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INTELLIGENT TRANSPORTATION SYSTEMS – EARLY DEPLOYMENT PLAN FOR THE SAN FRANCISCO BAY AREA

Deliverable 8c: Draft Final Report

Prepared for

Metropolitan Transportation Commission

by

DKS Associates

In Association with
Moore Iacofano Goltsman Inc.
Rockwe1 International Corporation
Apogee Research, Inc.

July 2, 1996

CC: *sent to Dale Thompson - 8/8/96*

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EARLY DEPLOYMENT PLAN OVERVIEW

The Intelligent Transportation Systems Early Deployment Plan for the San Francisco Bay Area has been an effort to define priorities for use of Intelligent Transportation Systems (ITS) in the region over the next five to ten years. Intelligent Transportation Systems is the name given to techniques which improve the operation, safety, or convenience of the transportation system by using electronics and communications to collect, process, disseminate, and act on information in real time.

The ITS Early Deployment Plan focuses on both institutional issues and technological opportunities. It seeks to blend analysis of end user needs, evaluation of numerous technologies, and assessment of the desires and capabilities of the region's institutions, to identify the uses of ITS that best meet the Bay Area's regional transportation policies, particularly the Metropolitan Transportation System (MTS) Management Strategy. Desired end products of the effort are education, consensus on an action plan, and partnerships for deployment. The building of institutional "infrastructure" is as critical as the more usual capital investments for the ultimate success of early ITS deployment.

GOALS

The Early Deployment Plan had three central goals:

- Provide information about ITS to, and solicit input from, a broad range of stakeholders
- Build a regional consensus on an Action Plan for early ITS deployment
- Develop partnerships for ITS deployment

Although the study was open to and involved all stakeholders including private firms, it was recognized that it would be inappropriate for a public planning process to develop plans for purely private sector investments in ITS ventures. The plan is focused on those ITS actions that the public sector can take alone or in partnership with the private sector.

RELATIONSHIP TO THE MTS MANAGEMENT STRATEGY

The Metropolitan Transportation System (MTS) is the multimodal system of regional significance-that is, those facilities and services that are crucial to the freight and passenger mobility needs of the nine-county Bay Area. The MTS is owned and operated by over 100 different agencies. The MTS Management Strategy states that streets, highways, and transit services that comprise the MTS should be cooperatively planned and operated as if they were integral elements of a single system. The Management Strategy, shown in Figure ES-l, has two defining elements.

1) A set of five core principles outlining a multimodal approach to system management that gives appropriate emphasis to people movement during commute hours and correspondingly appropriate emphasis to traffic flow during off-peak hours,

2) A commitment to cooperative planning at the corridor scale, to ensure that the management strategy can be tailored to local conditions and that local governments participate in the process of corridor management.

ITS provides a variety of tools that facilitate the real-time management and operation of the MTS. The ITS Early Deployment Plan is intended to advance the MTS Management Strategy by focusing deployment efforts on the ITS elements that best support multimodal management at the corridor level. Indeed, the majority of projects developed to improve the operation and management of the MTS, ranging from development of a call box system to coordinated operation of freeways and arterial streets to TransLink, include some aspect of ITS.

Defining and implementing MTS Management Strategy Projects typically requires several agencies to work together to define a common problem, conceptualize a feasible solution, secure funding, and create institutional arrangements to jointly implement and operate the project.

Figure ES - 1. The Partnership's MTS Management Strategy

The Partnership's strategy for managing the Metropolitan Transportation System has two defining elements: 1) a set of five core principles, and, 2) a commitment to cooperative planning at the corridor scale. The core principles outline a multi-modal approach to system management that gives appropriate emphasis to people movement during commute hours and correspondingly appropriate emphasis to traffic flow during off-peak hours. The emphasis on corridor planing ensures that the management strategy can be tailored to fit local conditions. It also ensures local governments a real opportunity to participate in the process of system management.

The five core principles which define the Partnership's management strategy can be summarized as follows:

1. Streets, highways, and transit services should be planned, operated and priced as if they were integral elements of a single system.

2. Transportation and land use should be better coordinated to enhance accessibility while reducing the need for travel.

3. The transportation system should be designed to provide convenient access to jobs and services, to move goods efficiently and reliably, to facilitate the interregional movement of people and goods, and to shelter the region's communities and its natural environment from traffic overload.

4. Despite limited resources, the region can effectively resolve the conflict between these goals if it adopts a strategy of system management that is tailored by corridor and time of day. Specifically:

    - The management plan should emphasize operational improvements that enhance the ability of the transportation system to move people during peak commute hours and its ability to move vehicular traffic during off-peak hours.

    - When considering the supplementary capacity necessary to serve the commute peak, priority should be given to projects and programs which will enhance the operation and coordination of mass transit, provide incentives for ridesharing and transit use, and increase the capacity and continuity of the arterial street system; and,

    - When considering operation improvements necessary to improve the flow of traffic, priority should be given to those corridors which play a critically important role in freight movement.

5. Operational improvements alone will not be sufficient to maintain mobility. Continuing investment – coupled with innovations in pricing and technology – will be required to meet the needs of a growing population and economy. Thus, it is essential to coordinate planning for management and investment.

BENEFITS OF ITS

The transportation improvements made possible by ITS include increased efficiency, increased safety, increased comfort, reduced cost, and increased reliability. ITS can assist in the transportation of both people and goods, and can reduce the negative impacts of transportation activities on the surrounding community.

Among the benefits of ITS are:

- The ability to **continuously manage and fine-tune** the transportation system's operation in response to unpredictable fluctuations in travel demand and incidents that interrupt the normal operation of roadways and transit systems.

- The ability for travelers to **choose travel time, mode, and route efficiently** based on real-time roadway and transit status information.

- The ability to **coordinate and integrate** the operation of the various elements of the Metropolitan Transportation System by collecting and exchanging real-time transportation system operations data.

- The ability to **reduce the cost of operating and maintaining** transportation facilities and services through more efficient use of existing facilities, and automated or remote operation and monitoring of equipment.

- The ability to provide **increased safety and security** to travelers by automated or remote monitoring of transportation facilities, vehicles, and hazardous cargoes and by provision of mayday alarms for travelers in distress.

- The ability to **make travel more convenient** by providing real-time information about current conditions and options, increasing the reliability of travel, and by providing electronic payment mechanisms for tolls, fares, and parking.

THE EARLY DEPLOYMENT PLANNING PROCESS

Development of the EDP began in February 1995, funded by a $450,000 grant from the Federal Highway Administration (FHWA). Work was shaped by input from an Advisory Board that included representatives from public agencies, private companies, advocacy groups, and private citizens. Advisory Board members also reviewed draft versions of all intermediate and final products of the study. Other mechanisms for information dissemination and involvement in the study were the following:

- A four-issue newsletter series mailed to 1,000 people;
- Public outreach meetings; and
- Focus groups

The ITS Early Deployment Planning process involved the following primary steps:

- Identify transportation problems facing the Bay Area
- Identify ITS services that can address those problems
- Identify and evaluate ITS projects that can provide needed services
- Develop an Action Plan for implementing the projects critical for the region
- Document the study process and results in this report

Some 133 Bay Area transportation problems were identified and were grouped in the following categories:

- Problems Related to Lack of Facilities
- Problems Related to Travel Delays
- Problems Related to Lack of Information
- Problems Related to Safety and Security
- Problems Related to Regulations and Charges
- Problems Related to Comfort, Convenience, and Ease of Use
- Problems Related to Environmental Impacts

The early deployment planning process then identified 41 different ITS services, 35 of which were found to be relevant to early deployment of ITS in the Bay Area. A priority was assigned to these ITS services reflecting their effectiveness in addressing the region's transportation problems, and the extent to which a service is compatible with regional transportation policies and goals.

The next step was to identify projects that have the potential to provide needed ITS services. A total of 36 different project types were identified. These projects are described, along with the results of project evaluation and recommendations for deployment, in Table ES-l.

The six project evaluation criteria were:

- Support for the MTS Management Strategy
- Technical Achievability
- Institutional Achievability
- Effectiveness
- Customer Acceptability
- Scalability and Integratability

The project evaluation process revealed several projects that are of strategic significance for the region and therefore a high priority for deployment. These are the focus of the Action Plan. The Action Plan also recommends an on-going support service for the MTS Management Strategy, including deployment of ITS projects that support the MTS Management Strategy, and it includes a description of funding options for ITS projects.

Throughout development of this Early Deployment Plan, the System Operation and Management (SOM) committee of the Bay Area Partnership provided review and oversight of the early deployment planning process to ensure it properly addressed regional transportation policies. The SOM committee meets monthly and is responsible for coordinating implementation of the MTS Management Strategy.

THE ACTION PLAN

The Action Plan is comprised of the following eight actions:

Action #1 - Deploy a Probe Vehicle System for Measuring Travel Times

Probe vehicles, vehicles equipped with tags scanned by readers at several points during their journeys, are the most promising method of obtaining real-time information about travel time on surface streets and freeways, and are the only way to continuously monitor route-selection patterns. This information allows travelers to choose the route with the lowest travel time and allows transportation system operators to monitor the impacts of incidents and subsequent traffic management actions. In Houston, over 10,000 people use the Internet each month to access travel time information collected by a probe vehicle system.

Using the estimated 200,000 Bay Area vehicles that by the end of the century will carry electronic toll tags, this Action Plan element will monitor average travel times of vehicles traveling between Cordelia and San Francisco by both the I-80 and I-680/SR 24 routes, and along major arterial roadways in central Contra Costa County, Roadside readers installed at strategic locations will note when a tag passes and determine average travel time between readers. A computer will compare the time of arrival of tags at adjacent readers. The project will act as a demonstration and pilot project for eventual deployment of a regional probe vehicle system. The system will continuously provide accurate travel time information to travelers via TravInfo.

Action #2 - Expand the Freeway Traffic Operations System

The Caltrans freeway Traffic Operations System (TOS) provides rapid response to freeway incidents and provides travelers and freeway operations personnel with real-time information about current freeway conditions. A similar freeway management system installed in Minneapolis increased the average rush hour speed from 34 to 46 mph and reduced the accident rate by 27%.

This Action Plan element will expand Caltrans' freeway Traffic Operations System by installing vehicle detectors and CCTV cameras on another 70 miles of inner freeways. When completed, virtually all of the inner freeways and many other freeway segments will be instrumented. This will enable rapid response to incidents and real-time status information for travelers via TravInfo. This element also entails completion of the regional Transportation Management Center in Oakland to make full use of the field devices and to effectively and efficiently manage the freeway network. This work will include the provision of data and video exchange links to local jurisdictions and agencies, enabling coordinated multi-agency responses to incidents on all elements of the metropolitan transportation system. These links will also facilitate coordination of ramp meters and local traffic signals to minimize congestion on local streets.

Action #3 - Deploy Advanced Traffic Signal Systems

Advanced traffic signal systems use computers and traffic sensors to monitor traffic flow and signal operation, and to automatically adjust signal coordination timings as conditions change. The resulting improved operation and coordination of traffic signals can significantly reduce the number of stops and amount of delay experienced by traffic. An advanced traffic signal system installed in Abilene, Texas, also resulted in a 10% reduction in vehicle emissions.

This action item calls for local agencies to continue to upgrade traffic signal systems to take advantage of modem technologies and techniques such as traffic responsive timing selection and adaptive timing using a central computer. These systems will also be able to provide travelers with real-time information about conditions at traffic signals via TravInfo.

Action #4 - Deploy Transit Fleet Management Systems

Transit fleet management systems continuously monitor the location and status of transit vehicles, allowing operations personnel to arrange rapid response to emergencies involving the transit vehicle, provide real-time vehicle location or arrival time information for waiting passengers, refine schedules, and take corrective action when a vehicle falls behind schedule. A transit fleet management system installed in Toronto enabled a 4% reduction in the fleet size, and Baltimore MTA improved on-time performance by 23%.

These systems are already operating at BART and Napa. This action item calls for installation of GPS or similar automated vehicle location devices and other monitoring equipment on the vehicles of major Bay Area transit systems so that the central dispatcher can be kept informed of the exact location and schedule adherence of all vehicles at all times. Each system should provide real-time schedule adherence information to Travlnfo, include a data exchange link between transit systems to enable coordination of operations where services overlap, and provide links to corridor transportation management systems where appropriate.

Action #5 - Deploy Corridor Transportation Management Systems

Corridor transportation management systems integrate freeway and traffic signal operations and add surface street traffic surveillance, surface street motorist information, and interagency data exchange for coordinated operation and incident management. This enables the involved agencies to integrate their operating systems and procedures, and to collectively manage transportation from a corridor-wide perspective. Travelers get seamless and consistent information and coordinated traffic controls.

A system being installed in the I-HO/Route 17 corridor in Santa Clara County will instrument and coordinate the facilities of seven traffic management agencies and also includes a planned connection to a transit fleet management system to coordinate transit operations and facilitate priority for transit vehicles at traffic signals in the future. This action item calls for corridor transportation management systems to be deployed in the I-880 corridor in Alameda County and the I-680 and Route 4 corridor in central Contra Costa County. All such systems will provide real-time information to travelers via TravInfo.

Action #6 - Expand TravInfo

Regional traveler information systems collect, process, and disseminate real-time traveler information for all roadways and transit systems in an area. Travelers can obtain information both before and during a journey. The information can be used to choose the best time, mode, and route of travel, and to monitor the status of incidents affecting their planned route. A test of a traveler information system in Orlando showed an average 19% reduction in travel time for vehicles receiving the information.

In Fall 1996, TravInfo will begin operation as the Bay Area's regional traveler information system. This action item calls for expanding TravInfo to gather and process the additional information made available by the above action items, and for linking TravInfo to the TransCal regional traveler information system in the I-80 corridor between San Francisco and RenoLake Tahoe to assist travelers planning inter-regional travel.

Action #7 - Deploy the TransLink Joint Electronic Transit Fare Card

With a joint electronic fare card, travelers can board or transfer to any transit vehicle without having to know the fare or have correct change. Studies have shown that such systems can reduce the time needed for passenger boarding by up to a half and reduce the cost of fare collection by up to a third. A smart card may be able to be used for parking and other services too.

This action item calls for deployment of a joint electronic fare card for the Bay Area's transit systems in accordance with the TransLink Program Plan. This plan, developed by MTC and the transit operators, calls for implementation of a joint electronic fare card for all Bay Area transit agencies within five years.

Action #8 - Enhance Rideshare Matching Services

Rideshare matching services provide a central database of people wanting to share a ride to and from work. The computer searches for people with the same general origin and destination and outputs a list of potential ridesharing partners. Such a service greatly facilitates ridesharing and helps reduce the number of vehicles on the road during the commute period.

This action will enhance current carp001 and vanpool based rideshare matching systems in the Bay Area by allowing self service registration and match list download at any time from any location, by providing more detailed and customized information about rideshare and transit options, and by allowing same-day rideshare matching for particular trips, especially for the ride home when a rider is unable to use his or her formal car-pool. These enhancements will encourage increased use of ridesharing and increase the productivity of personnel providing rideshare matching and related services.

The eight ITS projects included in this Action Plan form a core ITS infrastructure for the Bay Area. These projects interact with each other through data exchange links, as shown in Figure ES-2. In particular, they directly or indirectly supply valuable real-time information to TravInfo for dissemination to travelers.

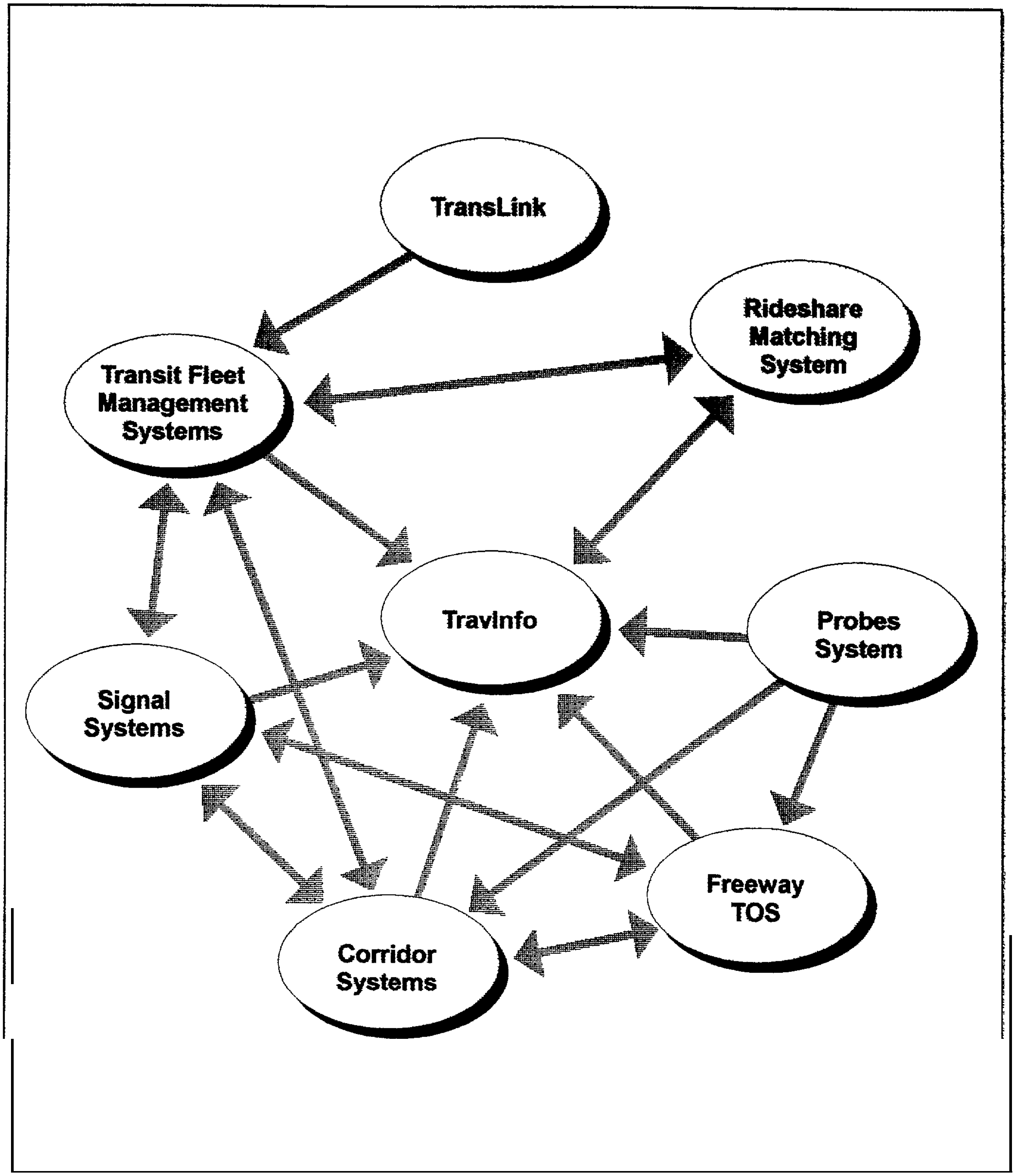

Figure ES-2. Interactions Between Action Plan Elements

SUPPORT SERVICES FOR THE MTS MANAGEMENT STRATEGY

The MTS Management Strategy is predicated on the belief that the MTS must be operated more efficiently, and that the joint and cooperative management of the individual systems and services of the MTS offers a major opportunity to achieve that increased efficiency. The eight elements of the EDP Action Plan utilize proven means to provide real-time operation and management of the MTS. The following services are intended to support and encourage agencies to work together to implement the MTS Management Strategy. MTC's support services are available for the Action Plan projects, and other projects that help achieve the goals of the MTS Management Strategy.

Education and Information Dissemination: Keep agency staff and elected officials fully informed regarding the status of MTS Management Strategy projects, proposals and opportunities for new Management Strategy projects, and evaluations of ITS projects throughout North America. This service includes an active program by MTC to disseminate information to all agencies, as well as providing research, presentations and workshops in response to requests from Bay Area partners.

Technical Assistance: The limited staff resources available at most individual agencies are inadequate to document the existence and magnitude of a shared operational problem and conceptualize alternative technical solutions to address the problem. MTC will provide staff support and technical input to multi-agency attempts to solve MTS operational problems. Where appropriate, this will include technical assistance to research potential ITS and other MTS Management Strategy options, formulate project proposals, and develop funding applications. Staff from the partner agencies would need to be responsible for the design and implementation of funded projects, either through in-house resources or inclusion of needed consultant assistance within the funding application.

Partnership Formation: MTC will assist local agencies forming and maintaining a multi-agency partnership, including assistance in identifying all needed partners, arranging and facilitating initial meetings of the partners, and supporting the new partnerships's efforts to initiate a Management Strategy project. Efforts to identify innovative funding options or operating strategies, including partnerships or other business relationships with the private sector, will be supported where appropriate. MTC will also assist with formulation of written inter-agency agreements, such as a Memorandum of Understanding, Joint Powers Agency, or Cooperative Agreement.

FUNDING FOR ITS

ITS projects must compete with other types of transportation projects for traditional general program funds; there is no permanent funding source specifically dedicated for ITS projects. The Federal Department of Transportation occasionally arranges dedicated funding for pioneering or demonstration ITS projects. There is usually no regional or formula allocation of these grant funds and the Bay Area must compete with all parts of the country. TravInfo has been largely funded by ITS Field Operational Test fund grants from the FHWA, but that program is not currently funding new projects.

The existing funding source most applicable for ITS projects is the Traffic Systems Management (TSM) program, which targets freeway and roadway operational improvements. Currently, about 70% of TSM funds are used for ITS projects. Certain ITS projects, including smart shuttles and traffic signal systems, are eligible for grants from the Transportation Fund for Clean Air (AB 434). Other funding pots are not now widely used for ITS projects. However some ITS projects are eligible under traditional capital programs such as the Surface Transportation Program or FTA Section 9. For example, a bus replacement grant could cover automatic vehicle location (AVL) equipment, even though the cost of AVL may be a small portion of the total grant.

The Bay Area has recently applied for a FHWA Model Deployment Initiative grant. This program will provide $20 million in its first year, to be divided among two or three regions to complete deployment of a comprehensive ITS infrastructure showcasing the potential to integrate core ITS projects.

ITS projects usually involve installation of new systems and equipment that require annual expenditures for operation and maintenance. Most roadway project funding programs are not practical sources for on-going operation and maintenance funding. The reauthorization of ISTEA may explicitly address this issue.

Table ES-l. Summary of Project Recommendations

Project	Recommendations
Travel Information Projects	
TravInfo Expansion - Link additional data sources to TravInfo, especially real-time data	Action #6: Expand TravInfo Other: Encourage all agencies to provide more real-time data.
Integrate TravInfo/TransCal/YATI - Exchange data among these three Northern California traveler information systems using emerging stand-ard interfaces	Action #6: Expand TravInfo Other: Monitor success of the interface standard and provide similar link to YATI and other systems when appropriate.
Real-Time Parking Information - Dynamic signs, radio trans-mitters, or TravInfo advise drivers of location and availability of parking	*Not an Action Plan Project* Other: Install systems where motorists have difficulty knowing where to find parking and this causes significant wasted travel, congestion, or reduced economic vitality. Provide information to TravInfo too. Potential sites include BART stations and other transit hubs, Union Square area in downtown San Francisco, Stanford University, Oakland Coliseum, 3Com Park at Candlestick Point, the Shoreline Amphitheater, and the new Giants stadium in San Francisco.
Auto-to-Transit Transfer Advice - Dynamic signs or radio transmissions advise drivers of nearby transit option when highway congested	*Not an Action Plan Project* Other: Do test at West Oakland BART, Larkspur ferry, or North Concord BART using existing variable message signs on adjacent freeways. Evaluate effectiveness before proceeding with other deployments.
Location Information for Pedestrians - Visually impaired pedestrians with a special receiver can get site information such as traffic signal status, transit service, and hours of operation	*Not an Action Plan Project* Other: Wait for results of the current trial in San Francisco before deploying elsewhere. Encourage the private sector to provide a general purpose system based on subscription, rental, or advertizing revenue. The visually impaired could receive public subsidy to cover cost of receiver or service if necessary.
Roadway Management Projects	
Expand Freeway Traffic Operations System (TOS) - Add sensors, dynamic signs, CCTV cameras, advisory radio, and ramp meters at key locations	Action #2: Expand the Freeway Traffic Operations System Other: Further expand TOS as opportunities for cost effective installation arise.
Probe Vehicle System - Use electronic toll collection tags or other tags to measure average travel times on freeways and arterial roads	Action #1 : Deploy Probe Vehicle System
Local Arterial Performance Monitoring - Use vehicle sensors to better measure performance (travel time, queue length, etc.).	*Not an Action Plan Project* Other: Evaluate results of Santa Clara County trial Not needed if regional probe vehicle system is successfully deployed.

Project	Recommendations
Decision Support for Freeway Incidents - Develop software to help TMC operators make decisions during incidents	*Not an Action Plan Project* Other: After TMC fully operational, monitor effectiveness and compare with similar systems in other metropolitan areas. Develop links with transit and arterial management systems.
Variable Speed Limit Signs - Vary speed limit during poor visibility and other hazards	Not *an Action Plan Project* Other: Monitor effectiveness of systems elsewhere. Deploy only if proven effective and only where expected to help solve an existing high accident rate. Link to Travlnfo if implemented.
Advanced Traffic Signal Systems - Use improved signal coordination techniques, including traffic responsive pattern selectton and adaptive timing	Action #3: Deploy Advanced Traffic Signal Systems Other: Connect all signals to computers for automatic fault monitoring, remote management, and information collection.
Integration of Transportation Management Systems - Link systems--including roads and transit-and coordinate their operation	Action #5: Deploy Corridor Transportation Management Systems Other: Integrate adjacent traffic signal systems where needed for cross-boundary signal coordination. Link signal and transit systems where needed for transit priority.
Smart Corridor Expansion or Replication - Provide traffic surveillance, motorist information, data exchange, and incident management in congested corridors	Action #5: Deploy Corridor Transportation Management Systems Other: As local conditions permit, deploy corridor transportation management systems in all corridors in which most through travel occurs on freeways and incidents cause diversion to parallel surface streets.
Expand Freeway Service Patrol Coverage - Provide GPS-equipped motorist assistance patrols on more freeways and expressways	*Not an Action Plan Project* Other: Expand motorist assistance patrols to all freeways and expressways with no shoulder for disabled vehicles. Provide the service during times when the road is operating at or near capacity.

Project	Recommendations
Transit and Rideshare Projects	
TransLink Joint Fare Card - Allow the same electronic fare card to be used on any transit system	**Action #7: Deploy the TransLink Joint Electronic Transit Fare Card** **Other: Integrate with fleet management system where appropriate. Allow use of same card for parking payment if possible.**
Real-Time Transit Fleet Management Systems - Automatically track vehicles and monitor schedule adherence and emergencies	**Action #4: Deploy Transit Fleet Management Systems**
Transit Priority at Signals - Change traffic signal timing to reduce delay for an approaching transit vehicle	***Not an Action Plan Project*** **Other: Do trial deployments of bus priority using advanced technologies with and without fleet management system.**
Stop Annunciation on Transit - Automatically announce next stop for transit riders	***Not an Action Plan Project*** **Other: Implement as needed for ADA. Automate using fleet management system where available.**
Real-Time Information for Transit Riders - Give riders time of arrival of next vehicle and transfer details	***Not an Action Plan Project*** **Other: Implement at high patronage transit stops and on high patronage vehicles once fleet management system is available. Coordinate with Travlnfo.**
CCTV Surveillance for Transit - Install closed circuit TV cameras on transit vehicles, stops, and parking lots	***Not an Action plan Project*** **Other: Implement in high crime areas and isolated stops and parking lots.**
Smart Shuttles - Use vehicle tracking and dynamic routing to provide on-demand shuttles	***Not an Action Plan Project*** **Other: Implement a trial smart shuttle service for general use. Stanford University area looks promising as test site.**
Smart Parks/Transit Transfer Centers - Enhanced-park and-ride lots and transfer centers with real-trme information and on-demand shuttles	***Not an Action Han Project*** **Other: Use results of Silicon Valley Smart Corridor "smart parks" feasibility study to help evaluate and plan other sites.**
Real-Time Shared Vehicle Brokering - Enable short term re-use of vans, station cars, and other shared vehicles	***Not an Action Plan Project*** **Other: Test concept with small scale local services before attempting regional system.**
Enhanced Prearranged Rideshare Matching - Provide self-serve on-line registration, customized information, and same-day ride matching	**Action #8: Enhance Rideshare Matching Services**
Real-Time Rideshare Matching - Organized, paid hitch-hiking with security and door-to-door service	***Not an Action Plan Project*** **Other: Monitor the Ontario experiment and plan a system in the Bay Area if and when feasible.**

Project	Recommendations
Emergency Response and Automated Enforcement Projects	
Enhanced 911 Dispatch - Improve 911 cellular phone call response time	*Not an Action Plan Project* Other: Conduct a study to determine the most appropriate modifications to make to the existing CHP 911 dispatch system for both rapid answering and accurate location.
Hazardous Materials Database - Give emergency services personnel instant access to database of hazardous materials on a vehicle involved in an accident or spill	*Not an Action Plan Project* Other: Monitor the Contra Costa County system. If successful and cost effective, extend to other areas and shippers.
Red Light Violation Cameras - Sensors trigger a camera to identify driver and vehicle running a red light	*Not an Action Plan Project* Other: Implement at intersections and areas with a high accident rate due to red light violations.
Speed Limit Violation Cameras - Radar speed sensor triggers a camera to identify driver and vehicle exceeding speed limit	*Not an Action Plan Project* Other: Implement as part of neighborhood traffic control measures where local residents support it.
Speeding Deterrent Display - Radar measures speed and displays speed to approaching driver	*Not an Action Plan Project* Other: Use on streets with a speeding problem where speed violation cameras are unacceptable or too expensive to operate.
Other Candidate Projects	
Install Weigh-in-Motion for Trucks - Identify and weigh trucks while moving on the freeway to avoid inspection stops	*Not an Action Plan Project* Other: Deploy weigh-in-motion at all high volume truck weighing stations in Bay Area.
Heavy Container Tracking - Record weight of containers on electronic tags and use to avoid overweight trucks	*Not an Action Plan Project* Other: Do not implement unless shipping industry adopts and installs a universal read-write electronic tag on all containers and a means of recording the container's weight on the tag.
Expand Electronic Toll Collection on Bridges - Install ETC on Golden Gate Bridge compatible with Caltrans system on other bridges	*Not an Action plan Project* Other: Implement electronic toll collection on all toll bridges in the Bay Area, including the Golden Gate Bridge.
Bay Bridge Congestion Pricing - Vary tolls on Bay Bridge as level of congestion changes	*Not an Action Plan Project* Other: Continue to seek enabling legislation from the state.
High Occupancy Toll Lanes - Single occupant vehicles use electronic toll collection to pay to use spare capacity in HOV lane	*Not an Action Plan Project* Other: Deploy as part of new HOV lane construction where the required lane separation and enforcement areas can be provided. Deploy on existing HOV lanes if and when technological advances overcome enforcement problems.
Smart Cards for Parking Payment - Allow motorists to pay parking charges, including meters, with smart cards or cash	*Not an Action Plan Project* Other: Wait until a universal smart card is in common use.

1. Background

EARLY DEPLOYMENT PLAN OVERVIEW

The Intelligent Transportation Systems Early Deployment Plan for the San Francisco Bay Area has been an effort to define priorities for use of Intelligent Transportation Systems (ITS) in the region over the next five to ten years. Intelligent Transportation Systems is the name given to techniques which improve the operation, safety, or convenience of the transportation system by using electronics and communications to collect, process, disseminate, and act on information in real time. In this context, "real time" means that an action occurs within a time frame consistent with the dynamic nature of the information or use thereof.

