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Organizing for ITS: Computer Integration Transportation Phase 1: Results for Arterial and Highway Transportation Management Centers

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ABSTRACT

Computer Integrated Transportation (CIT) is envisioned as an integrated network of public and private transportation organizations, each with unique responsibilities, but working toward a common mission of facilitating travel across all modes of transportation. The objective of this study is to evaluate alternative frameworks for CIT from an institutional perspective. This was accomplished through site visits and interviews at existing Transportation Management Centers (TMCs), along with focus group sessions in which strategies for CIT were presented to TMC managers and staff for their comments and discussion. The study found that four factors: (1) time-frame, (2) linking information to actions, (3) broadcast orientation, and (4) embracement of new technologies have profound implications for Intelligent Transportation Systems' (ITS) implementation and research. Each demands careful deliberation at the strategic level, and possibly changes in how transportation agencies are organized.

Keywords: **Transportation Management Centers, Traffic Management, Intermodal Transportation**

EXECUTIVE SUMMARY

Computer Integrated Transportation (CIT) is envisioned as an integrated network of public and private transportation organizations, each with unique responsibilities, but working toward a common mission of facilitating travel across all modes of transportation. CIT is designed to achieve effective coordination of the overall transportation system, while at the same time respecting the individual responsibilities of participating agencies. Within these bounds, CIT draws on resources (e.g., emergency crews, traffic control, etc.) both internally and externally, as needed to ensure the smooth operation of the transportation system. Intelligent Transportation Systems (ITS) are the technological enabling force for achieving CIT.

The objective of this study is to evaluate alternative frameworks for CIT from an institutional perspective. To this end, existing transportation management centers (TMCs) were first surveyed in depth to assess existing capabilities. Site visits were conducted at all Caltrans TMCs, as well as at three city TMCs (Anaheim, Los Angeles, and San Jose). These interviews were followed up by a series of four focus group sessions, in which strategies for CIT were presented to TMC managers and staff for their comment and discussion. Finally, a follow-up survey was administered to each TMC, to assess future directions for California TMCs.

Throughout the study, we encountered considerable enthusiasm for ITS. Participants were nearly unanimous in their belief that ITS has improved their working relationships with other agencies, and that one of the most important benefits of ITS was improved coordination. While participants generally felt that a decentralized organizational structure was more practical, leadership-based structures might be viable in the future, provided that the benefits could be demonstrated. There was also a strong commitment among state agencies, and some local agencies, toward implementing ITS services. In most cases, participants felt that the ITS services should be assigned along the lines of current agency responsibilities. With respect to internal organization, the ultimate answer would depend on costs analyses and technical feasibility, and not so much on institutional considerations.

Despite the enthusiasm for ITS, significant obstacles lie ahead. Participants were worried about the ability to fund and maintain ITS. They were worried that parochial interests might stand in the way of improved coordination. They were worried that some agencies were not sufficiently supportive of innovation and change. And they were concerned that the benefits of ITS might not be documented, which could stand in the way of future deployments.

While the participants' focus was on the deployment of ITS, their comments also have relevance for the ITS research program.

Time-Frame Nearly across the board, participants focused on short-range applications of ITS, mostly in the time frame of five years or less.

Linking Information to Actions Transportation management requires the coordinated effort of multiple agencies, and multiple divisions within agencies. Unfortunately, it appears that some of these organizations suffer from divided responsibilities.

Broadcast Orientation TMCs, as they exist today, disseminate information via broadcast technologies (changeable message signs, radio stations, etc.), and collect information in aggregate (mostly via loop detectors). ITS presents the opportunity for targeting information collection and dissemination to individual vehicles, drivers or travelers. Evolution from a broadcast orientation to a "narrow-cast" orientation is a major challenge.

Embracing New Technologies While all participants were enthusiastic toward ITS within the context of their current functions, there was some hesitation toward expanding their functions.

Mutual Interests If TMCs are truly to fulfill the mission of enhancing mode transitions, the needs and interests of the various involved parties should be understood and appropriately incorporated.

Incentive/Mechanism for Cooperation There is no established mechanism *or* channel for building cooperation. Each joint effort is established on a case-by-case basis, and often demands great leadership and political will to overcome the institutional barriers. A mechanism or catalyst is needed to encourage cooperation.

To conclude, the above factors have profound implications for ITS implementation and research. Each demands careful deliberation at a strategic level, and possibly changes in how transportation agencies are organized, and how they relate to each other.

Phase 2 of this project, which is now underway, will focus on non-automobile TMCs, and supporting agencies. The goal will be to identify ways to coordinate transportation across all agencies involved in transportation, within the framework of Computer Integrated Transportation, and to identify a preferred organizational structure.

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1 INTRODUCTION

Advances in information, computation, and communication technologies in the 1970s, 1980s and 1990s have stimulated remarkable changes in business practices throughout the world. For instance, with the advent of computer-integrated-manufacturing (CIM), it is now possible to accurately track, automate and control production from the moment raw materials are extracted from the ground until finished products are delivered to customers.

Today, intelligent transportation systems (ITS) offer much the same opportunity for transportation that CIM held for manufacturing. Encompassing a spectrum of electronic and communication technologies, ITS may one day achieve computer-integrated-transportation (CIT), where both the users and operators of transportation systems can effortlessly obtain and exchange information, to facilitate travel across all modes of transportation, and perhaps even substitute travel with telecommuting. While there are important differences between CIM and CIT, such as controlling objects versus people and the increased demand for inter-organizational coordination under CIT, the similarities are significant. Most importantly, CIT, like CIM, would exchange information across organizational units to synchronize and coordinate movements of goods or people from one place to another.

1.1 Vision of Computer Integrated Transportation (CIT)

Computer Integrated Transportation is envisioned as an integrated network of public and private transportation organizations, each with unique responsibilities, but working toward a common mission of facilitating travel across all modes of transportation. CIT is designed to achieve effective coordination of the transportation system, while at the same time respecting the individual responsibilities of participating agencies. Within these bounds, CIT draws on resources (e.g., emergency crews, traffic control, etc.) both internally and externally, as needed to ensure the smooth operation of the transportation system.

1.2 Study Objective

The objective of this study is to evaluate alternative frameworks for CIT from an institutional perspective. To this end, existing transportation management centers (TMCs), were first surveyed in depth to assess existing capabilities. Site visits were conducted at all California Department of Transportation (Caltrans) TMCs, as well as at three city TMCs (Anaheim, Los Angeles, and San Jose). These interviews were followed up by a series of four focus group sessions, in which strategies for CIT were presented to TMC managers and staff for their comment and discussion. Finally, a follow-up survey was administered to each TMC, to assess future directions for California TMCs. The initial survey, focus groups and follow-up surveys are the basis for our evaluation of alternative frameworks for CIT.

1.3 Paper Organization

The remainder of the paper is divided into seven major sections. First, the concept of Computer Integrated Transportation is introduced, along with key organizational issues associated with CIT. Next, a literature review is provided, concentrating on organizational designs for transportation management centers, and issues in computer integrated manufacturing. This is followed by summarized results from our survey of existing TMCs. Then findings are presented from the focus groups and follow-up surveys. Finally, survey and focus group findings are interpreted, and recommendations are provided on how to implement CIT.

2 ORGANIZATIONAL ISSUES

This section is divided into three sub-sections. First, organizational structures are discussed from the perspective of how agencies coordinate with each other (i.e., inter-organizational structures). Next, this section examines how ITS functions might be assigned among agencies. Finally, the section looks at how ITS functions are executed within agencies (i.e., intra-organizational structures), concentrating on the issues of automation, communication infrastructure, and distribution of responsibilities between remote and central locations.

Before we embark on outlining the inter- and intra-organizational structures, it is important to define the potential participants in CIT. There are in general five different types of traffic management centers: (i) highway TMCs--operated by Caltrans in California, mostly concerned with managing traffic on highways; (ii) arterial TMCs--operated by cities or counties, concerned with controlling the signals for arterial traffic; (iii) transit TMCs--operated by transit agencies, concerned with scheduling and operating the transit fleets; (iv) emergency TMCs--operated by emergency agencies, concerned with dispatching emergency vehicles such as police, fire trucks, and ambulance; and (v) commercial TMCs--operated by trucking or shipping companies, concerning with the movements of goods and scheduling and operating their fleets. These different types of traffic share the same road network, and coordinating their movements and information may be beneficial to all parties. *In this initial study, the focus of the surveys was on highway and arterial TMCs, although the discussion of inter-organizational structure also include transit TMCs.* There are other types and modes of traffic, such as via rail, sea and air, Each of them may be part of or may interact with the above five TMC types. The research of their interaction is generally out of the scope of this project; we may revisit them in a follow-up study.

2.1 Inter-Organizational Structures

The organizational structure defines responsibilities among jurisdictions, and defines the patterns of coordination and communication. The goal is to enable both public and private agencies to work effectively with each other. Two fundamental alternatives are "leadership" and "decentralized" structures, as discussed below.

2.1.1 Leadership Structures

Under this vision, certain traffic management centers are designated (or created) to act as leaders among satellite centers. Coordination may occur at any of several levels, ranging from simple exchange of information, to responding to requests, to active control. Leadership can be defined on a functional basis or on a locational basis, as discussed below.

Functional Leader For a metropolitan region, the functional leader is responsible for coordinating a function, such as arterial signal control, incident response, traveler information, etc. (figure 1). The leader TMC is activated when there is a need to pull together resources across jurisdictional lines, or to synchronize across jurisdictional lines. Functional leaders communicate, as equals, with each other. Functional leaders communicate as leaders to their satellites. Within a given function, or area, satellites may or may not communicate with each other. For example, a functional leader might be responsible for coordinating traffic signals across an entire metropolitan region. Its satellites would then be the signal control systems of the municipalities and districts that constitute the region.

Locational Leader Within a district, the locational leader is responsible for coordinating all functions (figure 2). The leader TMC is activated when there is a need to coordinate resources across functions. Locational leaders communicate, as equals, with each other. Locational leaders communicate as leaders to their satellites. Within a given area, or function, satellites may or may not communicate with each other. For example, a locational leader might be responsible for coordination of all ITS functions (signal control, traveler information, vehicle identification, etc.) within a county. Its satellites could then be TMCs that specialize in particular ITS functions that serve the county.

2.1.2 Decentralized Structures

Under this vision, no TMC is designated as a leader (figure 3). Coordination is achieved through exchange of information, perhaps accompanied by protocols as to how one jurisdiction should respond to another (in a manner like mutual aid pacts for fire districts). Communication patterns may be defined geographically (e.g., among adjacent districts) or functionally. However, no TMC assumes leadership over others.

2.1.3 Information Exchange

The type of information exchanged between agencies, and the protocols in place for how an agency responds to this information, define the "degree of coordination." The degree of coordination is in fact a spectrum, with control at one extreme, and isolation at the other. Lo et al. (1993) identified four steps in this spectrum:

I Coordination via occasional meetings, phone calls, faxes or electronic mail

II Established data links among TMCs, so that the TMCs can observe each other's real-time traffic patterns and controls.

III TMCs not only observe each others patterns, but respond to patterns of external agencies, through prescribed protocols.

IV TMCs not only exchange information, but TMCs are empowered to issue commands to external TMCs (i.e., TMCs within another agency) under prescribed conditions (such as from a leader to a satellite).

The critical issue in TMC organization is not just whether leaders exist, but also the degree of coordination that the leader TMC achieves. Leadership might be at Level I, in which case the leader is the focal point of coordination meetings, or it might be as strong as Level IV, in which case the leader can directly control its satellites.

