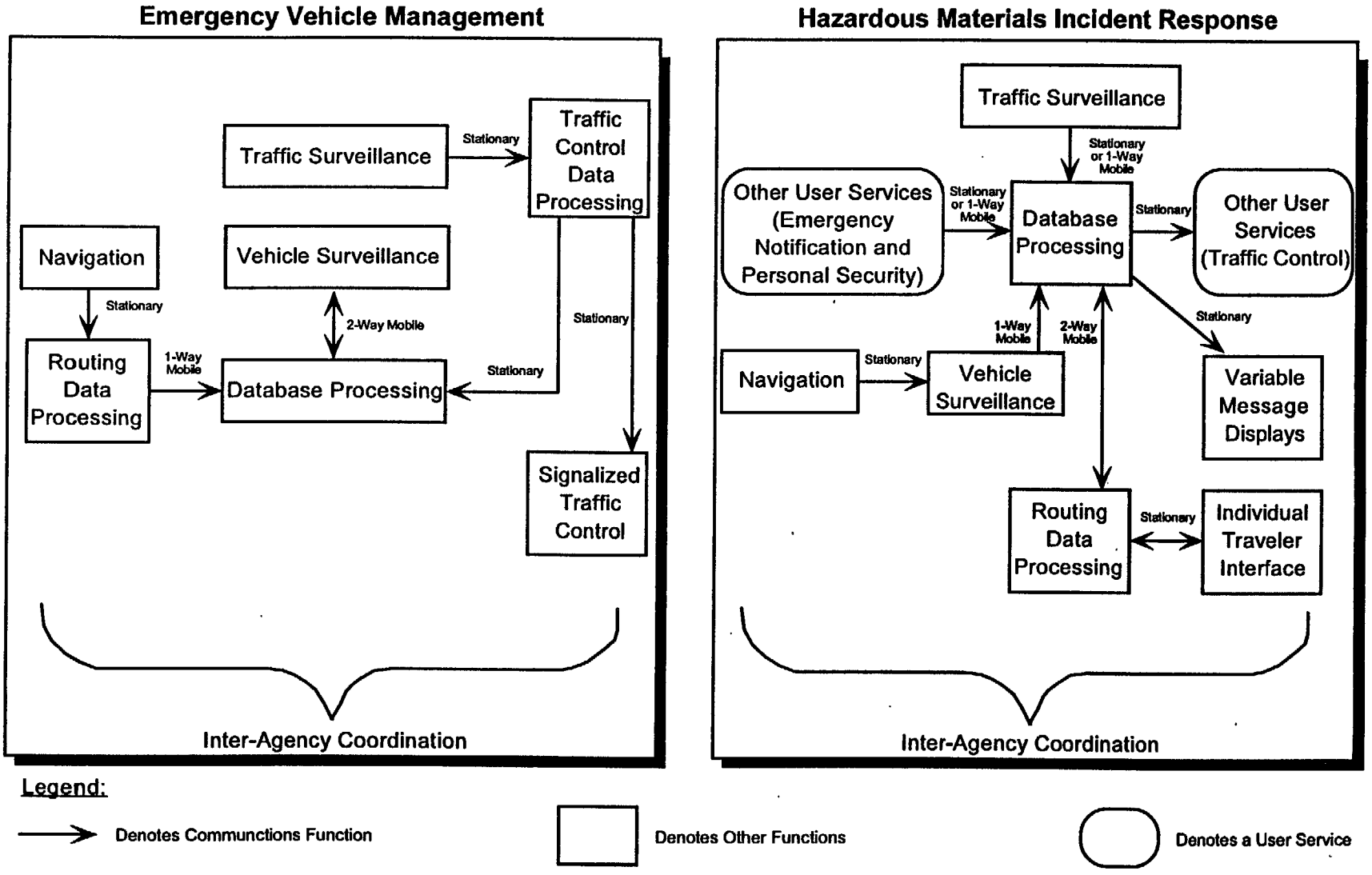
User Service Requirements



User Service Requirements



User Service Requirements



Sacramento Area Council of Governments

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