The ITS Early Deployment Plan focuses on both institutional issues and technological opportunities. It seeks to blend analysis of end user needs, evaluation of numerous technologies, and assessment of the desires and capabilities of the region's institutions, to identify the uses of ITS that best meet the Bay Area's regional transportation policies, particularly the Metropolitan Transportation System (MTS) Management Strategy. Desired end products of the effort are education, consensus on an action plan, and partnerships for deployment. The building of institutional "infrastructure" is as critical as the more usual capital investments for the ultimate success of early ITS deployment.

Goals

The Early Deployment Plan had three central goals, each with several objectives.

1. The EDP planning process was intended to be broadly inclusive, reaching out to transportation stakeholders from all sectors and interests, and providing educational information as well as opportunities for input.

   Objectives:

   - Educate regional stakeholders on ITS by providing information on Intelligent Transportation technologies and services.

   - Solicit a wide assortment of ideas and concepts for ITS implementation.

- Enable participants to gain ownership of the Early Deployment Plan.

2. The EDP planning process was intended to develop a consensus on an action plan for ITS implementation which supports regional transportation planning goals.

Objectives:

- Identify and evaluate technology and deployment options for ITS.
- Support the Metropolitan Transportation System management strategy.
- Support Regional Transportation Plan goals of improving mobility, promoting equity, enhancing sensitivity to the environment, supporting economic vitality and supporting community vitality.
- Gather broad-based support around a plan for short- and medium-term ITS projects in the region.

3. The EDP planning process aimed to build partnerships to foster ITS deployment.

Objectives:

- Enable establishment of public/public partnerships for specific ITS projects that cross jurisdictional boundaries;
- Enable establishment of public/private partnerships to permit innovative joint arrangements for ITS deployment.
- Enable establishment of private/private partnerships to tailor technologies to the Bay Area.

Although the study was open to and involved all stakeholders including private firms, it was recognized that it would be inappropriate for a public planning process to develop plans for purely private sector investments in ITS ventures. The plan is focused on those ITS actions that the public sector can take alone or in partnership with the private sector.

Relationship to the MTS Management Strategy

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2) A commitment to cooperative planning at the corridor scale, to ensure that the management strategy can be tailored to local conditions and that local governments participate in the process of corridor management.

ITS provides a variety of tools that facilitate the real-time management and operation of the MTS. The ITS Early Deployment Plan is intended to advance the MTS Management Strategy by focusing deployment efforts on the ITS elements that best support multimodal management at the corridor level. Indeed, the majority of projects developed to improve the operation and management of the MTS, ranging from development of a call box system to coordinated operation of freeways and arterial streets to TransLink, include some aspect of ITS.

Defining and implementing MTS Management Strategy Projects typically requires several agencies to work together to define a common problem, conceptualize a feasible solution, secure funding, and create institutional arrangements to jointly implement and operate the project.

Benefits of ITS

The transportation improvements made possible by ITS include increased efficiency, increased safety, increased comfort, reduced cost, and increased reliability. ITS can assist in the transportation of both people and goods, and can reduce the negative impacts of transportation activities on the surrounding community.

Among the benefits of ITS are:

- The ability to continuously **manage and fine-tune** the transportation system's operation in response to unpredictable fluctuations in travel demand and incidents that interrupt the normal operation of roadways and transit systems.

- The ability for travelers to **choose travel time, mode, and route efficiently** based on real-time roadway and transit status information.

- The ability to **coordinate and integrate** the operation of the various elements of the Metropolitan Transportation System by collecting and exchanging real-time transportation system operations data.

- The ability to **reduce the cost of operating and maintaining** transportation facilities and services through more efficient use of existing facilities, and automated or remote operation and monitoring of equipment.

- The ability to provide **increased safety and security to** travelers by automated or remote monitoring of transportation facilities, vehicles, and hazardous cargoes and by provision of mayday alarms for travelers in distress.

- The ability to **make travel more convenient** by providing real-time information about current conditions and options, increasing the reliability of travel, and by providing electronic payment mechanisms for tolls, fares, and parking.

Real-time information is the essential ingredient for most ITS projects. Different elements of ITS are enhanced if they can share their data and keep each other informed of current and planned actions. New computer and communications technologies and techniques make ITS more practical, more affordable, and more capable now than in the past. There are now more opportunities to utilize ITS, and fewer opportunities to improve transportation through traditional capital-intensive projects. We have no choice but to operate our existing transportation infrastructure more efficiently, and ITS allows us to do that.

2. The Early Deployment Planning Process

TECHNICAL APPROACH

Early Deployment Plan development began in February 1995, using a $450,000 grant from FHWA. The overall work program for the EDP was divided into the following eight tasks:

Phase 1: Analysis of Transportation System Opportunities and Constraints

Task 1: Establish and Maintain Institutional Liaison
Task 2: Assess Institutional Capabilities and Current Technology Use
Task 3: Define Transportation Problems and Opportunities
Task 4: Propose Potential User Services
Task 5: Revise Phase 2 Workplan

Phase 2: Development of the Deployment Plan

Task 6: Develop Alternative Regional Deployment Strategies
Task 7: Analyze Alternative Deployment Strategies
Task 8: Prepare Action Plan, Final Report, and Outreach Materials

Task 1 efforts continued through both phases of project work,

The project was primarily a sequential planning and consensus building process. In general, the tasks built upon each other as consensus was developed on the various elements that contributed to the final action plan.

OUTREACH AND STAKEHOLDER INVOLVEMENT

The ITS Early Deployment Plan was shaped by the input of stakeholders. Public agencies, private companies, advocacy groups, and private citizens have all provided input and reviewed draft versions of the intermediate and final products of the study. The principal mechanisms for information dissemination and involvement in the study were the following:

- An EDP Advisory Board met monthly throughout the study. Participation was open to everyone, and some 150 people attended at least one meeting. Agendas and draft deliverables for review were mailed to approximately 500 people who attended meetings or expressed interest in maintaining ongoing involvement in the project. The Advisory Board was the primary review panel for study products. Meetings were professionally facilitated and all comments recorded.

- During the study, four different editions of an early deployment plan newsletter, called Smart Moves, were mailed to approximately 1,000 people involved in Bay Area transportation issues. The four page, two color, newsletter provided information about past, present and upcoming activities associated with the Early Deployment Plan. Each newsletter described the Advisory Board and its meeting schedule and gave an open invitation to attend.

- A series of public outreach meetings were held at critical junctures during the study to disseminate information and obtain input from people unable to participate via the Advisory Board. Outreach meetings were held in Pleasant Hill, San Jose, San Rafael, San Carlos, and Oakland, and announced in the newsletter.

- Several focus groups were conducted to find out more about the types of problems and ITS projects of interest to local roadway and transit operators, and to encourage collaborative deployment efforts. As a result of these meetings, partnership groups are now moving forward with new ITS projects in different parts of the region.

WORK TASKS

The first work task provided support for outreach and stakeholder involvement as described above. The second task provided a background review of existing conditions in the Bay Area, including both the region's institutional capabilities and current use of ITS technologies. The task report highlighted both the institutional hurdles and opportunities facing ITS deployment in the Bay Area.

In Task 3, some 133 Bay Area transportation problems were identified, and were grouped in the following categories:

- Problems Related to Lack of Facilities
- Problems Related to Travel Delays
- Problems Related to Lack of Information
- Problems Related to Safety and Security
- Problems Related to Regulations and Charges
- Problems Related to Comfort, Convenience, and Ease of Use
- Problems Related to Environmental Impacts

Appendix A lists all 133 problem statements. These were then rated as high, medium, or low priority for the region based on their extent and severity in the region's transportation system.

Intelligent Transportation Systems can provide many different services that can help address problems for both users and operators of the transportation system. In Task 4, the early deployment planning process identified 41 different ITS services, which include the 30 ITS User Services defined by FHWA and expand on them. Six of these services were determined to be unready for deployment or inappropriate for public-sector involvement; these were excluded from further study. Table 1 shows the assessed priority of the remaining 35 ITS services. The priority rating reflects the effectiveness of a service in addressing the region's transportation problems, and the extent to which a service is compatible with regional transportation policies and goals.

ITS services are described more fully in Appendix B.

The next step, completed in tasks 6 and 7, was to identify projects that have the potential to provide needed ITS services. Thirty-six different project types were identified. These projects are described, along with the results of a project evaluation and recommendations for deployment, in the following chapter of this report. The project design and evaluation criteria are also listed in that chapter and described more fully in Appendix C.

Table 1. Priority of ITS Services

High	Medium	Low
Traffic Responsive Signal Timing	Real-time Traffic System Performance Monitoring *	Traffic Responsive Lane, Turn, and Parking Restrictions
Traffic Responsive Freeway Ramp Metering	Real-time Transit System Performance Monitoring +	Real-time Air, Sea, Rail Travel Information
Real-time Transit Operations Control	Incident Detection (All Modes) +	Real-time Bicycle Travel Information
Transit Priority at Traffic Signals	Real-time Parking Information	Dynamic Fares, Tolls, and Parking Fees
Incident Diagnosis and Response	Real-time Rideshare Matching	Demand Responsive Transit Route Deviation
Real-time Transit Information	On-demand Shuttles	Electronic Parking Fee Payment
Real-time Roadway Information	Electronic One-stop Credentials (for Trucks)	Multipurpose Smart Card (Fares and Purchases)
Electronic Transit Fare Payment	Automated/Remote Equipment Monitoring	Distress Signaling (Mayday)
Electronic Toll Collection	Automated/Remote Equipment Control	Real-time Emergency Vehicle Operations Control
No-stop Compliance Checks (for Trucks)	Security Surveillance of Transit and Parking	Real-time Hazardous Materials Location Monitoring
	Emergency Vehicle Signal Preemption	Driver Warnings (Nearby & In-vehicle Hazards)
	Portable Database of Safety Information (Hazmat)	
	Automated Traffic Regulation Enforcement	
	Automated Vehicle Emissions Enforcement	

+ At least one high priority service relies on this service.

Note: The order in which services are listed within a column has no significance.

The project evaluation process revealed several projects of strategic significance for the region and therefore a high priority for deployment. These are the focus of the Action Plan, which is discussed in Chapter 4. The items in the Action Plan call for implementation of the highest priority projects that form a foundation for ITS in the region and provide the most critical servicies for the majority of travelers. A separate section of the Action Plan calls for establishing an on-going support service for the MTS Management Strategy. Funding opportunities are also described.

POLICY REVIEW

The System Operation and Management (SOM) committee of the Bay Area Partnership provided review and oversight of the early deployment planning process to ensure it properly addressed regional transportation policies. The SOM committee meets monthly and is responsible for coordinating implementation of the MTS Management Strategy, of which ITS projects are a key element. Committee members represent numerous agencies responsible for planning, funding or operating major portions of the MTS.

Members received a mailing containing the latest EDP products and recommendations prior to each meeting. At each meeting, the MTC project manager gave a summary of current EDP activities and issues in the plan's development. The committee provided comments and direction on policy issues.

3. Projects Evaluated

INTRODUCTION

This chapter presents the design and evaluation of the various Intelligent Transportation Systems (ITS) projects proposed for early deployment in the San Francisco Bay Area. The candidate projects, and design and evaluation criteria, were identified or refined largely by members of the Early Deployment Plan's (EDP) Advisory Board.

Projects are divided into five categories:

- Traveler Information Projects
- Roadway Management Projects
- Transit and Rideshare Projects
- Emergency Response and Automated Enforcement Projects
- Other Candidate Projects

The six evaluation criteria are:

- Support for the MTS Management Strategy
- Technical Achievability
- Institutional Achievability
- Effectiveness
- Customer Acceptability
- Scalability and Integratability

The evaluation criteria are more fully described in Appendix C.

The criteria were used to evaluate the suitability of each project for regional deployment, and also to tailor aspects of project design to improve project concepts and determine how they could best be implemented in the Bay Area. As generic projects were evaluated, the criteria were used to identify the conditions or characteristics needed for a specific project to be successful and worthwhile. For example, if a criterion showed a project to be most desirable under certain circumstances, those circumstances were recorded as guidelines for identifying and prioritizing specific projects of that type.

This chapter presents the results of the design and evaluation process. For each project, the following information is recorded:

- A description of the project
- Current status of the project
- Summary of the overall design and evaluation findings
- Action Plan Elements
- Other Deployment Actions

Table ES-1 in the Executive Summary presents an overview of the findings for all projects.

TRAVEL INFORMATION PROJECTS

TravInfo Expansion

Project Description

TravInfo is a traveler information system that collects and disseminates real-time performance and incident information for freeways, major arterials, transit routes, and other transportation facilities in the Bay Area.

TravInfo receives incident information for all freeways and many rural arterials from the California Highway Patrol's (CHP) computer-aided dispatch system in Vallejo. However, the region currently has limited capabilities to monitor the impacts of such incidents on traffic or transit in real time. Caltrans' CCTV surveillance and vehicle detection system covers only about 70 miles of the 500-mile freeway system, and it will be many years before it is expanded to all freeways in the region. There are virtually no suitable surveillance facilities in place for arterial roadways. Most such roadways are not operated and policed by Caltrans and the CHP.

Real-time information for transit services will be equally sparse when TravInfo commences operation later this year. Initially, the system will rely largely on verbal reports from transit vehicle operators, observers, and dispatchers. BART has a comprehensive and permanently staffed transit vehicle and service surveillance system that generates accurate real-time information, AC Transit is designing a real-time fleet management system that could generate more useful information, Napa has a transit fleet management system, and surveillance systems are being planned by other transit agencies, but TravInfo is not currently able to receive data from these systems.

This project would expand both the breadth and depth of TravInfo by identifying additional sources of information and providing permanent communication links between those sources and the TravInfo system. Examples of enabling technologies which would be employed in this project include real-time surveillance of roadways and transit, real-time data fusion, and communications links between such subsystems.

Project Stations

TravInfo is scheduled to commence operation in the fall of 1996. It is currently operating in a test mode. The system is operated by a private contractor and is housed in the regional Transportation Operations Center at the Caltrans District 4 headquarters in Oakland.

Project Design and Evaluation

Summary - Expansion of TravInfo to include real-time data for all freeways, arterial roadways, and transit systems would greatly enhance the value of TravInfo and be of great assistance to Bay Area travelers. The cost of accessing such real-time data once it is available to the operating agency is relatively small and the project would be very cost effective. However, further real-time data will not be available until other ITS projects are deployed to collect it. TravInfo should add links to such systems as they come on line.

Support for MTS Management Strategy - TravInfo's basic function of merging multiple data sources promotes integration of transportation system elements, a strategy which is enhanced as data sources are added into the system. Depending on the data added, expansion of TravInfo can also provide enhancement of the operation and coordination of mass transit, provision of incentives for ridesharing and transit use, and benefit to corridors critical for freight movement, which are all goals of the MTS management strategy.

Technical Achievability - The technology needed for the expansion of TravInfo to communicate with and accommodate data from other sources is available today. TravInfo has been designed with such expansion in mind, including allowance for multiple regional traveler information centers if needed.

Institutional Achievability - An active steering committee of stakeholders is already in place, and the core partnership of MTC, Caltrans, and CHP exists. In order to expand TravInfo, real-time data from transit agencies and local jurisdictions would be needed Providing data to TravInfo puts few demands on a participating agency if the process is automated; thus TravInfo expansion should have few institutional barriers.

Effectiveness - The initial phase of TravInfo will be operational in the spring of 1996, with limited real-time data. Additional real-time data will be added in the second phase of TravInfo, which will allow the system to cover a broader geographic area, by including real-time arterial street and transit fleet data. Thus, the overall effectiveness of TravInfo will be enhanced. Additional data sources will make TravInfo more efficient and allow additional users to benefit from the program. It will also increase the market for value-added resellers of the information, thus encouraging further private sector investment in information distribution services.

Customer Acceptability - Travelers will welcome additional information from TravInfo. It is the chaIlenge of value-added resellers to organize and present the information so that travelers can easily use the information they want.

Scalability and Integratability - TravInfo can be expanded to any scale. The project would involve permanent communications links to other traffic management systems for data collection.

Action Plan Elements

Action #6 calls for linking Travlnfo to additional sources of data, some of which are already available and others that will be provided by planned ITS initiatives. The action item includes automating the data collection process and incorporating the new data in the data processing, fusion, storage, and dissemination processes at the TravInfo center. The major new data sources expected to be available within the next few years include additional freeway surveillance data, transit data from fleet management systems, arterial roadway incident and status information from corridor transportation management systems, traffic signal malfunction reports and traffic volumes and density from advanced traffic signal systems, inter-regional travel conditions from TransCal and other Advanced Traveler Information Systems in Northern California, and highway maintenance and incident information from the Caltrans fleet dispatch system.

Other Deployment Actions

All transportation agencies should identify opportunities to capture real-time data of value to travelers and pass it to TravInfo.

Integrate TravInfo/TransCal/YATI

Project Description

TravInfo is a traveler information system being developed for the nine-county Bay Area. TransCal includes a traveler information system for the I-80 and SR 50 corridor between San Francisco and the Reno/Lake Tahoe area. The Yosemite Area Traveler Information (YATI) system will provide information for travelers destined for the Yosemite national park. Each system is being developed independently, although the partners involved in each project have met to discuss use of common standards and other issues.

This project would provide a data exchange capability among the three Northern California traveler information systems so that a traveler can receive information from all three systems using any one of the systems. For example, a traveler in any one of the three coverage areas could receive information about conditions in all three areas from the same telephone call or other information source. This would involve high-speed communications links among computer databases and standardization of data formats.

Project Status

Representatives from each of the traveler information systems are involved in an effort to identify standards for traveler information exchange. No further work has yet been done towards integration.

Project Design and Evaluation

Summary - Integration of TravInfo, TransCal and YATI would enable travelers to access urban and inter-regional transportation information through a single source. Each project would be enhanced by the ability to provide information outside its immediate vicinity, thus increasing the benefit to users. Standardization of traveler information systems, such as in the Smart Traveler project, will contribute to the success of this project. The most cost effective initial project would be integration of TransCal and TravInfo due to similarity and proximity of systems.

Support for MTS Management Strategy - The integration of these three projects would increase the attractiveness of TravInfo, thus advancing integration of transportation system elements, which is a goal of the MTS management strategy.

Technical Achievability - The three ATIS projects are being developed separately, although TransCal and TravInfo have a common development platform and are largely compatible. To integrate the three projects, high-speed communications links among computer databases and standardization or translation of data formats would be needed. The needed communications technology is readily available. Format conversions will be more problematic, but achievable.

Institutional Achievability - Travlnfo and TransCal have many common partners and a reasonably close working relationship. YATI has different partners. TravInfo is focused on commuter travel in a large urban area. TransCal and YATI are focused on recreational travel and support for the local tourist industry. Integration enhances the usefulness of each system. The integration of these three traveler information systems could be made a part of a larger effort to standardize and integrate all such systems throughout California, as part of Caltrans' statewide Smart Traveler program. Integration with systems outside the state may need to await development of national standards.

Effectiveness - Providing the user with the ability to access information about each of these three service areas through one source would enhance the effectiveness of each system. The customer base for each system is expanded to those with access to all three. The project is likely to be cost effective assuming the data format conversion task is not too onerous and private-sector participants are a promising funding source for the project.

Customer Acceptability - Travelers will welcome access to additional information as long as the integration is done in a way that does not overburden local users with additional menu choices that they rarely use, nor slow access to local information.

Scalability and Integratability - The successful integration of these three programs could lead to more linkages in the future. For example, real-time travel information in a consistent format for San Diego, Los Angeles, Yosemite National Park, the Bay Area, Lake Tahoe and the rest of northern California could be very valuable for long distance travelers, making the market for consumer products larger and more profitable to Value Added Resellers.

Action Plan Elements

Action #6 calls for integration of TravInfo with TransCal.

Other Deployment Actions

Emerging standards for traveler information exchange should be used to eventually link TravInfo with the Yosemite Area Traveler Information system and other regional traveler information systems.

Real-Time Parking Information

Project Description

This project would provide real-time data on which parking facilities have spare capacity and would provide directions for getting to those parking facilities. It applies to areas with multiple parking facilities serving the same general destination area or a single parking facility with limited accessibility or maneuvering space for traffic unable to find a parking space.

It is expected that many independent such projects would be deployed. The technologies used in such projects could include real-time parking surveillance, changeable message signs, advisory radio transmitters, and a communications link to TravInfo.

Parking information systems could be installed for any parking facility that overflows and for which it is difficult or inefficient for approaching motorists to find alternatives. Parking information systems could operate full time, or only during special events or Christmas shopping. Information could be disseminated by dedicated variable message signs or radio transmitters in the immediate vicinity, or by wide area means such as TravInfo.

Project Status

A system of variable message signs and advisory radio transmitters has been installed around the San Jose Arena to guide approaching motorists to the various parking lots and garages serving that facility. City personnel select different messages as the parking lots are observed to fill to near capacity. The City of San Francisco is installing traffic detectors and variable message signs at Coit Tower to advise approaching motorists of the degree of congestion at the parking lot at the top of the hill. The detectors are used to automatically vary the message depending on the length of the queue waiting for a parking spot.

Project Design and Evaluation

Summary - Real-time parking information would provide travelers with the ability to make route and mode choice decisions either before beginning a trip or en route. Through variable message signs, highway advisory radio or TravInfo, this information would be available to a broad range of motorists. Programs could be implemented on a small local scale or integrated with larger regional programs.

Support for MTS Management Strategy - Real-time parking information does not directly address the goals of the MTS management strategy.

Technical Achievability - Many of the larger parking facilities in the Bay Area are not equipped with the ability to provide real-time parking occupancy information. This can be done by counting cars entering and leaving, by automatic detection of occupancy in sample spaces, or by video surveillance of selected areas of the facility. Variable message signs and radio transmitters are needed to disseminate the information locally, in addition to a feed to TravInfo. The needed technologies are readily available.

Institutional Achievability - Parking facilities in an area may be privately or publicly owned. All owners would need to cooperate in a multi-facility project, and all would need assurances that potential customers were not being unnecessarily directed elsewhere. The messages and thresholds for triggering different messages would have to be developed cooperatively. As long as the emphasis is on traffic management when facilities are full, such cooperation should be forthcoming. Unfortunately there is little incentive for a parking facility operator to fund such a system. Its benefits usually do not accrue to the parking facility owner, but to the public. Therefore, such systems will likely have to be funded and implemented by the public sector, even for privately owned parking facilities.

Effectiveness - This project would be effective in addressing the common problems associated with insufficient parking availability. When parking is scarce, travelers can be given information about alternative modes of travel before starting their trip. To be effective, such information may need to include predictions of expected conditions up to an hour ahead. Implemented near a destination, real-time parking information would help motorists find a parking space rapidly and reduce wasted traffic circulation. These projects are likely to be most cost effective in areas with heavy demand for parking, frequent parking shortages, and multiple parking facilities or areas that can serve the same core destination(s). Such conditions are most commonly found in the downtown area in larger cities, at universities and colleges, and at event sites.

Customer Acceptability - Users would clearly see benefit in real-time parking information, provided that information is accurate. From a public relations viewpoint, parking access is one area that virtually every motorist can understand, visualize, and want to see improved.

Scalability and Integratability - Parking information systems could be deployed in any area with parking shortages and multiple parking facilities. Such systems need not be integrated with each other assuming their service areas do not overlap. All such systems should have a link to TravInfo.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Local agencies should install parking information systems where motorists have difficulty knowing if parking is still available or where to find parking and this causes significant wasted travel, congestion, or reduced economic vitality. Such systems should include a link to TravInfo so that parking information can be disseminated to travelers before they commence a trip and while en route.

Potential sites for parking information systems include BART stations and other transit hubs, the Union Square area in downtown San Francisco, Stanford University, the Oakland Coliseum, 3Com Park at Candlestick Point, the Shoreline Amphitheater, and the new Giants stadium in San Francisco.

Auto-to-Transit Transfer Advice

Project Description

This project would provide motorists with the advance information needed to divert to a transit system when faced with a major delay due to traffic congestion ahead. Prior to a point of major congestion and delay, the system would provide variable message signs or radio transmissions to motorists advising of tram, ferry, or express bus service, schedule and parking availability at a nearby station or terminal for a transit alternative. In addition to the variable message signs and advisory radio transmitters, such projects would also require real-time surveillance of transit parking facilities and transit vehicle schedule adherence.

Freeway projects involve at least Caltrans and a transit agency, and perhaps a local jurisdiction. Both the roadway operator and the transit agency directly benefit from such projects.

Project Status

Such systems are planned for the West Oakland BART station and the Larkspur ferry terminal. Neither project is yet funded or designed.

Project Design and Evaluation

Summary - Auto-to-transit transfer advice projects may help reduce congestion on the freeways and promote transit use. However, few Bay Area transit stations have the needed excess parking capacity, and when freeways are unusually congested, the available parking spaces are likely to be utilized by motorists who already divert to transit based on their direct observation of congestion or traffic reports on the radio. A trial project could be valuable to test the feasibility and effectiveness of the concept prior to wide-scale deployment.

Support for MTS Management Strategy - Auto-to-transit transfer advice projects support the MTS management strategy by coordinating the operation of roadway and transit elements of the transportation system, and by providing incentives for the use of transit.

Technical Achievability - There are several proven technologies available for use in auto-to-transit transfer advice systems, and such projects are technically achievable. The freeway traffic operations system (TOS) currently being implemented by Caltrans will provide the real-time freeway congestion information needed to activate the system. Video surveillance, or key parking stall occupancy detection, can be used to determine the availability of parking spaces at the transit station. Roadside variable message signs, advisory radio transmitters, and traffic reports on the radio and television can be used to give the mode transfer advice to motorists. Additional travel information dissemination facilities are expected to become available in the Bay Area after the TravInfo system becomes operational in April 1996. Such projects would be dependent on the freeway TOS system being implemented by Caltrans. The timing of the implementation of the freeway TOS in that particular area would need to be considered before deploying an auto-to-transit transfer advice project at a specific site.

Institutional Achievability - Auto-to-transit transfer advice projects are institutionally achievable. They are relatively small scale and not complex projects. Deployment will usually require the cooperation of Caltrans, a transit agency, and a local city.

Effectiveness - Several factors could limit the effectiveness of auto-to-transit transfer advice projects. Motorists are likely to become of aware of major incidents on the freeway ahead by means of existing travel information dissemination facilities such as radio traffic reports. TravInfo will further enhance the ability of motorists to receive traffic congestion information. Motorists may therefore already know about congestion and divert to transit without the need for a dedicated motorist information system. The effectiveness of the system is also limited by the amount of spare parking capacity at the transit station. Most transit stations do not have significant excess parking capacity, and construction of additional parking for this use alone is not likely to be cost effective.

Such a system may be most valuable when congestion on the freeway is mildly, rather than dramatically, worse than normal. This is a common condition. Under these circumstances, motorists are likely to be less inclined to divert to transit unless they are sure the transfer time will be short (a bus, train, or ferry is about to leave) and that there is convenient parking available. Under these conditions, the auto-to-transit transfer system could help prevent the freeway becoming more congested, and would help fully utilize spare capacity on the transit system. The site-specific information needed for motorists to make such a real-time transfer decision will not be available through TravInfo when it first starts operation. Such information could be disseminated via TravInfo if and when the data become available. The real-time transit departure and parking availability information at that particular site are the primary benefits of the project, but are applicable only at sites with significant excess parking capacity.

Customer Acceptability - Auto-to-transit transfer advice systems can be made easy to use if accurate and complete information is provided. It will not be practical to provide all the information needed on a variable message sign. Rather, such a sign would be used to direct motorist's attention to a radio broadcast, telephone number, or other means of providing details on the current level of congestion on the roadway, the departure time of the next transit vehicle, the availability of parking, fares, and perhaps the schedule or headways for return transit trips later in the day.

Scalability and Integratability - Auto-to-transit transfer advice systems, as defined, are specific to particular sites. However, they can be replicated at a number of suitable sites, **and** ultimately real-time schedule and parking information for all transit stations should be available to all travelers at all locations via TravInfo. Such a project would serve as auseful test of the value of monitoring parking availability and providing real-time transfer advice to motorists.

Action Plan Elements

This project is not included in the Action Plan.

0ther Deployment Actions

The concept should be tested at the West Oakland BART station, the Larkspur ferry terminal, or the North Concord BART station. Further deployments should await the results of the initial trial.

Location Information for Pedestrians

Project Description

At intersections, transit stops, and points of interest for travelers, basic information about the site including its name, orientation, current status, and distance and direction to adjacent sites would be transmitted. Pedestrians and transit riders, especially those that are visually impaired, would be able to hear the voice transmission when close to a site, using a special radio or infrared receiver. At signalized intersections, the transmitted information would include the current status of the signal's pedestrian indications, to guide the visually impaired. At bus stops and on transit vehicles, the system would provide information to visually impaired patrons.

The system could focus solely on the visually impaired or could be expanded to serve as a personal guide for anyone, especially tourists and other visitors unfamiliar with the area. The radio could use different channels by which the user could choose different types or levels of information.

Such systems could be deployed by any local jurisdiction acting independently. However, if transit information is to be included, the transit operator's cooperation would be needed. It is highly desirable that all projects adopt the same standard transmission system to enable use of the same receiver in any area. The project may be a good candidate for privatization, especially if expanded beyond the visually impaired. Advertizing may be feasible as a source of revenue.

Real-time transit fleet management systems are needed to provide "next bus" information at transit stops and "next stop" information (including timed transfer opportunities) on the transit vehicle. The project to provide stop annunciation on transit vehicles is an alternative method of addressing ADA requirements for transit vehicles.

Project Status

A trial system for visually impaired pedestrians has recently been implemented in downtown San Francisco.

Project Design and Evaluation

Summary - Pedestrian location information would provide for safer travel for visually impaired travelers, and could be expanded to include tourists and the general public. Real-time transit and intersection information would make the service more attractive to general users. Further deployment in the Bay Area should await the results of a trial now underway in San Francisco.

Support for MTS Management Strategy - This project does not directly address the goals of the MTS Management Strategy.

Technical Achievability - The technology needed for such projects is available. A trial system is now operating in San Francisco. The addition of real-time transit information would add a level of complexity.

Institutional Achievability - Such systems could be deployed by any local jurisdiction acting independently. However, if transit information is to be included, the transit operator's cooperation would be needed. It is highly desirable that all projects adopt the same standard transmission system to enable use of the same receiver in any area. The project may be a good candidate for privatization, especially if expanded beyond the visually impaired. Advertizing may be feasible as a source of revenue.

Effectiveness - Pedestrian location information would enable visually impaired users to travel more safely and conveniently. While the small number of such users would limit the project's cost effectiveness, such a system could meet ADA requirements where low-tech solutions are inappropriate. The project would be most cost effective where the volume of pedestrians is high, such as in the downtown area of large cities. The infrastructure needed could not be justified in areas with low pedestrian volumes.

Customer Acceptability - The current trial in San Francisco will test user reaction to the system deployed there. If the user interface is adequate, the system should be attractive to visually impaired pedestrians, and could also be popular with tourists and other visitors unfamiliar with the area. Receivers could be rented at airports, train stations, transit centers, and hotels.

Scalability and Integratability - The pedestrian location information system could expand from the visually impaired market to the general public, particularly tourists. Also, the program could expand (i.e. on several channels) to include a wide array of information. The same system could be deployed in multiple areas within the Bay Area.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Further deployment should await the results of the current trial in San Francisco. The private sector should be encouraged to provide a general purpose system based on subscription, rental, or advertizing revenue. The visually intpaired could receive a public subsidy to cover the cost of the receiver or service if necessary.

ROADWAY MANAGEMENT PROJECTS

Expand Freeway Traffic Operations System (TOS)

Project Description

This project would expand on the currently funded Traffic Operations System projects to provide surveillance detectors, closed circuit television cameras, changeable message signs, highway advisory radio, and ramp meters on all of the Bay Area's freeways. These field devices are linked to a permanently staffed control center at the Caltrans District 4 headquarters in downtown Oakland. There operators monitor conditions and implement actions to minimize the impacts of incidents such as stalls and accidents.