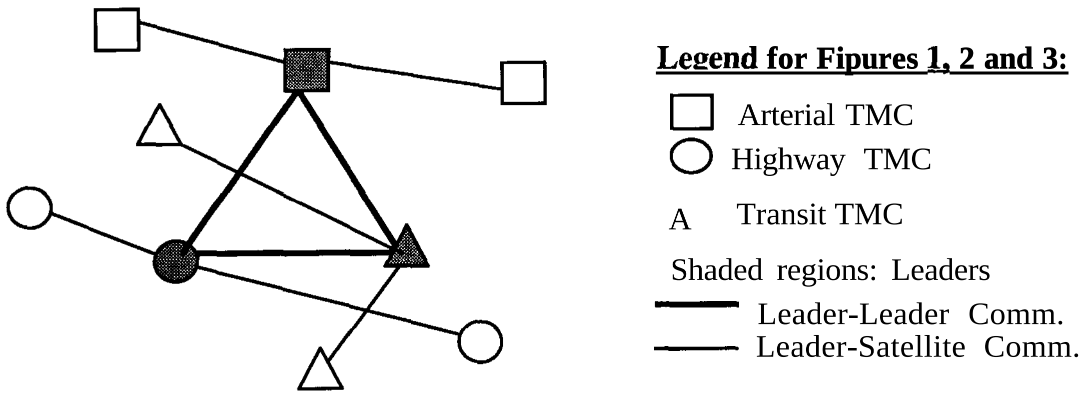

Figure 1 Organizational structure for functional leadership

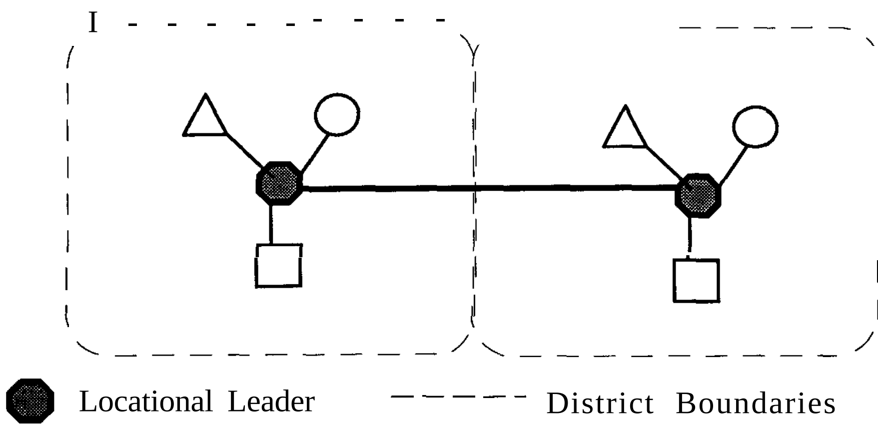

Figure 2 Organizational structure for locational leadership

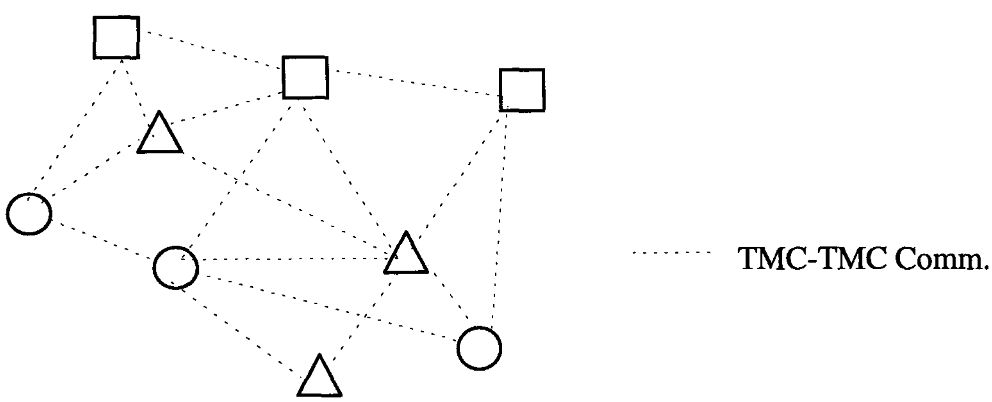

Figure 3 Decentralized organizational structure

2.1.4 Critical Issue

Organizational structure is instrumental to all aspects of ITS, but especially to incident response. Relevant issues include:

-- Establishing channels of communication among cooperating organizations, to ensure that each party has the best available information.

-- Defining roles and responsibilities for remote command centers, to complement personnel at the incident scene.

-- Insuring that information systems can be employed to guide the routing of emergency vehicles, assignment and deployment of resources, sequencing of activities at the incident.

2.2 Assignment of ITS Functions

CIT should be capable of providing a range of ITS functions today, and be flexible for expanding to new ITS functions as they are developed. The organizational structure provides a framework for determining where and how these functions are implemented and coordinated. As an ideal, such a framework would remove these decisions from the burden of political wrangling, and speed the adoption of ITS.

The following describes example ITS functions. Our objective is to determine which organizational structure will be most effective at implementing these functions, and to determine who should be assigned the responsibility for these functions.

2.2.1 Managerial Reporting and Control

This category of functions is aimed at long-term improvements in the transportation system. Through daily, weekly, monthly and annual reporting on system performance (including accident statistics, travel times, on-time performance, patronage, congestion, etc.), the reporting system draws managerial attention to the most urgent problems, and speeds their resolution.

Managerial reporting relies on a range of ITS technologies, most importantly surveillance, communication, and management information systems. Managerial reporting can be applied to capacity planning, roadway improvements, staffing and resource deployment, and signal control strategies. Most importantly, managerial reporting offers the impetus for continuous improvement in overall system performance, by drawing attention to the most critical problems.

2.2.2 Operational Control

The minute to minute decisions needed to keep the transportation system up and running, at maximum efficiency, fall in the category of operational control.

Normal Operational Control pertains to operation in the absence of unusual disturbances or incidents. For the large part, these functions do not require human intervention. Examples include adaptive signal control, automatic-vehicle-identification (AVI) and automated toll collection, automated vehicle inspection, real-time schedule control and computer-based surveillance systems.

Incident Based Operational Control pertains to operation in the event of accidents, adverse weather, stalled vehicles, etc. These functions ordinarily demand human intervention, both at the site by incident response crews, and at the TMC, to direct the response, employ changes in signal plans and send out traveler advisories. Example technologies include incident command centers, mobile communication, expert systems for signal plan selection, and traveler information systems, both at the site and away from the incident.

2.2.3 Critical Issue

For many of the new ITS functions, it is unclear which agency should take lead responsibility. Automated Vehicle Identification (AVI), for instance, is designed to serve a multitude of functions, including toll collection, freeway surveillance, and perhaps even communication to the vehicle. The data collected is useful to toll collection agencies, traffic operations, and perhaps law enforcement. Automated vehicle inspection also has the potential to serve a range of agencies, including air quality districts, motor vehicles, law enforcement, and, with possible implementation of automated highways, traffic operations. In both cases, the effectiveness of the technology hinges on both assigning lead responsibility to the right agency, and establishing the means to share the relevant information.

2.3 Internal Organization

Within any organization, an ITS function can be implemented in a variety of ways. It might be centralized at a management center, or it might be distributed among field units. A function might be computer automated, or it might entail extensive human intervention. Finally, a function might be specialized, or it might be an aspect of higher level functions.

2.3.1 Centralized Versus Distributed

Most ITS functions require communication of surveillance information from the field, assessment of the information, and execution of actions. In a centralized system, decision making (whether automated or not) is concentrated at a single location. As a consequence, communication requirements may be large, while, on the positive side, scale-economies might be exploited. In addition, centralization distances the decision makers from the field (the consequence being a loss in familiarity with actual conditions). In a distributed system, decision making is localized, perhaps in lower level management centers or, perhaps, in fully automated field units. The advantages and disadvantages are then the opposite of the centralized approach.

2.3.2 Automation

Automation can free humans from the more tedious work, so they can focus on higher level decisions. Already, incident detection algorithms can free up operators' attention, and adaptive signal control can reduce the need for manual overrides. However, during abnormal situations, it may not be appropriate to rely on automatic responses. Computers might then serve as decision support tools rather than decision making tools. TMCs could, for instance, activate incident management procedures only after a human confirmation, or perhaps the human could actively direct the response procedures. The primary issue is then, which type of ITS functions demand human involvement, which types would benefit from a combined computer/human approach, and which can be entirely automated. This assessment, in turn, affects the economics of distributed and centralized strategies.

2.3.3 Specialized Versus Encompassing TMCs

Most existing TMCs are geared toward performing two major functions: incident management and signal control, both of which entail various supporting functions (e.g., dispatching emergency vehicles or traffic surveillance). However, many of the proposed ITS functions do not fall neatly into the existing categories. AVI for automatic toll collection, for instance, might conceivably be integrated into general roadway surveillance, and potentially even supplant it. The two distinct avenues for implementation are to: (1) incorporate new functions within the functions served by existing TMCs, or (2) create new TMCs that operate with some degree of autonomy. The choice, of course, depends on the nature of the function, both at a technical level and an institutional level.

2.3.4 Critical Issue

ITS now enables greater flexibility in controlling traffic signals, including automatic readjustment of cycle and phase lengths through adaptive control systems, and the ability to remotely change signal plans in response to incidents and events. Critical issues include:

-- Distributing processing capabilities between centralized TMCs and roadside controllers.

-- Identifying the circumstances where human intervention and/or computer intervention are desirable and beneficial, and providing computer tools to support decision-making.

-- Determining whether signal control responsibilities should be integrated with incident management in an encompassing TMC, or whether they should be performed in specialized TMCs.

3 LITERATURE REVIEW

By far the most extensive study on TMC organization is a report by Booz-Allen and Hamilton (1993): "Institutional Impediments to Metro Traffic Management Coordination." The study includes a literature review on organizational theory and TMC practices, as well as results of interviews with TMC personnel in six metropolitan areas. The study's major conclusions are concerned with overcoming obstacles to multi-agency coordination, and include the following:

> "Discussions with metropolitan area professionals...indicate that current laws, regulations, and rules are generally sufficient to permit traffic management coordination and ATMS implementation."
> (p. 2-2)

> "Most agencies/jurisdictions do not want nor foresee the need for any significant organizational restructuring to improve traffic management coordination or implement ATMS technologies."
> (p. 2-2)

> "The political unit that controls the financial resources has the ability to shape how ATMS is provided and how institutional arrangements are structured." (p. 2-3)
>
> "There is a lack of rigorous cost/benefit analysis to justify large public investments in ATMS technologies, although there is strong support among traffic managers for these technologies."
> (p. 2-3)

The study further provides a list of 30 recommended solutions, the most important of which include developing a "vision of evolutionary ATMS implementation", and developing "work plan guidelines for implementing ATMS" ("a step-by-step 'cookbook approach for implementing one, or more, ATMS technologies in an area").

Carve11 et al. (1994) provide a case-study on improving interagency coordination, based on a traffic signal control project in North Dallas County. The project avoided disagreements by first creating a multi-agency steering committee, and then developing guidelines aimed at promoting cooperation. These included funding restrictions (only supporting projects that would benefit multiple cities), procurement coordination (cities used normal procurement procedures, but submitted documentation to the steering committee for approval), and hardware flexibility ("cities were free to use their own controller specification but it had to contain minimum criteria").

Other relevant research includes papers on ITS System Architecture. Varaiya (1993), for instance, describes a layered structure that, to a degree, also defines an organizational structure. However, Varaiya's work is not directed at the institutional issues that arise in cross-jurisdictional coordination. Hall (1992) proposed a framework for defining transportation architectures which spans modes (for both goods and people). He classifies architectures along the dimensions of communication medium (e.g., audio, visual, electronic, mechanical and verbal/non-verbal), assignment of functions to transportation entities, and degree of coordination. This framework will be used in structuring organizational designs within the proposed work.

Outside of ITS, there is an extensive literature on Computer Integrated Manufacturing (CIM), and the use of information systems to redesign and improve business processes. As already mentioned, the work on CIM is somewhat analogous to Computer Integrated Transportation, especially with respect to the goal of coordinating diverse departments and organizations. Example papers include Duchessi et al. (1989) and Walbank (1988), which discuss CIM from the perspective of controlling factory inventories (somewhat analogous to controlling delays on highways).

4 INITIAL SURVEY

In the initial phase of our research, as mentioned earlier, we focused on highway (operated by Caltrans) and arterial (operated by cities) TMCs. All seven Caltrans TMCs--District 3 (Sacramento), District 4 (Vallejo/Bay Bridge), District 6 (Fresno), District 7 (Los Angeles), District 8 (San Bernardino), District 11 (San Diego), District 12 (Santa Ana)--and three city TMCs (Anaheim, Los Angeles, and San Jose) were surveyed in person (Lo, Hall and Windover, 1993). (After the survey, we discovered that we missed two city TMCs in California: San Diego and Irvine.) This study focused on strategic issues, including functionalities, coordination among TMCs and with other systems (such as emergency agencies) and, to a lesser extent, facilities, hardware and software components. Results are categorized according to the issues presented earlier: organizational structures, assignment of ITS functions and internal organization.

4.1 Organizational Structures

By and large, TMCs in California have a decentralized organizational structure. Each TMC is responsible for its own function and area, with no TMCs designated as leaders. The Caltrans TMC Master Plan (1993), however, proposes establishing a leader within each of three groups: Valley (Sacramento and Fresno), Coastal (Bay Bridge, Vallejo, and San Jose), and Southern (Los Angeles, San Bernardino, Santa Ana, San Diego, City of Los Angeles Automated Traffic Surveillance and Control (ATSAC) system, and Anaheim).

Existing coordination among these three groups is infrequent. When it occurs, it is at level I (occasional meetings, etc.). Fresno (Caltrans District 6) and the Southern group maintains a level II coordination: real-time incident information such as major incidents on Highway 5 or 99, and weather information such as dense valley fog are shared via the California Highway Patrol (CHP) Bulletin Board. Within the Valley group, Fresno (Caltrans District 6) maintains level I coordination with Sacramento on a daily basis. For the Coastal group, the Vallejo TMC (Caltrans District 4) maintains a close tie with the hub at the Bay Bridge, loop detector data, and video images collected from CCTVs are compressed and transmitted from the Bay Bridge hub to the Vallejo TMC. In the near future, the capability of controlling CCTVs and ramp metering rates from Vallejo will also be added--level II coordination will be maintained between them. Coordination between the San Jose TMC and Caltrans TMCs is lacking at this moment. However, during our visit, the San Jose TMC expressed a strong interest in establishing such a link.

For the Southern group, level II coordination exists among Caltrans and city TMCs. Caltrans TMCs include Los Angeles, Santa Ana, San Bernardino, San Diego, and Fresno, and city TMCs include Anaheim and ATSAC. They exchange incident information via the CHP Bulletin Board, which is a modem-accessible real-time on-line database system. In addition, Caltrans Los Angeles and Santa Ana TMCs, city of Anaheim TMC, and ATSAC recently developed a direct data linkage, which allows them to retrieve real-time graphic displays of traffic and control information among themselves. The Smart Corridor project, which is planned as a coordinated effort between Caltrans and city TMCs to manage traffic along the Santa Monica freeway, will examine the benefits of having level III coordination.

All seven Caltrans TMCs collocate CHP and Caltrans staff. This arrangement facilitates better communication between Caltrans and CHP for managing incidents. Coordination between Caltrans TMCs and emergency units, such as fire, ambulance and police, is often through the CHP Communication Center, though most of the TMCs have direct lines accessible to these units. Most Caltrans TMCs, via the Traffic Management Teams (TMTs), coordinate with organizers of major events to manage traffic. This coordination happens much more frequently for TMCs that oversee traffic around major trip generators, such as Disneyland in Anaheim. The TMCs located in the Central Valley, including Sacramento, Fresno, and San Bernardino, often coordinate with the weather services to obtain potential hazard information, such as fog conditions.

Coordination between the city TMCs and other systems is infrequent. They will inform the police if their CCTVs spot accidents; or, during special events, they will coordinate with the police and the event organizer to manage traffic.

4.2 Assignment of ITS Functions

4.2.1 Caltrans TMCs

Table 1 lists the functions performed at the TMCs. All Caltrans TMCs have a surveillance capability, most commonly with loop detectors and CCTVs. It is expected that all Caltrans TMCs will have an on-line surveillance capability in the near future. In addition, all Caltrans TMCs have installed Call Boxes for emergency situations along major highways.

Incident management is an important function in all Caltrans TMCs. Most Caltrans TMCs apply a multitude of ways to obtain incident information, including call boxes, aerial surveillance during rush hours, drivers' reports using cellular phone calls, reports by Caltrans or CHP field personnel via 2-way radio, and to a lesser extent, loop detector information and CCTVs. Different TMCs have different procedures and means of responding to incidents. Recently, freeway service patrol (FSP) is used as an element to reduce the response time to incidents by patrolling the freeway systems and responding to and clearing of incidents.

All Caltrans TMCs have some means of providing traffic information to travelers. The information content is mostly limited to locations of incidents and severe congestion, construction detours, or lane closures. Sometimes, roadway conditions, such as fog and snow, are also disseminated, especially for highways in the Central Valley or mountainous areas. The means of dissemination include Changeable Message Sign (CMS), Highway Advisory Radio (HAR), via the broadcast media and to a lesser extent via third party information providers (e.g., TeleText and Easylink). Some TMC supervisors mentioned the use of the Caltrans Highway Information Network (CHIN) and Caltrans Highway Information Broadcasting Network (CHIBN) for disseminating traffic information.

All Caltrans TMCs have ramp metering systems. All ramp meters use the Type 170 controller. The majority of the ramp meters are operating in a dynamic but isolated mode, which means there is no coordination between neighboring meters. Also, coordination between ramp meters and neighboring arterial signals does not presently exist in California, although some near-term operational tests are being planned.

Disnatchine of emereencv vehicles, such as fire, ambulance, and police, to an incident scene is conducted via the CHP Communication Center. CHP's Computer Aided Dispatch (CAD) System is a tool developed to assist in this task, which provides an on-line "live" database to facilitate communication as the events are occurring.

4.2.2 City TMCs

All the city TMCs we visited have an on-line surveillance capability. Loop detector data are the major information source, which are used for monitoring and sometimes for adjusting the timing plans in real time. CCTVs are also often deployed at critical intersections to verify the effects of the timing plans.

Arterial signal control is the major function for all three city TMCs. The TMCs act as central controllers to the signal systems. All three systems can be run under a fully traffic responsive mode (though it was reported that this mode was seldom used). Instead, the normal mode of operation involves the using of a combination of time-of-the-day plans and frequent manual override during rush hours. All of them have aggressive plans for expansion, stressing the existing computer and communication software and hardware.

Table 1 Functionalities of California Auto-Based TMCs.

Functionalities	Caltrans TMCs (7 total) Occurrence	City TMCs (3 total) Occurrence
Surveillance	7	3
Loop detectors	5	3
CCTVs	3	3
Magnetic detectors	1	0
Microwave detectors	1	1
Optical detectors	1	1
Call boxes	7	0
Traveler info.	7	1
Output means:		
CMS	7	1
HAR	7	1
3rd Party Device	4	1
Media	7	1
Arterial signal control	0	3
Ramp metering system	7	0
Law enforcement	0	0
Incident management	7	1
Detection means:		
ccl-v	3	0
Call box	7	0
Detector/algorithm	3	0
Aerial Surveillance	7	0
Reports	7	1
Emergency evacuation	1	2
Special events' handling	7	3
Hazardous mat. routing	1	0
Transit scheduling	1	0
Inter-modal coordination	0	1

4.3 Internal Organization

4.3.1 Centralized versus Distributed Operations

From a communication and surveillance perspective, all TMCs adopted or attempted to establish a centralized approach. Various efforts are underway to bring the surveillance information from the field on-line to the TMCs. For example, loop detector data and CCTV videos are transmitted to the TMC via a variety of ways: dedicated phone lines, coaxial cable, leased phone line, microwave, radio frequency, fiber optics, and twisted pairs.

Similarly, most TMCs are using or developing a centralized approach for signal control. Mainframe computers or workstations are used by Caltrans at the TMCs to derive appropriate metering rates and communicate with the type 170 controllers at the field to control ramp meters. In a similar fashion, city TMCs control their signals from a central location, and provide manual overrides to the signal plans remotely if necessary. The TMC mainframe computers also often serve as a central traffic database repository. Occupancy, volume, speed, and device status data collected from the field are aggregated and archived periodically.

Within each organization or division, the dispatching of response vehicles to incidents is operated in a centralized fashion. Examples include Caltrans Maintenance branches, the CHP computer aided dispatch (CAD) system, and the CHP Communication Center. These highly centralized operations allow the TMCs to achieve economy of scale, as indicated by their relatively modest size of operational staff--less than 10 in all cases--, facilities, and budgets (see Lo et al, 1993).

The few examples of a distributed mode of operation include the CHP command-and-control and the traffic management teams at the incident scene, and the FSPs, though their dispatch are still operated at the centrally located TMCs. In these cases, decisions are made at the field units.

4.3.2 Automation

Three areas of automation may be useful to the major functions performed at the TMCs: (i) signal control; (ii) incident detection and response; and (iii) performance report. For signal control, Caltrans TMCs are using variants of three versions of ramp metering software: San Diego Ramp Meter System developed in 1978; District 7 in-house developed version, and the Bay Bridge version developed in 1974. As discussed earlier, these software programs derive the meter rates in a dynamic but isolated way, which means coordination between neighboring meters does not exist. For the city TMCs, they share the similar software platform: graphical display software developed by JHK & Associates (1989), UTCS (Urban Traffic Control System) developed by the Federal Highway Administration (FHWA) to handle database and communication, and TRANSYT-7F to develop timing plans based on historical traffic patterns. All three systems can be run under fully traffic responsive mode, though it was reported that this mode is seldom used, and frequent manual overrides are required to augment the pre-set timing plans.

For incident detection, the TMCs use software that derives the speeds along major highways based on occupancy and volume data. The speed data are then color-coded based on pre-specified ranges and displayed on wall-mounted maps or computer monitors to alert the operators to potential incidents. For incident response, there is no automated or semi-automated procedure to assist the dispatchers, although it was reported that an expert system based decision support system is being developed in Districts 4 and 12 to facilitate this task.

It is useful to automate the production of performance report regularly from the archived traffic data. Although it was reported that traffic data are archived regularly, they are not produced automatically in a format that is useful to the managerial level for operation improvement, such as adjusting the pre-set timing plans or reviewing the incident response procedures. This aspect has been overlooked by most TMCs.

5 FOCUS GROUPS

The aim of the focus groups was to facilitate discussion among experts in TMC operations regarding organizational structure, functional assignment and internal operations, as a way of documenting the strengths and weaknesses of the various alternatives. A total of four meetings were held, two in Northern California (at Caltrans District 4 headquarters) and two in Southern California (at Caltrans District 12 headquarters). In each location, a morning meeting concentrated on managerial issues, and an afternoon meeting concentrated on technical issues (see Appendix for agendas). The invitation list was generated in cooperation with Caltrans Traffic Operations in Sacramento and Caltrans Divsion of New Technology and Research, representing the following agencies:

California Highway Patrol	Headquarters TMCs
Caltrans Headquarters:	Emergency Management Mass Transportation Division of New Technologies and Research Public Information Toll Bridges Traffic Operations Transit Planning
Caltrans Districts:	Maintenance Toll Bridge Traffic Operations
City Traffic Departments	Anaheim, Irvine, Los Angeles, Menlo Park, San Diego San Jose, Santa Ana
Planning Organizations	Alamada Congestion Management Authority (CMA), Los Angeles Metropolitan Transportation Authority (LAMTA), Metropolitan Transportation Commission (MTC), San Diego Association of Governments (SANDAG), Southern California Association of Governments (SCAG), Santa Clara Congestion Mangement Authority (CMA)
Transit	Alemada Contra-Costa Transit, Bay Area Rapid Transit (BART), Los Angeles Metropolitan Transportation Authorigy (LAMTA), San Franciso Municipal Railway Association (MUNI), Organce Country Transportation Authority (OCTA), Sacramento, SamTrans, San Bemadino Transit San Diego Transit

Several weeks in advance of the focus groups, invitees were mailed a copy of the PATH working paper on existing TMCs (Lo, Hall and Windover, 1993), and a discussion paper on issues in TMC organization (Hall, Lo and Minge, 1994). The format of the meetings was discussed in the cover letter, and an agenda was provided. An R.S.V.P. was requested, and follow-up phone calls were used as reminders. A total of 50 people attended the four meetings, some of whom attended multiple meetings.
The meetings began with introductions, and a 10 minute review of the survey on existing TMCs. This was followed by a 10 minute presentation on TMC organizational issues. At this point, the thrust shifted to discussion. In the managerial sessions, the discussion was divided into four blocks, centering on the issues of: (1) traffic signal control and coordination, (2) incident management, (3) automated vehicle identification, and (4) managerial reporting and control. Each topic was introduced by presenting a list of opportunities and concerns (see Appendix). At this point, the facilitator opened the discussion to the group, by requesting comments on institutional aspects of the technologies, and the strengths and weaknesses of alternative organizational designs. The discussion was only directed to the extent needed to keep on topic and on schedule, and to allow all participants opportunity to speak. The format for the technical sessions was similar, with the exception that managerial reporting and control was not included, and participants were instructed to focus on technical issues, such as communication protocols and software requirements. Identical formats were used in Northern and Southern California.

5.1 Findings

The findings are categorized according to major themes, which tended to be common among all focus group sessions. (Abridged transcripts will be available upon request.) These themes are:

- Funding for Deployment and Operation, and Establishing Effectiveness
- System Maintainability
- Achieving Coordination, Without Sacrificing Control
- Conflict Resolution, and Establishing Common Goals
- Protocols for Information Exchange
- Public Image, and Ensuring Privacy
- Management Reporting

Funding Perhaps to no surprise, there was a strong consensus among all four groups that carefully directed funding was essential to implementing ITS. Local agencies, especially small cities, lack both the budget and staff to implement existing technologies, and it seems unrealistic that these agencies would divert already tight funds to advanced technologies. Beyond the basic budget squeeze, there was a strong sentiment that state and federal funding should be used to leverage agencies toward better coordination, by targeting funds toward inter-jurisdictional projects. Comments in this regard were highly consistent with Booz-Allen & Hamilton's (1993 conclusion that "the political unit that controls the financial resources has the ability to shape how ATMS is provided."