Deployment will take place solely on Caltrans facilities, but the support of local agencies and MTC is needed for funding and effective application, especially of ramp metering. The MTS Management Strategy project is building a consensus approach to the operation of the freeways in conjunction with other roadways and transit systems.

Project Status

The existing system covers only seventy miles of freeway. Currently funded projects will expand TOS to cover approximately 60% of the region's 500 miles of freeways over the next few years.

Project Design and Evaluation

Summary - Expansion of the freeway traffic operations system (TOS) directly addresses the problem of freeway congestion and can improve travel conditions for large numbers of travelers. It also provides the real-time information needed for travelers to choose a different time, mode, or route of travel. The introduction of ramp metering is often controversial and requires close cooperation with local jurisdictions. The other chief obstacle to full deployment of an expanded TOS is funding. In order to minimize costs and maximize the cost effectiveness, TOS should be expanded first in areas with the most severe freeway congestion, and where possible, in conjunction with freeway construction projects. Initial deployment should focus on those TOS elements essential for incident management.

Support for MTS Management Strategy - Expansion of the freeway traffic operations system (TOS) will provide the real-time monitoring and control capability needed to integrate the operation of the freeways with other transportation facilities. It will provide much of the information distributed to travelers via TravInfo and enable coordinated operation of surface streets and freeways. Freight movement will benefit from the operational improvements on several freeways that have a high proportion of truck traffic.

Technical Achievability - The freeway TOS can be expanded using the same proven technology used in the initial projects or could use new technologies. There are no technical hurdles or risks associated with the project. The project is compatible with the national ITS architecture. Some parts of the expansion would logically be implemented as part of planned freeway widening or improvement projects.

Institutional Achievability - Some local jurisdictions have questioned the cost effectiveness of the TOS for specific freeway segments without viable alternative routes, and others object to the implementation of the ramp metering portion of the system. Funding the complete regional system will be difficult; full funding of the TOS was proposed in the draft 1994 Regional Transportation Plan but was not included in the adopted RTP. Given the high cost of expanding the TOS, expansion should initially focus on only those freeways that often experience congestion, and those TOS elements essential for incident management. Expansion of the TOS can be undertaken by Caltrans working independently, except that implementation of the ramp metering portion requires the cooperation of local jurisdictions. Caltrans will need to work closely with local jurisdictions in all areas in which TOS is installed to develop a consensus operating plan for each corridor.

Effectiveness - The effectiveness of the TOS has been demonstrated in numerous similar systems operating around the world. The TOS allows incidents on the freeways to be detected, diagnosed, and managed quickly and efficiently. The Bay Area has a network of freeways that provide alternative routes for most long distance trips, and the TOS gives travelers the real-time information needed to choose the best route. Ramp metering can help keep traffic flowing smoothly and increase throughput. Given the large volume of traffic and trucks that use freeways, the project is cost effective.

Customer Acceptability - The traffic flow monitoring portion of the TOS is invisible to the motorist. Variable message signs are easy to read and advisory radio transmitters provide detailed information via the ordinary radio receivers in cars. The most controversial aspect of the TOS is ramp metering. Many motorists don’t appreciate the overall benefit that results from metering cars as they enter the freeway. The expansion of ramp metering in the Bay Area may need a concerted public relations effort to explain its benefits to the public and their elected representatives.

Scalability and Integratability - The TOS can be readily expanded to any freeway segment in the Bay Area. An interface between the TOS and Travlnfo is being built to provide travelers real-time information about conditions on the freeways. Links are planned between the TOS and local jurisdiction traffic management systems for integrated corridor management. Links between the TOS and regional transit systems have been proposed to facilitate intermodal transfers when a freeway is unusually congested.

Action Plan Elements

Action #2 calls for adding basic TOS coverage to a further 70 miles of inner freeways. This would provide coverage of all inner freeways except for Route 13 in Oakland and a segment of I-280 between Route 92 and Route 85 in the Palo Alto area, both of which have low rates of incidents.

Other Deployment Actions

TOS should be further expanded to all freeways in the region. Every opportunity should be taken to minimize costs by installing only essential equipment and combining installation with other freeway improvements where possible.

Probe Vehicle System

Project Description

This project would measure the current travel time of vehicles on the freeways and major arterial roadways by comparing the time that vehicles with electronic tags pass strategically located tag readers. Initially the system would use readers installed near selected freeway-to-freeway interchanges and near the intersection of major arterial routes. Ultimately, it could be expanded to provide readers at regular intervals on all freeway segments and at all major intersections on arterial roadways.

The system involves communications between the tag readers and a central computer that continuously calculates the travel time between pairs of adjacent readers. The system could distinguish HOV travel times from other vehicles where there are separate HOV lanes. Travel time information would be disseminated to travelers via TravInfo. The system could also provide comprehensive origin-destination data for use in traffic operation evaluation and transportation planning.

The tags that will be used for electronic toll collection on the region's toll bridges could be used as probes. Separate dedicated tags could also be used, especially in areas such as southern Santa Clara County where toll tags are not likely to be widely used due to the distance from toll bridges.

Project Status

A partnership of MTC, Caltrans, and local agencies in central Contra Costa County has applied for TSM funding for an initial probe vehicle system the freeways between Cordelia and San Francisco, and on major arterial roadways in central Contra Costa County. The system will measure the travel times on alternative routes and provide that information to travelers so that the optimum route can be selected.

Project Design and Evaluation

Summary - A probe vehicle system would provide valuable travel time information for both travelers and system operators. Such information is not available by other means on many freeways and on all arterial roadways. The project appears technically achievable and is similar to a system now operating in Houston using electronic toll tags. Electronic toll tags may not be the most cost effective approach for a regional system due to the low volume of toll tags in areas distant from toll bridges, and the relatively high cost of tag readers.

Support for MTS Management Strategy - A probe vehicle system would support the MTS management strategy by enabling a direct comparison of the current travel times by different facilities and modes. Accurate travel time information can ensure that travelers are optimizing their choice of time, mode and route of travel.

Technical Achievability - The deployment of toll tag probes is dependent on further implementation of the electronic toll collection (ETC) project. ETC is currently in acceptance testing, and is likely to be successful given the success of similar electronic toll collection projects in other parts of the country. Toll tag probes could use a multi-lane tag reader rather than the lane-by-lane readers used at the toll booths. These have been successfully developed in other toll tag probe projects and are not expected to be a major hurdle. Software for processing tag data and calculating travel times has been developed for a similar project in Houston and could be adapted for use in the Bay Area.

Caltrans is predicting that 200,000 tags will be issued for toll collection in the Bay Area. That number of tags should be sufficient for probe purposes on freeways feeding toll bridges, and for basic monitoring of major surface streets feeding those freeways. Additional tags can be distributed just for probe purposes if **needed.** The tag manufacturer has indicated that the additional readers will have a negligible impact on battery life.

Separate monitoring of HOV lanes is desirable so that HOV travel times can be reported separately. In Houston this is done using specially focused reader antennae; a similar approach could be used in the Bay Area.

Institutional Achievability - A probe vehicle system project can be deployed by Caltrans and MTC working with local jurisdictions and cooperating with the TravInfo team to develop the interface for data distribution. Although the system would not be able to identify the vehicles or their owners, privacy concerns may be raised and must be addressed to prevent their becoming an obstacle to deployment. Experience in Houston suggests that people accept the system when its operation is explained.

Effectiveness - A regional probe vehicle system would provide invaluable travel time and route choice data. It would enable accurate real-time travel times for all alternative routes to be reported to travelers. The current travel time of SOVs, HOVs and transit could be reported so that the fastest mode and route could be chosen. It would allow roadway operators to fine tune traffic operations based on real-time performance measurements. It would enable transit agencies to more accurately predict the arrival time of vehicles delayed by unusual traffic congestion. Travel time information could be used to automatically detect and report incidents and unusual congestion on both the freeways and surface streets. Route choice trends could be monitored to assist in formulating messages to travelers during incidents. Historical data could be used for evaluating alternative operating strategies and planning improvements.

A probe vehicle system would provide a more accurate measure of travel times on freeways and arterial roadways than can be obtained in any other way. Loop detectors at third to half mile spacings on freeways can provide an estimate of travel time by measuring spot speeds, but many segments of freeways will not have that density of loop detectors installed for many years to come if ever. Since tag readers are not installed in the road pavement like loops and are needed only every several miles, they can be installed economically and independent of freeway improvement projects. Readers and antennae can be readily relocated or adjusted when a freeway is widened, and can continue to operate during freeway construction activities. On surface streets, probe vehicles are the only proven method of continuously measuring travel times.

Customer Acceptability - There is no action required of motorists and no direct interface between the probe vehicle system and travelers. The information generated from the system will be distributed by TravInfo and will be of considerable benefit to travelers. A public relations campaign may be needed at first to explain the project and to allay privacy concerns.

Scalability and Integratability - The expansion of a probe vehicle system based on toll tags would be limited to those areas surrounding toll bridges where the density of toll tags would be sufficient. Additional toll tags could be distributed in other areas, but at considerable expense. A different tag and reader system may be the most practical for the ultimate regional system.

The project has great potential for integration with other ITS systems since it can leverage the region's investment in an electronic toll collection system, provides valuable data to Travinfo, and provides performance data to system operators for use in monitoring and fine tuning the operation of the transportation system.

Action Plan Elements

Action #l calls for deployment of a probe vehicle system on major freeways and selected arterial roadways surrounding the region's seven toll bridges. The system could use electronic toll tags unless a superior system can be found. The first stage of deployment will be in the Cordelia-to-San Francisco corridor.

Other Deployment Actions

No other deployment actions are recommended.

Local Arterial Performance Monitoring

Project Description

This project would install additional sensors, and computer systems as needed, to continuously collect the information needed to calculate arterial traffic flow performance measures such as average delay, travel time, stops, and queue lengths, for dissemination to motorists and for real-time optimization of traffic operations.

Such a system could be deployed by a local jurisdiction independent of other installations. Deployment would logically focus on the most congested routes first. Such systems are ultimately needed throughout the Bay Area, unless an alternative approach, such as a probe vehicle system, is used instead.

Project Status

No comprehensive real-time arterial performance monitoring systems have been deployed in the Bay Area. Some cities have deployed, or are in the process of deploying, automated counting systems that can be used to model historical conditions and to calculate an approximate level of service for a historical time period. Some agencies have deployed video detection systems that could be used in the future to measure vehicle queues in real-time. No systems in the Bay Area can accurately measure travel times, delay, or number of stops in real time.

Project Design and Evaluation

Summary - An accurate local arterial performance monitoring system is not technically achievable at this time. However, a low cost trial of the use of advance loop detectors for making an estimate of congestion and perhaps travel times may be worthwhile to test the concept. If and when a technical means is found for such a system, it would be highly beneficial if a probe vehicle system is not deployed instead.

Support for MTS Management Strategy - Local arterial performance monitoring addresses the objectives of the MTS management strategy in two ways. It can help increase the ability to monitor and manage arterial streets by enabling operators to fine tune signal timings and motorist information, and it can provide incentives for transit use by reporting the magnitude of delays on the arterial streets when congested.

Technical Achievability - Although it is easy to measure traffic volumes, speed, and occupancy at specific points on the roadway, it is difficult to convert these point measurements to an accurate indication of the overall level of congestion, travel time, or average speed along a surface street segment. The traffic is delayed at intersections and does not travel at the same speed between points of detection. In theory, the length of the queue at a traffic signal can be measured using a series of point detectors or video image processing, but these techniques are expensive to deploy at all intersections, and are not practical for measuring the very long queues that may build up during severe congestion. Video imaging techniques now in development may allow individual vehicles to be tracked between cameras so that the probe vehicle method can be used to measure travel times locally. However, that technology is not yet proven, and may be too expensive for widespread deployment. The only proven technique for measuring arterial performance is by electronic tags on probe vehicles, a project which is discussed separately above, since it is logically deployed regionally rather than locally.

Real-time roadway network models have been developed to continuously estimate network performance. This technique is used in some adaptive signal timing systems. The estimates of delay or travel time that could be derived from models are probably not accurate enough to pass on to travelers. These models make simplifying assumptions and break down under conditions of severe congestion, which is when travelers most need accurate information.

It may be possible to derive some approximate travel time estimates from occupancy data collected by advance detector loops at actuated traffic signals. A trial project using this approach could be implemented at low cost to test the concept. Such a trial would be best performed using an existing computerized traffic signal system that is able to collect the needed data from existing advance loops. Other than such a trial, an accurate and comprehensive arterial performance monitoring system that uses local sensors rather than a probe vehicle approach, does not seem feasible for early deployment.

Institutional Achievability - The project could be deployed by one agency acting independently, and has no significant institutional barriers. Neighboring jurisdictions would be interested in performance data concerning conditions that might affect their local systems.

Effectiveness - If an accurate local arterial performance measurement system could be achieved, it would be very beneficial and effective as a source of real-time information for travelers and for the system operator. A traffic signal timing system could, in theory, self optimize using the real-time measure of performance. Such a system would also provide valuable historical performance data for use in transportation planning and before-and-after evaluations.

Customer Acceptability - The project would not involve any direct interface with travelers, but travelers would benefit from both the improved arterial operation and the real-time information that are derivatives of the system.

Scalability and Integratability - If and when such a project becomes technically achievable, local arterial performance monitoring could be deployed on all arterial roadways in the Bay

Area. Local performance monitoring would probably be an integral part of a traffic signal management system.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

A trial of the use of advance detector loops for estimating travel times could be conducted in San Leandro, Santa Clara County, or central Contra Costa County. San Leandro is implementing an advanced traffic signal system which includes a detector data collection system and database that could facilitate the processing of detector data. Santa Clara County is planning to use an extensive network of vehicle detectors to measure the level of traffic congestion as part of a traveler information system. Agencies in central Contra Costa County plan to monitor vehicle detectors as part of a proposed probe vehicle system deployment, and may be able to use travel time information from the probe vehicle system to calibrate a detector based model.

Decision Support for Freeway Incidents

Project Description

This project would provide a decision support computer system to assist operators in analyzing data and making quick and appropriate decisions in response to incidents on the freeways. The software would analyze data collected from the field and suggest alternative courses of action including the projected impacts of each option. The needed technology consists of computers and software at the Caltrans Traffic Operations Center.

Project Status

Caltrans plans to implement a decision support system as part of the freeway traffic operations system (TOS).

Project Design and Evaluation

Summary - A decision support system for freeway incidents would help analyze incidents, identify an appropriate response faster, and identify a better response than an unassisted operator would choose. How much faster and better the incident response would be is uncertain, and is dependent on the skill of the system developers and the accuracy of the real-time data which it uses.

Support for MTS Management Strategy - Expansion of the freeway traffic operations system (TOS) will provide the real-time monitoring and control capability needed to integrate the operation of the freeways with other transportation facilities. Freight movement will benefit from the operational improvements on several freeways that have a high proportion of truck traffic.

Technical Achievability - Decision support systems for freeway incidents have been developed and implemented in other areas. It is a software development task that could draw on the experience of other areas, but which would need to be largely customized for the particular conditions and type of traffic operations system here in the Bay Area. It would be dependent on the freeway traffic operations system (TOS) to supply the needed real-time data,

Institutional Achievability - While the project could be deployed by Caltrans working independently, the cooperation of the CHP and local jurisdictions would be needed for specific response actions that the system might recommend. Each local jurisdiction is likely to have concerns with specific proposed response plans, which Caltrans will need to address. Liability issues may arise if full automation is implemented.

Effectiveness - A decision support system would help analyze incidents, identify an appropriate response faster, and identify a better response than an unassisted operator would choose. How much faster and better the incident response would be is uncertain, and is dependent on the skill of the system developers and the accuracy of the real-time data which it uses.

Customer Acceptability - Travelers will not interact directly with the system but will indirectly benefit from improved incident management.

Scalability and Integratability - Such systems can always be improved by investing more effort in further software development and refinement. Similar systems could be deployed for transit agencies and even local jurisdictions, but the availability of suitable real-time data is uncertain. The freeway incident decision support system may eventually be able to be linked to transit fleet management systems and to local traffic signal management systems to take into account the current status of other roadways and transit facilities in selecting or formulating a response plan.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

A decision support system should be implemented after the freeway traffic operations system is fully operational. The system design should benefit from lessons learned in other metropolitan areas where similar systems have been implemented.

Variable Speed Limit Signs

Project Description

This project would provide variable message signs on freeways and major roadways to reduce the speed limit when visibility (e.g. fog) or incidents warrant a slower speed. Enabling technologies include visibility sensors, variable message signs, and data processing.

Project Status

A variable speed limit project is one of the options being studied for improvements to Doyle Drive in San Francisco. No other projects are planned in the Bay Area.

Project Design and Evaluation

Summary - Variable speed limit systems could enhance the safety of Bay Area roadways subject to severe reductions in visibility due to fog. However, the Bay Area does not experience major chain reaction accidents in fog, and the effectiveness of the system is somewhat uncertain due to a potential transfer of responsibility for choosing the safe speed from the motorist to the system operator. A trial installation in one location would be wise prior to wide spread deployment.

Support for MTS Management Strategy - Variable speed limit signs do not directly address the objectives of the MTS management strategy.

Technical Achievability - Variable speed limit signing has been deployed in other areas and uses mature technology for both sensing ambient conditions and displaying the variable speed limit. Such a system would not be dependent on other projects.

Institutional Achievability - The project could be deployed by a single roadway owner, but enforcement of the variable speed limit may rely on the CHP or other law enforcement agency not directly associated with the roadway owner. Responsibility for posting weather-specific speed limits may also pose liability risks.

Effectiveness - The project could enhance the safety of Bay Area roadways subject to severe reductions in visibility due to fog. The safety effect is derived not from a warning of the low visibility but from the reduction of vehicle speeds to a uniform and low speed suitable for the level of visibility. The Bay Area has not experienced the major chain reaction accidents that have occurred during fog in some areas, and this may be due to the familiarity of Bay Area drivers with foggy conditions.

The vehicle code requires motorists to drive at a speed appropriate for the conditions. If a variable speed limit is displayed, it may imply to drivers that the safe speed decision is being taken out of the hands of the driver. For liability reasons, an operating agency may have to set conservatively low speed limits, and these may in turn breed disrespect for the variable speed limit and fail to achieve the desired uniform speed. In severe conditions, it may be difficult for drivers to read the speed limit signs and drivers may even be dangerously distracted from the driving task while trying to read signs. However, in such severe conditions, drivers would probably be driving quite slowly anyway.

Customer Acceptability - Drivers are likely to welcome a system that improves safety, providing the speed limits are reasonable.

Scalability and Integratability - An initial installation could be expanded or replicated anywhere in the region. Control and monitoring of the signs would logically be integrated with the freeway traffic operations system (TOS) or a local traffic signal system. The visibility data and current speed limit information should be distributed to travelers via TravInfo.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

The effectiveness of similar systems deployed in other urban areas should be evaluated before proceeding. If deployment proceeds, it should be only where needed to help reduce a high accident rate and should include a link to Travlnfo.

Advanced Traffic Signal Systems

Project Description

This project would provide computerized traffic signal systems where they do not already exist, and upgrade existing systems to add traffic-responsive signal timing selection or adaptive timing. Computerized traffic signal systems provide remote monitoring and management of signals, and ensure clocks in coordinated signals are always synchronized. Traffic-responsive timing selection enhances coordinated traffic signal operation by using vehicle detectors to continuously measure changes in traffic volumes and by automatically selecting the most appropriate timing pattern for current traffic conditions. This represents an improvement over traditional signal coordination operation, in which timing patterns are changed at fixed times of the day based on historical traffic conditions.

Adaptive signal timing goes one step further and provides the ability to automatically develop and fine tune coordinated signal timing patterns as traffic conditions change. The cycle length and other coordinated timing parameters could vary from one cycle to the next. This enables the operation of coordination signals to be continuously optimized for current traffic conditions. It' represents an improvement over traffic-responsive signal timing selection because it does not rely on selection from a few fixed timing patterns. Instead, the timing patterns are developed on-the-fly and explicitly for current traffic conditions.

Examples of enabling technologies for advanced traffic signal systems are traffic sensors, advanced traffic signal controllers, software for traffic responsive operation, and data communications between the field and central computers.

Project Status

The majority of larger cities in the Bay Area have computerized traffic signals in operation or planned. Several of these cities already use traffic-responsive signal timing selection. Adaptive signal systems are planned for some Bay Area cities.

Project Design and Evaluation

Summary - Advanced traffic signal system projects can significantly reduce stops and delays for traffic on arterial roadways. Such projects will be most cost effective if deployed on higher volume roadways designed to carry through traffic and where signal coordination is non-existent or inadequate even after fine tuning efforts using the existing system. Roadways with multi-phase signals and unpredictable fluctuations in traffic volumes are more likely to benefit from traffic-responsive timing plan selection and adaptive timing. Projects should coordinate signals without regard for jurisdictional boundaries, and this may involve integration of systems operated by different agencies.

Support for MTS Management Strategy - The primary way in which advanced traffic signal systems support the metropolitan transportation system management strategy is by increasing the ability to consciously manage the operation of the arterial roadway network. Projects that improve the efficiency of traffic signals used by transit vehicles can also enhance the operation of road-based transit vehicles. Similarly, signal system improvements on roadways heavily used by trucks can provide a significant benefit to freight movement.

Technical Achievability - Advanced traffic signal system technology and techniques are proven and robust. Even adaptive signal timing systems have been in use around the world for nearly twenty years, although further improvements can be made. Modem systems use mass market modular hardware and standard interfaces to minimize the risk of premature obsolescence. Projects that adhere to standards such as the National Transportation Communications for ITS Protocol (NTCIP), the Model 2070 controller, and NEMA standards for in-cabinet equipment, address the need for open architectures. Advanced traffic signal systems are not dependent on other projects or systems.

Institutional Achievability - There are few institutional obstacles to the deployment of advanced traffic signal systems within a single city, though complexity increases in multi-jurisdictional projects. Such systems can be implemented by a single agency without the need for complex partnerships, although systems should be designed for future integration with systems operated by neighboring jurisdictions to facilitate coordination of traffic operations across jurisdictional boundaries. Improvements to traffic signal systems tend to generate little public opposition and therefore are supportable by public funds. There are few opportunities for private sector funding. Systems can be designed to minimize labor and other costs involved in operation and maintenance.

Effectiveness - Advanced traffic signal systems are an effective transportation management tool. These systems have an extensive track record of success in cost effectively improving the efficiency of urban arterial roadways and reducing the air pollution impacts associated with stop/start traffic. Improved signal coordination is a primary source of project benefits, but there are many other benefits including more rapid response to equipment faults, incident detection, reduced signal operating and maintenance costs, and the ability to change signal timings as part of dynamic traffic management strategies. Many of the benefits of advanced traffic signal systems require multijurisdictional partnerships, especially for MTS roadways.

Since the project can significantly reduce delays on arterial roadways, it can have a negative impact on residential and other adjacent land uses by attracting higher volumes of traffic to that facility, and increasing the average speed of traffic, though usually without increasing midblock speeds. Such projects may also encourage additional overall vehicle trips. On the other hand, improvements in traffic flow on arterial streets that are designed to accommodate the traffic and have appropriate abutting land uses, can help encourage motorists to use such facilities rather than less appropriate streets such as those that pass through residential areas.

Advanced traffic signal systems provide the flexibility to adjust signal timings during the day as part of a dynamic traffic management strategy. For example, gateway signals can be used to meter excessive through traffic into an area during peak periods, while providing a high level of service for all traffic, including regional shopping traffic, during off peak times. Signals near schools can have longer Walk display times when large numbers of children are crossing the street, but can be shorter at other times to reduce delays to motorists.

These projects will be most cost effective if deployed on higher volume roadways designed to carry through traffic and where signal coordination is non-existent or inadequate even after fine tuning efforts using the existing system. The most cost effective technology will depend on the specifics of the setting. Roadways with multi-phase signals and unpredictable fluctuations in traffic volumes are more likely to benefit from traffic-responsive timing plan selection and adaptive timing. In dense grid networks, fixed time-of-day systems may be sufficient.

Customer Acceptability - The benefits of advanced traffic signal systems usually accrue from the accumulation of small benefits at many intersections, and are therefore often not fully appreciated by the public. Changes in signal operations also often involve additional delay for a few motorists as the trade-off for reduced delay for many other users. The negative impacts for the few are more likely to be noticed and result in a complaint than the improvements for the many who rarely communicate their appreciation. The user acceptability of such systems is enhanced if the implementation process includes a public relations program that informs the public of what changes will be made, the project’s goals and benefits, and the tradeoffs involved.

Scalability and Integratability - Advanced traffic signal systems can be readily expanded to cover any number of traffic signals over any area, and can be linked with other arterial and freeway traffic and transit management systems. Expanding the scale of projects across increasing numbers of jurisdictions will likely result in greater effectiveness, but also greater institutional difficulties.

Action Plan Elements

Action #3 calls for deployment of advanced traffic signal systems and upgrading of existing systems where appropriate for higher volume arterial roadways. Traffic responsive pattern selection should be used where traffic volumes fluctuate unpredictably. Adaptive timing should be used where volumes change rapidly or often, where traffic patterns are complex, and where some signals require a much longer cycle than others. Advanced signal system should include a data feed to TravInfo.

Other Deployment Actions

All traffic signals should eventually be connected to a computer for automatic fault monitoring, remote management, and information collection.

Integration of Transportation Management Systems

Project Description

This project would integrate the operation of separate transportation management systems, especially those operated by different agencies or jurisdictions, to ensure continuous and consistent coordination of transportation operations across system boundaries. It can be as simple as two or more adjacent cities installing a common timing reference system or data exchange link between their traffic signal systems and agreeing on joint operating procedures to maintain coordination of traffic signals across jurisdictional boundaries. Other examples are the coordination of a freeway ramp metering system with a local traffic signal system and integration of traffic signal systems with transit fleet management systems to enable transit priority. Another example is the linking of fleet management systems operated by two transit agencies that have overlapping routes or shared transfer points, so that each agency is aware of the location and status of the other operator's buses.

Enabling technologies include wide area communications networks, a standard communications protocol, and real-time data processing.

Project Status

Various agencies in the Bay Area have implemented integrated operation for adjacent systems. Others are planning such linkages. Advanced traffic management systems operated by seven separate agencies are being integrated as part of the larger scale Silicon Valley Smart Corridor project in the Highway 17/I-880 corridor in Santa Clara County. Another project is underway to integrate multiple signal systems in the I-880 corridor in Alameda County.

Project Design and Evaluation

Summary - Integration of transportation management systems can coordinate the operation of different elements of the Bay Area's transportation system. Each operator is kept informed of conditions in adjacent or related systems, and the involved agencies can implement coordinated responses to incidents and other unexpected changes in conditions. Such projects could prove highly effective but will pose the greatest institutional challenges. Projects are likely to be most effective when specific applications of the interconnection are identified and the project designed accordingly,

Support for MTS Management Strategy - This project directly supports the goal of integrating the operation of transportation system elements, and enhances the operation and coordination of mass transit.

Technical Achievability - All systems can be readily integrated to some degree, but comprehensive integration may be complex depending on the specific systems involved. Systems that are likely to be most easily interconnected and integrated are those that:

- Employ standard interfaces and communications protocols
- Are open and highly modular
- Are relatively new and based on modern practices and standards
- Have a distributed processing architecture and use networked computers
- Are widely deployed and have strong support

Integration of systems may require specialized hardware and custom software development, but is technically achievable.

Institutional Achievability - Integration of systems owned by different agencies will require a high level of cooperation among those agencies, both for the technical aspects of integration and for the on-going operation of the interconnected systems. A successful project requires a long term commitment by all parties to make available data to the other system(s) and to accept input from the other system(s) as needed for effective integration of operations. It also requires on-going cooperation to coordinate operating plans and to maintain the systems' integration during system upgrades. System integration may enable two or more agencies to share operating staff by allowing monitoring and control of all systems from one location. This may be done permanently or only during emergencies or outside of normal working hours. An inter-agency agreement is often needed to clarify responsibilities and liability issues.

Effectiveness - Integration of transportation management systems can coordinate the operation of different elements of the Bay Area's transportation system. Bach operator is kept informed of conditions in adjacent or related systems, and the involved agencies can implement coordinated responses to incidents and other unexpected changes in conditions. Projects are likely to be most effective when specific applications of the interconnection are identified and the project designed accordingly. Examples of specific applications for integrated systems are:

- Traffic-responsive signal timing plan selection across jurisdictional boundaries.

- Priority treatment at traffic signals for transit vehicles that are behind schedule.

- Coordinated and simultaneous adjustment of the timing of ramp meters and adjacent traffic signals.

- Coordinated messages on variable message signs and advisory radio transmitters in different jurisdictions during incidents.

- Coordination of transit operations during incidents in areas of overlapping service between transit agencies.

- Shared use of operating staff.

Customer Acceptability - Integrated systems do not normally involve any new direct interface with travelers, but travelers will benefit from resulting improvements in service. Travelers expect a seamless transportation system and do not want artificial barriers due to multiple separate operating agencies.

Scalability and Integratability - Integration of transportation management systems could be expanded and replicated until all relevant systems in the Bay Area are interconnected. Nearly all systems are candidates for integration.

Action Plan Elements

Action #5 calls for deployment of corridor transportation management systems. This includes interconnection and coordination of existing transportation management systems operated by different agencies.

Other Deployment Actions

Adjacent signal systems should be linked where needed for cross-boundary signal coordination. Signal and transit systems should be linked where needed for transit priority at traffic signals.

Smart Corridor Expansion or Replication

Project Description

This project would expand or replicate the Silicon Valley Smart Corridor in other areas within the region. The smart corridor concept provides and integrates real-time management and operation of surface streets, freeways and transit services in a corridor or area. It involves the implementation of advanced real-time traffic and transit management systems where they do not already exist, traveler information systems including changeable message signs (CMS) and advisory radio, incident management facilities, communications links between systems operated by different agencies and local jurisdictions, and development and implementation of joint operating procedures.

Similar projects are under consideration for the I-880 corridor in the East Bay, the I-680 corridor in central Contra Costa County, and the Doyle Drive corridor in San Francisco.

Project Status

Smart corridor projects are being discussed for the I-880 corridor in Alameda County, and for the I-680 corridor in central Contra Costa County.

Project Design and Evaluation

Summary - Expanding or replicating the Silicon Valley smart corridor system would integrate real-time management and operation of surface streets, freeways and transit services in additional corridors. The corridors likely to benefit the most from such a system are those dominated by one or more freeways that experience frequent incidents and for which there are multiple alternative routes using surface streets. Early deployment of a smart corridor will be feasible and cost effective only if the local jurisdictions in the corridor already have computerized traffic signal systems covering the freeway diversion routes.

Support for MTS Management Strategy - Expansion or replication of the Smart Corridor concept would integrate transportation system elements, increase the capacity and continuity of arterial streets, and benefit corridors critical for freight movement. In its ultimate configuration, it can also enhance the operation and coordination of mass transit,

Technical Achievability - The technology being used in the Silicon Valley Smart corridor is directly applicable in other corridors. The wide area data exchange network being implemented in the initial project is designed to be expanded or replicated elsewhere.

Institutional Achievability - Most such projects would involve Caltrans, the CHP, a county, several cities, and at least one transit agency. The wide variety of participants adds institutional complexity. Successful deployment would require a firm partnership among such agencies, and common goals.

Effectiveness - Expanding or replicating the Silicon Valley smart corridor system would integrate real-time management and operation of surface streets, freeways and transit services in additional corridors. The corridors likely to benefit the most from such a system are those dominated by one or more freeways that experience frequent incidents and for which there are multiple alternative routes using surface streets. Early deployment of a smart corridor will be feasible and cost effective only if the local jurisdictions in the corridor already have computerized traffic signal systems covering the freeway diversion routes.