On the flip side, many felt that funding would be more plentiful if the benefits of ITS were carefully documented. The FHWA Field Operational Test (FOT) program was identified as an important element of this effort. However, evaluation was also viewed as important to non-FOT projects, and many felt that ITS systems should routinely generate data for evaluation purposes. As in the Booz-Allen & Hamilton study, rigorous cost/benefit analysis was strongly supported.

Maintainability There was also a strong sentiment that more care should be given to ensuring the long-term maintenance of systems as they are implemented. Participants expressed strong concern that the systems being implemented today may have diminished effectiveness because they are difficult to maintain, or because there is insufficient funding for maintenance. A solution would be to include maintenance cost as an explicit factor in system selection, along with redesigning systems if maintenance costs are prohibitive. In addition, a life-cycle budgeting approach was supported, to ensure that future funding is sufficient for adequate maintenance.

Coordination There was considerable discussion on the viability of leadership based organizations, with no strong consensus. On one hand, many argued that no agency would yield "control" of their transportation system to another, due to liability reasons, or a desire to retain "ownership." As stated in the Booz-Allen and Hamilton study (1993): "By agreeing to permit another entity to "control" their infrastructure, they may feel that others will make decisions and take actions that may not be supported by their own constituents." (p. 5-8)

On the other hand, several examples were cited of cities that had successfully turned over control of traffic signals to other agencies, without encountering major obstacles. Overall, there appeared to be agreement that adoption of leadership type organizations hinged on three critical factors: (1) funding incentives, (2) demonstrated benefits, and (3) coordination from a neutral agency, most likely a Metropolitan Planning Organization. These factors are needed to convince governing bodies to participate in such efforts. On the other hand, Booz-Allen & Hamilton's conclusion that "regional ownership is unlikely" (p. 5-8) also likely holds true, and that a more realistic scenario would be where each jurisdiction retains ownership, but allows regional coordination under tightly prescribed conditions.

There appeared to be few obstacles to decentralized structures, so long as this was interpreted as simple information exchange, without control. However, participants were skeptical that information exchange was sufficient to achieve coordination. Success would depend on the procedures enacted to respond to information, which would require careful study.

Overall, participants appeared to be less concerned about the type of organization structure, than about ambiguity. For instance, participants saw fewer problems with an outside agency completely taking over operations, than with an outside agency that might occasionally assume control (perhaps in response to an incident). Hence, there was a strong consensus that whatever organizational structure is implemented, roles and responsibilities must be precisely defined.

Conflict Resolution Several participants commented that coordinated systems are difficult to implement because different agencies have different goals and objectives. For instance, some cities are quite supportive of projects to improve throughput on major arterials, and to allow their use for diverted freeway traffic, while many are absolutely opposed. Support or opposition can often be traced to traffic impacts on residents and the significance of the traffic to the city's tax base. And because city councils respond to differing constituencies, they naturally have different objectives.

As one participant stated, "when the vision is common, the opportunities are there." There was a strong consensus that transportation agencies need to define such a vision, and to establish processes for resolving conflicts when they arise.

Information Exchange No one stated that major technical obstacles stand in the way of coordinating ITS systems. What is most needed is to define the interfaces. As a first step, high priority was given to developing interchange standards for signal plans. This might be followed by interface standards for other elements of the transportation system. In this regard, the TravInfo project (i.e., a federally funded ATIS field operational test project in the SF Bay Area) was cited as an example for traveler information.

There was a consensus, however, that standards should be devised by committees of experts through a consensus process, and not legislated or imposed by higher level agencies.

Public Image There was great concern among participants that all projects be sufficiently well conceived to pass the test of public scrutiny. This meant that ITS applications should provide tangible benefits to individuals, and should stay away from traffic enforcement or other aspects of control. Public image was an especially large concern in AVI systems. There was a consensus that agencies should be totally open with the public about all possible uses for AVI information prior to deployment. Furthermore, many felt that AVI tags should only be used for limited purposes, such as toll collection. Broadening their use, to traffic surveillance, vehicle inspection, etc., especially after the fact, was viewed as risky, as it opens the "big brother" specter.

Management Reporting There was a strong consensus that the success of ITS hinged on demonstrated cost-effectiveness. To this end, it was suggested that the State of California establish a "mobility index", which would be a common yardstick used in all regions to measure the performance of the transportation system on a daily, weekly, monthly and annual basis. To this end, it was viewed as essential that new systems have built in capabilities for archiving data, so that these statistics could be automatically generated, and that the State should develop standards for how these data are reported. This may result in a uniform management information system, which enables access to a broad range of transportation statistics, including delays, traffic volumes, transit usage, and accidents. This information could then be used for an array of purposes, including staffing, **Auto-Based** safety improvements, and transportation planning.

The focus groups concluded with a discussion of ITS opportunities and obstacles, which are summarized below:

Opportunities

- Faster and better information for travelers and TMC operators, which would enable better choices.
- Multi-agency and multi-modal coordination.
- Creation of additional resources

Obstacles

- Individual agencies that may not strive for the common good.
- Resistance to change and "turf" battles.
- Inability to maintain systems.
- Liability and privacy concerns
- Inability to fund deployment and operation

6 FOLLOW-UP SURVEY

Subsequent to the focus group meetings, follow-up surveys were distributed to each participating organization. The survey was divided into three sections, covering objectives and plans (including assignment of ITS functions), joint efforts, and internal organization. A copy of the survey can be found in the Appendix. Surveys were administered over the phone in cases where no written response was received. A total of fourteen surveys were completed, each representing the view points of a particular organization. They include responses from four city TMCs, the CHP, and nine Caltrans Districts/Branches. In Caltrans Districts where the Operations and Maintenance Branches are separate, both branches were surveyed. The results of the surveys are discussed in the following.

6.1 Strategic Objectives

The 5-year strategic objectives of TMCs tend to build from existing capabilities (see table A6-1 in the Appendix), including the following:

- Improve surveillance capabilities
  --expanding loop detector and CCTV coverage
- Expand information dissemination means
  --more CMSs and HARs and other means
- Improve incident management
  --shortening incident identification and response time
- Reduce congestion through reducing demand
- Improve traffic control
  --coordinated ramp meters, and advanced/adaptive traffic control
- Establish open traffic control standards and protocols
- Implement Electronic Toll Collection (ETC) on toll bridges
- Develop regional TMC
- Make TMCs independent of each other's operations
- Improve motorist and officer safety
- Develop "intermodal capabilities" in TMC
- Introduce seamless service/operations between jurisdictions and departments
  --between districts and cities, and between maintenance and operations
- Secure funding for more work
- Reduce maintenance/operations costs

Looking further to the future, there were few responses for a 20-year time frame. Responses included the following, some of which are not entirely strategic or long-term:

- Secure funding
- Develop regional TMC
- Develop real-time information capabilities
- Install traffic signal management programs
- Utilize public/private partnerships to implement ITS
- Utilize technology to improve traffic flow
- Develop intermodal TMC

To accomplish these objectives, the following new technologies were suggested:

- Statewide compatible communication protocol
- Communication system--fiber optics, leased lines, etc.
- On-line surveillance capabilities--improve coverage and reliability of loop data, CCTV
- Real-time signal control capabilities from TMC

- Information dissemination installations--kiosks, CMSs, HARs
- Automatic Vehicle Location (AVL) for incident response equipment
- Incident management decision support systems, including incident detection algorithms
- Performance evaluatory reports
- An information database or system that all regional modes can connect with

In addition, the need for additional staff and budget resources was stated.

6.2 Assignment of ITS Functions

Based on the twenty-seven ITS user services (or functions) listed by the IVHSProgram Plan (1994), the survey asked the priorities of functions to be performed by the TMC in the 5- and 20-year time frames. The detailed responses are tabulated in table A6-4 in the Appendix. Table 2 summarizes the results by expressing the percentage of responses that fall on the high, medium, low categories.

For the 5-year priority functions, 86% of the organizations indicated that incident management should have high priority. In addition to incident management, over half of the organizations agreed that the following functions should have high priority in the 5 year time frame: pre-trip information, driver information, travel demand management, emergency vehicle management, traffic control, ride matching and reservation, and emergency notification. And over half of the organizations indicated that these functions should have low priority: route guidance, travel payment, electronic payment services, commercial vehicle operations, personalized public transit, all the travel safety related functions except emergency notification, and automated vehicle operations. Table A6-4 in the Appendix indicates that the responses for the areas of traveler information and traffic management varied among organizations. For example, CHP viewed pre-trip information and driver information as high priority items; travel demand management was considered high by all Caltrans Operations branches surveyed; and all city TMCs indicated traffic control as their high priority function. In summary, other than incident management, different TMCs have considerably different priorities.

For the 20-year period, the consensus among the organizations gets clearer. All of them indicated that pre-trip information should have high priority, 92% said incident management is a high priority function, and 90% indicated that driver information is important. A comparison of the responses for the 5-year versus the 20-year period indicates that all functions received higher priorities in the longer term future, though most organizations still considered commercial vehicle operations as low priority items. (This reflects the point of view of current Caltrans or city TMC operators who were interviewed; it does not necessarily imply that commercial vehicle operations are low priority ITS items.) Moving up in priority are public transit and travel safety.

Summarizing, these results suggest that the TMC's role should evolve gradually to encompass more functions. In shorter time frames, in addition to traffic management, more traveler information functions will be included, while in longer time frames, additional functions related to public transit and travel safety may eventually become important.

Table 2 The priority of potential TMC functions for the 5- and 20-year time frames expressed as the proportion of responses indicated by the surveyed organizations

ITS Functions	Response Percentage (%)					
	5-year Priority			20-year Priority		
	High	Medium	Low	High	Medium	Low
Traveler Information	50	17	33	83	10	8
Pre-trip information	50	17	33	100	0	0
Driver information	75	8	17	90	10	0
Traveler service information	42	25	33	70	10	20
Route guidance	33	17	50	70	20	10
Traffic Management	47	19	34	63	18	18
Incident management	86	7	7	92	8	0
Travel demand management	50	25	25	70	20	10
Emergency vehicle management	50	8	42	60	30	10
Traffic control	67	25	8	80	10	10
Travel payment	0	33	67	33	22	44
Electronic payment services	27	18	55	45	18	36
Commercial Vehicle Operations	14	20	66	20	21	59
Commercial vehicle pre-clearance	25	17	58	40	20	40
Commercial vehicle admin.	9	18	73	11	22	67
Commercial fleet management	8	25	67	10	20	70
Public Transit	26	31	43	46	38	16
Ride matching & reservation	50	25	25	50	40	10
Enroute transit information	18	36	45	60	30	10
Personalized public transit	18	27	55	36	36	27
Public transport management	18	36	45	36	45	18
Travel Safety	19	15	66	29	40	31
Public travel security	33	17	50	50	30	20
Emergency notification	55	18	27	67	33	0
Automated safety inspection	9	9	82	9	45	45
On-Board safety monitoring	9	0	91	9	9	82
Lateral collision avoidance	9	18	73	27	45	27
Longitudinal collision avoidance	9	18	73	27	55	18
Intersection collision avoidance	9	27	64	27	55	18
Vision enhancement	0	18	82	18	45	36
Safety readiness	20	20	60	20	50	30
Pre-crash restraint deployment	36	9	55	36	27	36
Automated vehicle operations	9	18	73	23	38	38

6.3 Joint Efforts and Coordination

Joint efforts generally fall into the following three categories, as listed below:

- Manage the transportation system more efficiently for non-recurrent congestion--control traffic diversion
- Achieve joint signal management strategies--"green waves flow across jurisdictional boundaries."
- Provide seamless transitions across modes
- Improve roadway safety and incident response

Many of the reported joint efforts are in the planning or negotiation stage. For example, TravInfo, when implemented in the Bay Area, will be an important field operational test for the joint efforts among MTC, CHP, city and Caltrans TMCs, and the private sector. Presently, the significant existing joint effort occurs between Caltrans and CHP in managing and operating all Caltrans TMCs. By collocating at the same site and sharing real-time incident information, Caltrans and CHP are able to work together to coordinate the incident management responsibilities. In some areas, CHP, Caltrans, and County Transportation Authority work together to manage the FSP program and analyze its impacts. To some extent, some cities demonstrated some success in forming the traffic signal management program to coordinate signal control with neighboring cities. Other cities have established data communication links with Caltrans for surveillance purposes. (The detailed responses are included in tables A6-2 and A6-3 in the Appendix.)