Customer Acceptability - Travelers generally support traffic management projects, and especially those that are particularly effective in dealing with freeway incident related traffic. The messages presented on message signs and advisory radio need to be carefully chosen to be easy to understand, accurate, and effective. Users will then come to trust and effectively use such devices.

Scalability and Integratability - Smart Corridor projects are expandable to the extent that the corridor or area served can benefit from this treatment. The Smart Corridor concept could be replicated in other portions of the Bay Area and later tied into the Silicon Valley project, or the existing corridor could be extended. The real-time data assembled as part of smart corridor operations is usefully passed to TravInfo for broad dissemination to travelers.

Action Plan Elements

Action #5 calls for corridor transportation management systems in the I-880 corridor in Alameda County and the I-680 corridor in Central Contra Costa County. These have existing advanced traffic signal systems and local agencies already working together.

Other Deployment Actions

As local conditions permit, deploy corridor transportation management systems in other corridors in which most through travel occurs on freeways and incidents cause diversion to parallel surface streets.

Expand FSP Coverage

Project Description

This project would expand the Freeway Service Patrol to include roving tow trucks on additional freeway segments, expressways or other key highways. The trucks would be tracked using Global Positioning System (GPS) satellites to facilitate rapid and appropriate dispatch and management.

Project Status

The region uses a formula based on factors such as the traffic volume, frequency of incidents, and shoulder width to set priorities for expenditure of state funds available for motorist service patrols. At present only major freeway segments have FSP coverage.

Project Design and Evaluation

Summary - Expansion of the freeway service patrol coverage to major arterial roadways would enable disabled vehicles to be more rapidly cleared from facilities such as the expressways in Santa Clara County. This would reduce incident related congestion and secondary accidents. Expanded service is likely to be most cost effective on roadways with the highest traffic volumes, and especially those with shoulders too narrow to accommodate a disabled vehicle or high accident rates.

Support for MTS Management Strategy - Expanding FSP coverage to major arterial roadways would help maintain the capacity of those facilities, which is a goal of the MTS management strategy.

Technical Achievability - Freeway service patrols have been successfully used in the Bay Area for several years. The GPS technology used to track the vehicles has been proven in several applications.

Institutional Achievability - Regional consensus would be required for use of state funds. The operation and dispatch of additional FSP service would logically be conducted by the CHP as with the current freeway patrols. The project could be deployed by local agencies independently if local funds are used.

Effectiveness - FSP service has been shown to reduce response times for incidents on major facilities, which in turn reduces the time for queue dissipation related to the incident. Increased FSP service would not only contribute to congestion reduction, it would also increase safety on the roadways by reducing secondary incidents. Expanded service is likely to be most cost effective on roadways with the highest traffic volumes, and especially those with shoulders too narrow to accommodate a disabled vehicle or high accident rates.

Customer Acceptability - The user acceptability for FSP service is extremely high. FSP service is one of the more visible efforts for congestion management, and has received praise from motorists in the Bay Area.

Scalability and Integratability - Expanding FSP to other areas in the Bay Area would not be difficult to implement, as long as dedicated funding was available. The fact that tow trucks are tracked using GPS may afford some travel time information to TravInfo by using these trucks as vehicle probes.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Motorist assistance patrols should be provided on all freeways and high volume expressways with no shoulder for disabled vehicles. The service should be provided during times when the road is operating at or near capacity.

TRANSIT AND RIDESHARE PROJECTS

TransLink Joint Fare Card

Project Description

This project would deploy the next generation of electronic fare cards to provide a contactless smart card, which travelers can use on any transit system, and possibly for other purposes.

A universal electronic fare card would offer convenience for transit patrons and several benefits for transit operators, including reduced risks associated with cash handling, automatic gathering of statistics on passenger boardings and transfers, and increased ridership. The key enabling technology is the stored-value smart card.

Project Status

BART and the Contra Costa County Transportation Authority have already tested the first generation of TransLink. The next stage of the project is currently is underway in accordance with the TransLink Program Plan developed by MTC and the transit agencies. Potential smart card technologies are being investigated. The plan calls for implementation of a trial smart card system during 1997, and full deployment starting in 1998.

Project Design and Evaluation

Summary - A joint fare card would make transit travel easier for Bay Area users, reduce fare collection costs, and allow transit operators to gather statistics on passenger boardings and transfers. A smart card system is now being investigated, and if a suitable standard card can be identified, its widespread adoption by Bay Area transit agencies would be beneficial. Implementation of the new card on each agency's system would be done most cost effectively in conjunction with planned fare collection system upgrades.

Support for MTS Management Strategy - The TransLink fare card would integrate transportation system elements, enhance the operation and coordination of public transit and provide incentives for transit use in the Bay Area, all of which are goals of the MTS Management Strategy.

Technical Achievability - The joint fare card used in the initial testing of TransLink used a magnetic strip card, similar to a BART fare card, and the card readers proved unsuitable for installation on transit vehicles. Contactless smart card options are now being investigated. This technology is relatively new. Although the technology is sound, no clear standards or universally accepted card has yet emerged in the market place. It is desirable that the card adopted by the Bay Area transit agencies be a universal one that can be used by travelers to purchase other goods and services too.

Institutional Achievability - BART and the Contra Costa County Transportation Authority (CCCTA) have already been involved in a previous trial of shared electronic fare cards. MTC is providing active leadership in the TransLink program, and a partnership among all of the major transit agencies is currently operating. Because each transit provider has different fare policies and collection systems, the project is complex and involves many trade-offs and compromises.

Effectiveness - A joint fare card would make transit more convenient and attractive for users. The Bay Area has over 20 transit providers, and the TransLink card would allow seamless transit transfers between transit operators. Automatic gathering of statistics on passenger boardings and transfers would be very useful for transit operators and transit planners. The use of smart cards will also reduce the quantity of cash handled by operators and reduce passenger boarding times, however a significant share of riders may need to use TransLink for operators to see savings greater than the maintenance costs for the additional fare collection equipment.

The smart cards would be most effective for the high volume urban transit systems and systems with large numbers of inter-operator transfers. Implementation of the new card on each agency's system would be most cost effectively done in conjunction with planned fare collection system upgrades.

Customer Acceptability - A smart card that allowed the user access to multiple transit operators, without the need for the user to figure out transfer and fare policies, would be perceived as beneficial by the user. The public perception of transit is often a major deterrent to using the service, and the TransLink card would contribute to improving this aspect. The system would be particularly attractive to travelers if the same card could be used to purchase other goods and services.

Scalability and Integratability - The TransLink joint fare card would allow the incorporation of multiple transit providers and perhaps other transportation services such as parking fee payment.

Action Plan Elements

Action #7 calls for deployment of the TransLink fare card in accordance with the TransLink Program Plan. The system should first be deployed on the major transit systems such as BART, AC Transit, Muni, Santa Clara Valley, Golden Gate, SamTrans, and Caltrain.

Other Deployment Actions

The fare collection system should be integrated with fleet management systems where appropriate. If possible, allow the same smart card to be used for parking payment and other services.

Real-time Transit Fleet Management Systems

Project Description

This project would provide transit agencies with real-time fleet management systems that include automatic vehicle location, so that travelers can be kept informed of transit vehicle arrival times and incidents, and dispatchers can rapidly detect and respond to schedule deviations. A silent alarm on the transit vehicle would allow rapid notification of dispatchers in emergencies, and the exact location of the reporting vehicle would be instantly known. Such systems can also provide automatic monitoring of transit vehicle subsystems and diagnosis and reporting of faults. Enabling technologies include Global Positioning System (GPS) satellites and other vehicle tracking technologies, mobile data terminals, vehicle subsystem sensors, mobile communications links between the transit vehicle and the control center, and central data processing. Real-time information gathered from the system can be provided to TravInfo for distribution to travelers.

Project Status

BART and Napa have operating fleet management systems. AC Transit is in the process of implementing a system. MUNI and Santa Clara County Transit District are planning fleet management systems.

Project Design and Evaluation

Summary - Transit fleet management systems help keep travelers informed, and improve security for transit vehicle operators and passengers. The cost of these systems can be offset by reduced fleet sizes and other operating cost savings. The cost effectiveness of systems can be optimized by carefully assessing the need for each feature given the particular operating conditions of that agency. A basic system with just vehicle tracking and emergency alarm is often all that is needed. Added features such as data exchange, passenger counting, fare box monitoring, engine monitoring, etc. may not be cost effective in many instances. Multiple agencies with overlapping service areas can reduce costs and facilitate integrated operations by sharing a fleet management system.

Support for MTS Management Strategy - Transit fleet management systems enhance the operation and coordination of public transit. They can make transit more attractive by making travel times more reliable and by providing real-time information to travelers such as the arrival time of the next bus or train. Fleet management systems also enable integration of transit with other elements of the transportation system, such as traffic signal priority for transit vehicles that are running behind schedule.

Technical Achievability - The technology needed for transit fleet management systems is mature and readily available. Such systems have been in operation for many years. Availability of the Global Positioning System (GPS) has further reduced the cost of these systems while making them more effective, flexible, and reliable. GPS is less reliable in the "urban canyons" of central city CBDs, possibly necessitating supplementary systems such as guideposts or dead-reckoning. Some projects in the past have suffered due to expensive and unreliable roadside equipment. All systems require radio communications for data exchanges between the dispatch center and the transit vehicles. This data link can be combined with the voice radio system if designed appropriately. The system requires electronic and communications equipment installed on the transit vehicles. It is normally necessary to equip the entire fleet to allow any vehicle to be used on any route.

Institutional Achievability - Real-time transit fleet management systems can be deployed by individual transit operators, or multiple agencies can cooperate in the implementation of a shared system if desired. Agreements between agencies for shared systems could be difficult to reach; in such cases, data-interchange systems may be a preferable method of enabling coordinated fleet management. In addition to the initial cost, there is an on-going operation and maintenance cost. Cost savings resulting from increased operating efficiency can more than offset the cost of these systems. Improved schedule adherence, for example, can reduce the needed fleet size. Labor unions have resisted the introduction of such systems in some agencies, primarily out of fear of the system being used for constant and inappropriate monitoring of vehicle operators; in other cases they have strongly supported the security features of fleet management systems. Involvement of vehicle operators in the system design can help allay fears.

Effectiveness - Transit fleet management systems have a track record of measured success in improving on-time performance, keeping travelers informed, enabling schedules to be refined, and improving security for transit vehicle operators and passengers. The cost of these systems may be offset because they can enable the operating agency to reduce the fleet size and other operating costs. Small scale fleet management systems are now available for small fleets, though some operators may have insufficient ridership to justify the investment. Vendors typically offer a range of options for these systems, each one adding functions to the basic system. The cost effectiveness of systems can be optimized by carefully assessing the need for each feature given the particular operating conditions of that agency. A basic system with just vehicle tracking and emergency alarm is often all that is needed. Added features such as data exchange, passenger counting, fare box monitoring, engine monitoring, etc., may not be cost effective in many instances.

Customer Acceptability - These systems involve no direct interface with the traveler, although the information they generate can be used to keep travelers informed of vehicle arrival times and unusual conditions during incidents. An operating agency can publicize the existence of the emergency alarm system to both deter crime and make passengers feel more secure. Passengers also benefit from the improved on-time performance and reduced bunching possible with such systems.

Scalability and Integratability - Real-time transit fleet management systems can be implemented in any transit agency in the Bay Area. It is possible to expand a system operated by one agency to be shared with another agency, especially for basic systems without data exchange. Agencies with overlapping service areas can interconnect their systems to exchange information needed for improved coordination of their services. Fleet management systems can be linked to traffic signal management systems to enable traffic signal priority for transit vehicles that are running behind schedule.

Action Plan Elements

Action #4 calls for deployment of fleet management systems for regional rail transit systems and bus systems with high ridership. A data exchange capability should be provided between systems where needed for coordination of overlapping services. The fleet management systems should provide real-time information to TravInfo.

Transit Priority at Signals

Project Description

This project would provide transit priority at traffic signals either for all transit vehicles or only for those that are behind schedule. Such systems can improve transit schedule adherence and reduce the number of transit vehicles needed to compensate for schedule slippage.

When a suitably equipped or designated transit vehicle is detected approaching the traffic signal, the signal is instructed to adjust its timing to reduce the amount of time the vehicle would otherwise have to wait at the intersection. This may involve advancing the start of the green display for the transit vehicle or retarding its end. Priority can be given at all signals or only selected signals such as those near transit transfer centers, those on the busiest transit routes, or those that involve the greatest delay for transit vehicles.

Simple systems provide priority for all transit vehicles. More sophisticated systems can provide priority for only selected vehicles such as those that are running behind schedule. This requires an automated vehicle location system that tracks transit vehicles and identifies those running late. Enabling technologies include transit vehicle detectors, advanced signal controller software, and communications links between transit and traffic management systems.

Project Status

Transit priority is provided for some transit vehicles at some traffic signals in San Francisco, Santa Clara County and Napa A bus priority system is being implemented in Rohnert Park.

Project Design and Evaluation

Summary - Transit priority at traffic signals can improve the on-time performance of transit. Basic systems using existing signal preemption technology can be effective in areas with relatively low traffic volumes or long transit vehicle headways. Improved priority algorithms in traffic signal controllers, improved bus location monitoring during its approach to intersections, and transit fleet management systems that invoke priority only for vehicles running behind schedule, are needed before transit priority can be widely deployed in the Bay Area. A demonstration project using such techniques would be useful in the short term to accelerate the development and testing of these technologies which are needed to minimize negative impacts on traffic operations.

Support for MTS Management Strategy - Transit priority at traffic signals supports the MTS management strategy by enhancing the operation of on-street transit services. It also improves the integration of transit and arterial roadway operations, so they function more as a single system, and it gives the flexibility to optimize the transportation system's capacity to move people at peak hours.

Technical Achievability - The technology needed for basic signal priority systems has been available and in use for many years for emergency vehicle preemption, but is not suitable for many transit applications. Such preemption systems can be inefficient and quite disruptive for other traffic. Adapting emergency vehicle preemption systems for transit is often feasible only where traffic volumes are low or moderate and the number of transit vehicles receiving priority is low, or in traffic signal systems with short cycle lengths and simple phasing.

Efficient transit priority in many parts of the Bay Area requires more sophisticated vehicle location monitoring techniques and signal controller software. The vehicle detection system needs to be sensitive to the distance from the approaching transit vehicle to the intersection, and ideally, should report the length of the queue of traffic between the bus and the intersection. The location of the transit vehicle relative to transit stops is also relevant. Detection schemes that provide all such capabilities are not yet available, but partial solutions are on the market.

The traffic signal controller software needs to be able to selectively skip phases and/or extend the duration of a green display, and to provide an efficient means of maintaining or rapidly restoring signal coordination. Several controller software vendors are in the process of developing suitable software as part of the current move to a new generation of advanced traffic controllers.

In areas with traffic congestion and frequent transit service, it is desirable to provide full priority only for transit vehicles that are running behind schedule. It is generally not practical to rely on the transit vehicle operator to determine schedule adherence and to activate the priority request. Instead, an automatic vehicle tracking system is needed to monitor the progress of all transit vehicles, to identify those that are significantly behind schedule, and to activate priority at selected signals for late vehicles only. Technology suitable for tracking transit vehicles and determining schedule adherence is available and has been in use for several years elsewhere in the U.S.

Institutional Achievability - To be institutionally achievable, transit priority projects require close and on-going cooperation between the transit agency and the local jurisdiction(s) that operate the traffic signals. Institutional obstacles to transit priority systems often revolve around conflicting priorities between traffic departments and transit operators. Traffic agencies often have concerns about the ability to maintain auto traffic flow while providing priority to transit vehicles.

Priority systems that rely on a vehicle mounted transmitter that sends a signal directly to the traffic signal equipment, introduce an added complication in that all transit vehicles and signals need to use the same detection scheme. This can require adoption of a regional standard because transit service areas overlap, and there are multiple local jurisdictions within most transit agencies' service area.

Effectiveness - Transit priority at traffic signals can be a highly effective means of enhancing transit schedule adherence, but must be implemented carefully to prevent negative impacts on other traffic. Given the current state of signal priority technology development and the absence of automated vehicle location systems for most Bay Area transit systems, signal priority for transit is likely to be effective in the short term only for projects which have one or more of the following characteristics.

- Intersections have spare capacity and a relatively high level of service when priority is active.
- Transit service is infrequent when priority is active.
- Signals have a means of accurately detecting the position of the transit vehicle relative to the intersection (e.g. track or overhead detectors for light rail vehicles or trolley buses).
- Priority is provided at only a few selected critical intersections where delays to transit vehicles are severe and the negative impacts to traffic are tolerable.
- The transit agency has a means of identifying vehicles that are running behind schedule.

New technologies would enable transit priority systems to be far more effective and to be deployed in many more areas. An ideal system would allow the level of priority afforded transit vehicles to be adjusted during the day and from one signal to the next to fully utilize any spare intersection capacity to assist transit, without significantly inconveniencing other road users. A bus would be tracked continuously as it approaches an intersection and the signal operation modified only as and when needed to clear the queue of traffic and allow the bus to pass with minimum delay. Signal coordination would be restored immediately after the bus passes.

Customer Acceptability - Transit travelers have no direct interaction with a system that provides priority for transit vehicles at traffic signals, but some motorists, cyclists, and pedestrians may notice an increase in delay at signals when priority is in effect. Such projects may benefit from a public relations effort to explain the project, its goals, and the trade-offs involved. If publicized to riders, transit priority systems should be well received, since they have the potential to substantially improve transit's on-time performance.

Scalability and Integratability - Current systems can be replicated in many locations but have limited potential for integration. A transit priority system using new technologies could be extended to any number of suitable traffic signals. Most bus and light rail transit operators throughout the Bay Area could benefit from such advanced systems. The detection, vehicle tracking, and signal controller technologies involved can be implemented as a part of other systems such as advanced traffic signal systems, transit fleet management systems, and signal preemption for emergency vehicles. An early deployment of an advanced technology system would serve as a useful demonstration project.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

A trial transit priority project using advanced technologies for diesel bus priority should be deployed as a demonstration of the potential benefits. Such a project could be implemented on Hesperian Boulevard in conjunction with the new traffic signal system being implemented in San Leandro and the new transit fleet management system being implemented by AC Transit.

Stop Annunciation on Transit

Project Description

This project would provide automatic stop annunciation on transit vehicles in accordance with the Americans with Disabilities Act (ADA). The system would use a recorded or computer generated voice announcement in advance of each stop. The announcement can be manually triggered, but is most reliable if automatically triggered using the vehicle tracking component of a fleet management system or roadside transmitters. Enabling technologies include advanced voice recorder/players, in-vehicle variable message signs, and mobile communications between the transit control center and transit vehicles, or between roadside transmitters and the vehicle.

Project Status

Several Bay Area transit agencies have at least semi-automated systems in operation or planned. Napa Valley Transit plans to automate its manual system using its existing automated vehicle location capability.

Project Design and Evaluation

Summary - Stop annunciation systems address the requirements of the ADA and assist visually impaired passengers and those not familiar with the area. Automated announcements requires integration with a fleet management system that includes automatic vehicle location services. It may be cost effective only where drivers do not reliably announce stops manually.

Support for MTS Management Strategy - Transit stop annunciation systems can make transit more attractive and convenient for visually impaired travelers.

Technical Achievability - The technology needed for electronic stop annunciation is mature and in use in other parts of the country. Automatic triggering of announcements relies on an automatic vehicle location (AVL) system, which is usually part of a real-time fleet management system, discussed separately as another project.

Institutional Achievability - Stop annunciation systems can be deployed by a transit agency acting independently. Such systems are often not viewed as a high priority by operating agencies due to the limited number of passengers needing the service. The ADA legislation is the major motivation for deployment.

Effectiveness - Automatic stop annunciation is a very effective means of advising visually impaired passengers of upcoming transit stops and meeting the requirements of the ADA on systems where drivers do not reliably or clearly announce stops. It is likely to be most cost effective if implemented as a module in a fleet management system. The system can also be useful for other passengers as a reminder of an upcoming stop, to point out landmarks and major destinations for those not familiar with the area, and to announce opportunities for transferring to other transit facilities.

Customer Acceptability - As long as the announcements are clear and given an appropriate distance before arriving at the stop, passengers generally welcome such systems. Involvement of visually impaired passengers in designing the system can help ensure its success.

Scalability and Integratability - Such systems could be deployed individually by each Bay Area transit agency. Automatic triggering of the announcements requires integration with an automatic vehicle locating system. These systems can be made a part of a more comprehensive passenger information system with both visual and audible messages provided both on the transit vehicles and at stops. Such comprehensive systems are discussed below as a separate project.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Stop annunciation systems should be installed as needed for ADA.

Real-time Information for Transit Riders

Project Description

This project would provide dedicated visual displays or audible transmissions at transit stops and on transit vehicles to advise patrons of transit vehicle arrival times, upcoming stops, and transfer opportunities. Such systems can use personal communications devices and variable message signs, with communications links to a transit control center.

Project Status

BART provides visual and audible notifications of next train arrival time, transfer opportunities, and incident reports, for patrons waiting on station platforms. AC Transit is considering the installation of real-time information kiosks at transit centers and the Oakland airport.

Project Design and Evaluation

Summary - Real-time information systems for transit riders can make transit more attractive and convenient. They are feasible only for agencies with a real-time transit fleet management system that can provide accurate real-time information for travelers. They are most cost effective if deployed at transit stations with high volumes of patrons, and on high capacity transit vehicles.

Support for MTS Management Strategy - Real-time information for transit riders can help make transit more attractive and convenient for travelers.

Technical Achievability - The technology needed for these systems is mature and readily available. Interactive kiosks, variable message signs, and audible messaging systems have been in use for many years. Several options are available for communications links between a central computer and the information devices in the field and on vehicles. BART has both visual and audible messaging at stations. The primary technical obstacle is not the technology, but a lack of accurate real-time information. Such systems cannot be implemented for most Bay Area transit agencies until a real-time fleet management system is available to provide the needed information.

Institutional Achievability - These systems can be deployed by a transit agency acting independently, although the cooperation of local jurisdictions may be needed for installation of roadside equipment at transit stops. For operators to provide information about connecting services, they must agree on a common system or data interchange format. A real-time transit information system requires a commitment to on-going operation and maintenance. If advertizing were allowed, especially on visual displays, it may be possible to attract private sector funds, or even implementation and operation by the private sector. BART has privatized passenger information displays at some stations.

Effectiveness - Real-time information for transit riders can be quite beneficial in making transit more attractive. Passengers are kept informed of unusual conditions, the arrival time of the next bus or train, and transfer opportunities. Such services will obviously be most cost effective when deployed at high volume transit stops or on high capacity vehicles. This maximizes the number of passengers benefiting from the investment.

Customer Acceptability - The information system provides a direct interface with travelers via a visual display or audible announcement. Because it is a consumer-oriented project, it will have broad public visibility and should have high consumer acceptance. Kiosks at transit stations may include a keypad or touch screen with menus of choices for additional information. If carefully designed, such systems have proven acceptable and useful to travelers.

Scalability and Integratability - Real-time information systems for transit riders will likely be implemented on an operator-by-operator basis and can be installed at individual transit stops or on individual transit vehicles independent of other installations. Such systems can be expanded to cover any number of stops and vehicles. Their operation relies on integration with a fleet management system as the source of real-time information. It is possible that a company could eventually deploy such services independently using information from TravInfo. This is not likely to occur soon and would likely be a viable operation (with advertizing) in only large volume transit stations.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Systems that provide real-time information for transit riders should be deployed at high volume transit stations and on high patronage transit vehicles, once a fleet management system is available to collect the information.

CCTV Surveillance for Transit

Project Description

This project would install closed circuit television cameras on transit vehicles and at transit parking facilities and stations/stops to enhance passenger safety. A cable or wireless communications link can allow the video to be viewed in real time, or it can be recorded on site.

Project Status

Many Bay Area transit agencies have security cameras in place or planned. BART will implement a trial wireless video feed from trains later in 1996. AC Transit is including on-board CCTV cameras in new bus purchases.

Project Design and Evaluation

Summary - Video surveillance for transit facilities can deter crime and provide added security for transit patrons. It is most cost effective if deployed in high crime areas and isolated parking lots.

Support for MTS Management Strategy - Video surveillance at transit stops, parking lots, and on transit vehicles can help make transit safer and more attractive, enhancing its operation and removing barriers to its use.

Technical Achievability - Video surveillance technology is mature and readily available. Continuous slow-scan transmission from on-board vehicles to the dispatch center requires a data radio link. Video cameras at transit stops and parking lots can transmit compressed video by leased or dial-up telephone lines.

Institutional Achievability - Video surveillance can be installed by the transit agency with the cooperation of local jurisdictions where necessary for installation of cameras on roadside structures. It would not likely involve partnerships between transit agencies; however a transit operator may wish to work with the local police department to develop monitoring and response plans.

Effectiveness - The greatest benefit of video surveillance is the crime deterrence effect and the resulting sense of added security for transit passengers. These effects can help make transit more attractive. Cameras need to be positioned so as to avoid privacy intrusions in residential areas and to avoid vandalism to the camera. Video surveillance is likely to be most cost effective in high crime areas and at isolated parking lots. Systems with real-time communications are likely to be more effective at crime response, but carry much higher capital and operating costs.

Customer Acceptability - Some travelers may resent the privacy intrusion of video surveillance, but most will welcome the added security it affords. Security surveillance cameras are becoming ubiquitous in public buildings and people seem to accept them as a net benefit.

Scalability and Integratability - Surveillance cameras can be installed at any site or any transit vehicle independent of other installations. Video surveillance can be extended to all transit stops, parking lots, and vehicles if needed. Such systems could be integrated with traffic surveillance systems in some areas to share the cost of infrastructure.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

CCTV surveillance cameras should be installed on transit facilities in high crime areas, and at isolated parking lots.

Smart Shuttles

Project Description

This project would provide shuttle vans that are tracked and can be rerouted in real time to pick up call-in passengers. Shuttles could readily serve employment centers, colleges, event venues, other major trip generators, and transit hubs including BART and CalTrain stations. Experiments are underway in other metropolitan areas to use smart shuttles as an alternative to fixed-route transit, especially in low density areas. Enabling technologies include the Global Positioning System (GPS) satellites and other vehicle tracking systems, real-time scheduling software, mobile data terminals, and mobile communications between a control center and the shuttle vehicles.

Project Status

A partial deployment is underway in Santa Clara County to facilitate transfers between paratransit vehicles and fixed-route services. Other projects are in early planning, including a demand responsive shuttle using route deviation in the Menlo Park and Stanford University area.

Project Design and Evaluation

Summary - Smart shuttles have not yet been proven, but hold great promise as a new form of transit able to serve markets for which fixed route service is not cost effective. One or two trial projects seem appropriate in the short term, with further deployments in the longer term only if the initial experience here and in other parts of the country is favorable. The conditions under which a smart shuttle service are most likely to be successful have been identified.

Support for MTS Management Strategy - Smart shuttles can provide an enhanced transit service, which is a basic goal of the MTS management strategy.

Technical Achievability - The technology needed for tracking and managing smart shuttles is available and has been in use for several years, primarily as part of fixed-route transit fleet management systems. Three alternative modes of shuttle operation might be appropriate for different applications and markets.

- Normal fixed-route scheduled operation.
- Loosely scheduled operation with limited route deviation to get closer to passenger origin and destination sites.

- Door-to-door service on demand.

The more flexible modes have a greater demand for ITS technology.

Institutional Achievability - Some smart shuttle systems could be implemented by a single transit agency acting independently. Others would require the cooperation of multiple agencies, complicating implementation. Operating costs include a full time operator who takes calls from customers, determines the appropriate vehicle to provide the service, and directs the shuttle to the pick-up and drop-off locations. There is potential for private sector funding support if the shuttles can effectively link major employment centers to regional transit service. There is potential both for mutual cooperation or for competitive friction between the shuttle operator and taxi companies.

Effectiveness - Smart shuttles have not been widely deployed or proven yet. The major challenge lies not in the technology but in the logistics of efficiently serving multiple requests for service from riders spaced randomly in time and space. There is some uncertainty as to whether a fundable system can serve customers rapidly enough to attract a viable ridership. Such systems are likely to be most effective and to serve as an alternative to fixed-route transit where several of the following conditions exist:

- Population density and ridership are too low to support an economical fixed-route transit service.
- There are a limited number of major trip generators to or from which passengers commonly want to travel.
- The shuttle can conveniently connect with regional transit systems to serve long distance travelers.
- Passengers are able and willing to pay a premium fare in return for the added convenience of door-to-door service.
- There is a significant number of potential passengers for whom driving a car is not a viable option.
- Security concerns in the area make a door-to-door service particularly attractive.
- The shuttles serve an identifiable community with comprehensive and nearby local employment, shopping, health care, educational, and other services.

Smart shuttles may offer a cost effective alternative to fixed route service during non-peak periods. Smart shuttles may also serve traditional paratransit passengers, especially outside of peak periods, but the special needs of paratransit passengers may pose challenges.

Customer Acceptability - Demand-responsive shuttles present travelers with a trade-off relative to fixed-route transit and are likely to appeal to some users and not others. The shuttle offers increased convenience in terms of both reduced walking distance and more flexible time of travel, but less certainty in arrival time both at the origin and destination. While users can be expected to support increased travel options, it is unclear how willing they would be to pay fares for smart shuttle service.

Scalability and Integratability - Smart shuttles initially are likely to be focused on relatively small and separate service areas. In the long run, multiple shuttle services could overlap and offer interchanges for travel between two such service areas, but service areas are likely to remain small due to the logistical problems associated with servicing large areas. Interfaces with fixed-route transit will likely be a part of all smart shuttle implementations, and as such these projects offer an opportunity to extend existing transit services into areas difficult to serve with fixed-route transit.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

A trial smart shuttle service should be deployed to test the concept. An existing shuttle could be converted to demand responsive service by adding a basic vehicle tracking system. The Menlo Park and Stanford University area has been identified as a potential site for a smart shuttle demonstration project.

Smart Parks/Transit Transfer Centers

Project Description

This project would construct enhanced park-and-ride lots and transit transfer centers at strategic locations along freeways with easy access, convenience shops and services for travelers, child care, smart shuttles to nearby employment centers, integration with fixed-route transit service, and with real-time information for travelers. Enabling technologies include automated vehicle location systems, variable message signs, interactive kiosks, real-time shuttle scheduling software, mobile communications, and personal communications devices.

Project Status

A smart park-and-ride lot project is in the planning stages as part of the Silicon Valley Smart Corridor. A smart transit transfer center is planned for the Doyle Drive corridor in San Francisco.

Project Design and Evaluation

Summary - Smart parks would combine many "everyday" services with ITS elements in a unique manner. The ability to deliver ITS services would be enhanced by the overall critical mass of the smart park and the overall number of services provided. The net effect is a convenient and attractive modal transfer site that will facilitate parking and riding. Smart parks are likely to be most effective when located at natural gateways into a congested urban area, with transit services converging or intersecting near the site. There are many technical and institutional hurdles to be overcome including attracting a critical mass of service providers, arranging convenient access from the freeway, and providing the site with quality transit services.

Support for MTS Management Strategy - Smart parks would integrate transportation system elements and facilitate the coordination of public transit, both of which are goals of the MTS Management Strategy.

Technical Achievability - Smart parks would combine several aspects of other transportation projects. The smart parks would rely on real-time transit fleet management systems for information generation, and TravInfo or dedicated subsystems for information dissemination. Many of the elements of smart parks are commonly used today, but are not located in close proximity to one another (elements such as commercial retail businesses, automotive services, transit transfer centers, day care centers and park-and-ride lots). The challenge is to attract the needed critical mass of services, which would need more than the park-and-ride patrons as customers. The project also relies on convenient access from and to the freeway and quality transit service.