When asked about the technical problems for joint efforts, the responses were generally optimistic. Some mentioned the need to establish common communication protocols and to build the physical communication links, for instance: "there is no real technical problem; it just takes time to decide on the standards". Some pointed out to the need of "getting the involved groups together and understanding mutual problems". Others noted that "getting the momentum going is difficult--Let's wait for someone else to do it". One district complained about the inflexible policies of Caltrans's funding and payment. Other mentioned difficulties include: "cities have cut back their traffic engineers due to budget crunch", and "it's a challenge to sell these programs to the politicians". In summary, inter-jurisdictional and institutional concerns pose great challenges to the establishment of joint efforts.

6.4 Internal Organization

The survey results on internal organization are discussed along two dimensions: centralized versus distributed operations, and automation

6.4.1 Centralized versus Distributed Operations

For each of the four functions listed--incident management, fleet management, signal control, and traveler information--the survey asked for the current and desired levels of centralization for their operations. The detailed results are listed in table A6-5 in the Appendix. table 3 summarizes the results by expressing the percentage of responses in the high, medium, and low categories. Presently, most organizations considered their operations tilted toward the low levels of centralization, which would mean that many of the operations and decisions are made at the fields or at distributed locations. What is more interesting is the comparisons of their current and desired levels. For most functions, many organizations want to increase the level of centralization, especially for signal control and ramp metering. One noticeable exception is incident management. While Caltrans Operations branches desire to centralize the operation, CHP and Caltrans Maintenance branches want to maintain it in a decentralized fashion. This is no surprise, since the Operations branches are concerned about diverting traffic from the scene through signal control strategies--which can be achieved from the TMC, while CHP and the Maintenance branches are concerned about clearing the scene--which is best achieved at the scene. Aside from incident management, these results are consistent with the trend of channeling both surveillance and control capabilities from the field to the TMCs.

Table 3 The current and desired levels of centralization of TMC functions expressed as the proportion of responses indicated by the surveyed organizations

ITS Functions	Response Proportion (%)					
	Current Level			Desired Level in 5 years		
	High	Medium	Low	High	Medium	Low
Incident management	31	23	46	31	38	31
Fleet management	50	25	25	60	40	0
Signal control	20	50	30	82	18	0
Traveler Information	10	40	50	64	18	18
Ramp metering	0	50	50	100	0	0

6.4.2 Level of Automation

In a similar way, the survey asked the organizations the current and desired level (in 5 years) of automation for the following functions: surveillance, communication with cooperating agencies, traveler information, incident detection, incident management, fleet management, and signal control. Detailed responses are tabulated in Table A6-6 in the Appendix. Table 4 summarizes the results by expressing the proportion of responses that indicated the high, medium, and low categories. The organizations estimated that most of the functions are performed currently at low levels of automation. Generally, they desire to improve the level of automation for almost all functions in 5 years. There are also some skeptics about the levels of automation achievable for some functions in 5 years. For example, some city TMCs doubted the automation of incident detection; and some Caltrans districts doubted the automation of communication among agencies, traveler information, and fleet management. Nevertheless, the general trend is that automating the functions is a desirable thing to achieve in the future.

Table 4 The current and desired levels of automation of TMC functions expressed as the proportion of responses indicated by the surveyed organizations

ITS Functions	Response Proportion (%)					
	Current Level			Desired Level in 5 years		
	High	Medium	Low	High	Medium	Low
Surveillance	17	33	50	67	25	8
Communication w/ agencies	18	18	64	67	25	8
Traveler information	18	36	45	67	25	8
Incident detection	9	36	55	75	17	8
Incident management	8	54	38	50	50	0
Fleet management	0	25	75	0	67	33

7 OBSERVATIONS

This paper has presented a vision of Computer Integrated Transportation (CIT), which is an integrated network of public and private organizations working toward a common mission of facilitating travel across all modes of transportation. Intelligent Transportation Systems (ITS) serve as an enabling force for CIT, providing the technological capabilities for its fulfillment. Just as important, however, is how CIT fits within the institutional environment of state and local agencies. This paper has worked toward the end of understanding how CIT, and ITS, can be implemented within the organizational framework of these agencies.

Throughout the study, we encountered considerable enthusiasm for ITS. Participants were nearly unanimous in their belief that ITS has improved their working relationships with other agencies, and that one of the most important benefits of ITS was improved coordination. While participants generally felt that a decentralized organizational structure was more practical within the current institutional environment, leadership based structures might be viable in the future, provided that the benefits could be demonstrated.

There was also a strong commitment among state agencies, and some local agencies, toward implementing an array of ITS services. In most cases, participants felt that the ITS services should be assigned along the lines of current agency responsibilities. With respect to internal organization, the ultimate answer would depend on costs analyses and technical feasibility, and not so much on institutional considerations.

Despite the enthusiasm for ITS, significant obstacles lie ahead. Participants were worried about the ability to fund and maintain ITS. They were worried that parochial interests might stand in the way of improved coordination. They were worried that some agencies were not sufficiently supportive of innovation and change. And they were concerned that the benefits of ITS might not be documented, which could stand in the way of future deployments.

While the participants' focus was on the deployment of ITS, their comments also have relevance for the ITS research program. In some cases, this is not so much reflected in specific comments as in participants' priorities and attitudes, as expressed in focus group sessions. These are summarized below.

Time-Frame Nearly across the board, participants were focused on short-range applications of ITS, mostly in the time frame of five years or less. For instance, participants showed considerable enthusiasm for, and detailed knowledge about, signal control systems and incident response strategies. On the other hand, medium-range applications, such as AVI, evoked much less discussion and interest. In the follow-up survey, few strategic objectives were stated beyond the five-year time-frame.

Linking Information to Actions Transportation management requires the coordinated effort of multiple agencies, and multiple divisions within agencies. Unfortunately, it appears that some of these organizations suffer from divided responsibilities. In some cases, for instance, information is not being collected by the organization that is empowered to act on the information. This is most apparent in incident response strategies, where the focal points of transportation information, TMCs, have limited power in responding to incidents.

Broadcast Orientation TMCs, as they exist today, disseminate information via broadcast technologies (changeable message signs, radio stations, etc.), and collect information in aggregate (mostly via loop detectors). ITS presents the opportunity for targeting information collection and dissemination to individual vehicles, drivers or travelers. AVI is one aspect of this opportunity. Other aspects include safety devices, in-vehicle signage, and eventually automated highways. Evolution from a broadcast orientation to a "narrow-cast" orientation will likely require significant changes in the function and organization of TMCs.

Embracing New Technologies While all participants were enthusiastic toward ITS within the context of their current functions, there was some hesitation toward expanding their functions. Lack of funding was an obvious concern. Just as important, perhaps, were that some agencies are nervous that they will be perceived as invading someone else's turf. While this type of caution has helped create a cooperative spirit among agencies, it has also created an obstacle to innovations in how transportation is organized, which may ultimately affect ITS implementation.

Mutual Interests The focus group study started by inviting a list of potential participants spanning transportation modes. However, the participation from transit agencies was not encouraging. This perhaps points to a need of better communication between the transit agencies and the TMCs, so that mutual interests may be shared. In the absence of the transit agencies, the proponents for adding intermodal elements in TMCs came from Caltrans, the city TMCs and MPOs. If TMCs are truly to fulfill the mission of enhancing mode transitions, the needs and interests of the various involved parties should be understood and appropriately incorporated.

Incentive/Mechanism for Cooperation There is no established mechanism or channel for building cooperation. Each joint effort is established on a case-by-case basis, and often demands great leadership and political will to overcome the institutional barriers. Presently, there is limited demand from below or incentive from above for TMCs to cooperate with other agencies. To a great extent, each TMC is self-contained and there is no urgent need to work with others. A mechanism or catalyst is needed to encourage cooperation.

To conclude, the above six factors have profound implications for ITS implementation and research. Each demands careful deliberation at a strategic level, and possibly changes in how transportation agencies are organized, and how they relate to each other. From the research perspective, the greatest risk is that innovative ITS concepts may have no home: because they are difficult to implement within existing organizations; because the long-term plan for their incorporation and coordination has not been fully developed; because there may be no one within operating agencies to advocate the concept; and because agencies are not always empowered to act on the information that they generate.

It should be pointed out that the organizational issues facing ITS are not unusual. Wilson (1989) describes the importance governmental agencies place on autonomy. He states that by finding a unique functional niche, organizations avoid external competitors. In the process, however, they tend to avoid taking on new tasks that deviate from their traditional core responsibilities. As an example, he cites the Army's decision to develop a large helicopter fleet, out of deference to an agreement with the Air Force which forbade purchase of fixed wing aircraft, rather than to technical considerations favoring helicopters over alternatives. In ITS, there are similar risks: that technological choices may be driven by long-standing organizational functions, rather than by what is best for the overall system.

To overcome these potential barriers, we believe that is it essential to reconsider the lines drawn between organizations, both within and between agencies, to determine whether they still make sense in the ITS environment. Further, it is essential to strengthen the dialogue between the researcher and practitioner communities, so that the two groups work together in developing a plan and a vision for computer integrated transportation.

8 FUTURE RESEARCH

Phase 2 of this project, which is now underway, will focus on non-automobile TMCs, and supporting agencies. This will include surveys of local police, fire and emergency services; commercial operators; transit systems; and third party information providers. The goal of phase 2 will be to identify ways to coordinate transportation across all agencies involved in transportation, within the framework of Computer Integrated Transportation, and to identify a preferred organizational structure.

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10 APPENDIX

1) **Agendas for Focus Group Meetings**
2) **Attendance at Focus Group Meetings**
3) **Issues Discussed at Focus Group Meetings**
4) **Follow-up Survey**
5) **Survey Results**

1) FOCUS GROUP AGENDAS

Organization for ITS/Computer Integrated Transportation
Northern California Forums
Caltrans District 4, February 23

A.M. Agenda (Managers Meeting)

9:30-9:40	Introductions	
9:40-9:50	Survey of Existing TMCs	Hong Lo
9:50-10:00	Organization for ITS Study Objectives	Randolph Hall
10:00-11:10	Organizational Issues ■ Signal Control & Preemption ■ Incident Management/Transit Support ■ AVI Applications	
11:10-11:40	Managerial Reporting	
11:40-12:00	Summary	

P.M. Agenda (Technical Meeting)

1:00-1:10	Introductions	
1:10-1:20	Survey of Existing TMCs	Hong Lo
1:20-1:30	Organization for ITS Study Objectives	Randolph Hall
1:30-3:00	Technical Issues ■ Signal Control/Preemption ■ Incident Management/Transit Support ■ AVI Applications	
3:00-3:15	Summary	

Organization for ITS/Computer Integrated Transportation
Southern California Forums
Caltrans District 12, March 25

A.M. Agenda (Managers Meeting)

9:30-9:40	Introductions	
9:40-9:50	Survey of Existing TMCs	Hong Lo
9:50-10:00	Organization for ITS Study Objectives	Randolph Hall
10:00-11:10	Organizational Issues ■ Signal Control & Preemption ■ Incident Management/Transit Support ■ AVI Applications	
11:10-11:40	Managerial Reporting	
11:40-12:00	Summary	

P.M. Agenda (Technical Meeting)

1:00-1:10	Introductions	
1:10-1:20	Survey of Existing TMCs	Hong Lo
1:20-1:30	Organization for ITS Study Objectives	Randolph Hall
1:30-3:00	Technical Issues ■ Signal Control/Preemption ■ Incident Management/Transit Support ■ AVI Applications	
3:00-3:15	Summary	

2) ATTENDANCE AT FOCUS GROUPS

Northern California

Ken Baxter	CHP HQ Planning
Glenn Behm	Caltrans District 4
Dave Driscoll	Caltrans District 3
Ted Eichman	CHP
Charles Felix	City of San Jose
Jeff Georgevich	Metropolitan Transportation Commission
Bob Guinn	Caltrans District 4
James Helmer	City of San Jose
Wayne Henley	Caltrans Traffic Operations HQ
Larry Jellison	Caltrans District 3
Barry Loo	Caltrans
Cyrus Mashoodi	Caltrans
Denis O'Connor	Caltrans DMT
Roger Henderson	Alameda County CMA
Jim McCrank	Caltrans District 4
Joe Palen	Caltrans New Technology
Jim Purse11	Caltrans Traffic Operations HQ
Robert Ratcliff	Caltrans New Technology
Ernie Rinde	Caltrans District 3
Ismael Sot0	Caltrans
Dale TenBrock	Caltrans HQ
Jay Walter	Caltrans District 6

Southern California

Don Allen	Caltrans District 8
Ken Ahacic	CHP San Diego
Yochan Baba	City of Anaheim
Ken Baxter	CHP HQ Planning
Joseph Brahm	Caltrans District 7
Ross Cather	Caltrans District 11
Steve Celniker	City of San Diego
David Dutcher	Caltrans District 11
John Duve	SANDAG
Dennis Elefante	OCTA
Stuart Harvey	Caltrans District 11
Joe Hecker	Caltrans District 12
Duncan Hughes	City of San Diego
Duane Kendall	CHP - Inland
Allan Kirst	Caltrans District 8
Cyrin Kwong	Caltrans District 8
Steve Leung	Caltrans District 7
Stan Lisiewicz	Caltrans District 7
Mark Lucy	OCTA
Dwight McKenna	CHP
Keith Myers	Caltrans District 12
Jeff Namba	Caltrans District 7
Vinh Nguyen	City of Santa Ana
Jim Paral	City of Anaheim
Bill Pasley	CHP - LA
Dennis Poirier	San Diego-Coronado Bridge
Tony Sarrniento	Caltrans District 8
TC Sutaria	City of Santa Ana
John Thai	City of Irvine
Jack Upton	CHP Inland

3) ISSUES DISCUSSED AT FOCUS GROUP MEETINGS

DISCUSSION FORMAT

For each example ITS technology, discuss pros and cons of alternatives: (1) external organization, (2) assignment of functions, and (3) internal organization.

- First, what are the implications for your agency (realism, importance, cost, effectiveness, etc.)?

- Second, is there a consensus?

All comments will be recorded and documented.

Remember, we are looking for your expertise on how best to implement ITS.

TECHNOLOGY 1: ADAPTIVE/COORDINATED SIGNAL CONTROL

Opportunities:	Signal Cycle Lengths/Offsets Respond to Prevailing Real-time Traffic Conditions
	Automated Changes/Adjustments to Signal Patterns
	Human Intervention in Response to Incidents
	Multi-modal Coordination, Including Signal Preemption.
	Inter-jurisdictional Coordination, to Eliminate Delays at Boundaries/Ramps
Concerns:	Facilitating Information Exchange
	Synchronization of Adaptive Systems
	Compatibility
	Conflicting Objectives (e.g., surface streets vs. highways)
	Cost sharing
	Responsibilities for operating and maintaining communication net and databases
	Resolving disagreements

TECHNOLOGY 2: INCIDENT RESPONSE

Opportunities:	Centralized Dispatching and Routing of Emergency Crews
	Remote Command Centers to Complement Personnel on the Scene
	Traveler Information to Re-route/ Re-schedule
	Comprehensive Surveillance for Immediate Response and Assessment
	Transit Re-routing; Supplemental Transit Service
Concerns:	Ensuring that all Objectives are Satisfied, Including Safety, Minimal Delay, Minimal Cost, etc.
	Ensuring that Info is Communicated to the Right People at the Right Time
	Establishing Roles and Responsibilities

TECHNOLOGY 3: AVI APPLICATIONS

Opportunities:	Vehicle Inspection, to Ensure Proper Maintenance, Registration, Air Quality
	Automated Toll Collection and Congestion Pricing
	Traffic Surveillance and Data Collection (e.g., o-d patterns)
	Traffic Code Enforcement
	Transit Fleet Monitoring/Schedule Control
	Communication to/from traveler.
Concerns:	BIG BROTHER (privacy)
	Multitude of Agencies/Sharing of Information
	Lead Responsibilities
	Security Issues (monetary transactions)

4) FOLLOW-UP SURVEY

COMPUTER INTEGRATED TRANSPORTATION SURVEY

California PATH
February/March 1994

This survey is intended to accompany a series of meetings held by PATH to explore organizational strategies for implementing Intelligent Transportation Systems (ITS) in the State of California. The specific purpose of the survey is to document the objectives, concerns and success stories of individual agencies.

Most of the questions are open-ended. If space is insufficient, please feel free to append additional pages, or to write on the back of the questionnaire.

Please answer all questions from your own perspective (i.e., from the perspective of the department or agency that you oversee).

Please mail completed surveys by March 11 to:

Hong Lo
California PATH
University of California
Richmond Field Station, Building 452
1301 S. 46th Street
Richmond, CA 94804
(510) 231-5605

THANK YOU FOR YOUR PARTICIPATION!

A) OBJECTIVES AND PLANS OF YOUR AGENCY OR DEPARTMENT

1a) What are your strategic objectives in implementing ITS over the next five years?

1) ______________________________

2) ______________________________

____

4) ______________________________

1b) Currently, what are your most critical programs to fulfill these objectives?

1) ______________________________

2) ______________________________

____

1c) What additional surveillance/information collection capabilities do you need to fulfill these objectives?

____

2) ______________________________

3) ______________________________

1d) What additional control capabilities (signal control or other) do you need to fulfill these objectives?

1) ______________________________

2) ______________________________

3) ______________________________

1e) What additional information dissemination capabilities do you need to fulfill these objectives?

1) ____________________

2) ____________________

3) ____________________

1f) What additional communication capabilities do you need to fulfill these objectives?

1) ____________________

2) ____________________

3) ____________________

1g) What additional TMC capabilities do you need to fulfill these objectives?

1) ____________________

2) ____________________

3) ____________________

1h) What additional incident management capabilities do you need to fulfill these objectives?

____

2) ____________________

3) ____________________

li) What additional managerial information capabilities do you need, and what managerial functions would this information support?

1) ____________________

2) ____________________

____

2) What are your strategic objectives in implementing ITS over the next 20 years?

1) ______________________________

2) ______________________________

3) ______________________________

3) The following table lists potential ITS user services. From the perspective of your agency, please provide the following information:

a) rank these services as high priority (H), medium priority (M) or low priority (L), for a 5-year horizon and 20-year horizon.
b) indicate your expected role, as either leadership (L) or support (S).
c) suggest a lead agency (your agency or other).

	PRIORITY (H,M or L) 5-year	20year	ROLE (L or S)	LEAD AGENCY
Traveler Information				
Pre-trip Information	____	____		________
Driver Information	____	____		________
Traveler Services Info	____	____		________
Route Guidance	____	____		________
Traffic Management				
Incident Management	____	____		________
Travel Demand Management	____	____		________
Emergency Vehicle Management	____	____		________
Traffic Control	____	____		________
Travel Payment	____	____		________
Electronic Payment Services	____	____		________
Commercial Vehicle Operations				
Commercial Vehicle Pre-clearance	____	____		________
Commercial Vehicle Admin	____	____		________
Commercial Fleet Management	____	____		________
Public Transit				
Ride Matching & Reservation	____	____		________
En Route Transit Information	____	____		________
Personalized Public Transit	____	____		________
Public Transport Management	____	____		________
Travel Safety				
Public Travel Security	____	____		________
Automated Safety Inspection	____	____		________
On-board Safety Monitoring	____	____		________
Lateral Collision Avoidance	____	____		________
Longitudinal Collision Avoidance	____	____		________
Intersection Collision Avoidance	____	____		________
Vision Enhancement	____	____		________
Safety Readiness	____	____		________
Pre-crash Restraint Deployment	____	____		________
Automated Vehicle Operation	____	____		________

Priority: H, high; M, medium; or L, low
Role: L, lead; or S, support

B) JOINT EFFORTS

1) Please describe joint ITS efforts that are already underway between your department or agency and another department or agency.

1) ____

____

2) ____

____

3) ____

____

4) ____

2) For each effort cited above, describe the information that your are currently providing, or intend to provide, to the cooperating department(s)/ agency(ies).

1) ____

____

2) ____

____

____

____

4) ____

3) For each effort cited above, describe the information that you are currently receiving, or intend to receive, from the cooperating department(s)/ agency(ies).

1) ____

____

2) ____

____

3) ____

____

4) ____

4) In relation to your objectives, what results do you expect from each of these efforts?

1) ____________________
____
2) ____________________
____
3) ____________________
____
____

5) What capabilities have you established for automated exchange of information, in each of these efforts?

____
____
2) ____________________
____
3) ____________________
____
4) ____________________

6) On a technical level, what problems (if any) were encountered in these efforts?

1) ____________________
____
2) ____________________
____
3) ____________________
____
4) ____________________

7) More generally, what solutions can you offer for facilitating joint ITS efforts?

1) ____________________
____
2) ____________________
____
3) ____________________
____
4) ____________________

C) INTERNAL ORGANIZATION

1) For each of the functions listed below, indicate the current internal level of centralization, and the desired level of centralization five years from now. (A high level of centralization means that decision making is concentrated at a single location; a low-level indicates that decision making is localized in field units, which may be fully automated.)

For each function, indicate low (L), medium (M), high (H) or not applicable (NA)

Function	Current Level of Centralization (L, M, H or NA)	Desired Level in 5 years (L,M,H,NA)
Incident Management	____________	____________
Fleet Management	____________	____________
Signal Control	____________	____________
Traveler Information	____________	____________
Other ______________________	____________	____________

2) For each of the functions listed below, please indicate the current and desired level of automation (L, M, H or NA):

Function	Current Level of Automation (L,M,H or NA)	Desired Level in 5 years (L,M,H,NA)
Surveillance	________	________
Communication with Cooperating Agencies	________	________
Traveler Information	________	________
Incident Detection	________	________
Incident Management	________	________
Fleet Management	________	________
Signal Control	________	________
Other ________________	________	________

D) AGENCY INFORMATION (optional)

1) What agency and department do you represent? ____________________

2) What location do you represent? ____________________

3) Name ____________________

THANK YOU FOR YOUR TIME!

5) FOLLOW-UP SURVEY RESULTS

(This page only contains the heading.)

Table A6-1 The 5-year strategic objectives, critical programs and resources requirements of the organizations.

Organization	5-year Strategic Objectives	Critical Programs	Additional Capabilities/Resources Req'd
Caltrans District A Operations	1. Reduce Congestion 2. Increase efficiency of existing freeway system 3. Improve motorist travel decisions 4. Enhance safety	1. Ramp metering 2. Integration of TMC systems 3. CCTV	1. More CCTV locations for full coverage 2. Improved CCTV reliability 3. Integration with CHP's CAD 4. Improved loop detector reliability 5. Faster, easier and more automated ramp meter control 6. Coordination with local agency traffic control system 7. Combine CHP, Caltrans and city traffic info at the TMC 8. Complete fiber optic system 9. Capability of sending info to all who want it 10. Point to multi-point distribution 11. Automate HAR system 12. Enhanced central computational info center capabilities 13. Improve incident clearing time 14. Improved two-way radio communication for incident management 15. Improved access to logged info
Caltrans District A Maintenance	No objectives involving IVHS	None	1. Better knowledge of the nature of incidents, what equipment should be dispatched? CCTVs are helpful for this.