Institutional Achievability - Smart parks would require the cooperation of multiple parties including Caltrans, one or more transit agencies, and private sector retailers and service providers. Joint development, operating and maintenance agreements would need to be created for each location. This complex institutional arrangement will complicate deployment of smart park projects. If large employment centers were to use the smart park for an employee shuttle location, there may be opportunities for private-sector financial participation in smart park development.

Effectiveness - Smart parks would combine many "everyday" services with ITS elements in a unique manner. The ability to deliver ITS services would be enhanced by the overall critical mass of the smart park and the overall number of services provided. The net effect is a convenient and attractive modal transfer site that will facilitate parking and riding. Smart parks are likely to be most effective when located at natural gateways into a congested urban area, with transit services converging or intersecting near the site. Because smart parks have not been fully implemented before, estimates of effectiveness are somewhat speculative.

Customer Acceptability - Travelers will use the park-and-ride facility if it is convenient, efficient, and secure. The real-time transit and shuttle information would have to be easy to access and accurate.

Scalability and Integratability - A smart park necessarily integrates a number of ITS services at a single geographic site. There is a strong possibility of replicating smart parks throughout the region if successful. Each one would be tailored to the specific site and community in which it would exist.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Use the results of the Silicon Valley Smart Corridor "smart parks" feasibility study to help evaluate and plan other potential sites.

Real-time Shared Vehicle Brokering

Project Description

This project would provide a central clearinghouse and information system for shared use vehicles available for hire, or use in paratransit, including station cars at BART stations, spare paratransit vehicles, and vanpool vans during the day. Enabling technologies include real-time vehicle scheduling and management software, and mobile communications.

Project Status

BART will provide shared station cars at the Sybase site in Emeryville. Vehicles will be tracked using GPS. Through a grant from the Haas Foundation, Chevron's carp001 vans will be used to take the elderly to supermarkets.

Project Design and Evaluation

Summary - A real-time shared vehicle brokering system has the potential to make more efficient use of shared ride vehicles and reduce overall vehicle operating costs. However, the effectiveness of such a system is uncertain due to numerous complexities and issues that need to be resolved. A small scale pilot project may be appropriate.

Support for MTS Management Strategy - A shared vehicle brokering system could reduce the cost of owning and operating shared-ride vehicles and therefore help make ridesharing more attractive.

Technical Achievability - There are no technical barriers, per se, but the logistics of such a system are quite complex, especially for a wide area system. The database and demand/supply matching process need to consider the geographic location of vehicles and potential users, travel times between sites, and allowances for return time slippage. An initial project may concentrate on one area, such as downtown San Francisco, as a trial.

Institutional Achievability - The complex institutional structure needed for a shared vehicle brokering project is a prime reason few such programs currently exist. The system would require the cooperation of numerous vehicle owners, drivers, and users. Insurance, liability, vehicle maintenance, and back-up service issues need to be resolved. The operating agency or company would have to commit at least one person full time for operation of the system.

Effectiveness - The effectiveness of a shared vehicle brokering system is uncertain due to the complexities and issues involved. A small scale pilot project is probably appropriate to test the concept. Such a project is likely to be most successful and effective in an area with a high density of available vehicles and potential users, such as in San Francisco.

Customer Acceptability - The acceptability of the service to users depends on how reliable and convenient the service can be made. The vehicle owners or normal users will object to a system that interferes with their normal use of the vehicle or causes a deterioration in the condition of the vehicle, but other users would appreciate the convenience of having vehicles from the pool available for their use. Casual users will need assured availability at scheduled times and convenient pick-up and return locations.

Scalability and Integratability - If the system is successful, it could be expanded to the entire Bay Area, either as a single system or multiple regional systems.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

The concept should be tested with a small scale local service before attempting a regional system.

Enhanced Prearranged Rideshare Matching

Project Description

This project would enhance current carpool and vanpool based rideshare matching systems by adding the following services.

1) Automate both the registration process and the match list issuance. Allow a prospective driver or rider to enter the needed information and to receive a match list with little or no input from a human operator. Allow users to update their information on-line. Customers could have 24 hour access from any location.

2) Provide more detailed and customized information about rideshare, transit, and bicycle options, for both registered and unregistered travelers. Automatically extract information pertinent to the traveler based on information about that traveler's needs.

3) Allow same-day rideshare matching for particular trips, especially for the ride home when a rider is unable to use his or her formal Carpool, during emergencies including "spare the air" days, and ride sharing for special events and major destinations such as airports. Such casual matches may be arranged a day ahead or just an hour or two ahead.

The project would use improved ridematching software.

Project Status

RIDES now offers a same-day ride matching and traveler information service for San Francisco Airport. Solano Commuter Information provides limited same-day rideshare matching.

Project Design and Evaluation

Summary - An enhanced prearranged rideshare matching service would help make ridesharing more attractive. The project would involve enhancements to the existing regional and employer-based rideshare matching systems.

Support for MTS Management Strategy - An enhanced prearranged rideshare matching system would help make ridesharing more attractive.

Technical Achievability - The technology needed for the project is available, but accurate database maintenance may be a challenge. The RIDES database and registration system could be modified to add a self service option and to expedite short term matches when a traveler is unable to use their normal ride home.

Institutional Achievability - The project could enhance the existing rideshare matching services operated by RIDES under contract to MTC, Solano Commuter Information, and by employers.

Effectiveness - The project would help make ridesharing easier and more reliable. It would also provide more targeted information to travelers who may be candidates for ridesharing, thus attracting more riders. The cost of the project should be relatively low, adding to its cost effectiveness.

Customer Acceptability - The self-service rideshare matching service would involve a direct interface with the traveler. It needs to be carefully designed to ensure ease of use and generation of an appropriate match list. The announcement of the new service could be made a part of the outreach portion of the project.

Scalability and Integratability - The project would be a one-time effort, assuming it is applied to the existing regional ridematching system. Further improvements and refinements could be made to the system in the future.

Action Plan Elements

Action #8 calls for deployment of an enhanced prearranged rideshare matching service as described above.

Real-time Rideshare Matching

Project Description

Develop a system that allows travelers to rapidly arrange a ride with motorists traveling in the same direction for any destination. Participating drivers and passengers would be pre-screened, registered, and issued with mayday devices and smart cards that facilitate both identification and payment . Participating vehicles have to meet minimum standards and would be equipped with an automated vehicle location device. Drivers would check in at the start of trip by giving their destination and planned route. Passengers desiring a shared ride would call in and give their current location and destination. A computer would match passengers with drivers and inform each of the selection. When the two parties first meet, the smart cards would authenticate their identity for the other person. At the end of the passenger's journey, the smart card is used to automatically transfer the appropriate payment to the driver based on the distance traveled. To ensure security, the vehicle is continually tracked and both parties carry a mayday device. If multiple complaints are received about a driver or passenger, they are dropped from the system.

The system could be started by a lead agency such as MTC. Once operating, it could be offered to the private sector to take over operation, either independently via a bidding process, under a controlled franchising arrangement, or under direct contract to the public agency lead. An initial project might target the UC Berkeley or Stanford university areas which are likely to have an above-average proportion of travelers willing to try a system like this.

Project Status

There are no plans for such a project in the Bay Area at this time. A trial system is being implemented in Ontario, California.

Project Design and Evaluation

Summary - A real-time rideshare matching system has the potential to greatly increase the amount of ridesharing and reduce single occupant vehicle usage. There are several hurdles which need to be overcome to make such a system successful, including the reluctance of people to share rides with strangers, liability and insurance issues, and the need to attract a critical mass of participants. An initial implementation may be most likely to succeed if it is focused on the area around a major university where there are likely to be more travelers willing to share rides.

Support for MTS Management Strategy - A real-time rideshare matching system would provide substantial incentives for ridesharing.

Technical Achievability - The technology needed for tracking vehicles, mayday alarms, mobile communications, ride matching software, and smart card payment systems are now available. A small-scale implementation of such a project is being undertaken in Ontario, California, but no full implementation of real-time ridematching is in operation in the U.S. The central challenge to deployment is achieving the critical mass of users needed to make the system effective. If there are too few riders there will be insufficient fares to attract drivers, and if there are too few drivers there will be insufficient ride opportunities to attract riders.

Institutional Achievability - The system could be established by a public agency or a private company. By charging a percentage of fares and/or registration fee in return for the ride matching and security service, the system should be self funding. Such a system is likely to be opposed by the taxi industry unless it can be demonstrated that stranded riders will increase taxi usage or subsidized taxis are formally included as a guaranteed ride home. Legal, liability, and insurance issues associated with organized payment for travel in private automobiles need to be resolved.

Effectiveness - If the project can overcome implementation hurdles and can build the needed critical mass of riders and drivers, it has the potential to dramatically increase ridesharing and reduce the use of single occupant vehicles in the Bay Area. It would be financially self supporting and highly cost effective in terms of initial investment to launch the service. It could have a negative impact on transit ridership.

Customer Acceptability - Both the drivers and riders would need to purchase and use devices involved in security, communications, and electronic payment. These need to be made inexpensive and easy to use. For the initial launch of the system, it will be necessary to seed the market area with free or heavily subsidized devices to attract the initial participants. A major publicity campaign would be needed to explain the system and recruit both riders and drivers. Once fully operational, however, the system could be very attractive for both drivers and riders. Drivers get paid for a trip they need to make anyway, and riders would get door-to-door on-demand transportation for a fare which would be far less than a taxi, less than the cost of using their own vehicle, and not significantly greater than transit fares. Despite the planned security measures, many people may be reluctant to share rides with total strangers. It may be difficult to attract enough participants to make the system viable, especially initially. Once it is established with a favorable track record, ridership would likely increase.

Scalability and Integratability - The project could serve a limited area or corridor initially, but it would be more effective if it covered a larger portion of the region. If the concept is successful, it may be possible in the future to have more than one system operating competitively to ensure central services are efficient.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Monitor the Ontario experiment and plan a system in the Bay Area if and when feasible.

EMERGENCY RESPONSE AND AUTOMATED ENFORCEMENT PROJECTS

Enhanced 911 Dispatch

Project Description

This project would enhance the 911 cellular telephone emergency call system at CHP's computer-aided dispatch (CAD) center in Vallejo and other law enforcement agencies, to better handle the rapidly increasing volume of 911 calls from cellular telephone users reporting travel related incidents, and to locate the caller. A new Federal Communications Commission ruling requires that within five years, the CHP must be able to determine the location of a cellular 911 caller to within approximately 400 feet. The system would enable calls to be responded to more quickly and appropriately. Potential technologies that could be used include automated telephone answering systems and cellular telephone locating systems.

Project Status

The project is in the early planning stage.

Project Design and Evaluation

Summary - An enhanced 911 dispatch system for the CHP would improve response times for emergencies on the region's highways. A detailed design effort is needed to investigate and choose among alternative approaches.

Support for MTS Management Strategy - An enhanced 911 dispatch system would not directly address the goals of the MTS management strategy, but indirectly supports other systems that do, including TravInfo and incident management systems, by ensuring that incident information is made available as quickly as possible.

Technical Achievability - Technology is available for handling large numbers of phone calls and assisting operators to screen, record, prioritize, or redirect the enquiries. Cellular telephone locating systems are being tested. A detailed design effort is needed to determine how best to tackle the problem.

Institutional Achievability - The project could be implemented by the CHP with the cooperation of local law enforcement agencies in those parts of the system that entail a rapid redirection of the call to local agencies. Geolocation of the cellular telephone will require implementation of a locating system that could be shared by all public safety answering points in the Bay Area, and possibly with private sector services such as those needed to support in-vehicle mayday devices.

Effectiveness - The system would alleviate current bottlenecks in 911 service that result in delayed response to emergencies. It could also reduce operating costs by more efficiently screening and handling calls. The automatic telephone locating system would enable a caller to be located accurately even if the caller is unsure of their position or unable to communicate clearly.

Customer Acceptability - Travelers would welcome a system that improves the response time for 911 calls. However, members of the public expect an immediate human response to a call and could reject any solution that involves a menu selection. Similarly, any redirection of calls would have to be very quick and secure. A public outreach campaign may be needed to explain any such changes in procedures.

Scalability and Integratability - The system would likely be first implemented at the CHP dispatch center in Vallejo, but could be replicated at all local law enforcement agencies to assist with landline 911 calls too. The systems operated by the different agencies need to allow for rapid redirection of calls between agencies.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

A study should be conducted to determine the best way to upgrade the existing CHP dispatch system to handle the additional cellular 911 call volume and to automatically locate the caller,

Hazardous Materials Database

Project Description

This project would provide in-the-field emergency service personnel with instant access to shippers' databases of hazardous material cargoes. The information would be accessed either by use of portable databases on laptop computers, or communications with a central computer containing the information. Such computer databases would be continually updated with the latest information by data communications from the shippers.

Project Status

One such project is being implemented in Contra Costa County. Others have not yet started.

Project Design and Evaluation

Summary - A hazardous materials database system would reduce the time needed to identify and remove potentially hazardous spills on roadways and railroads. The project can be implemented by any emergency services agency with the cooperation of shippers. It would be efficient if all interested agencies cooperated in a shared system to reduce costs for both the agencies and the shippers.

Support for MTS Management Strategy - A hazardous materials database system would not directly address the goals of the MTS management strategy, but would do so indirectly by reducing the time needed to identify and clear potentially hazardous spills.

Technical Achievability - The technology needed for the project is mature and readily available. Computer databases, data exchange between computers, and mobile communications are proven technologies. Data exchange links between the emergency response agency and the cargo shippers are always subject to the need for upgrades as shippers change their systems. The use of industry standard interfaces and communications protocols is helpful in this regard.

Institutional Achievability - The system can be implemented by a single emergency services agency in cooperation with shippers. Data collection and maintenance must be done in a manner which meets the needs of both government and industry for the public-private partnership to operate smoothly.

Effectiveness - The project would reduce the time needed to identify and remove potentially hazardous spills. Unknown materials spilled from trucks is a common cause of lengthy highway closures. The project would also reduce risks to personnel involved in materials identification and removal by providing complete safe-handling information.

Customer Acceptability - The system does not require a direct interface with travelers, but travelers would benefit from the faster response to potentially hazardous spills. Public support is likely to be high for any project which reduces the risk from hazardous materials shipping.

Scalability and Integratability - Any emergency services agency could implement such a system. It is desirable that such agencies cooperate to share a common system to simplify procedures for the shippers and encourage their cooperation. A central clearinghouse of data from shippers is desirable. All agencies would access this one database and shippers would only need to update one database.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

The Contra Costa County hazardous materials database project should be monitored, and if successful and cost effective, extended to other areas and shippers.

Red Light Violation Cameras

Project Description

This project would install vehicle detectors and cameras at traffic signals to automatically identify vehicles that illegally enter the intersection after the signal has been red for more a specified time period. Citations are sent in the mail to confirmed violators.

Project Status

San Francisco has a red light violation demonstration project underway. Several other cities in the Bay Area are planning systems.

Project Design and Evaluation

Summary - Red light violation cameras reduce the incidence of accidents at traffic signals due to red light violation. Since the cost of operation and maintenance is largely paid for from revenue from fines, the projects are quite cost effective.

Support for MTS Management Strategy - Red light violation cameras do not directly address the goals of the MTS management strategy.

Technical Achievability - Red light violation cameras have been used around the world for many years. The involved technology is mature and readily available.

Institutional Achievability - Red light violation cameras can be implemented by any local jurisdiction acting independently. As a safety project, such projects are often politically popular. The legal issues surrounding these systems have been fully addressed in recent legislation in California, but concerns about the appropriateness of automatic enforcement could still discourage jurisdictions from implementing such projects. Operation and maintenance of the equipment is usually handled by the system vendor in return for a share of the revenue from fines.

Effectiveness - Red light violation cameras have been shown to be effective in reducing the incidence of accidents at traffic signals due to red light violation. Since revenue from fines helps pay for the cost of operation and maintenance, the projects can be quite cost effective.

Customer Acceptability - The public reaction to red light violation cameras is likely to be mixed. Many people will usually support the project due to its safety benefits, but some will object to the principle of automatic enforcement. The only direct interface between the equipment and travelers would come in the form of police citations, which shows the unpopular, punitive aspect of the program. Signs are posted to warn motorists that a camera may be operating at an intersection or group of intersections. Even so, a public relations effort is appropriate to explain the project when first deployed.

Scalability and Integratability - Red light violation cameras can be installed at any traffic signal. The deterrent effect is maximized if camera housings are installed at multiple intersections in an area so that motorists are never sure which intersections are being monitored at any given time. These systems stand alone and do not normally interface with other traffic management systems.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Red light violation cameras should be installed at intersections with a high incidence of accidents due to red light violations.

Speed Limit Violation Cameras

Project Description

This project uses temporary or permanent roadside camera and radar installations to automatically record the speed and identification of vehicles that are significantly exceeding the speed limit, and to issue citations.

Project Status

Several local agencies in the Bay Area use this system.

Project Design and Evaluation

Summary - Speed limit violation cameras are effective in reducing speeding by motorists, but tend to be unpopular with motorists. Since a police officer has to be present, they may not offer a significant cost advantage over normal radar speed enforcement. Some argue that the speeding deterrent display (see separate project discussion) is just as effective without being punitive.

Support for MTS Management Strategy - Speed limit violation cameras do not directly address the goals of the MTS management strategy.

Technical Achievability - Speed limit violation cameras have been used around the world for many years. The involved technology is mature and readily available.

Institutional Achievability - Speed limit violation cameras can be implemented by any local jurisdiction acting independently. Although such projects enhance road safety, they are often controversial because so many drivers tend to exceed the speed limit that it is not commonly viewed as being especially dangerous. In California, speed limit violation cameras must be attended by a police officer in order to issue a citation.

Effectiveness - Speed limit violation cameras are effective in reducing speeding by motorists. Since a police officer has to be present, they may not offer a significant cost advantage over normal radar speed enforcement. Some argue that the speeding deterrent display (see separate project discussion) is just as effective without being punitive.

Customer Acceptability - Many motorists object to the use of speed limit enforcement cameras on principle. There is no direct interface between the equipment and travelers, apart from the issuance of speeding tickets.

Scalability and Integratability - Speed limit violation cameras can be installed either permanently or temporarily at any suitable roadside location. Their effectiveness as a deterrent to speeding is maximized if they are deployed at various sites and times within an area so that motorists never know when they might come across a camera. Such systems do not interact with other ITS projects.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Implement speed limit vioiation cameras where the local community supports that approach and alternative measures, including speeding deterrent displays, have failed to address a speeding problem.

Speeding Deterrent Display

Project Description

This project uses roadside radar and a digital sign to measure and display the speed of approaching vehicles as a deterrent to speeding. Speeding motorists are not cited, but "shamed" into travelling slower.

Project Status

Several Bay Area cities already use this system.

Project Design and Evaluation

Summary - Speeding deterrent displays are effective in reducing speeding by motorists, but probably less so than speed enforcement cameras. Since the displays do not have to be manned while in operation, they are less expensive to operate. They are likely to be cost effective relative to other speed control measures for arterial roadways.

Support for MTS Management Strategy - Speeding deterrent displays do not directly address the goals of the MTS management strategy.

Technical Achievability - Speeding deterrent displays have been used around the world for many years. The involved technology is mature and readily available. The displays are usually mounted on a trailer or other portable platform, and relocated regularly.

Institutional Achievability - Speeding deterrent displays can be implemented by any local jurisdiction acting independently.

Effectiveness - Speeding deterrent displays are effective in reducing speeding by motorists, but probably less so than speed enforcement cameras. Since the displays do not have to be attended while in operation, they are less expensive to operate. They are likely to be cost effective relative to other speed control measures for arterial roadways.

Customer Acceptability - The displays show the speed of an approaching vehicle in large numerals. Motorists generally accept such devices as an appropriate speed control measure that is not punitive.

Scalability and Integratability - Speeding deterrent displays can be deployed at any suitable roadside location. Their effectiveness as a deterrent to speeding is maximized if they are deployed at various sites and times within an area. They are not likely to interact with other ITS projects.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Where excessive speeding is a problem, speeding deterrent displays should be tried as a speed management technique before moving to more punitive and expensive solutions such as speed enforcement cameras.

OTHER CANDIDATE PROJECTS

Install Weigh-in-Motion for Trucks

Project Description

This project would install weigh-in-motion (WIM) scales and associated automatic vehicle identification and by-pass capabilities at all truck inspection stations in the Bay Area. The system uses electronic tags on trucks to identify the vehicle as it approaches the in-pavement scales. Real-time access to a central computer database enables a rapid check of the trucking company's status and compliance record.

Project Status

Weigh-In-Motion is being installed at the I-880 truck inspection station in Fremont, and is planned for implementation at others.

Project Design and Evaluation

Summary - Weigh-in-motion can significantly reduce travel times and operating costs for trucking companies, reduce the workload for manual surveillance personnel at truck inspection stations, and reduce the risks associated with heavy trucks exiting and entering the freeway at inspection stations. WIM can be financially self supporting via user fees, and therefore should be quite cost effective.

Support for MTS Management Strategy - Weigh-in-motion systems benefit freight movement, which is a goal of the MTS management strategy.

Technical Achievability - Weigh-in-motion scales and the associated truck identification and screening systems are new technologies but have been deployed in several projects around the country and proven to operate as planned. A standard system has been developed for use the southwestern states as part of the HELP/CRESCENT project, and this system is being deployed at truck inspection stations elsewhere in California.

Institutional Achievability - WIM stations are installed by Caltrans and operated by the CHP. The trucking industry has had mixed reactions to WIM. Some have embraced it and fit transponders to their trucks so they can take advantage of it. Others have objected to the user fees and are not participating at this time. It is anticipated that sufficient trucking companies will participate to make the system effective.

Effectiveness - Weigh-in-motion can significantly reduce travel times and operating costs for trucking companies, and reduce uncertainties in travel times. Assuming a significant proportion of trucks use the weigh-in-motion system, these installations can significantly reduce the workload for manual surveillance personnel at truck inspection stations, and can reduce the risks associated with heavy trucks exiting and entering the freeway at inspection stations. WIM can be financially self supporting via user fees, and therefore should be quite cost effective.

Customer Acceptability - The trucking industry is in favor of weigh-in-motion, but some trucking companies have objected to the user fees.

Scalability and Integratability - WIM can be installed at any truck inspection station independent of other installations. There is no need for integration with other systems; however, the transponders used for verifying truck participation should adhere to regional and national standards. They may also be useful in a probe vehicle project.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Install weigh-in-motion at all high volume truck inspection stations in the Bay Area.

Heavy Container Tracking

Project Description

This project would weigh and track heavy containers at area ports using electronic tags to prevent overweight trucks from entering highways. Containers would be weighed during the off-loading process and their weight written to an electronic tag affixed to the container. Tag readers at the exit from the port area would monitor the tags and flag any containers that exceed a threshold. These trucks would be inspected and weighed if necessary to check for excessive axle loadings.

Project Status

There are no plans to deploy such a system in the Bay Area.

Project Design and Evaluation

Summary - Heavy container tracking at ports could reduce the incidence of overloaded trucks entering the highways, but would require tags fitted to all containers and may not be a cost-effective solution.

Support for MTS Management Strategy - If use of tags proves to be a less intrusive manner of inspecting containers, it could be an improvement to freight operations, an MTS management strategy.

Technical Achievability - The required technology is available. It may not be feasible to get all containers tagged, since containers are shipped globally, not only through the Bay Area.

Institutional Achievability - The project would require the cooperation of the port, the shippers, and the CHP. Shippers may be reluctant to participate in any project which increases inspections of cargo, imposes new administrative requirements, or requires the additional cost of tags fitted to containers.

Effectiveness - Assuming all parties cooperate in its implementation, the project would be at least partially effective in preventing overweight loads from entering the highway. Even lighter containers can exceed axle load limits if placed on an inappropriate truck. Normal truck scales already existing at the port may be more effective and less expensive.

Customer Acceptability - The container owners may object to the tags being added to containers. Trucking companies may object to trucks being unnecessarily delayed for inspection on exit from the port.

Scalability and Integratability - The project is limited to ports, but could be deployed at San Francisco and other smaller ports, in addition to Oakland, the region's main container port.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

This project should not be deployed unless the shipping industry adopts a suitable standard electronic tag on containers.

Expand Electronic Toll Collection on Bridges

Project Description

This project would expand the current project to install electronic toll collection on all Caltrans **operated** toll bridges, and provide a similar system on the Golden Gate bridge. The project involves electronic tags on vehicles and tag readers at toll booths.

Project Status

A Caltrans project to deploy electronic toll collection on all of its Bay Area toll bridges is scheduled for completion in 1998. The system is currently being tested on the Carquinez bridge. The Golden Gate Bridge Highway and Transportation District is planning to add a compatible electronic toll collection system on the Golden Gate bridge.

Project Design and Evaluation

Summary - Expansion of electronic toll collection to all toll bridges, including the Golden Gate bridge, would reduce delays for motorists at all toll booths in the region. The same system should be deployed on all bridges as soon as the initial trials at the Carquinez bridge are successfully completed.

Support for MTS Management Strategy - Expansion of electronic toll collection does not address the goals of the MTS management strategy.

Technical Achievability - The technology needed for the expansion of electronic toll collection is in use on a number of toll facilities throughout the country. Caltrans is currently testing an electronic toll collection system on the Carquinez bridge.

Institutional Achievability - The system can be deployed by the bridge operator acting independently, though the CHP will likely be involved to ensure appropriate enforcement.

Effectiveness - Expansion of electronic toll collection to all toll bridges, including the Golden Gate bridge, would reduce delays for motorists at all toll booths in the region, and reduce toll collection costs.

Customer Acceptability - Motorists are in favor of electronic toll collection. It is highly visible to consumers and provides them with direct benefits. Use of the system is optional and easy.

Scalability and Integratability - This project would be an-expansion of the existing ETC program now being evaluated in the Bay Area. Further, the ETC program could pave the way for a congestion pricing demonstration project. Using the toll tags as probe vehicles would provide valuable data for TravInfo and other transportation planning applications.

Action Plan Elements

This project is not included in the Action Plan.

Other Delpoyment Actions

Electronic toll collection should be implemented on all toll bridges in the Bay Area, including the Golden Gate bridge.

Bay Bridge Congestion Pricing

Project Description

This project would move forward with the plan to vary tolls on the Bay Bridge in response to levels of congestion. Such a system could help reduce peak hour congestion and encourage use of high occupancy vehicles, which do not have to pay a toll, and transit. The additional toll revenue would be used to fund transit and HOV related projects. Enabling technologies include real-time traffic surveillance, and dynamic toll adjustments.

Project Status

The project has stalled due to lack of political support. Enabling legislation is required at the State level.

Project Design and Evaluation

Summary - Congestion pricing on the Bay Bridge could be effective at managing peak period congestion and reducing the amount of single occupant vehicle travel on that facility. However, the project is politically unpopular and attempts to obtain the enabling legislation have failed. Changing public perception and the critical need for seismic retrofit funding, may enable the project to move forward in the near future.

Support for MTS Management Strategy - Congestion pricing would provide incentives for ridesharing and transit use, a goal of the MTS Management Strategy. It provides a tool for active management of toll facilities and optimizes movement of people, not vehicles, during peak hours.

Technical Achievability - The technology for congestion pricing is not an obstacle, as it is a policy issue more than a technological one. Electronic toll tags would make implementation easier, but would not be the critical path to its success.

institutional Achievability - The project can be implemented by Caltrans, though coordination with providers of substitute transportation services is especially important. The project requires enabling State legislation in order to change the existing tolls and then vary tolls throughout the day. It is a controversial project that will need to be carefully explained to the public and elected officials in order to be successful. Issues such as equity and how the additional money collected is used are important in the development of the project.

Effectiveness - Congestion pricing on the Bay Bridge promises to be very effective at managing peak period congestion and reducing the amount of single occupant vehicle travel on that facility. Much, but not all, of the peak period SOV reduction should transfer to

HOV/transit modes. However, some will appear as extended congestion either side of the peak period as travelers choose an earlier or later time of travel. It may also result in additional congestion on alternative routes, especially the San Mateo bridge.

Customer Acceptability - Although drivers would welcome a reduction in peak-hour congestion, the most visible component of a congestion pricing program may be the increased tolls, which would be unpopular if the benefits are not evident. The project's potential benefits would need to be thoroughly explained and demonstrated to the public.

Scalability and Integratability - If successful on the Bay bridge, congestion pricing could be extended to other toll bridges.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

Continue to seek enabling legislation from the state.

High Occupancy Toll Lanes

Project Description

This project would install electronic toll collection facilities on high occupancy vehicle (HOV) lanes to enable single occupant vehicles to use the lane in return for paying a toll. Tolls could then be used to fund construction of more HOV lanes or other programs. The toll would vary with the level of congestion to ensure HOV lanes are fully utilized but always free flowing.

Enforcement would be difficult for existing Bay Area HOV lanes due to the absence of space for a separation zone and enforcement areas.

Project Status

There are no high occupancy toll lanes in the Bay Area. HOT lanes are being studied as part of a freeway widening project on US 101 in the Santa Rosa area.

Project Design and Evaluation

Summary - High occupancy toll lanes using electronic toll collection would ensure HOV lanes are fully utilized while generating revenue to fund additional HOV facilities or other transportation system improvements or services. The system is not technically feasible on most existing HOV lanes in the Bay Area because of the lack of space for a lane separation zone and enforcement areas. It could be cost effective on new HOV facilities if included in the freeway design. HOT lanes are likely to be most successful where traffic congestion in the SOV lanes is severe for considerable distances and over considerable periods of time.

Support for MTS Management Strategy - High occupancy toll lanes could indirectly support the MTS Management Strategy goal of providing incentives for ridesharing, if the revenue is used for building additional HOV facilities.

Technical Achievability - Enforcement would be difficult for existing Bay Area HOV lanes due to the absence of space for a separation zone and enforcement areas. A monthly subscription system with a windshield decal could be used, but this would not allow dynamic control of the price to influence the demand for SOV usage of the HOV lane. Until new techniques are developed for enforcement in unseparated lanes, implementation may be feasible only on new facilities where a separator and enforcement areas are part of the design. The toll tags used for high occupancy toll lanes would logically be compatible with the electronic toll collection system now being installed on Bay Area toll bridges.

Institutional Achievability - The project could be implemented by Caltrans with the cooperation of the CHP for enforcement. It may be possible to privatize the operation, as was done on SR 91 in Southern California. There may be opposition to construction of new facilities for use by solo drivers.

Effectiveness - High occupancy toll lanes using electronic toll collection would ensure HOV lanes are fully utilized while generating revenue that may be used to fund construction of other transportation system improvements or services. HOT lanes are likely to be most successful where traffic congestion in the SOV lanes is severe for considerable distances and over considerable periods of time.

Customer Acceptability - Experience in Southern California suggests that SOV drivers are prepared to pay for use of the HOV lane. New HOT lanes may prove more popular than HOV lanes, since more drivers would have the opportunity to use them. The price can always be set at a level that will attract the appropriate number of users, even though that may have to be quite low at times.

Scalability and Integratability - HOT lanes could be deployed on any suitable freeways in the Bay Area. The electronic toll tags used for HOT lanes should be the same as those used for the toll bridges. The additional toll tags and readers deployed for HOT lanes could act as probe vehicles to collect travel time information.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

High occupancy toll lanes should be considered as part of new HOV lane construction where the required lane separation and enforcement areas can be provided. Deployment on existing HOV lanes will have to wait until technological advances overcome enforcement problems.

Smart Cards for Parking Payment

Project Description

This project would install parking meters that accept smart cards as well as cash, and install smart card readers at parking garage exits. The smart cards store a cash value which is decreased when a payment is made. Cards may be inserted in a slot, or contactless proximity cards could be used.

Project Status

There are no active projects to provide smart card payment options at Bay Area parking facilities.

Project Design and Evaluation

Summary - Smart cards for parking meters and garages would provide a convenience for motorists, but would increase the cost of parking meters. The project is likely to be practical and cost effective once a universal smart card is in common use.

Support for MTS Management Strategy - Smart cards for parking payment do not directly address the goals of the MTS Management Strategy, except to the extent that the same card can be used to pay transit fares.

Technical Achievability - It is possible, but expensive, to incorporate smart card readers in individual parking meters. The meters need to include a means for selecting the time or amount to be paid. Initially, the meters would also need to accept cash for those motorists without cards. As the use of cards becomes more universal, card-only meters could be used, with a card dispenser installed at regular intervals so that those without a card can purchase one.

Institutional Achievability - The project could be deployed by a local jurisdiction acting independently, but a regional partnership would be needed initially to establish a standard, assuming a national standard is not in place. If the card were combined with the TransLink program, participation in the TransLink financial clearinghouse would be needed.

Effectiveness - A smart card for parking meters would provide a significant convenience for motorists who would not have to find correct change and would reduce the operator's cash handling costs. However, such a project is unlikely to be cost effective until smart card readers are mass produced and inexpensive. A surcharge for card use may be able to recover the added cost. Implementation is likely to be most cost effective where installation of new meters or parking garage payment systems is already planned.

Customer Acceptability - A smart card that allowed the user to park at equipped meters, without the need for the user to have the specific amount of change, would be perceived as beneficial by the user. A smart card that could also pay for transit fares and other goods and services, would be even more beneficial and attractive.

Scalability and Integratability - The parking payment smart card could be integrated with the TransLink joint fare card, which would allow multiple transportation uses.

Action Plan Elements

This project is not included in the Action Plan.

Other Deployment Actions

No deployment is recommended until a universal smart card is in common use.

4. Action Plan

OVERVIEW

The EDP Action Plan sets out the steps that the region's public agencies need to take over the next five years to gain maximum advantage from ITS in the on-going effort to improve the management and operation of the Metropolitan Transportation System (MTS). The Action Plan focuses on initiatives of strategic significance to the region. The action items selected will:

- Support the region's MTS Management Strategy, which calls for the management of all of the regionally significant transportation facilities as a single integrated multimodal system.
- Provide substantial and visible benefits to travelers, and increase the productivity of transportation system operators.
- Leverage current investments in ITS in the region, especially TravInfo, which is the region's travel information system, and Caltrans' freeway Traffic Operations System.
- Form a core infrastructure of basic ITS elements that provide a solid foundation for further ITS deployments to improve the operation and management of the MTS.
- Integrate the different ITS projects to leverage each investment and have the full system be more than the sum of its parts.
- Recognize the crucial role of individual local agencies in the successful deployment of ITS, the limited resources available to those local agencies, and the need for those agencies to work together and with the private sector.

The San Francisco Bay Area is already making significant use of Intelligent Transportation Systems. This Action Plan envisions a substantial expansion of ITS deployment. When all actions are completed, Bay Area travelers will have the benefit of a comprehensive regional intelligent transportation systems infrastructure.

Before they commence a journey travelers will have convenient access to current travel times and any unusual conditions for all modes-freeways, surface streets, and transit-and for alternate routes. Once underway, travelers will be able to receive continuous updates to that information and will benefit from traffic and transit management systems that continuously monitor and fine tune the transportation network operation. Travelers wishing to transfer between transit systems or between modes will be assisted by coordinated operation of transit systems, a single fare card accepted by all major transit operators, and real-time information about the arrival time of individual transit vehicles. If an incident occurs on a roadway or transit vehicle, the system will enable a rapid and coordinated response by all involved agencies including guidance on alternative modes and routes, and real-time operations adjustments to accommodate diverting travelers. Transportation system operators will benefit from increased staff productivity and an improved operations management capability.

ACTION PLAN ITEMS

Eight elements compose the EDP Action Plan:

Action #l - Deploy a Probe Vehicle System

Action #2 - Expand the Freeway Traffic Operations System

Action #3 - Deploy Advanced Traffic Signal Systems

Action #4 - Deploy Transit Fleet Management Systems

Action #5 - Deploy Corridor Transportation Management Systems

Action #6 - Expand TravInfo

Action #7 - Deploy the TransLink Joint Electronic Transit Fare Card

Action #8 - Enhance Rideshare Matching Services

Detailed descriptions of each action item follow.

The order in which the action items are listed and numbered does not suggest a priority. All action items can proceed simultaneously. However, several of the new sources of data involved in the expansion of TravInfo will not be available until other action items are first completed. Other interdependencies between projects need to be considered during design and implementation, and are referenced in the individual action item descriptions below.

The action items represent the highest priority projects that form a foundation for ITS in the region and provide the most critical services for the majority of travelers. There are numerous ITS projects discussed in Chapter 3 that are not included in the regional Action Plan but are worth pursuing as opportunities arise. The following are some categories of ITS projects that should be considered by individual agencies or partnerships of agencies, but are not part of the regional Action Plan:

- Projects that test promising new techniques, such as smart shuttles, advanced transit priority at signals, and arterial performance monitoring using vehicle detectors.
- Projects that enhance or expand existing regional systems, such as expansion of electronic toll collection to the Golden Gate Bridge, installation of Weigh-ln-Motion at all truck inspection stations, and enhancement of the cellular 911 response system.
- Other projects that offer a high benefit/cost ratio in a particular locality or situation or address a particular local need, such as red light violation cameras, stop annunciation on transit vehicles, parking information systems, and video surveillance of transit vehicles and facilities.

Each Action Plan item includes a rough estimate of deployment cost. This plan does not identify funding sources for implementation, however-to be deployed, projects will need to compete successfully within the traditional regional transportation funding processes. Potential funding sources are discussed later in this chapter.

Each project will require a project sponsor. In some cases this may be a regional or state agency, but more frequently it will be a partnership of local agencies or an individual agency. A later section in this chapter describes how MTS Management Strategy support services proposed to be provided by MTC can help local agencies in ITS deployments.

Action #1 - Deploy a Probe Vehicle System

For travelers to make informed and efficient travel decisions when using the Metropolitan Transportation System, and for agencies to effectively operate the system, accurate real-time information is required. Apart from details of incidents, the information most useful to travelers is the current travel time on alternative routes and modes. Point speed measurements, which can be readily obtained from vehicle detectors, can be used to estimate overall travel times on freeways, since traffic flow is generally uninterrupted between sensors. However, on surface streets where traffic movement is routinely interrupted by intersections, the most promising method of obtaining accurate real-time travel time information, is the use of probe vehicles. Probe vehicles are also the only way to continuously monitor route selection patterns for both freeways and surface streets.

Probe vehicles are vehicles that are identified at known points and known times during their journey. The time and location information is processed by a computer that calculates the time it took for that vehicle to travel between the two points. If many such vehicles are monitored in this way, an average current travel time for that roadway segment can be determined and reported to both travelers and traffic management system operators. Similarly, the computer can calculate route selection trends by combining data on the paths taken by many such vehicles. Operators can use such information to optimize overall operation of the roadway network by adjusting. traffic control devices and the information disseminated to travelers.

Probe vehicles provide information that allows travelers to choose the route with the lowest travel time and allows transportation system operators to monitor the impacts of incidents and subsequent traffic management actions. In Houston, over 10,000 people use the Internet each month to access travel time information collected by a probe vehicle system.

This action item calls for deployment of a probe vehicle system in the Bay Area. An economical approach is to take advantage of the estimated 200,000 vehicles to be fitted with electronic toll tags in the region over the next several years as part of the electronic toll collection system being installed by Caltrans. Development of an electronic toll collection system is underway for the seven Caltrans toll bridges in the Bay Area, and all bridges except the Golden Gate Bridge will have the system installed by 1998. A large proportion of daily commuter trips cross at least one of the instrumented bridges, and the electronic tags are expected to be widely distributed.

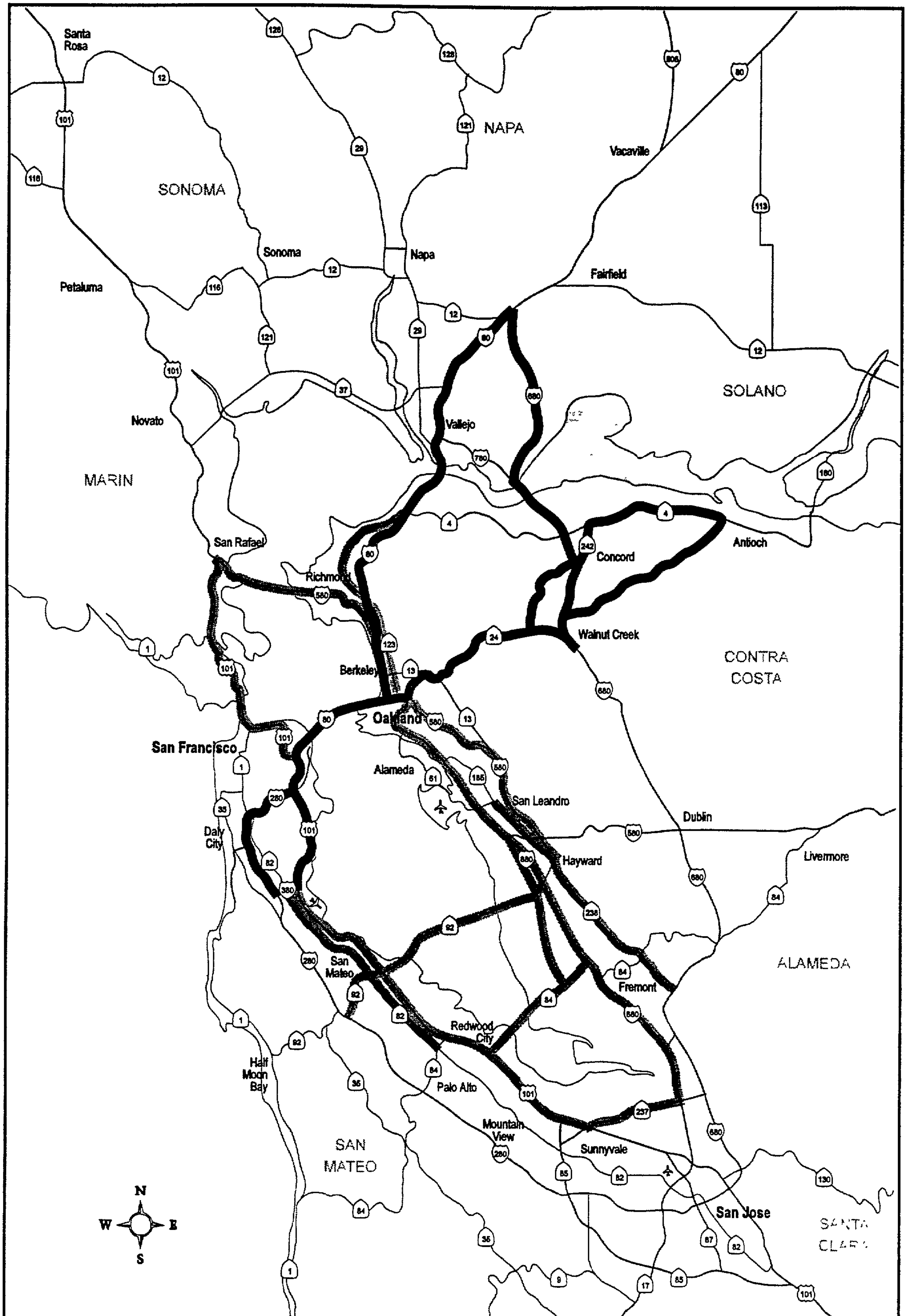
In this Action Plan element, special tag readers will be installed at strategic locations along freeways and selected arterials to record the tag identification number and time when a tag passes. This information will be transmitted to a computer at the Caltrans Transportation Management Center (TMC) in Oakland where the travel time and routing data will be assembled from all tagged vehicles. TravInfo, which is co-located with the Caltrans TMC, will provide average travel time information to travelers. The tag identification number will be discarded, and no record kept of the travel time or route selection of individual tags, thus maintaining the privacy of travelers. The probe vehicle system will be totally separate from the electronic toll collection system.

The project is planned to be funded in stages. In the initial phase, costing an estimated $2,000,000, special tag readers will be installed on I-80 from Cordelia to the Bay Bridge, I-680 from Cordelia to Highway 24, Highway 24 from I-680 to the Bay Bridge, Highway 4 from Pittsburg to I-680, and 80/US 101 from the Bay Bridge through San Francisco to I-380. Ygnacio Valley Road and Kirker Pass Road from Pittsburg to I-680 will also be instrumented. Together, these highways represent the major alternative commuter routes in the northeast quadrant of the Bay Area, as shown in Figure 1.

Assuming the initial deployment is successful, the probe vehicle system should then be extended to cover US 101 and I-880 south to Route 237, I-580 between the Bay Bridge and Route 238, US 101 between Novato and the Golden Gate Bridge, East 14th Street/Mission Boulevard between San Leandro and Fremont, Hesperian Boulevard between San Leandro and Union City, El Camino Real north of Palo Alto, and San Pablo Avenue from Pinole to Oakland. This added coverage, estimated to cost a further $2,000,000, will provide accurate travel times on most of the major freeways and parallel routes surrounding the Bay. Most sections of Santa Clara County are excluded from the initial five year deployment, however, due to the expected low number of toll tags in that area, which is remote from toll bridges.

The system will be installed by a partnership of agencies led by MTC and Caltrans. Local jurisdictions will be involved in locating readers on the selected arterial roadways and will receive a continuous transmission of the travel time and route selection data for their area. Alternative approaches using separate but less expensive tags and readers should be explored as part of the system design.

The deployment of a probe vehicle system can proceed independent of the freeway Traffic Operations System (TOS) expansion, described in Action #2, since the two serve different purposes. The TOS is primarily a freeway management tool that provides accurate traffic counts for example, but gives only basic and qualitative traveler information. The probe vehicle system is primarily a traveler information tool that provides travelers with accurate travel time measurements. The probe system also provides route selection pattern data of value in traffic management, and travel time information for surface streets.



Stage 1 Stage 2

Figure 1. Probe Vehicle Coverage Area

Action #2 - Expand the Freeway Traffic Operations System

Caltrans is implementing a freeway Traffic Operations System (TOS) that uses closed-circuit television cameras and vehicle detectors to monitor conditions on the region's freeways, ramp meters to avoid freeway overload, and variable message signs and advisory radio transmitters to advise motorists of adverse conditions and alternative freeway routes. This system is operated continuously by Caltrans and CHP personnel at the regional Transportation Management Center (TMC) in Oakland. A major function performed by the system is rapid response to, and clearance of, freeway incidents such as accidents and stalled vehicles. It also provides real-time information about current conditions on each freeway segment, such as the current level of congestion, and passes this information to TravInfo, the regional traveler information system.

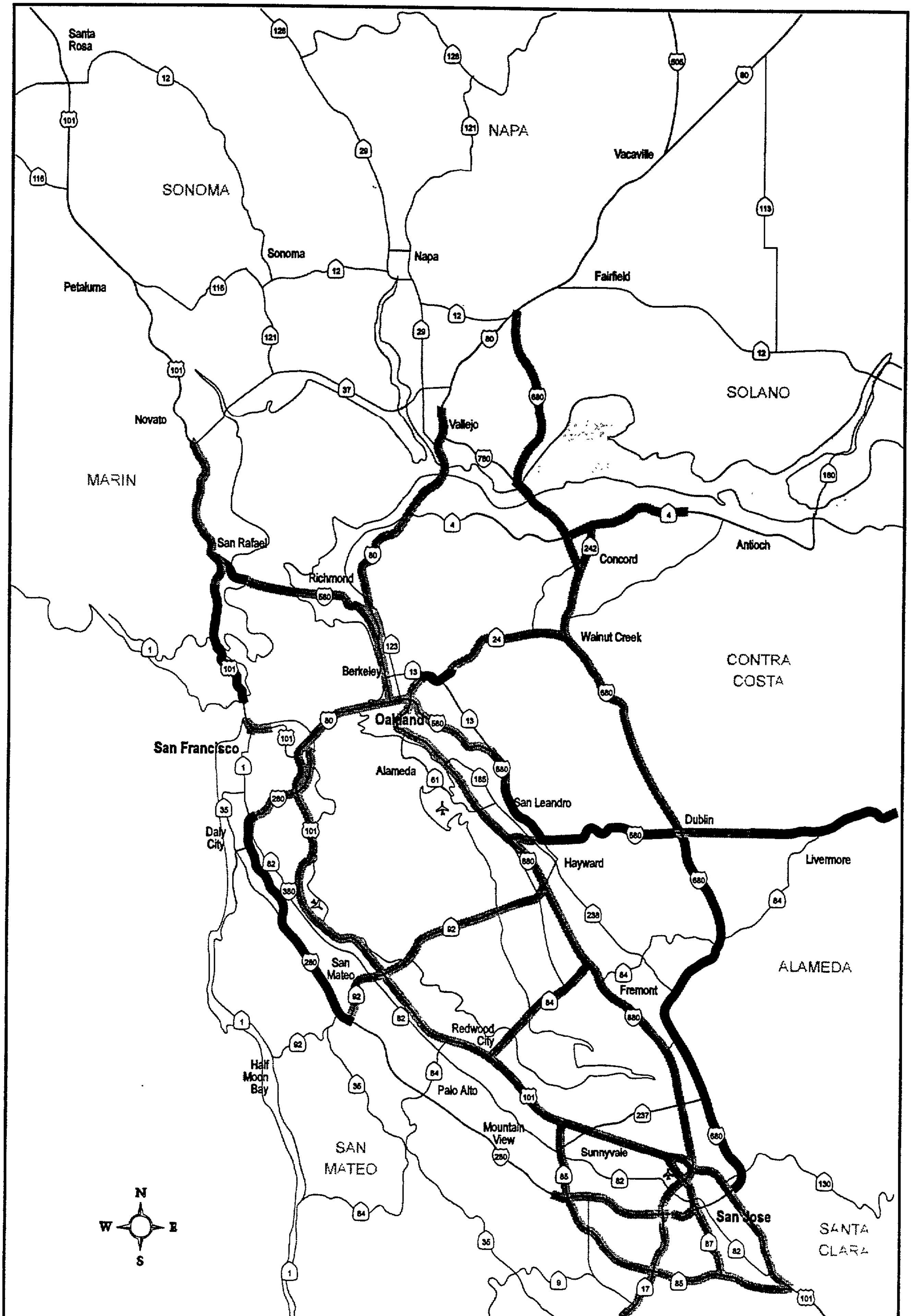
The freeways are a major element of the metropolitan transportation system. The TOS helps keep those facilities operating efficiently, and enables travelers to be kept informed of current freeway conditions. A similar freeway management system installed in Minneapolis increased the average rush hour speed from 34 to 46 mph and reduced the accident rate by 27%.

When currently funded elements of the freeway traffic operations system are completed, it will cover approximately 290 miles of the region's 500 miles of freeways. This action item is aimed at expanding TOS to install critical missing elements and to at least partially cover all the most heavily used portions of the freeway system.

This Action Plan element calls for active traffic surveillance, using traffic detectors and closed circuit television cameras, of all major freeways in the inner Bay Area that have a high rate of incidents. This will enable remote monitoring and management of incidents on all segments of those freeways, and will provide more detailed real-time information to travelers via TravInfo, including comparative information for alternative routes and modes. The freeway segments with highest priority for surveillance are as follows:

- Marin-101, Golden Gate Bridge to Route 1
- San Mateo-280, Route 92 to the San Francisco County line
- Alameda-580, 150th Avenue in San Leandro to I-680
- Alameda-580, Portola Avenue in Livermore to the San Joaquin County line
- Alameda-680 and Santa Clara-680, I-580 to US 101 in San Jose

These segments, shown in Figure 2, total approximately 70 miles; once they are instrumented, Route 13 in Oakland and a section of I-280 between Route 92 in Los Altos and Route 85 in Cupertino would be the only inner freeways without surveillance. These two freeway segments are not a high priority for surveillance since they have a low rate of incidents.



Currently Funded ▬ Action Plan

Figure 2. Freeway Traffic Operations System Coverage

This Action Plan element includes completing power and communications links to loop detectors already installed during freeway reconstruction projects, using either normal cabinets and controllers or Smart Call Boxes. Where there are no existing sensors, vehicle detectors should be installed only at each interchange. The detection should cover both the mainline and on-ramp lanes, the latter serving both ramp metering and traffic counting. The information from these detectors can be used to calculate the combined volume and off-ramp volumes. Although the design of TOS has previously called for placing detectors at one-third mile increments to permit incident detection, this function is now performed by cellular telephone reports, permitting the wider spacing proposed in this Action Plan item.

Where freeway reconstruction work is scheduled within five years of detector installation, off-pavement sensors mounted on sign or bridge structures should be used where feasible rather than loops. Cameras should be installed at an average spacing of one mile. The estimated cost of providing this level of surveillance for the designated 70 miles of freeway is $9,000,000, based on an estimated cost of $130,000 per mile. Adequate resources must also be provided to maintain these surveillance systems.

Where ramp metering is planned, all on-ramp construction and reconstruction projects should continue to provide the ramp geometry and in-ground equipment needed. Metering should be implemented as part of corridor management strategies developed in concert with local jurisdictions. Additional variable message signs and highway advisory radio transmitters should not be deployed until the effectiveness of existing devices is ascertained.

This Action Plan element also entails completion of the Transportation Management Center in Oakland to make full use of the field devices and to effectively and efficiently manage the freeway network. This work should include the provision of data and video exchange links to traffic and transit management systems operated by local jurisdictions and agencies. These links will enable coordinated multi-agency responses to incidents on all elements of the metropolitan transportation system, and will enable the operators of each element to monitor conditions on other elements. The data exchange links will also facilitate coordination of ramp meters and local traffic signals to minimize congestion on local streets. In this way, the freeway TOS becomes an integral part of a larger Metropolitan Traffic Operations System (MTOS) that includes both freeways and surface streets.

Expansion of the TOS can proceed independent of the probe vehicle system, as discussed in Action #l.

Action #3 - Deploy Advanced Traffic Signal Systems

Arterial roadways are an important part of the Metropolitan Transportation System (MTS). They provide local mobility and access, and connect the local street network to freeways. In many cases, major arterial roadways provide the primary connection between communities. Arterial roadways also carry most of the region's local transit services.

The capacity and level of service offered by an arterial street is often dictated by signalized intersections. ITS techniques provide several ways to improve signal operation, most of which rely on vehicle detectors and equipment fault monitoring systems to provide continuous data to a computer. The computer processes the information and either alerts an operator of a problem or automatically adjusts signal timing to accommodate changes in traffic. Such data processing occurs both on the street in computerized traffic signal controllers and in a central computer communicating with all signals.

Improved operation of traffic signals, especially improved coordination of signals, can significantly reduce the number of stops and amount of delay for motorists and transit riders. An advanced traffic signal system installed in Abilene, Texas, also resulted in a 10% reduction in vehicle emissions,

Most of the traffic signals on arterial roadways in the Bay Area already use such detection and data processing technology to some extent. However, there are different levels of sophistication in these signal systems, each suited to different situations, and many arterial streets can benefit from added functionality. This action item intends to expand the use of advanced traffic signal systems by enhancing systems, where needed, to provide the optimum type of signal operation for the local conditions. This may involve installing additional sensors, upgrading signal controllers, providing data communications, adding a central computer, or upgrading an existing computer system.

The MTS Arterial Operations Strategies project is developing a regionally. consistent set of procedures for identifying techniques for improved operation of the arterial streets in the MTS. These strategies will include the use of advanced traffic signal systems where applicable, and will help identify those arterial streets that would benefit the most from these systems.

While the proper signal technology must be determined for each road individually, the deployment of advanced traffic signal systems should generally focus on arteries with high traffic volumes, relatively closely spaced traffic signals, free flowing traffic between signals, and adjacent land uses compatible with an enhanced arterial operation. Time-of-day coordination pattern selection is sufficient for many streets, especially those with predictable variations in traffic volumes during the day. Most arterial streets in the Bay Area suited to signal coordination already have this basic form of coordination.

Traffic responsive pattern selection is most beneficial where traffic volumes fluctuate unpredictably such as may occur during special events, due to seasonal or recreational travel, or due to traffic temporarily diverting from a freeway during an incident. Several agencies already use this technique, including Santa Clara County on its expressways. High priority candidates for adding this capability include San Pablo Avenue from Richmond to Oakland, Hesperian Boulevard from Hayward to Fremont, Bascom Avenue from I-880 in San Jose to Lark Avenue in Los Gatos, El Camino Real from Santa Clara to Daly City, Crow Canyon Road in San Ramon and Castro Valley, Stevens Creek Boulevard in Cupertino and San Jose, and Ygnacio Valley Road and Kirker Pass Road in Walnut Creek and Concord. Some segments of these arterial roads already have traffic responsive operation in place or planned.

Adaptive timing is most valuable where traffic volumes change often or quickly, where traffic patterns are complex, where some signals require a much longer cycle length than others, and where it is difficult to achieve needed two-way progression using traditional fixed cycle coordination. Sites that have been identified as candidates for adaptive timing include the San Tomas Expressway in Santa Clara County, California Boulevard in Walnut Creek, Hesperian Boulevard in San Leandro and San Lorenzo, Fair Oaks Avenue and Mathilda Avenue in Sunnyvale, and 19th Avenue/Park Presidio in San Francisco. There is no adaptive timing currently in use in the Bay Area except for an outdated green-wave system used on some streets in Sunnyvale.

Signal systems operated by different agencies should be interconnected as needed and cooperatively operated to provide seamless coordination across jurisdictional boundaries, even where traffic responsive or adaptive timing is used. Nearly all of the streets referenced above span multiple jurisdictions. The wide area computer network being developed for corridor management systems is equally applicable for interconnection of adjacent traffic signal systems. Shared use of operations personnel should be considered as a means of minimizing operating costs and enabling extended hours for on-site staffing.

Advanced traffic signal systems are a part of the Intelligent Transportation Systems (ITS) core infrastructure. They are a key ingredient in other ITS systems such as corridor transportation management, advanced signal priority for transit vehicles, and real-time information for travelers. The estimated cost of advanced traffic signal system deployments over the next five years is approximately $8,000,000, based on an average cost of $700,000 per project for twelve projects.

Action #4 - Deploy Transit Fleet Management Systems

Enhanced operation and coordination of public transit is a core principle of the MTS Management Strategy. The operation of mass transit systems can be enhanced if dispatchers have accurate real-time information about each vehicle, including its exact location, the number of passengers on board, and the vehicle's status including any equipment malfunctions and emergencies involving passengers or the driver. This information can be provided by a fleet management system that tracks the location and status of each vehicle and allows data transmissions between each vehicle and the dispatch center.

Transit fleet management systems have been proven effective in deployments across the country. They can reduce operating costs and enable the following functions:

- Dispatchers can accurately monitor the schedule adherence and passenger loading of each vehicle and implement mitigating actions when a vehicle falls too far behind schedule or cannot accommodate more passengers.
- Vehicles scheduled to meet at transit transfer centers can be held for a short time if the late vehicle will arrive shortly.
- Accurate real time information, including the time of arrival of the next vehicle, can be given to waiting passengers.
- Police and other emergency services can rapidly respond to emergencies involving a transit vehicle since a silent alarm can be sent instantly and the vehicle's exact location is always known.
- Historical performance measures collected by the system can be used to fine tune schedules, identify vehicle operators needing additional training, and measure system improvements over time.
- Traffic signal priority can be provided only for transit vehicles that are significantly behind schedule.
- Records of actual vehicle arrival and departure times can be used to verify or counter claims by passengers and can help settle legal disputes.
- Stop annunciation can be automated using the vehicle's known location.

A transit fleet management system installed in Toronto enabled a 4% reduction in the fleet size, and Baltimore MTA improved on-time performance by 23%.

BART and the Napa transit system already have fleet management systems, and AC Transit is currently implementing a system which will be operational in 1998. This action item calls for regional assistance for further deployment of transit fleet management systems, especially for transit properties with high ridership, such as the Santa Clara Valley transit system, SamTrans, Muni, and Golden Gate. In addition, Caltrain can be equipped very economically given the small number of trains but high number of passengers per train. Tracking of Caltrain trains will also enable enhanced management of rail grade crossings on the peninsula.

Each system should be designed and implemented to minimize costs and provide only those functions most needed initially. Systems should be designed to enable other modules or functions to be added economically in the future. Where possible, on-board equipment should be funded as part of new vehicle purchases or radio system upgrades. Operators should consider teaming in joint procurement arrangements so they can share the costs of design and engineering and take advantage of economies of scale found in larger equipment purchases. All systems should take full advantage of the lessons learned by other transit agencies in similar deployments, including the experiences of Napa and AC Transit.

Each system should provide real-time schedule adherence information to TravInfo for individual routes and individual runs on each route, so that travelers can be provided with next-vehicle arrival time information. Each should also include a data exchange link to enable coordination of operations where services overlap and at shared transit centers. Each system should also enable a link to a corridor transportation management system, such as the Silicon Valley Smart Corridor, where appropriate. The same data format may be appropriate for the TravInfo, inter-operator data exchange, and corridor management system interfaces. Transit fleet management systems should use data communications and equipment interface standards being developed by various standards development organizations for on-vehicle, center-to-vehicle, and center-to-roadside communications.

The aspects of transit fleet management systems of greatest regional significance are the ability to provide real-time transit information to TravInfo, exchange data between transit operators with overlapping service areas, operate timed transfers, effectively share costs of design and implementation of transit fleet management systems between agencies, and share results of early experiences among all operators.

Action #5 - Deploy Corridor Transportation Management Systems

A core principle of the MTS Management Strategy is the integration of transportation system elements including coordination of real-time operations of freeways, arterial streets, and mass transit systems.

Such coordination can assist travelers at any time, but is particularly valuable in response to major incidents, such as an accident that blocks lanes on a freeway for an extended length of time. During such incidents, travelers often benefit from changing mode or route. To make good travel choices, travelers need accurate information about current conditions on all modes and routes. Diversions can overcrowd other routes and modes and require immediate changes to the operation of roadways and transit systems to accommodate the sudden fluctuation in demand.

Corridor transportation management systems integrate freeway and traffic signal operations and add surface street traffic surveillance, surface street motorist information, and interagency data exchange for coordinated operation and incident management. This enables the involved agencies to integrate their operating systems and procedures, and to collectively manage transportation from a corridor-wide perspective. Travelers get seamless and consistent information and coordinated traffic controls.

The Silicon Valley Smart Corridor is an example of an Intelligent Transportation System currently being deployed in the Bay Area that will enable coordinated real-time operation of freeways, surface streets, and transit systems in the I-880 and Highway 17 corridor in Santa Clara County. The $5 million system, to be completed in 1998, involves upgrades to existing advanced traffic signal systems, installation of closed circuit television cameras and vehicle sensors for monitoring traffic on both the freeway and adjacent arterial streets, installation of variable message signs on the arterial streets to alert motorists of current travel conditions, and a wide area computer network and data exchange capability between the traffic control computers operated by each of the seven agencies (five cities, the county, and Caltrans) responsible for traffic management in the corridor. The design includes a connection to the Santa Clara Valley Transportation Authority transit control center in the next phase of deployment. The agencies will develop joint operating procedures to collectively manage transportation in the corridor, including coordinated response to incidents. Real-time data exchanged between computers will automate some actions such as changes in signal timings.

This action item is aimed at providing a similar capability in other corridors in the Bay Area. Such systems will be most valuable in corridors in which most through travel occurs on one or more freeways and where incidents on a freeway often result in large scale diversion of travelers to parallel local surface streets, though they are valuable any place freeway and arterial systems interact closely. Deployment is likely to be most feasible in areas where local jurisdictions already operate computerized traffic signal systems and where the efficient movement of both traffic and transit is a high priority for the local community. Corridor management systems do not require that a regional transit system such as BART of Caltrain be located parallel to the freeway, since most travelers considering diverting to transit would make decisions based on pre-trip information provided by TravInfo rather than en route. However, where sufficient transit capacity exists to accommodate diversion, real-time information and management of transit should be incorporated into the corridor system.