Caltrans District B	1. Provide real time information to system users 2. Seamless transition between modes	1. Partnership with MPO for regional IVHS strategic plan	1. Incident detection algorithms for whatever medium selected 2. Communications infrastructure 3. Partnerships b/t operators 4. Ultimately information dissemination will be done by a third party 5. Develop a single info system that all regional modes can connect with 6. Make the Caltrans TMC the central hub for info system, regional TMCs can tie into it 7. Improve FSP 8. Provide decision info to travelers real time
Caltrans District C	1. Upgrade TMC to allow IVHS development 2. Make TMC a testbed for IVHS technologies 3. Connect with transit agencies and cities to exchange info 4. Split computers and install upgrades to make TMC independant 5. Co-locate with CHP	1. TMC upgrade project	1. Need for more traffic monitoring stations (loops) 2. Upgrade 170 controllers to 2070s 3. Enhance signal interconnect, coordination, and central control 4. Improve info dissemination such as by cable TV, personal computer link, phone info, kiosks or other public areas such as airports, office buildings, transit stations, etc. 5. Install fiber optic backbone 6. Connect to other TMCs (city and Caltrans) and transit agencies, airports, etc. 7. Improve incident detection with more sensors amd CMSs 8. Coordinate with local agencies to reroute traffic 9. Generate reports to evaluate operations 10. Personnel training

Caltrans District D	Install elements to provide information to the traveling public such as HAR, CMS, media.	TMC will provide framework for implementing	1. Addl. surveilance reqd. includes loops, video image processing and call boxes/9 11 calls 2. Metering at ramps, freeway to freeway connectors and on the mainline provides control 3. Disseminate real time info to public via HAR, CMS, media and cable TV 4. Complete fiber optic system 5. Locate and complete our TMC
Zaltrans District E	1. Monitor field conditions from TMC via loops and CCTV 2. Expand CMS and HAR coverage 3. Expand ramp meters and CCTV	1. Secure funding	1. soft/hardware to put the collected data in a usable format 2. signal and ramp metering control capabilities from TMC 3. Kiosks for local employers 3. Comm. network--fiber optics and leased lines 4. GIS for region mapping 5. "Statewide committment to one compatible comm. system" 6. Develop a system that requires less operator interaction 7. Ability to call out tow trucks from TMC
Caltrans District F Operations	1. Reduce congestion through reducing demand 2. Reduce notification/identificaiton and response time of incidents	1. Development of regional TMC 2. Upgrading existing system to have real-time information capabilities	1. Expand existing system via loops and CCTV 2. Look for a tech. to replace loops, i.e video image processing 3. Real-time control and ramp metering system 4. Provide real-time info, including freeway speed data, to the media 5. Develop an expert sys. to assist operators in making decisions 6. Enhance process capabilities to get the status of the freeway system (s.t. the operators can understand) 7. More CMSs and HARs 8. Provide info to maintenance for better coordination

Caltrans District F Maintenance	1. Implement ETC on state toll bridges 2. Integrate maintenance into present TOC 3. Integrate maintenance into new TMC 4. Complete EOC	1. "All projects under way"	1. "Maintenance resources" 2. "Make certain new equipments & installations are maintainable"
Caltrans District G	1. Construct TOS (TMC, CCTV, CMS, ramp meters) already funded 2. Secure funding for regional TMC	1. Obtain further funds e.g. via ISTEA "IVHS Early Deployment" funding opportunities 2. Construct funded TOS	1. Hard/software for operating/monitoring CCTV, CMS, and ramp meters 2. Additional staff and equipments (trucks, CMS, CCTV, ramp meters)
City A	1. Improve traffic flow at high congestion points. 2. Better response to recurring and non-recurring congestion. 3. Seamless service for traffic between jurisdictions.	1. SCOOT traffic-adaptive system. 2. Master traffic control computer for non-SCOOT intersections. 3. Communication systems, using fiber optic and other communication media.	1. More and improved traffic detection. 2. Direct communication with Caltrans TMC. 3. Possibly video surveillance. 4. Improve communcation systems.
City B	1. Implement advanced/adaptive traffic signal control 2. Establish open traffic control standards and protocols 3. Enhance/upgrade existing traffic infrastructure 4. Integrate multi-modal transportation objectives/systems into TRAC	1. Integrated ramp metering/adaptive signal control project 2. Caltrans/City/University fiber optic Intertie project 3. Ongoing signal rehabilitation and traffic system programs	1. Collect transit and toll road data 2. Collect O/D data using vehicle image detection systems 3. Expand adaptive traffic signal control 4. Obtain knowledge based expert system 5. Integrated "open" traffic database 6. Enhance existing fiber optic infrastructure 7. Design open information dissemination systems for exchange, coordinate with local cable company 8. Expand wan capabilities for data exchange 9. Need dedicated radio frequencies for traffic control 10. Need more software engineers and more space for equipment 11. Need more CCTVs

City C	1. Implement traveler information systems 2. Install adaptive control/expert systems 3. Reduce maintenance/energy/operations costs	1. Develop policy for information distribution 2. SCOOT demonstration and VCI expert system 3. Install system logging and remote trouble-shooting systems	1. Expand number of arterial detectors 2. Central monitoring systems/computers 3. Intertie with other agencies 4. Adaptive controllexpert system software and computers 5. Broadcast port capabilities for multiple users 6. Text based messages 7. Expand TMC to house equipment, more wiring
City D	1. Continue traffic signal management program (TSMP)--link CCTV, CMS, signals via comm. network	1. Install TSMP	1. CCTV, city-wide vehicle detection system 2. HAR, CMS 3. High speed comm link
CHP	1. Improve incident mangement 2. Improve motorist and officer safety 3. Improve commercial vehicle operations/inspections	1. TMC 2. Mobile Digital Computers 3. Call boxes and WIM	1. GIS 2. IR sensors for HOV enforcement 3. AVL 4. Ample frequencies to handle voice and data comm 5. Quicker incident cleanup 6. Ability to view incident remotely

Table A6-2 The present joint IVHS Efforts, and the information shared between the participating organizations.

Organization	Present Joint IVHS Efforts	Information Provided	Information Received
Caltrans District A Operations	1. IVHS coordination project with cities and CHP		
	2. TMC with CHP, Transit, others	All traffic info	All traffic info
	3. GIS	Graphical exchange of traffic info	Provide common communication platform and graphical information exhange
Caltrans District A Maintenance	1. Cooperate w/ Caltrans Traffic Operations Branch	Incident details	Incident details
	2. Coordinate w/ Caltrans Construction		
	3. Cooperate w/ CHP		
Caltrans District B	1. IVHS development plan with city	List of existing transportation problems that IVHS can address	Committee input
	2. Intermodal TMC	System architecture	
	3. Call box field operational test	Existing infrastructure	None
	4. Corridor plan		
Caltrans District C	1. Cooperate with CHP	Incident information	More data on 911 calls
	2. Data sharing with cities	Volumes, speed, delay times, incident information	Info from cities on special events
Caltrans District D	1. Share communication facilities with CHP	All information	
	2. Cooperation with cities (at an early stage)	Count data, etc	Traffic info on local routes
	3. Working on a joint plan with MPO		
Caltrans District E	1. "Operation Fog"--Caltrans/CHP	Fog information in valley	Fog info in valley
	2. Signal interconnect projects--Caltrans/Fresno city/county	Still under negotiation; potentially signal timing and incident notification	
Caltrans District F Operations	1. ATIS Project--MPO, CHP, city TMCs, and private co.s	Speed, volume and occu. data every minute for the entire highway network	1. local streets traffic conditions 2. transit conditions and schedules

	2. Coordination with the City TMC	Speed, volume and occu. data every minute for the entire highway network	1. local streets traffic conditions 2. signal plans
Caltrans District F Maintenance			
Caltrans District G	1. TMC--CHP/Caltrans	Real-time info on traffic incidents	Comments on proposed TMC; real-time info of traffic incidents
	2. FSP--joint CHP/Caltrans/County Transportation Authority effort	Statistical analysis of FSP data and report generation	FSP data
	3. ISTEA "Early Deployment Study:--joint MPO/Caltrans/city/county	Comments on scoping of planning study	Comments on scoping
	4. Call box program--Caltrans/Regional SAFE		
City A	1. SCOOT project with Caltrans.	None	None
	2. Regional IVHS planning effort with our MPO and Caltrans.	In planning stage, staff coordination	In planning stage, staff coordination
City B	1. Integrated ramp metering/adaptive signal control project with Caltrans	Design plans, system architecture, traffic counts, cabinet and controller specs	System architecture, database format, and ATC specs
	2. Fiber optic intertie project with Caltrans and the University	Design plans, fiber optic equipment specs, and CCTV specs	None
	3. Multimodal transportation facilities CCTV project with Caltrans	Design plans, fiber optic equipment specs, and CCTV specs	None
City C	1. "Intertie" with Caltrans for information exchange	Real time volume rates, occupancies, speed, and video on city traffic conditions	Freeway information
	2. Provide public with integrated road and transit information, in cooperation with transit agency	Real time volume rates, occupancies, speed, and video on city traffic conditions	Transit vehicle location probes, routes and schedules
	3. Several multi-agency signal coordination project along arterials.	Mutally agreeable coordinated timing plans	Mutally agreeable coordinated timing plans

City D	1. Designing comm link with Caltrans TMC	(to be developed in the future)	(potentially video image, and current traffic conditions)
	2. Comm link with adjacent city	Monitor intersections on a joint corridor, control from a remote location	Traffic counts and circulation data
	3. Comm link with second adjacent city	Coordination across jurisdictional boundaries, control strategies for interconnect capabilities	Traffic counts and circulation data
CHP	1. Smart call boxes in San Diego	CHP regional staff participation	
	2. TravInfo in the Bay Area	CHP regional staff participation; provide access in CHP's CAD	
	3. Signal/Surveillance FOT--Orange County/LA	CHP regional staff participation	

Table A6-3 The expected results from the joint efforts, the established capabilities for automated information exchange, the technical problems encountered and the solutions to facilitate joint IVHS efforts.

Organization	**Expected Results from Joint Efforts**	**Established Capabilities for Automated Info Exchange**	**Technical Problems Encountered**	**Solutions to Facilitate Joint IVHS Efforts**
Caltrans District A Operations			1. Maintenance 2. Proprietary hardware/software elements 3. Others	1. Co-locating TMCs including Caltrans, CHP, City and Transit 2. Fiber optic communication backbone 3. Open systems computer architecture
Caltrans District A Maintenance		TMC computer system		
Caltrans District B	Ultimate goal is to provide an efficient and effective system where transitions across modes are seamless	None	Need to develop an integrated transportation info system which can be used by all regional providers	Each MPO region must complete a plan of how to use IVHS tools to solve existing regional transportaiton problems and then integrate this into the current planning process, becomes a component of the R.T.P.
Caltrans District C	1. Better incident management 2. Improve flow of traffic through corridor 3. Achieve a coordinated approach to transportation	None	No technical problems, just funding and policy problems	Involve all parties in IVHS, see that momentum is maintained
Caltrans District D	Increase efficiency of the transportation system.	1. CAD system with CHP 2. Coordination with adjacent Caltrans Dist.	No real technical problems, more beaurocratic	Get rid of territorial issues
Caltrans District E	Joint operation and management of transportation corridor	None yet		Get compatible hard/software

Caltrans District F Operations	1. Manage freeway more efficiently--know when can or can't diver traffic 2. Achieve joint signal management strategies--	1. ATIS Project: consultants are working on comm protocols and standards 2. With City: consultant working on standards	No real technical problems; just takes time to decide on the standards	1. Get the involved groups together, understand mutual problems and derive solutions 2. Getting the momentum going is difficult--"Let's wait for someone else to do it" 3. Lack of staff--cities have cut back their traffic engineers 4. Major part of Smart Corridor (Rt 171880) is to get parties agree to enter the study; challenge is to sell it to the politicians
Caltrans District F Maintenance				
Caltrans District G	1. Implementation of the Regional TMC; a modern TOS on all metro. freeways 2. Implementation of FSP; AVL for FSP 3. IVHS Master Plan	1. Telephone; fax; modem; computer bulletin board; CHP CAD; loop monitoring capability via modem hook-up	Delays in getting equipment	1. Collocation of Caltrans Dispatch with CHP dispatch 2. Joint efforts are going well except Caltrans funding and payment policies are inflexible
City A	1. Successful traffic-adaptive traffic signal system 2. Regional IVHS plan to facilitate funding for IVHS deployment	None	None	1. Include Caltrans signals in SCOOT system 2. More staff-to-staff coordination
City B	1. Establishment of "open" systems and protocols, direct data exchange, adaptive control algorithms 2. Direct fiber optic intertie for info exhange between City, Caltrans and the University 3. Enhanced fiber optic infrastructure, implementation of autoscope technology to freeway ramps and security(?)	1. Redundant fiber optic ring in City's infrastructure 2. Direct high bandwidth fiber intertie	1. Determining exact ATC (20%) requirements/specs for project, gradual shifting from DOS environment to UNIX, incorporating adaptive signal control with existing traffic system 2. Establishing an intertie pedestal for Caltrans connection	1. Adequate staff commitment and technical expertise 2. Established fiber optic network and intertie with Caltrans, City and the University 3. Connection (wan) that is part of testbed

City C	1. Coordinated traffic control between freeways and arterials 2. Use bus vehicle probes for roadway information and provide for multi-modal traveler information systems 3. Coordinated signals along arterials crossing jurisdictional boundaries	1. Leased communication lines 2. Leased communication lines 3. Use of universal time-base	1. System protocols/ integration 2. System protocols/ integration 3. None	1. Require continuous communication and strong leadership 2. Need for standardizing system protocols
City D	1. Better coordination of signal along interjurisdictional arterials 2. Incident detection (future)	Access to our central computer system to review data from other cities	Establishment of common comm. protocols; establishment of physical comm. links	1. Utilize our system as a data repository for interjurisdictional systems 2. Sharing of video images 3. Utilize our system for joint incident management
CHP	1. Improve highway safety 2. Improve mangement of incidents and the highway system	1 via the presence of staff 2. CHPCAD 3. Statewide Integrated Traffic Record System (SWITRS)		

Table A6-4 The 5- and 20-year priorities of potential TMC functions and the suggested lead agency

User Services	Priority (5-year)			Priority (20 year)			Lead Agency
	High	Medium	Low	High	Medium	Low	
Traveler Information:							
Pre-trip Information	DAO, DB, DC, City B, City C, CHP	DFO, DE	DD, City A, DGO, DFM	DB, DC, DD, City A, City B, City C, CHP, DGO, DFM, DFO			Caltrans/TO/City/CHP, Caltrans Caltrans/TO/City, CHP/Caltrans, City, Caltrans, TMC, TravInfo, Caltrans, Caltrans, Caltrans/PS, Caltrans/PS
Driver Information	DAO, DB, DC, DD, City B, City C, CHP, DFM, DE	DFO	City A, DGO	DB, DC, DD, City B, City C, CHP, DGO, DFM, DFO	City A		Caltrans/TO/City/CHP, Caltrans/City, CHP/Caltrans, Caltrans, Caltrans, Caltrans, Caltrans, Caltrans, Caltrans, Caltrans/PS, Caltrans/other
Traveler Service Info	DAO, DB, City A, City B, DFM	DC, City C, DE	DD, CHP,DGO, DFO	DB, DD, City A, City B, City C, DGO, DFM	DC	CHP, DFO	Caltrans/TO/City/CHP, City, Caltrans, City, Caltrans, TMC, TravInfo, Caltrans, City, Caltrans/PS, City, State/City
Route Guidance	DAO, DB, DC, City B	City C, CHP	DD, City A, DGO, DFM, DFO, DE	DB, DC, DD, City B, City C, DGO, DFO	City A, CHP	DFM	Caltrans/TO/City/CHP, Caltrans/City, CHP/Caltrans, TMC Caltrans, Caltrans, Caltrans/PS, PS, Caltrans, Caltrans/other

DAO/M: Caltrans District A Operations/Maintenance DB: Caltrans District B DC: Caltrans District C DD: Caltrans District D DE: Caltrans District E DFO/M: Caltrans District F Operations/Maintenance DG: Caltrans District G CHP: California Highway Patrol TO: transit organization PS: Private sector

Traffic Management:							
Incident Management	DAO, DAM, DB, DC, DD, City A, CHP, DGO, DFM, DFO, DE, D7M	City B,	City C	DAM, DB, DC, DD, City A, City B, CHP, DGO, DFM, DFO, D7M	City C		CHP, Caltrans/City, Caltrans, CHP, Caltrans, CHP, CHP/Caltrans, Caltrans, Caltrans, CHP, City, CHP, Caltrans, Caltrans, Caltrans/other
Travel Demand Management	DAO, DB, City A, City C, DGO, DFO	DC, City B, DE	DD, CHP, DFM	DB, DD, City A, City B, City C, DGO, DFO	DC, DFM	CHP	Caltrans, Caltrans, Caltrans/TO/City, "Commuter Computer", Caltrans, Caltrans, Caltrans, Caltrans, Caltrans, City
Emergency Vehicle Management	DAO, DB, DC, DD, City A, CHP	DFO	City B, City C, DGO, DFM, DE	DB, DC, DD, City A, CHP, DGO	City B, City C, DFO	DFM	CHP, City, CHP, Caltrans/City, Caltrans, CHP, CHP, City, Caltrans, CHP
Traffic Control	DAO, DB, DD, City A, City B, City C, DFM, DFO	DC, DGO, DE	CHP	DB, DD, City A, City B, City C, DGO, DFM, DFO	DC	CHP	Caltrans, MPO, Caltrans/City, Caltrans, Caltrans, TMC, Caltrans, Caltrans, Caltrans, City, City, Caltrans, State/City
Travel Payment		DB, City B, DFO	City A, City C, CHP, DGO, DFM, DE	DAO, DB, City B,	City C, DFO	City A, CHP, DGO, DFM	Caltrans, Caltrans, MPO
Electronic Payment Services	DB, DFM, DFO	DC, City B	DD, City A, City C, CHP,DGO, DE	DAO, DB, DC, DFM, DFO	City B, City C,	DD, City A, CHP,DGO	Caltrans, Caltrans, Caltrans, Caltrans, Caltrans, Caltrans, MPO, Private Toll

DAO/M: Caltrans District A Operations/Maintenance DB: Caltrans District B DC: Caltrans District C DD: Caltrans District D DE: Caltrans District E DFO/M: Caltrans District F Operations/Maintenance DG: Caltrans District G CHP: California Highway Patrol TO: transit organization PS: Private sector

Commercial Vehicle Operations:							
Commercial Vehicle Pre-clearance	DC, DD, CHP	DAO, DB ,	City A, City B, City C, DGO, DFM, DFO, DE	DB, DC, DD, CHP	City B, DGO	City A, City C, DFM, DFO	Caltrans, PS, CHP/other, Caltrans, Caltrans CHP/Caltrans, TMC, Caltrans, Caltrans
Commerical Vehicle Administration	CHP	DAO, DB,	DD, City A, City B, City C, DGO, DFM, DFO, DE	CHP	DB, City B	DD, City A, City C, DGO, DFM, DFO	Caltrans, PS, CHP, CHP, PS, PS, PS
Commercial Fleet Management	DC	DAO, DB, City B,	DD, City A, City C, CHP, DGO, DFM, DFO, DE	DC	DB, City B,	DD, City A, City C, CHP,DGO, DFM, DFO	Caltrans, PS, PS, CHP, PS, PS, PS, PS, PS
Public Transit							
Ride Matching & Reservation	DAO, DB, DC, DD, City A, City C	City B , DFM, DFO	CHP,DGO, DE	DB, DC, DD, City A, City C	City B, DGO, DFM, DFO	CHP	Caltrans/TO/City, "Commuter Computer", MPO, TO/Caltrans, MPO, Caltrans/TMC, County, Caltrans, County, caltrans
En Route Transit Information	DB, DD,	DC, City B, City C, DFM	City A, CHP,DGO, DFO, DE	DAO, DB, DD, City B, City C, DFO	DC, City A, DGO	CHP	TO, MTDB, TO/Caltrans, MPO, TO, Caltrans, Caltrans Caltrans, TO, Caltrans/City
Personalized Public Transit	DB, DD,	DC, City B, DFM	City A, City C, CHP,DGO, DFO, DE	DAO, DB, DD, City B,	DC, City C, DGO, DFM	City A, CHP, DFO	TO, TO/Caltrans, MPO, PS, TO, TO, TO, TO, PS/City
Public Transport Mangement	City A, City B,	DB, DC, DD, DFM	City C, CHP, DGO, DFO, DE	DAO, DB, City B, City A	DC, DD, City C, DGO, DFM	CHP. DFO	TO, TO TO/Caltrans, MPO, TO, TO, TO, TO, MPO, City

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Travel Safety	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Public Travel Security	DC, DD, City A, CHP	DAO, DB,	City B, City C, DGO, DFM, DFO, DE	DB, DC, DD, City A, CHP	City C, DFM, DFO	City B, DGO	CHP, PS, PDs, CHP, CHP, CHP/PDs, Caltrans, CHP/PD, CHP/PD
Emergency Notification	DC, DD, City A, CHP, DFO, DE, DC	DAO, DB,	City C, DGO, DFM	DC, DD, City A, CHP, DFO, DC, DB	DB, City C, DGO, DFM		CHP, PDs/EMS, CHP, Caltrans (Haz.), CHP (others), Caltrans, Cities, Caltrans, Cities, City
Automated Safety Inspection	DD,	DC	DB, City A, City B, City C, CHP, DGO, DFO, DFM, DE	DD,	DB, DC, CHP, DGO, DFM	DAO, City A, City B, City C, DFO	CHP, PS, CHP, City/PD, CHP, CHP, Caltrans
On-board Safety Monitoring	DC		DB, DD, City A, City B, City C, CHP,DGO, DFM, DFO, DE	DC	DFM	DAO, DB, DD, City A, City B, City C, CHP, DGO, DFO	CHP, PS, PS, CHP, PS, PS, PS, PS
Lateral Collision Avoidance	DC	CHP, DE	DB, City A, DD, City B, City C, DGO, DFM, DFO	DC, DFO, DD	DAO, City B, CHP, DGO, DFM	DB, City A, City C,	PS, PS, Caltrans, Caltrans, Caltrans, Caltrans, PS, unknown
Longitudinal Collision Avoidance	DC	CHP, DE	DB, DD, City A, City B, City C, DGO, DFM, DFO	DC, DFO, DD	DAO, DB, City B, CHP, DGO, DFM	City A, City C,	PS, PS, Caltrans, Caltrans, Caltrans, Caltrans, Caltrans, unknown
Intersection Collision Avoidance	DC	City B, CHP, DE	DB, DD, City A, City C, DGO, DFM, DFO	DC, City B, DD	DAO, City C, CHP, DGO, DFM, DFO	DB, City A,	PS, Caltrans/Cities, Caltrans, PS, Caltrans/Cities, unknown
Vision Enhancement	⊛	DC, CHP	DB, DD, City A, City B, City C, DGO, DFM, DFO, DE	DD, DB	DC, City B, CHP, DGO, DFM	DAO, City A, City C, DFO	PS, PS/Caltrans, DMV, Caltrans, unknown Caltrans, PS, Caltrans

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Safety Readiness	City B, DFO	DC, DD	DB, City A, City C, DGO, DFM, DE	City B, DFO	DAO, DC, DD DGO, DFM	DB, City A, City C,	CHP/DMV, Caltrans, CHP/DMV, PS
Pre-crash Restraint Deployment	DB, DC, DD, CHP	City B ,	City A, City C, DGO, DFM, DFO, DE	DB, DC, CHP, DD	DAO, City B, DFM	City A, City C, DGO, DFO	PS, PS, DMV, CHP/Caltrans, Caltrans, PS, unknown CHP/Caltrans
Automated Vehicle Operation	DD,	DC, City B	DB, City A, City C, CHP, DGO, DFM, DFO, DE	DC, DD, DGO	DAO, City B, City C, DFM, DFO	DB, City A, CHP	Caltrans/PS, PS, Caltrans, Caltrans, PS, Caltrans, PS/other, Caltrans

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Table A6-5 The current and desired levels of centralization for the TMC functions.

Functions	Current Level			Desired Level in 5 years		
	High	Medium	Low	High	Medium	Low
Incident Management	DB, DC, City B, City C	DD, DFO, DE	DAO, DAM, City D, DFM, DGO, CHP	DB, DC, City B, DFO	DAO, DD, City D, DGO, DE	DAM, City C, DFM, CHP
Fleet Management	DB, DC	DAO,	DFO	DAO, DB, DC	DFO, DGO	
Signal Control	DB, City B,	DAO, DD, City A, City C, City D	DC, DFO, DE	DAO, DB, DC, DD, City A, City B, City D, DFO, DE	City C, DGO	
Traveler Information	City B,	DAO, DFO, City C, City D	DB, DD, DGO, DE, CHP	DAO, DB, DC, City B, City D, DFO, DE	DD, DGO	City C, CHP
Ramp Metering		DAO,	DC	DAO, DC		

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Table A6-6 The current and desired levels of automation for the potential TMC functions

Function	Current Level			Desired Level in 5 years		
	High	Medium	Low	High	Medium	Low
Surveillance	City B, CHP	DAO, DB, DC, City C	DD, City D, DE, DGO, DFM, DFO	DC, DD, City B, City C, CHP, DE, DGO, DFO	DB, City D, DFM	City A,
Communication w/ Cooperating Agencies	City B, CHP	DAO, DGO	DB, DD, City C, DE, City D, DFM, DFO	DB, DC, City A, City B, City C, CHP, DE, DGO	DD, City D, DFO	DFM
Raveler Information	CHP, DE	DAO, City B, City D, DFM	DB, DD, City C, DGO, DFO	DB, DC, DD, City B, City C, CHP, City D, DFM	City A, DGO, DFO	DE
Incident Detection	CHP	DAO, DC, City B, City C	DB, DD, DE, City D, DFM, DFO	DB, DC, DD, City A, City B, City C, CHP, DE, DFO	DGO, DFM	City D
Incident Management	City B,	DAO, DB, DD, DE, DFM, DFO, DC	DC, City C, DGO, City D, DFO	DB, DC, City A, City B, City C	DD, DE, DGO, City D, DFM	
Fleet Management		City B,	DAO, DC, DFO		DC, DD, City B, DFO	City A, DGO
Signal Control	City B, DFO	DA, DD, City A, City D	City C, DE, DGO, DC	DD, City A, City B, City C, DE, City D, DFO, DC	DGO	

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