Candidate corridors for deployment of a corridor management system include the US-101 corridor in Santa Clara and San Mateo Counties, the I-880 corridor in Alameda County, and the Route 24/I-680/Route 4 corridor in central Contra Costa County. Systems should first be installed in the I-880 and central Contra Costa corridors within the next five years, since these two candidates have existing advanced traffic signal systems and local agencies already cooperating in regional traffic management. The estimated cost of these two systems is $9,000,000.

Corridors that have no good alternative arterial routes to which traffic diverts locally during an incident on the freeway, such as the I-580 corridor in east Alameda County and US-101 in Marin, are not a high priority. A corridor management system would be useful in the I-80 corridor in Contra Costa and Alameda Counties which has San Pablo Avenue as a diversionary route, but deployment would be financially and politically challenging given the absence of existing advanced traffic signal systems, and the diversity of local jurisdictions' transportation priorities.

Both the US-101 and I-880 corridor systems could be built as extensions of the Silicon Valley Smart Corridor network, or separate systems could be developed initially and then joined later as needed. All deployments should use a common data exchange format based on the National Transportation Communications for ITS Protocol (NTCIP) to ensure compatibility. A partnership of local agencies formed around the East 14th Street and Hesperian Boulevard signal coordination projects and the I-880 corridor MTS Management Strategy initiative could serve as a useful starting point for deployment of a system in the I-880 corridor. Similarly, the TRANSPAC group of agencies in central Contra Costa County represents a useful partnership built around common traffic congestion problems and with a strong interest in regional solutions.

The freeway Traffic Operations System (TOS) is an essential part of corridor management systems, since it provides ramp metering, surveillance, motorist information, and rapid response to incidents on the freeway. Advanced traffic signal systems are another necessary building block, since they enable signal coordination timing to vary automatically as traffic diverts from the freeway to local arterial streets. Corridor systems integrate the freeway and traffic signal operations components and add surface street traffic surveillance, surface street motorist information, and inter-agency data exchange for coordinated incident management including coordinated management of rail transit facilities in the corridor. Corridor systems can also add a linkage to local transit fleet management systems to enable the transit agencies to have real-time access to detailed traffic operations information and to implement signal priority for transit vehicles that are running behind schedule.

Action #6 - Expand Travinfo

TravInfo is the Bay Area's clearinghouse for real-time traveler information. The system, which will commence operation in Fall 1996, will collect, process, and disseminate real-time traveler information for roadways and transit systems throughout the region. Initially, the primary sources of real-time data are the CHP emergency dispatch system for roadway incidents, the Caltrans Traffic Operations System (TOS) for information about freeway congestion, and ad hoc reports from transit operators and local emergency services. TravInfo's operation is funded through early 1998, but the system must by then become sustainable with little or no ongoing public subsidy.

More data are needed to enable TravInfo to fully achieve its goal of comprehensive traveler information for all modes and facilities in the Bay Area. The provision of such information directly supports the MTS Management Strategy by allowing travelers to see and compare conditions on all modes, facilities, and routes when making travel decisions. Several of the 'other action items in the Action Plan will generate additional data for TravInfo.

This action item calls for linking TravInfo to additional sources of data, some of which are already available and others that will be provided by planned ITS initiatives. This action item includes automating the data collection process and incorporating the new data in the data processing, fusion, storage, and dissemination processes at the TravInfo center. The estimated cost of the work is $3,000,000. The major new data sources expected to be available within the next few years are:

- Freeway and arterial roadway travel time information from the planned probe vehicle system and additional TOS equipment. (See Actions #l and #2)
- Transit vehicle schedule adherence, vehicle location, arrival time, and incident reports from existing and planned transit fleet management systems, including the AC Transit system scheduled for completion in 1998. (See Action #4)
- Arterial roadway incident and status information from corridor transportation management systems. (See Action #5)
- Traffic signal malfunction reports and traffic volumes and density from advanced traffic signal systems. (See Action #3)
- Inter-regional travel conditions from TransCal.
- Road maintenance and incident information from the Caltrans fleet dispatch system.

Integration of TravInfo with TransCal should be made a part of the statewide Smart Traveler program which aims to eventually standardize and link all traveler information systems in California. Integration with systems outside the state may need to await development of national standards.

Expansion of TravInfo will require the on-going operation of other Traveler Information Centers to collect and process data. TravInfo's design permits distributed operation, and San Jose is a likely location for a second TIC.

Action #7 - Deploy the Translink Joint Electronic Transit Fare Card

MTC leads a multi-agency effort to identify an electronic fare card suitable for use by all transit agencies in the region. Smart card technology appears to overcome reliability and processing speed problems encountered in early TransLink trials of traditional stored-value cards. The adoption and deployment of a standard card would directly support the MTS Management Strategy's core principle of enhancing the operation and coordination of mass transit.

A joint electronic fare card offers the following benefits:

- Travelers can purchase one card and use it on any transit system.
- Travelers need not know the fare or find the correct change.
- Travelers can more easily transfer between transit systems.
- Passenger boarding time can be reduced by up to half.
- Transit operators have less cash to process, reducing handling costs. TransLink card distribution and recharging, and transaction processing will also be more cost effective for operators than existing passes and transfers. The overall cost of fare collection per ride using TransLink could be as much as a third less than the existing cost, even when the initial capital cost is included.
- Operators could consider graduated fare schedules, such as time-of-day fares.
- Transit operators are provided with valuable statistics about ridership on each run of each route, and for transfers. With additional automated or manual stop identification input, statistics can be provided on a per-stop basis even for buses.

The TransLink Program Plan calls for implementation of the TransLink joint fare card on all transit systems within five years. The transit agencies continue to cooperatively work towards a trial implementation during 1997 and full deployment commences in 1998. The trial and initial deployment will focus on the major transit systems including BART, Caltrain, Muni, Golden Gate, AC Transit, and Santa Clara County. The estimated capital cost of full implementation is $17,000,000. Costs can be minimized by leveraging the benefit that the system offers financial institutions wanting to launch general purpose smart card services, and by installing equipment as part of planned fare collection system upgrades where appropriate. On-going operation and maintenance costs are projected to be significantly less than for current fare collection methods.

Adoption of an open architecture smart card system will have the following benefits:

- Transit agencies may not have to pay for dedicated supporting infrastructure such as card manufacturing, data processing, and recharging terminals.
- Transit passengers will be able to recharge their card at ATM machines and other convenient financial transaction terminals.
- Passengers may be able to use the same card for other purchases and payments.
- There will be greater opportunities to share deployment, operating and maintenance costs with the private sector and other users.
- The cost of equipment will be minimized due to economies of scale.
- The system can cost effectively evolve to support multiple card types, including both contact and contactless technologies.

It is not necessary to wait until all agencies are ready to implement the system simultaneously. Early adopters get the full benefits of an electronic fare collection system regardless of when other agencies begin using it. Passengers get additional benefits as more agencies support the card.

Action #8 - Enhance Rideshare Matching Services

The MTS Management Strategy emphasizes the movement of people, rather than vehicles, during peak travel periods, and encourages the use of high occupancy vehicles. Ridesharing is one way to increase the occupancy of vehicles and reduce the number of vehicles using the region's roadways. RIDES for Bay Area Commuters currently operates the regional rideshare database under contract to MTC. The database contains information about commuters looking for carp001 or vanpool opportunities, either as a driver or passenger, and the computer software can generate a list of potentially compatible commuters. Travelers can register and obtain a match list by contacting RIDES directly or via subregional rideshare assistance services such as Solano Commuter Information. Many larger employers also offer rideshare assistance programs that use the RIDES-maintained database.

This action will enhance current carpool and vanpool based rideshare matching systems by adding the following services.

1) Automate both the registration process and the match list issuance. Allow a prospective driver or rider to use a computer to enter the needed information and to receive a match list with little or no input from a human operator. Allow users to update their information on-line. Customers could have 24 hour access from any location.

2) Provide more detailed and customized information about rideshare, transit, and bicycle options, for both registered and ungistered travelers. Automatically extract information pertinent to the traveler based on information about that traveler's needs.

3) Allow same-day rideshare matching for particular trips, especially for the ride home when a rider is unable to use his or her formal carpool, during emergencies including "spare the air" days, and ride sharing for special events and major destinations such as airports. Such casual matches may be arranged a day ahead or just an hour or two ahead.

The estimated cost of the system modifications, training, and public relations campaign needed to implement these enhanced services is $l,OOO,OOO. Operating costs should not increase since any additional time needed for customer support due to an increased number of customers or specific services (e.g., same day ride matching) will be offset by reduced time needed for serving routine customers once self-service registration and match list generation is available.

The project would help make ridesharing easier and more reliable. It would also provide more targeted information to travelers who may be candidates for ridesharing, thus attracting more riders.

SUPPORT SERVICES FOR THE MTS MANAGEMENT STRATEGY

MTC will serve as lead agency on few projects in the Early Deployment Plan, even among those projects which make up the eight elements of the EDP Action Plan. Most will be implemented by a partnership of local agencies or by a single agency. Projects in the Action Plan all are regionally significant, however, and because MTC will not lead deployment of these regionally significant projects, it is the agency's responsibility to assist local project sponsors to help assure their success. The significance of the Action Plan projects lies not in their use of innovative technology, but in their use of active management techniques on transportation facilities. Analysis of projects for inclusion in the EDP has focused on the role of technology in enabling implementation of Metropolitan Transportation System (MTS) Management Strategy.

In developing the ITS Early Deployment Plan, the project team of MTC and consultants held numerous meetings and discussions with personnel in public agencies responsible for the planning and operation of much of the MTS, including both roadway and transit components. These meetings reveal an almost universal need and desire among local agencies for third-party assistance in the deployment of ITS projects, Local agencies reported that they lack knowledge of the new technologies involved in ITS and staff time needed to research and develop proposals. Many projects that hold great potential for addressing acknowledged transportation problems lack a local champion able and willing to play a leadership role in a partnership of agencies needed for deployment.

Project sponsors face many of these hurdles in developing other types of projects which implement MTS Management Strategy principles. Recognizing financial, environmental and political limitations, the MTS Management Strategy calls on transportation system operators to accommodate increasing demands for mobility by using active management techniques to improve the efficiency of the transportation system, rather than capital investment to enlarge the system. Key principles of this strategy include the planning and operation of streets, freeways and transit services as a single system; better coordination of transportation and land use; and a focus on corridor management which emphasizes the movement of people, rather than vehicles, at peak hours, emphasizes the movement of freight at other times, and targets capital investment at improving the continuity of arterials, coordinating public transit operations, and providing incentives for ridesharing and transit use.

Support Service Elements

To assist in implementation of the eight elements of the EDP Action Plan, MTC will provide on-going support for ITS deployment as part of broader MTS Management Strategy support services. The services available to local agencies from MTC will include education and information dissemination, technical assistance on project development, and assistance in formation and maintenance of interagency partnerships.

Education and Information Dissemination

MTC will provide ongoing education on ITS and the use of system management techniques to the region's transportation professionals, particularly public agency staffs, as well as to elected officials and the general public. This education will be provided in meetings of MTC-sponsored and staffed committees such as the TDM Task Force, in brief presentations to outside agencies such as county congestion management agencies, and to professional societies such as local ITE chapters. Where appropriate, MTC will convene or help sponsor special workshops on topics of interest to partner agencies. MTC will work with national organizations such as ITS America and Public Technology, Inc., and statewide groups such as CAATS, Calstart, and the Caltrans New Technologies and Research Program to leverage outside resources.

Such information can be general or specific to a field or project of special interest to an agency. Appropriate topics for the education program including MTS opportunities, benefits, new developments and technologies, and the status and results of current projects. In addition, MTC will disseminate information about opportunities and activities by issuing an occasional newsletter. MTC will maintain educational and presentation materials at its library for use by local agencies.

One focus of the education effort to the transportation community will be improving information sharing among local agencies so each is aware of MTS management projects undertaken in one part of the Bay Area, such as the AC Transit fleet management project or the Silicon Valley Smart Corridor, which could serve as models elsewhere in the region. Agencies considering such projects would be able to learn from the experiences gained by others further in the implementation process.

Technical Assistance

Many of the skills required for implementing MTS Management Strategy projects are unfamiliar to local agencies. Public works and highway departments are more familiar with construction and maintenance of facilities than with active management of their operations. Transit agencies must operate their systems in real-time, but are unfamiliar with ITS technologies that can make their operations more flexible and often have little experience tailoring their operations to improve coordination with connecting systems.

Unfamiliarity with new types of projects, and the lack of experience on needed skill sets to implement those projects, is frequently a barrier to agencies that wish to actively manage their component of the MTS. MTC will therefore give preliminary technical assistance to agencies and partnerships proposing MTS management projects, including those involving ITS. Such assistance will not provide complete design and implementation engineering services. It will provide sufficient technical input for an agency to formulate a sound project proposal and funding application, and can provide limited technical assistance to staff or consultants in the detailed design and implementation. Local agencies will still need to include the cost of design and implementation consultant services in project funding applications if the agency does not have the necessary resources in house.

MTC will also provide assistance in writing funding applications, including identification of potential and preferred funding sources and formation of a funding strategy, including possible private sector investment or revenue generating potential. Many of the available sources of public funding have criteria which favor projects involving partnerships, improving the efficiency of the transportation system, or involving ITS and other applications of innovative technology. Other funding programs which have typically been used for traditional capital projects are also appropriate for MTS management projects if a funding application is designed to respond to those sources' selection criteria. In addition, ITS projects often provide opportunities for private sector involvement, either because they demonstrate a new technology or because they provide valuable, and potentially profitable, services directly to the traveling public.

MTC will also proactively look for opportunities for coordination between projects. MTC staff will stay abreast of all MTS projects in the Bay Area and will have a general knowledge of projects elsewhere. Opportunities for integrating, leveraging, replicating, sharing resources or other synergies between projects will be identified.

Partnering Assistance

Because the MTS Management Strategy focuses on improving the coordination of disparate elements of the transportation system owned and operated by multiple agencies, projects to implement the strategy generally are implemented by a partnership public (and often private) entities. Such projects are inherently more difficult to initiate, develop and sustain, since no single agency has the incentive to lead the effort.

MTC, as the agency responsible for regional transportation coordination, will assist in the formation and maintenance of local partnerships seeking to implement MTS management projects. This element of the MTS management support service will carry on efforts begun as part of Phase I of the MTS Management Strategy project and the ITS Early Deployment Plan. In both projects, MTC convened groups of local agencies to discuss common transportation needs and propose projects to address them.

As part of the support service, MTC will assist local agencies in formulating project concepts, identifying the needed partners, arranging meetings between those partners, identifying the lead agency, and assisting that lead agency through the project initiation process. MTC will provide assistance in the formation of written inter-agency agreements such as a memorandum of understanding if needed, or a Transportation Management Agency.

Implementing Support Services

Many of the components of the MTS Management Support Service can be incorporated into existing MTC efforts. Indeed, a focus on the MTS Management Strategy should pervade all MTC activities, and all activities should consider whether ITS can serve as a lower cost alternative to traditional investment or can provide improved service. MTC staff should work with their local counterparts to make certain agencies are adopting principles of the MTS Management Strategy, are aware of the potential of ITS, and are not overlooking opportunities to form productive partnerships for projects which cross jurisdictional boundaries. The education component of this MTS support service will assist coordinators in this effort.

Other aspects of the support service must be explicitly adopted into MTC's work. In its current solicitation for consultant assistance, the Traffic Engineering and Technical Assistance Program (TETAP) is seeking firms with expertise in use of ITS. The next round of TETAP project solicitations should encourage applicants to put forward transportation systems management projects, and project selection criteria must reward such applications. MTC must also offer a framework for giving technical assistance to transit projects not eligible for TETAP funding,

Round 3 of the MTS Management Strategy project will again include direct MTC support of corridor partnerships. This effort should make direct use of Early Deployment Plan recommendations so participants consider appropriate ITS projects among their techniques for MTS management. MTC staff should take care to incorporate transit operators in corridor partnerships to prevent MTS Management Strategy efforts from focusing primarily on roadway operations.

Finally, future revisions of scoring criteria for regional funding programs should consider an application's adherence to MTS Management Strategy principles and EDP Action Plan recommendations. Some, such as the Transportation System Management (TSM) program, already share many of the same criteria, but none explicitly reference the list of MTS Management Strategy principles or the elements of the Action Plan. Any revisions to selection criteria must remain consistent with state and federal guidelines and must be adopted by the full Commission or by the Bay Area Partnership.

FUNDING FOR ITS

ITS projects must compete with other types of transportation projects for traditional general program funds; there is no permanent funding source specifically dedicated for ITS projects. The following table lists the major regional, state, and federal transportation funding programs for which at least some ITS projects are eligible.

Table 2. Major Funding Sources for ITS Projects

Funding Program	Annual Funds for Bay Area	Comments
Traffic Systems Management (TSM)	Total: $12m % ITS: 70%	Targeted to freeway and roadway operational improvements. ITS competes with auxiliary and HOV lanes.
Surface Transportation Program (STPI	Total: $51 m % ITS: 5%	General purpose and flexible funding, with large array of competing projects.
Transportation Development Act (TDA)	Total: $160m % ITS: Minimal	Bay Area dedicates to transit, primarily operations, with capital funds usually as local match to federal funds.
State Transit Assistance ETA)	Total: $24m % ITS: 10%	Mostly used for transit operations, with about 25% used for capital, including TransLink.
FTA Section 9 (capital)	Total: $85m % ITS: Minimal	Section 9 available for operations and capital; capital typically used for vehicle replacement.
FTA Section 3 -excluding New Rail Starts	Total: $73m % ITS: Minimal	Intended for major transit capital projects, including vehicle and facility replacement.
Transportation Fund for Clean Air (AB 434)	Total: $17m % ITS 25%	Separate return-to-source and discretionary portions. Smart shuttles, traffic signal, and other projects eligible.

In many funding applications, ITS is included as one component of a larger project. For example, the cost of new BART fare gates may include TransLink capabilities, and a freeway ramp improvement project may include TOS equipment. Therefore the estimates of spending on ITS are illustrative, rather than definitive. In addition, ITS projects are eligible even for the funding programs listed above as having a "minimal" ITS share. For example, a bus replacement grant could cover automatic vehicle location (AVL) equipment, even though the cost of AVL may be a small portion of the total grant.

The Federal Department of Transportation occasionally arranges dedicated funding for pioneering or demonstration ITS projects. Such programs are sporadic, unpredictable, and highly competitive. There is usually no regional or formula allocation of these grant funds and the Bay Area must compete with all parts of the country. TravInfo has been largely funded by ITS Field Operational Test fund grants from the FHWA, but that program is not currently funding new projects.

The Bay Area has recently applied for a FHWA Model Deployment Initiative grant. This program will provide $20 million in its first year, to be divided among two or three regions to complete deployment of a comprehensive ITS infrastructure showcasing the potential to integrate core ITS projects.

Other Federal agencies offer programs in which some ITS projects can compete. The Department of Commerce and the Advanced Research Program Agency (ARPA) of the Department of Defence both offer opportunities for innovative ITS projects that have commercial potential or can help with defence industry conversion. BART and private sector partners are developing a new train control system using Technology Reinvestment Program funds from ARPA. This project is also an example of a public/private partnership which contributes private sector investment in return for marketing rights to the final product.

ITS projects usually involve installation of new systems and equipment that require annual expenditures for operation and maintenance. Most roadway project funding programs are not practical sources for on-going operation and maintenance funding. The reauthorization of ISTEA may explicitly address this issue, but even if long term operation and maintenance become eligible expenditures under a program such as STP, agencies may prefer to use grant monies for capital purchases and use general revenues, which are better suited to smaller recurring expenditures, to fund operation and maintenance. These recurring costs may be viewed as the local match for grants. It is also possible to fund long term maintenance contracts as part of initial system purchases under some programs.

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Appendix A - Regional Transportation Problems

INTRODUCTION

In Task 3 of EDP development, 133 problem statements were developed reflecting specific problems in the Bay Area's transportation system that ITS could potentially address. This appendix lists and defines each of the identified regional transportation problems. Each problem is stated in a generic form and is assigned to one of the following categories.

- Problems Related to Lack of Facilities
- Problems Related to Travel Delays
- Problems Related to Lack of Information
- Problems Related to Safety and Security
- Problems Related to Regulations and Charges
- Problems Related to Comfort, Convenience, and Ease of Use
- Problems Related to Environmental Impacts

Within each of these categories, the problems are listed as either a "User/Community" problem or a "System Operator" problem. This is not to imply that system operators are not concerned with user and community problems. The former are problems which directly impact, and are perceived by, the community and users of the ground transportation system as well as operators. The "system operator" problems do not directly affect the user and therefore are not reported by users. However, they have an indirect impact on users due to their effect on system operation.

The term "operator" here applies to the public sector operators of the transportation system (roadways and transit systems) and not, for example, the operator of a fleet of trucks used for freight delivery. In this context, the latter is a user of the public street network. Problems faced by private fleet operators are addressed in the "user/community" category.

Several of the categories are further subdivided into smaller groupings. For example, *User/Community Problems Related to Travel Delays* are grouped into the subcategories, "Demand Exceeding Capacity", "Traffic Control Points", "Vehicle Interactions", and "Transit Operations". Each problem was assigned a high, medium, or low priority, depending on how widespread it is in the region's transportation system and how severe it is in the locations where it occurs.

The following sections list the problems by category, and indicate the priority (high, medium, or low) assigned to each problem.

Problems Related to Lack of Facilities

User/Community Problems

M Riscontinuties ***in Network*** - There are discontinuities in the road, rail, bus, bikeway, and sidewalk networks. These gaps in the system require users to travel extra distances or to use alternative modes.

M ***Limited Transit Service Areas*** - Transit does not serve certain areas at all, and serves other areas only some of the time.

M ***Limited Transit Feeders*** - Feeder service to line haul transit systems is often inadequate or nonexistent.

L ***Missing HOV Lanes*** - Some congested sections of freeways and expressways do not have HOV lanes.

L ***No Bicycles on Bridges*** - There is no bicycle access on most major bridges.

L No ***Bicycles on Transit*** - Bicycles cannot be taken on most transit vehicles, particularly at peak hours.

H ***Constrained Interreginal Links*** - There are limited connections between the Bay Area and the rest of the state. This concentrates travel on the few available links which frequently experience congestion during peak commute and recreational travel periods.

M ***Parking Shortage*** - There is a shortage of parking in some areas at some times. Inadequate parking capacity at certain transit stops is a particular problem. There is a shortage of parking for trucks, for both curbside deliveries and overnight parking.

System Operator Problems

M ***Demand/Capacity Imbalance*** - It is difficult to maintain a balance between the demand for a particular mode of travel, which is generally determined by land use decisions, and the capacity of the transportation infrastructure.

M ***Environmental Constraints*** - It is often environmentally impractical to provide additional road, rail, or bikeway facilities.

H **Constrained Funding -** The cost of providing and operating needed road, rail, bus, and bikeway networks exceeds available funding. Limited operating funds for transit is a particular problem.

H **Low Transit Ridership -** Low density developments (both residential and employment-generating) are unable to generate sufficient ridership to support traditional fixed route transit service, especially at night and on weekends. Low ridership on interregional trams threatens those services.

M **Park/Ride Low Utilization -** Park-and-ride lots for HOV and transit users are often either severely overcrowded or virtually empty.

H **Constrained Street Width** - Street widths are constrained and often cannot be widened, which causes through lanes, turn lanes, parking, and bicycle lanes to compete for the available space.

M **Constrained Transfer Terminals** - Transfer terminals, such as regional rail transit stations and ports, often experience congestion and have to allocate scarce space among competing demands.

Problems Related to Travel Delays

User/Community Problems

DEMAND EXCEEDING CAPACITY:

H ***Peak Period Congestion -*** Demand exceeds capacity at peak times causing service break down and traffic congestion. In addition to congestion on freeways and arterial roadways, parking lots fill up and motorists must look for a vacant space elsewhere. On transit systems it means transit vehicles are full and users have to wait for the next vehicle.

M ***Roadway Bottlenecks -*** Substandard or narrow roadway sections reduce capacity, causing bottlenecks that slow traffic, including buses.

H ***Incidents Reduce Capacity*** - Incidents on freeways, surface streets and transit systems reduce the capacity of those facilities and cause congestion.

M ***Diversion During Incidents -*** Major incidents cause diversion to other routes and modes, causing congestion and delay throughout the area.

M ***Roadwork Closures -*** Construction and repair activities often close lanes or reduce travel speed, and cause unexpected delays.

L ***Concentrated Buses*** - Concentration of buses at pulsed transfer centers causes traffic congestion, slowing all vehicles including buses.

L ***Concentrated Trucks*** - Concentration of trucks near ports causes traffic congestion.

L ***Special Events*** - Special events overload the transportation network (roadways, parking, and transit) surrounding event venues.

M ***School Traffic*** - Areas near schools experience localized congestion at the start and end of the school day.

M ***Through-Traffic*** - Through-traffic can overload arterial roadways designed for local travel.

M **Recreational Traffic** - Weekend and holiday recreational traffic peaks can overload roadways.

TRAFFIC CONTROL POINTS:

H **Traffic Signals** - Vehicles (including buses) have to stop at too many traffic signals. Large trucks sometimes experience additional stops because some traffic signal timings do not accommodate their slower acceleration and speed.

L **Stop Signs** - Vehicles (including buses) have to stop at too many stop signs.

L **Ramp Meters** - Vehicles (sometimes including buses) have to wait at ramp meters.

M **Toll Payment** - Vehicles (sometimes including buses and carpools) have to stop to pay tolls on bridges.

L **Railroad Gates** - Vehicles (including buses) have to stop when railroad gates are lowered.

L **Drawbridges** - Vehicles (including buses) have to stop when a drawbridge is raised.

M **Weigh Stations** - Trucks have to stop at weigh stations.

L **Bicycle Detection** - Actuated traffic signals often fail to detect the presence of bicycles.

VEHICLE INTERACTIONS:

M **Shared Lanes** - Turning traffic blocks through-traffic when there is no separate turn lane.

L **Buses Stopped in** Lane - Traffic is blocked by buses stopped in a travel lane at bus stops.

L **On-street Parking** - Vehicles maneuvering into on-street parking spaces or double-parking block a travel lane.

L **Ramp Meter Queue** - Queues from ramp meters can back onto local streets and delay local traffic.

L **HOV Lane Merges** - Merging at transitions between HOV lanes and normal lanes can cause traffic congestion.

TRANSIT OPERATIONS:

M ***Frequent Transit Stops*** **-** Transit is often slow (even when on schedule) due to frequent stops.

H ***Transit Headways*** **-** Headways between transit vehicles, especially long headways in off-peak periods, require passengers to wait.

H ***Transit*** Off ***Schedule*** **-** Transit vehicles are sometimes off schedule, causing riders to wait for late vehicles or to miss early vehicles.

L ***Fare Payment*** - Buses are sometimes delayed by passengers paying fares.

L ***Wheelchair Lifts*** **-** Transit vehicles are delayed when wheelchair lifts have to be used.

H ***Uncoordinated Transfers*** - Delays occur at transfers between transit services, especially when transit vehicle arrivals are not coordinated.

System Operator Problems

COORDINATION BETWEEN SYSTEMS:

M ***Coordination Between Agencies*** **-** Limited coordination between different operating agencies results in avoidable delay.

H ***Freeway/Local Coordination*** - It is difficult to coordinate local roadway and freeway operations because of their different operating characteristics.

M ***Equipment Incompatibilities*** - Equipment incompatibilities make it difficult to integrate operations between systems. Two particular problems relate to traffic signals and electronic fare payment equipment.

OPERATIONS MANAGEMENT:

H ***Difficult Signal coordination*** - It is difficult to get good signal coordination given real world complexities. Complicating factors include incompatible cycle lengths, long pedestrian phase times, the need for progression in both directions simultaneously, oversaturated intersections, irregular signal spacing, fluctuations in vehicle and pedestrian demand, etc.

H **Schedule Adherence** - It is difficult to keep all transit vehicles on schedule due to unpredictable variations in travel time.

L **Equipment Malfunctions** - Some equipment malfunctions go unnoticed and degrade the level of service. Examples include traffic signal detectors and missing bus stop signs.

M **Transit Priority** - It is difficult to provide priority service for transit vehicles at traffic signals without disrupting overall traffic flow.

M **Staff Resources** - The limited operations equipment and staff available to most agencies cannot adequately manage the whole road network or transit fleet, which results in avoidable delay.

L **Drawbridge Operation** - It is difficult to fund sufficient bridge tenders for 24 hour on-demand service.

DEMAND MANAGEMENT:

H **Peak Period Capacity** - It is difficult to provide sufficient capacity for peak periods.

H **Peak Period Demand** - It is difficult to reduce peak period traffic demand to match capacity.

M **Fluctuation in Demand** - It is difficult to match transit capacity to fluctuations in demand.

Problems Related to Lack of Information

User/Community Problems

H ***Travel Information*** **-** Travelers, truck operators, and emergency services can't get accurate, timely, or predictive information about travel conditions and options. This problem applies before a journey begins, while en route, and to all modes of transportation. It is a special problem for visitors not already familiar with local travel conditions.

M ***Parking Information*** - Drivers can't get accurate, timely, or predictive parking information as they approach their destination. This is a general problem but is particularly noticeable during special events and during the Christmas shopping period.

H ***Transit Arrival Time*** - Passengers are never sure when the next transit vehicle will arrive.

H ***Transit Service Information*** **-** Transit schedules and general information brochures sometimes are too complicated to quickly get the information needed for a particular journey.

L ***Bicycle Information*** - There is a lack of readily available current information about bicycle routes and facilities.

M ***Rideshare Information*** - Travelers are unaware of rideshare opportunities.

M ***Visitor Information*** **-** Area visitors lack information on local facilities, services, attractions, and transportation options.

L ***Truck Location*** **-** Freight fleet operators don't have accurate knowledge of the current location of their vehicles.

L ***Destination Information*** - A lack of information about current conditions at destinations leads to wasted travel. Examples include arriving at a destination to find that the movie one wants to see is sold out, or the item one needs is out of stock at a store.

M ***Visually Impaired Passengers*** **-** Transit systems sometimes don't provide visually impaired passengers with guidance to maneuver through transit stations or to know when they have reached their destination.

L ***Visually Impaired Pedestrians*** - Visually impaired pedestrians have insufficient guidance.

System Operator Problems

H **Field Conditions-** It is difficult to collect accurate information on current field conditions to identify operational problems and to measure facility or system performance.

L **User Input** - It is difficult to gather input from users for system evaluation and optimization.

M **Data Presentation** - It is difficult to translate raw data into information meaningful to travelers.

H **Influencing Travelers** - It is difficult to get information to travelers where and when needed to advise them of incidents, give warnings, or influence choices.

H **Showing Benefits** - It is difficult to quantify and demonstrate benefits of operational improvements. Examples include ramp metering, HOV lanes, and traffic signal timing.

H **Transit Promotion** - The benefits of transit are not well publicized or marketed. There is also a need to promote HOV lanes and park-and-ride lots, especially after they are first opened.

M **Transit Vehicle Location** - Transit fleet managers don't have accurate knowledge of the current location of their vehicles.

H **Planning** Data - There is a lack of accurate and inexpensive data for transportation planning.

Problems Related to Safety and Security

User/Community Problems

ACCIDENTS:

M ***Roadway Accidents*** - There are too many traffic, bicycle, and pedestrian accidents.

L ***LRT Accidents*** - LRT/automobile conflicts can cause serious accidents,

L ***Railroad Crossings*** - Railroad grade crossings can cause serious accidents.

M ***Fog*** - Dense fog can cause serious accidents.

L ***Explosive Cargoes*** - Explosive cargoes can cause serious accidents.

L ***Parked Cars*** - Parked cars opening doors cause serious bicycle accidents.

M ***Bicycles on Street*** - Bicycles and pedestrians are vulnerable to vehicle collisions where there is no separate path.

L ***Police Chases*** - High speed police chases cause serious accidents.

H ***Traffic Violations*** - Travelers often do not respect traffic laws. Examples include motorists and cyclists failing to stop at stop signs and stop lights, ignoring pedestrian right-of-way, and exceeding speed limits.

L ***Old Facilities***- Old facilities often do not meet today's design standards and are perceived as unsafe.

M ***Children and Elderly*** - Children and elderly travelers are involved in a disproportionate number of accidents.

SECURITY AND EMERGENCY SERVICES:

M ***Stolen Vehicles*** - Vehicles and bicycles are often stolen. This is a particular problem for bicycles, including bicycles parked at transit stops.

M ***Insufficient Enforcement*** - There is a perceived lack of police presence and enforcement of laws.

L ***Emergency Notification*** - Distressed travelers often have difficulty summoning help in remote areas.

M ***Park-and-Ride Security*** - Park and ride lots (serving ride sharing and/or transit) sometimes lack lighting and security.

M ***Crime on Tmnsit*** - Transit passengers sometimes feel vulnerable to crime.

L ***Emergency Service Response Time*** - People needing emergency services often feel the response time is too long.

System Operator Problems

M ***Stolen Vehicle Recovery*** - Stolen vehicles and bicycles are difficult to locate.

M ***Emergency Notification*** - Emergency service personnel often get inadequate or inaccurate information about the location of a distressed traveler

H ***Funding Competition*** - Safety projects often have to compete against other projects for scarce funding.

Problems Refated to Regulations and Charges

User/Community Problems

M *Truck Credentials* - Truck inspection, fees, and credential checking require extensive paperwork and increase freight costs.

L *Truck Restrictions in Tunnels* - Restrictions on the use of tunnels for explosive cargo increases freight costs.

L *Truck Route Restrictions* - Prohibition of trucks from some freeways and arterial roadways increases freight costs.

H *HOV lane Utilization* - HOV lanes are often viewed as underutilized.

L *Cost of Parking* - Parking in major city centers is expensive.

M *Cost of Tmnsi?* - Transit fares are too high for some people who are reliant on it.

System Operator Problems

M *Parking Management* - Parking regulations and payment systems are difficult to enforce and maintain.

M *HOV Enforcement* - High occupancy vehicle (HOV) preference systems are difficult to enforce. Examples include HOV lanes on freeways and expressways, HOV bypass lanes on freeway ramps, and HOV exemptions from tolls at bridges.

L *Speed Limit Enforcement* - Speed limits are difficult to enforce.

M *Signal Enforcement* - It is difficult to prevent red light violations at traffic signals and ramp meters.

M *Fare Fraud* - Fare collection is open to fraud by both users and operators. Differential fares for special categories of users is a particular problem.

H *ADA Requirements* - ADA requirements are expensive and can hinder service for others.

Problems Related to Comfort, Convenience, and Ease of Use

User/Community Problems

CONVENIENCE:

H ***Unpredictable Travel Time*** - Travel time is variable and unpredictable for all modes. Travelers have to allow for the worst case when on-time arrival is important.

M ***Ride Sharing Inflexible*** - There is a loss of privacy and flexibility when ride-sharing.

M ***Indirect Transit Routing*** - Transit routes often don't match desired travel routes. This means extra travel time and may involve transferring between transit routes.

M ***No Lute Night Service*** - There often is no inexpensive or convenient way to get home after transit service ends at night. Some people who rideshare have no transit service at any time as a fallback.

H ***Distant Transit Stops*** - Fixed route transit stops can be too far from passenger origins and destinations.

M ***Remote Park-and-Ride*** - Park-and-ride lots are often remote from shops and conveniences.

L ***Airport Congestion*** - Curbside congestion at airports restricts access.

COMFORT:

H ***Traffic/Bicycle Conflicts*** - Conflicts with traffic can make cycling and walking unattractive.

L ***Transit Comfort*** - Some transit vehicles are uncomfortable.

H ***Congestion Stressful*** - Driving in congested traffic is stressful.

M ***Rough Roads*** - Poor pavement and substandard alignment of roadways make driving uncomfortable.

EASE OF USE:

H ***Multi-system Transit Trips*** - Having to use multiple transit systems hinders trip planning and transfers. The traveler has to access multiple information sources, match multiple schedules, have change for multiple fares, and determine transfer locations.

L ***Transit Parking Control*** - The method of restricting rail station parking lots to patrons is a burden for transit patrons. This typically involves memorizing a parking space number and indicating the number on a validation machine inside the paid area at the station.

M ***Parking Payment*** - The payment methods for parking are difficult to use. Motorists have to find the correct change for meters, and remember to pay in advance or queue at payment booths in garages.

System Operator Problems

M ***Shared Parking Lots*** - Multi-purpose (shared use) parking lots are difficult to arrange and manage due to conflicting needs, competition for choice parking spaces, and inability to identify valid vehicles when space assignments are made.

Problems Related to Environmental Impacts

User/Community Problems

H ***Vehicle Emissions*** **-** Internal combustion engines emit air pollutants.

M ***Dust*** **-** Moving vehicles stir up dust.

H ***Noise*** - Vehicle noise can disturb neighboring activities. This is true of high speed traffic on freeways and is also true of large trucks and buses. Buses often travel in residential areas where noise is particularly annoying.

H ***Water Pollution*** - Runoff from transportation facilities and improper disposal of oil and other fluids can pollute waterways and ground water.

M ***Hazardous Materials*** - Truck accidents can lead to hazardous material spills.

M ***Neighborhood Intrusion*** - Through-traffic on local streets not designed or suitable for high traffic volumes, can seriously impact neighborhoods.

M ***Urban Growth*** - Provision of new or expanded transportation capacity can facilitate growth in trips or trip length.

H ***Underpayment by Motorists*** - Road users don't directly pay for facilities except toll bridges, and underestimate the true economic and societal cost of using roads and parking facilities.

System Operator Problems

M ***Emissions Violations*** - Many vehicles violate emissions laws despite required smog checks.

M ***Neighborhood Traffic Control*** - It is difficult to exclude through-traffic from local streets without hurting local users.

Appendix B - ITS Services

INTRODUCTION

Task 4 of the EDP process identified those ITS services which look most promising for early deployment in the San Francisco Bay Area. This appendix describes the available ITS services and the extent to which such services can address the Bay Area's transportation problems, which were documented in Deliverable 3c.

ITS services were divided into eighteen groups, of which fourteen were identified as relevant to the Early Deployment Plan. Each of these fourteen service groups was evaluated as to its potential impact on each of the 133 problem statements.

The Advisory Board assisted the project team in this task by evaluating many of the highest priority problems in a workshop setting. Further input was obtained from three outreach meetings and from the System Operations and Management (SOM) committee of the Bay Area Partnership. The resulting effectiveness ratings of the ITS service groups are shown in Table B- 1.

After assessing the effectiveness of the fourteen groups of ITS services, the EDP team looked at each of the 35 ITS services contained in those groups, and assigned those a High, Medium, or Low priority for early deployment, based on their effectiveness in addressing regional transportation problems and their compatibility with regional transportation policies and goals. The Advisory Board and SOM committee reviewed and fine tuned the priority assignments.

ITS SERVICES AND EVALUATION

Intelligent Transportation Systems can provide many different services for both users and operators of the transportation system. Forty-one individual ITS services were identified for the EDP, some of which are closely related and address similar problems. Services which are related in this way were combined into 18 service groups to simplify analysis.

Four italicized groups of ITS services were judged to be not directly relevant to the Bay Area's Early Deployment Plan and therefore of secondary importance. Deployment of services in three of these groups (Traveler Services and Destination Information, Commercial Fleet Management, and Driving Assistance) is primarily in the hands of the private sector and beyond the influence of a public sector planning initiative such as this project. The fourth service group (Automated Vehicle Control) is technologically immature and will not be ready for deployment within the time frame of the EDP. These four groups are italicized in the listing below.

The EDP Advisory Board and planning team evaluated the ability of each of the 14 primary groups to address the regional transportation problems identified in Task 3.

Group 1 - Traffic Control. Traffic control services allow roadway system operators to respond to changing traffic conditions in real time.

1.1 Real-time Traffic System Performance Monitoring
1.2 Traffic Responsive Signal Timing
1.3 Traffic Responsive Freeway Ramp Metering
1.4 Traffic Responsive Lane, Turn, and Parking Restrictions

Traffic control services address a large number of the Bay Area's transportation problems, including many high priority problems related to travel delays and lack of information.

Group 2 - Public Transit Management. Public transit management services enable real-time monitoring and management of public transit operations.

2.1 Real-time Transit System Performance Monitoring
2.2 Real-time Transit Operations Control
2.3 Transit Priority at Traffic Signals

Public transit management services address a large number of the Bay Area's transportation problems, including many high priority problems related to travel delays and lack of information.

Group 3 - Incident Management. Incident management services provide technical support for rapid detection and clearance of incidents on roadways and transit systems.

3.1 Incident Detection
3.2 Incident Diagnosis and Response

Incident management services address several of the Bay Area's transportation problems, and many of those are high priority problems due to the disruptive effects of incidents.

Group 4 - Travel Information. Travel information services inform travelers of current conditions and options for any travel mode.

4.1 Real-time Transit Information
4.2 Real-time Roadway Information
4.3 Real-time Parking Information
4.4 Real-time Air, Sea, Rail Information
4.5 Real-time Bicycle Information

The travel information group of services addresses a moderate number of the Bay Area's transportation problems, including high priority problems dealing with a lack of accurate real-time information about travel conditions and options.

Group 5 - Demand Management. Demand management services facilitate alternatives to use of single occupant vehicles in peak periods.

5.1 Real-time Rideshare Matching
5.2 Dynamic Fares, Tolls, and Parking Fees

The demand management group of services directly addresses several of the Bay Area's transportation problems, mostly those related to peak period demand/capacity imbalance on roadways.

Group 6 - Traveler Services and Destination Information Traveler services and destination information services provide travelers current information on travel related services and popular destinations.

6.1 Traveler Services Information
6.2 Destination Information

Group 7 - Personalized Public Transit. Personalized public transit services provide near door-to-door transit service on demand, using shared vehicles.

7.1 Demand Responsive Transit Route Deviation
7.2 On-demand Shuttles

Personalized public transit services directly address several of the region's transportation problems, and generally help to make transit more attractive and more feasible in low density suburbs.

Group 8 - Electronic Payment. Electronic payment services enable travelers to pay for transportation services easily and without cash.

8.1 Electronic Transit Fare Payment
8.2 Electronic Toll Collection
8.3 Electronic Parking Fee Payment
8.4 Multipurpose Smart Card

Electronic payment services address several of the region's transportation problems, some of which are high priority ones.

Group 9 - Commercial Vehicle Regulation. Commercial vehicle regulation services automate and streamline procedures for commercial vehicle regulation.

9.1 Electronic One-stop Credentials
9.2 No-stop Compliance Checks

Commercial vehicle regulation services address only a few of the region's transportation problems, but those are major problems for the trucking industry.

Group 10 - Commercial Fleet Management. ***Commercial fleet management services monitor and manage commercial fleet vehicles in real-time.***

10.1 Real-time Commercial Vehicle Operations Control
10.2 Real-time Cargo Location and Condition Monitoring

Group 11 - Facilities Operation and Maintenance. Facilities operation and maintenance services provide automatic or remote operation and monitoring of transportation facilities.

11.1 Automated/Remote Equipment Monitoring
11.2 Automated/Remote Equipment Control

Facilities operation and maintenance services directly address several of the region's transportation problems, and indirectly support most of the other ITS services by reducing the cost of operation and maintenance of ITS related equipment.

Group 12 - Traveler Security. Traveler security services provide a safer travel environment and rapid notification of emergency services when needed.

12.1 Security Surveillance of Transit and Parking
12.2 Distress Signaling

Traveler security services address only a few of the Bay Area's transportation problems, those related to a lack of security in public transit and parking facilities, and the difficulty of summoning help when needed in remote areas.

Group 13 - Emergency Vehicle Management. Emergency vehicle management services enable emergency services to respond more rapidly to incidents.

13.1 Real-time Emergency Vehicle Operations Control
13.2 Emergency Vehicle Signal Preemption

Emergency vehicle management services address only a few of the Bay Area's transportation problems, mainly by reducing emergency vehicle response time and indirectly by reducing the duration of incidents.

Group 14 - Hazardous Materials Management. Hazardous materials management services reduce the risks associated with hazardous materials shipments.

14.1 Real-time Hazardous Materials Location Monitoring
14.2 Portable Database of Safety Information

Hazardous materials management services directly address only the problem of environmental impacts associated with hazardous materials spills during a transportation accident.

Group 15 - Automated Law Enforcement. Automated law enforcement services deter violation of traffic regulations and other laws by automatic compliance monitoring.

15.1 Automated Traffic Regulations Enforcement
15.2 Automated Vehicle Emissions Enforcement

Automated law enforcement services directly address several of the Bay Area's transportation problems related to safety, lack of police resources for enforcement, and excessive disregard for traffic regulations.

Group 16 - Driver Warnings. The driver warnings service provides real-time warnings to motorists of hazardous conditions.

No separate services in this group.

The driver warnings service directly addresses only a few of the Bay Area's transportation problems, primarily those associated with roadway accidents.

Group 17 - Driving Assistance. ***The driving assistance service automates or enhances selected driver functions.***

No separate services in this group.

Group 18 - Automated Vehicle Control, ***The automated vehicle control service provides fully automated operation ("hands-off and feet-off) on selected highways.***

No separate services in this group.

Table B-l summarizes the evaluation of ITS service groups.

Table B-1. Summary of Effectiveness of ITS Groups

Very Effective	*Some what Effective*	*Not Very Effective*
1. Traffic Control	5. Demand Management	12. Traveler Security
2. Public Transit Management	7 . Personalized Public Transit	13. Emergency Vehicle Management
3. Incident Management	8. Electronic Payment	14. Hazardous Materials Management
4. Travel Information	9. Commercial Vehicle Regulation	16. Driver Warnings
	11. Facilities Operation and Maintenance	
	15. Automated Law Enforcement	

PRIORITY OF INDIVIDUAL ITS SERVICES

Input from the Advisory Board, outreach meetings, the System Operations and Management committee, and focus group meetings, was used to assign an early deployment priority to each of the 35 individual ITS services in the fourteen relevant ITS service groups. The priority assignment for each service reflects the effectiveness of a service in addressing the region's transportation problems, and the extent to which a service is compatible with regional transportation policies and goals.

Table B-2 shows the relationship between ITS services and current Bay Area regional transportation priorities. All of the high priority ITS services directly support one or more regional transportation priorities. In particular, they support Metropolitan Transportation System management strategies developed by the Bay Area Partnership.

By combining evaluations of service effectiveness and support for regional priorities, deployment priorities were determined for each of the 35 ITS services. These are shown in Table B-3.

Some services that are not a high priority in themselves are needed to enable one or more of the high priority services to be effective. For example, the high priority service of traffic responsive signal timing requires the medium priority service of real-time traffic system performance monitoring. Services that support high priority services in this way are noted in Table B-3.

The EDP Action Plan concentrated on projects that provide the high priority services. However, lower priority services were also included in the following ways.

- Some projects that provide high priority services also provide lower priority services.
- Some projects that provide medium or low priority services are needed as a prerequisite for projects providing high priority services.
- Some projects that provide medium or low priority services can be provided at very low cost and a high benefit/cost ratio. Costs may be low due to the nature of the project or because it can easily be added as an adjunct to an existing or planned project.

Thus all of the ITS services were considered as early deployment strategies were developed.

Table B - 2. ITS Service Priorities and Regional Transportation Priorities	
Service Name	**Relationship to Regional Transportation Priorities**
High Priority: Alternative deployment strategies will include projects implementing all of these services, and MTC will encourage formation of deployment partnerships.	
Traffic Responsive Signal Timing	Smart Corridor, Traffic Signal Tech Support are in JUMPStart Service improves ability to manage MTS. Multi-agency partnerships for this service could implement follow-on MTS Mgmt Strategy projects.
Traffic Responsive Freeway Ramp Metering	Caltrans' TOS is in JUMPStart. Service improves ability to manage MTS. Multi-agency partnerships for this service could implement follow-on MTS Mgmt Strategy projects.
Real-Time Transit Operations Control	Multi-agency partnerships for this service could implement follow-on MTS Mgmt Strategy projects. Promotion of alternatives to SOV use
Transit Priority at Traffic Signals	Multi-agency partnerships for this service could implement follow-on MTS Mgmt Strategy projects. Can lead to better integration of systems.
Incident Diagnosis & Response	Supports CMS strategies.
Real-Time Transit Information	Reg. Transit Telephone number; TravInfo are in JUMPStart Promotes alternatives to SOV use
Real-Time Roadway Information	TravInfo is in JUMPStart
Electronic Transit Fare Payment	TransLink is in JUMPStart
Electronic Toll Collection	Electronic Toll Collection is in JUMPStart
No-stop Compliance Checks	Weigh-in-Motion promotes efficient freight movement

Service Name	Relationship to Regional Transportation Priorities
Medium Priority: Where possible, alternative deployment strategies will include projects deploying these services.	
Real-time Traffic System Performance Monitoring	
Real-Time Transit System Performance Monitoring .	
Incident Detection .	Supports CMS strategies. Is major function of TOS
Real-Time Parking Information	
Real-Time Rideshare Matching	Promotes alternatives to SOV use
On-demand Shuttles	
Electronic One-Stop Credentials	
Automated/Remote Equipment Monitoring	
Automated/Remote Equipment Control	
Security Surveillance of Transit & Parking	
Emergency Vehicle Signal Pre-emption	
Portable Database of Safety Information	
Automated Traffic Regs Enforcement	
Automated Vehicle Emissions Enforcement	
Low Priority: Alternative deployment strategies will include these services if they can be implemented at low cost or can be easily included within higher priority projects.	
Traffic Responsive Lane, Turn & Parking Restrictions	Dynamic HOV lanes support Congestion Mgmt System strategies.
Real-Time Air, Sea, Rail Information	
Real-Time Air, Sea, Rail Information	
Real-Time Bicycle Information	CMS strategies encourage use of non-traditional modes
Dynamic Fares, Tolls, & Parking Fees	Cong. Pricing is in JUMPStart, is CMS strategy
Demand Responsive Transit Route Deviation	
Electronic Parking Fee Payment	
Multipurpose Smart Card	
Distress Signaling	
Real-Time Emergency Vehicle Operations Control	
Real-Time Hazardous Materials Monitoring	
Driver Warnings	
Note: * Denotes a service that must be deployed to permit deployment of certain other services	

Table B - 3. Priority of ITS Services

High	Medium	Low
Traffic Responsive Signal Timing	Real-time Traffic System Performance Monitoring *	Traffic Responsive Lane, Turn, and Parking Restrictions
Traffic Responsive Freeway Ramp Metering	Real-time Transit System Performance Monitoring •	Real-time Air, Sea, Rail Travel Information
Real-time Transit Operations Control	Incident Detection (All Modes) *	Real-time Bicycle Travel Information
Transit Priority at Traffic Signals	Real-time Parking Information	Dynamic Fares, Tolls, and Parking Fees
Incident Diagnosis and Response	Real-time Rideshare Matching	Demand Responsive Transit Route Deviation
Real-time Transit Information	On-demand Shuttles	Electronic Parking Fee Payment
Real-time Roadway Information	Electronic One-stop Credentials (for Trucks)	Multipurpose Smart Card (Fares and Purchases)
Electronic Transit Fare Payment	Automated/Remote Equipment Monitoring	Distress Signaling (Mayday)
Electronic Toll Collection	Automated/Remote Equipment Control	Real-time Emergency Vehicle Operations Control
No-stop Compliance Checks (for Trucks)	Security Surveillance of Transit and Parking	Real-time Hazardous Materials Location Monitoring
	Emergency Vehicle Signal Preemption	Driver Warnings (Nearby & In-vehicle Hazards)
	Portable Database of Safety Information (Hazmat)	
	Automated Traffic Regulation Enforcement	
	Automated Vehicle Emissions Enforcement	

* At least one high priority service relies on this service.

Note: The order in which services are listed within a column has no significance.

Appendix C - Project Design and Evaluation Criteria

This appendix presents the design and evaluation criteria used in selecting from and prioritizing the list of candidate Intelligent Transportation System (ITS) projects for early deployment in the San Francisco Bay Area.

Objectives

The following objectives were adopted as guiding principles in developing the project design and evaluation criteria.

System Balance - The ITS Early Deployment Plan should help achieve a balanced Metropolitan Transportation System (MTS). A balanced system makes appropriate and sustainable use of all transportation resources including road, transit (road, rail and water), bicycle, and pedestrian modes for personal travel, and road, rail, sea and air modes for freight movement, and it avoids overburdening a single component of the system. A balanced system provides a similar minimum level of service in all major transportation corridors throughout the nine-county region, recognizing that the transportation mode offering the best level of service for a particular trip purpose may vary from one area to another depending on the density of development and geographical constraints.

System Integration - The ITS Early Deployment Plan should coordinate and integrate the operation of the various elements of the Metropolitan Transportation System (MTS) regardless of which agency operates each element. All freeways, all streets, and all transit services should be planned and operated as integral elements of a single system. Jurisdictional boundaries should be invisible to users.

Intermodal Links - The ITS Early Deployment Plan should strengthen links between the different modes of transportation. Travelers should be able to easily transfer between modes. Travelers should have full knowledge of the travel options offered by each mode for any particular trip.

Build on Existing Institutions, Investments, and Policies - The ITS Early Deployment Plan should build on existing efforts, where possible, rather than starting anew. The plan should recognize and work with existing institutions. The plan should take full advantage of previous investments such as the region's existing transportation infrastructure, the region's existing communications infrastructure, and existing ITS projects. The plan should be consistent with existing transportation policies, including those at both the regional and local jurisdictional levels. In particular, the early deployment plan should be fully consistent with, and supportive of, the Partnership's MTS Management Strategy. The following section is *a summary of that strategy.

User and Operator Information - The ITS Early Deployment Plan should provide real-time information to both individual travelers and system operators. Travelers should be kept informed and treated as partners in the management of the transportation system.

Support for MTS Management Strategy

The criteria in this category are derived from the partnership's MTS Management Strategy core principles as stated above. Implementation of much of the MTS Management Strategy will require real-time operation and fine tuning of transportation systems. Intelligent Transportation Systems (ITS) are needed to enable such real-time management.

Integration of Transportation System Elements - This criterion was used to evaluate each project's contribution to seamless integration of transportation system elements, including integration between road and transit modes, integration between bus and rail, integration between freeway and surface streets, and integration of facilities operated by different agencies or jurisdictions.

Enhancement of the Operation and Coordination of Mass Transit - This criterion was used to evaluate the extent to which each project helps make mass transit more efficient. This includes consideration of issues such as schedule adherence, peak period capacity, and efficiency of passenger transfers between facilities operated by the same or different jurisdictions and between other modes and transit.

Provision of Incentives for Ridesharing and Transit Use - This criterion was used to evaluate the extent to which each project facilitates a shift from single occupancy vehicles to high occupancy vehicles (HOV). It includes consideration of how a project can make HOV use more attractive relative to driving alone. HOVs include occasional or informal ride sharing, organized car pools and van pools, shuttles, and traditional fixed route transit.

Increase in the Capacity and Continuity of Arterial Street System - This criterion was used to evaluate the extent to which each project reduces peak period delays and congestion for local trips made on arterial roadways instead of the freeway. This criterion is related to the strategy of keeping long distance travelers on the freeway and short distance trips on surface streets, in order to achieve an optimal and equitable overall balance and effective utilization of existing facilities.

Benefit to Corridors Critical for Freight Movement - This criterion was used to evaluate the extent to which each project improves the flow of traffic on facilities which are heavily used by trucks and which provide a vital link to freight related land uses.

Technical Achievability

Expected Availability and Readiness of Needed Technology - This criterion was used to evaluate whether the technology needed to make a project work is expected to be in place. This does not necessarily mean that all system components must be "proven and off-the-shelf". The development of new equipment, new software, new techniques, and new applications for previously deployed technologies may be necessary and desirable in some ITS projects. However, the underlying technology must be available and ready for use. In general, the greater the amount of new development involved, the greater the risk that the project will not achieve all of its objectives within time and budget constraints.

Reliability and Risk of Premature Obsolescence - This criterion was used to evaluate the effective life of the system and the amount of down time during its life. Systems which are based on older technology or inherently unreliable technology, were assumed to have a greater risk of being unreliable or prematurely obsolescent.

Compatibility with National ITS Architecture and Standards - This criterion was used to evaluate projects in terms of compatibility with national standards including the national ITS architecture. National standards may not be relevant for a few projects that are purely local in scope, do not involve interfaces to other systems or equipment, and for which there are no standards for use within the project itself. Most projects, however, will be able to take advantage of established standards either internally or in external interfaces, including standards for the presentation of information to users.

Risk of Chain Reaction Failures Due to Interdependencies - This criterion was used to assess the risk of a project foundering due to failure of another project on which it is dependent. This will involve assessment of both the number of dependencies and the status and risk associated with each such dependency.

Degree of Adherence to a Non-proprietary Open Architecture - This criterion was used to assess a project's dependence on or independence from a single vendor for future modifications or expansions. An open architecture implies use of self contained and separable modules, industry standard interfaces between the modules, and an industry standard user interface. Such systems can be upgraded by replacement of one or more existing modules with enhanced modules from different vendors, or by addition of more modules which again can be from any vendor. It is recognized that individual modules may be entirely proprietary and that proprietary modules are usually necessary and desirable to fully take advantage of private sector products, to encourage competition and innovation, and to encourage public/private partnerships.

Institutional Achievability

Ability to Compete for Public Funds and to Attract Private Funds - This criterion was used to assess the likelihood of a project being able to obtain and sustain adequate funding, either from public grants or through private participation, for design, implementation, operation and maintenance.

Partnership Needs and Opportunities - This criterion was used to evaluate how difficult it is likely to be to establish a working partnership between the agencies and other stakeholders whose cooperation is needed for deployment and operation.

Distribution and Equity Issues - This criterion was used to evaluate the extent to which each project would benefit all users of the transportation system. Issues include geographical coverage and accessibility to all segments of society including the very young, the elderly, and the poor.

Legal, Liability, and Privacy Concerns - This criterion was used to assess the likelihood of a project being delayed or entirely canceled due to challenges on legal, liability, or privacy grounds.

Compatibility with Other Bay Area Plans and Projects - This criterion was used to evaluate the extent to which each project is compatible with other transportation projects and plans in the region, including both ITS and non-ITS initiatives.

Adaptability to Local, State, and National Policy or Regulatory Changes - This criterion was used to evaluate projects in terms of the risk that they will be delayed or canceled due to a new or changed law, regulation, or policy in the future. Of particular concern were projects that are totally reliant on a single piece of legislation that either is yet to be enacted, or which is in place but is controversial and at risk of being revoked or changed in way that would jeopardize the project.

Organizational Capacity for Implementation and Operation - This criterion was used to assess the ability of the key partners to consistently provide the resources, expertise, and institutional support needed to implement the project and to operate and maintain the system in the future.

Risk of Institutional Failure – This criterion was used to evaluate other institutional risks not explicitly addressed in other criteria. An example is the risk of a falling out between the project partners, based on the degree to which their motivations and objectives are compatible. Another example is the risk of direct or indirect challenge or non-cooperation by a labor union.

Effectiveness

Effectiveness in Addressing Identified Transportation Problems - This criterion was used to evaluate the effectiveness of each project in addressing the transportation problems identified in Task 3 and reported in Deliverable 3c. The evaluation will follow the prioritization of problems developed in the deliverable.

Effectiveness in Delivering ITS Services, Especially High Priority Services - This criterion was used to evaluate the extent to which each project would provide the ITS services identified in Task 4 as beneficial for the Bay Area. This evaluation will consider the number of services provided from each of the high, medium, and low priority categories, and the extent to which each of those services is provided. Extent of service provision would be assessed in terms of both scale (i.e. geographical coverage) and function (i.e. the degree to which the service is provided in areas covered)

Cost Effectiveness Considering Implementation, Operation, and Maintenance Costs - This criterion was used to evaluate the cost of the project relative to the benefits it would provide. This process will consider operating and maintenance costs as well as initial implementation. The evaluation will necessarily be approximate and largely qualitative, as precise costs will be unknown for most of the candidate projects, and it will not be practical to quantify benefits.

Adverse Impacts, Including Environmental and Neighborhood Impacts - This criterion was used to identify any adverse impacts of each project, including exacerbation of problems noted in Deliverable 3c.

Flexibility to Support Different Needs and Operating Philosophies in Different Parts of the Region - This criterion was used to evaluate the flexibility of each project to accommodate different needs and operating philosophies in different parts of the Bay Area, resulting from various factors including historical and geographic constraints, land use, development density, local policies, etc.

Ability to support non-ITS activities such as transportation planning - This criterion was used to evaluate the extent to which each project could provide data of value to general transportation planning and other spinoffs.

User Acceptability

Ease of Use and Willingness of Users to Adopt Technology - This criterion was used to assess how easy a system will be to use and the ability of end users to understand and feel comfortable with any new technologies involved in the user interface.

User Involvement in Planning and Implementation - This criterion was used to assess the extent to which end users have been, or will be, involved in the planning and implementation of the proposed system.

Satisfaction of User Needs and User Perception of Benefits - This criterion was used to evaluate how well a project will satisfy the needs of end users, and the extent to which the users will perceive that benefit. Perceived benefits were considered in two ways. First was the extent to which benefits are visible and obvious to travelers who use the affected facility. For example, projects which provide dramatic benefits at a few locations (e.g. electronic toll collection) are often viewed as more beneficial than projects which have small or subtle benefits at any one location but affect many locations (e.g. advanced traffic signal systems). The second consideration was the number of users likely to experience the benefits. For example, a project, such as an information transmission system for the visually impaired, may have a dramatic benefit for those who use the system, but few users.

Incorporation of Public Relations Considerations - This criterion was used to evaluate the extent and effectiveness of public relations measures included in the project. Such measures may include outreach during system planning and design, dissemination of information about the project during implementation and initial start-up, and on-going marketing and support programs for users, especially first-time users.

Scalability and Integratability

Potential for Future Expansion - This criterion was used to evaluate the potential for a project to be expanded in the future to add capabilities or coverage.

Potential for Replication in Other Parts of the Bay Area - This criterion was used to evaluate the potential for a project to be replicated elsewhere in the region if the desirable geographic coverage is not achieved in the initial implementation. A key consideration here is the extent to which knowledge gained or systems developed in the initial project could reduce the cost or increase the effectiveness of a subsequent deployment in another area. This includes consideration of the applicability of the initial system to other areas and their local conditions.

Potential for Integration with Other Systems - This criterion was used to evaluate a project's potential for adding value to other projects and for acting as a module within a bigger system. Two primary considerations are the compatibility of the systems at the interface, and the extent to which integration would add value -- in other words, whether integration is possible or useful.

Usefulness as a Demonstration Project or Experimental Test Bed - This criterion was used to determine the value of a project as a proving ground or test bed for a system or application which has not yet been deployed, at least not under conditions similar to those in the Bay Area. The proving ground concept implies that the system will be replicated elsewhere in the region if the initial project is successful. The test bed concept applies to projects that provide an environment which facilitates the conduct of multiple tests of further systems or products of potential value in this and other projects.

Disclosure

This document has been prepared pursuant to a Professional Services Agreement between the Metropolitan Transportation Commission and DKS Associates for the Intelligent Transportation Systems Early Deployment Plan. The total amounts payable under this agreement is $400,000. This total contract amount represents compensation for multiple documents, of which this deliverable is one.